NXP Semiconductors
Reference Manual

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S32K39, S32K37, and S32K36 Reference Manual

Supports S32K396, S32K394, S32K376, S32K374, S32K366, and S32K364

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Chapter 1
About This Manual

1.1 Audience

This reference manual (RM) is intended for system software, hardware developers, and applications programmers who need to develop products using this chip. It assumes that its users understand operating systems, microprocessor system design, and basic principles of software and hardware.

1.2 Organization

The first four chapters of the manual provide the detailed introduction to S32K396 chip. The remaining chapters are grouped in functional categories that detail particular areas of functionality. Each grouping includes chapters that provide a technical description of individual modules as shown below:

- Core and Systems
  - Cortex-M7 Overview
  - Overlay Management Unit (OMU)
  - Miscellaneous Control Module (MCM)
  - Miscellaneous System Control Module (MSCM)
  - Virtualization Wrapper (VIRT_WRAPPER)
  - System Integration Unit Lite2 (SIUL2)
  - Crossbar Switch Lite (AXBS_Lite)
  - Peripheral Bridge (AIPS_Lite)
  - Direct Memory Access Multiplexer (DMAMUX)
  - Enhanced Direct Memory Access (eDMA)
  - Interrupt Monitor (INTM)
  - Semaphores2 (SEMA42)
  - Crossbar Integrity Checker (XBIC)
  - Extended Resource Domain Controller (XRDC)
- Memory and Memory Overview
  - Memory and Memory Interfaces
  - Embedded Flash Memory (c40asf)
  - Flash Memory Controller (PFLASH)
  - RAM Controller (PRAMC)
- Clocking
  - Clocking chapter
  - Clock Generation Module (MC_CGM)
  - Fast Internal RC Oscillator (FIRC)
  - Slow Internal RC Oscillator (SIRC)
  - Fast Crystal Oscillator Digital Controller (FXOSC)
  - Dual PLL Digital Interface (PLLDIG)

- Reset and Boot
  - Reset Overview
  - Reset Generation Module (MC_RGM)
  - Power-on Reset Watchdog (POR_WDG)
  - Boot Overview
- Security and Device GPRs
  - Security Overview
  - Hardware Security Engine (HSE_B)
  - Device Configuration Format (DCF) records
  - Device Configuration Module General-Purpose Registers (DCM_GPR)
  - Device Configuration Module (DCM)
  - Messaging Unit (MU)
- Modes and Power Management
  - Power Management chapter
  - Power Management Controller (PMC)
  - Mode Entry Module (MC_ME)
  - Power Control Unit (MC_PCU)
  - Wakeup Unit (WKPU)
- Safety
  - Safety Overview
  - Error Injection Module (EIM)
  - Error Reporting Module (ERM)
  - Fault Collection and Control Unit (FCCU)
  - Self-test General-Purpose Registers (SELFTEST_GPR)
  - Self-Test Control Unit (STCU2)
  - Register Protection (REG_PROT)
  - Clock Monitoring Unit – Frequency Check (CMU_FC)
  - Clock Monitoring Unit – Frequency Meter (CMU_FM)
  - Cyclic Redundancy Check (CRC)
- Real-time control
  - Power Conversion and Motor Control (PCMC)
  - Input Glitch Filter
  - Enhanced Flex Pulse Width Modulator(eFlexPWM)
  - Analog-to-Digital Converter (ADC)
  - SIGMA DELTA ANALOG TO DIGITAL CONVERTER(SDADC)
  - ADCBIST
  - FIR filter
  - Low Power Comparator (LPCMP)

  - Logic Control Unit (LCU)
  - Enhanced Modular IO Subsystem (eMIOS)
  - Body Cross-triggering Unit (BCTU)
  - Trigger MUX (TRGMUX)
  - CoolFlux DSP Subsystem
  - Enhanced Time Processing Unit (eTPU)
  - Sine Wave Generator (SGEN)
- Timers
  - Software Watchdog Timer (SWT)
  - System Timer Module (STM)
  - Periodic Interrupt Timer (PIT)
  - Real Time Clock (RTC)
- Communication Modules
  - Low Power Serial Peripheral Interface (LPSPI)
  - Low Power Inter-Integrated Circuit (LPI2C)
  - Flexible I/O (FlexIO)
  - CAN (FlexCAN)
  - De-serial Serial Peripheral Interface (DSPI)
  - Ethernet Media Access Controller (EMAC)
  - Low Power Universal Asynchronous Receiver/ Transmitter (LPUART)
  - Quad Serial Peripheral Interface (QuadSPI)
  - Zipwire
  - Serial Interprocessor Interface (SIPI)
  - LVDS Fast Asynchronous Serial Transmission(LFAST)
- Debug Modules
  - Debug Subsystem
  - JTAG Controller (JTAGC)
  - JTAG Data Communication (JDC)
- Analog Modules
  - Temperature Sensor (TempSense)

1.2.1 Attachments

This manual includes key information in the files attached to it. For example, memory map and I/O details. Use the content in these attachments in conjunction with this manual's content.

NOTE

Select the paperclip icon on the left side of the PDF window to see the list of attachments.

NOTE

A few security documents may not have attachments.

1.3 Module descriptions

Each module chapter has two main parts:

- The first section, *chip-specific [module name]* information, provides details such as the number of module instances on the chip and connections between that module and the other ones. Read this section *first* because its content is crucial for understanding the information in the other sections of the chapter.
- The subsequent sections provide general information about the module, including its signals, registers, and functional description.

The following figure shows you an example of this demarcation.

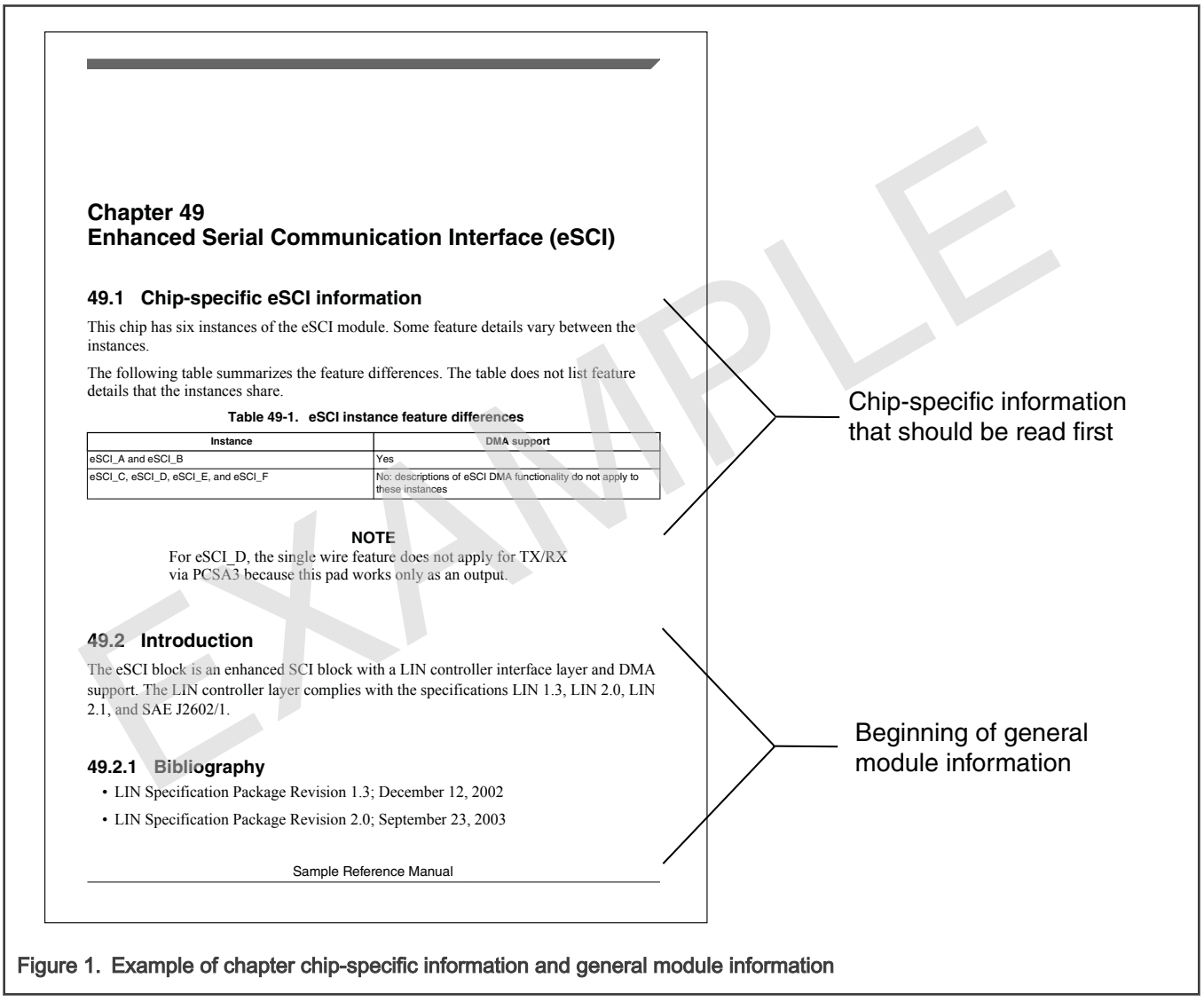


Figure 1. Example of chapter chip-specific information and general module information

1.3.1 Chip-specific information that clarifies content in the same chapter

The following figure shows an example of chip-specific information that clarifies general module information presented later in the chapter. In this case, the chip-specific register reset values supersede the reset values that appear in the register diagram.

Chapter 9
System Integration Unit Lite2 (SIUL2)

9.1 Chip-specific SIUL2 information

9.1.1 Feature configurations

In this device, the SIUL2_0 module instance does not support the following features described in the generic description:

- Interrupts
- DMA channels

9.1.2 Notes for IMCR

Out of reset, PA_00, PA_04, and PA_05 pads have JTAG input functionality selected by default. It should be disabled in the corresponding IMCR registers (IMCR61, IMCR60, and IMCR50 respectively) in order to use other functionality such as GPIO.

9.2 Introduction

9.2.1 Overview

The System Integration Unit Lite2 provides control over all the electrical pin controls and ports with 16 bits of bidirectional, general-purpose input and output signals. One of the most important functions of the SIUL2 is to enable the user to select the functions and electrical characteristics that appear on external device pins. It also controls the multiplexing of internal signals from one module to another and controls chip I/O. It supports as many as 32 external interrupts with trigger event configuration. The following figure is the block diagram of SIUL2 and its interfaces to other system components.

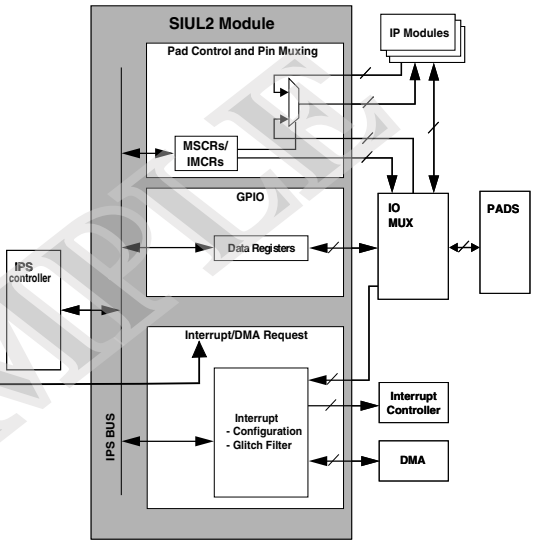


Figure 23. System Integration Unit Lite2 block diagram

This module provides dedicated pad control to general-purpose pads that can be configured as either inputs or outputs. The SIUL2 module provides registers that enable user software to read values from GPIO pads configured as inputs, and write values to GPIO pads configured as outputs:

- When configured as output, you can write to an internal register to control the state driven on the associated output pad.
- When configured as input, you can detect the state of the associated pad by reading the value from an internal register.
- When configured as input and output, the pad value can be read back, which can be used as a method of checking if the written value appeared on the pad.

To assist software development, GPIO data registers can be accessed using various mechanisms. These differing mechanisms allow support for port access or for bit manipulation without the need to use read-modify-write operations:

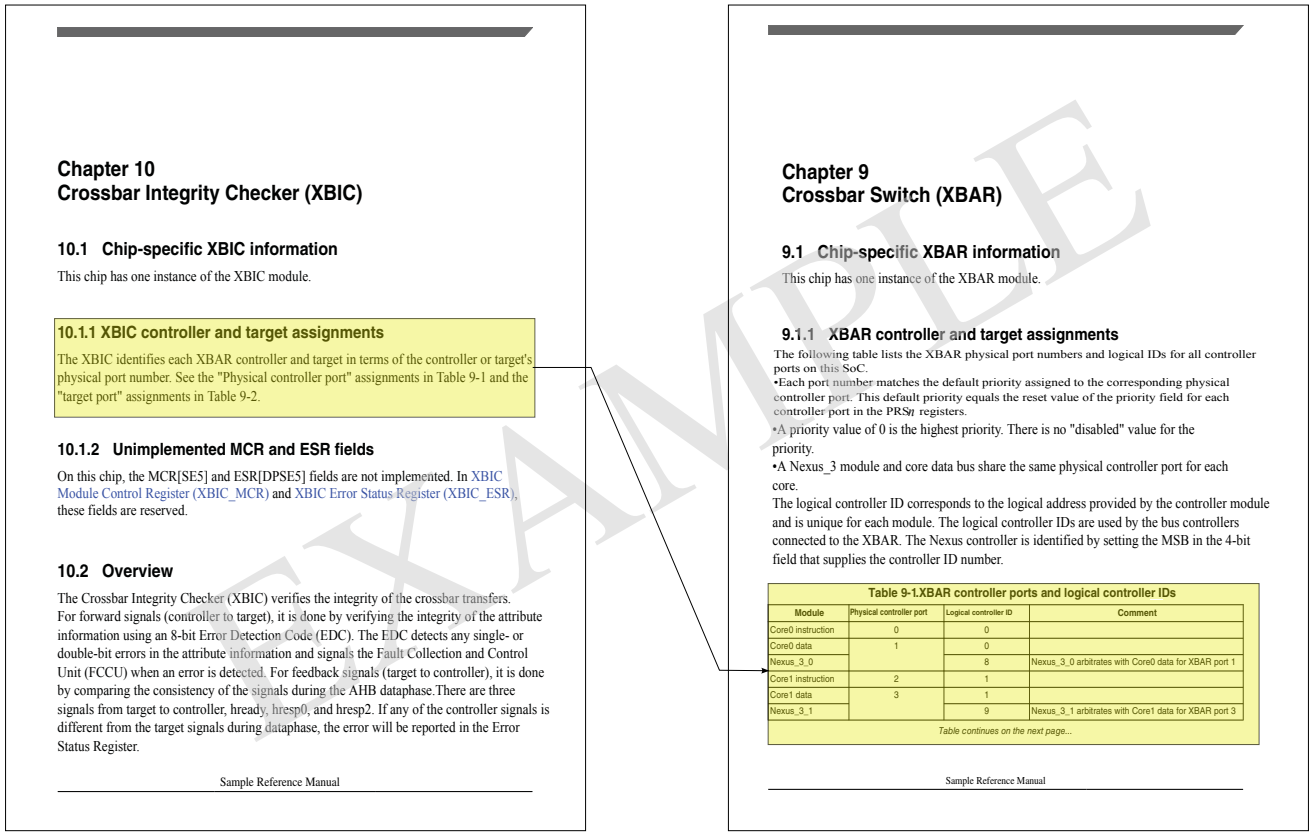
- Access to two 16-bit ports in one access
- Read/write access to a single bit
- A 16-bit port write with a bit mask, using single 32-bit access.

EXAMPLE

Figure 2. Example of chip-specific information that clarifies content in the same chapter

1.3.2 Chip-specific information that refers to a different chapter

Related chip-specific information may be provided in different chapters of the manual. The following figure shows an example of two such connected pieces of information. In this case, read both before you proceed.



Chapter 10
Crossbar Integrity Checker (XBIC)

10.1 Chip-specific XBIC information

This chip has one instance of the XBIC module.

10.1.1 XBIC controller and target assignments

The XBIC identifies each XBAR controller and target in terms of the controller or target's physical port number. See the "Physical controller port" assignments in Table 9-1 and the "target port" assignments in Table 9-2.

10.1.2 Unimplemented MCR and ESR fields

On this chip, the MCR[SE5] and ESR[DPSE5] fields are not implemented. In XBIC Module Control Register (XBIC_MCR) and XBIC Error Status Register (XBIC_ESR), these fields are reserved.

10.2 Overview

The Crossbar Integrity Checker (XBIC) verifies the integrity of the crossbar transfers. For forward signals (controller to target), it is done by verifying the integrity of the attribute information using an 8-bit Error Detection Code (EDC). The EDC detects any single- or double-bit errors in the attribute information and signals the Fault Collection and Control Unit (FCCU) when an error is detected. For feedback signals (target to controller), it is done by comparing the consistency of the signals during the AHB dataphase.There are three signals from target to controller, hready, hresp0, and hresp2. If any of the controller signals is different from the target signals during dataphase, the error will be reported in the Error Status Register.

Sample Reference Manual

Chapter 9
Crossbar Switch (XBAR)

9.1 Chip-specific XBAR information

This chip has one instance of the XBAR module.

9.1.1 XBAR controller and target assignments

The following table lists the XBAR physical port numbers and logical IDs for all controller ports on this SoC.

- Each port number matches the default priority assigned to the corresponding physical controller port. This default priority equals the reset value of the priority field for each controller port in the PRS*n* registers.
- A priority value of 0 is the highest priority. There is no "disabled" value for the priority.
- A Nexus_3 module and core data bus share the same physical controller port for each core.

The logical controller ID corresponds to the logical address provided by the controller module and is unique for each module. The logical controller IDs are used by the bus controllers connected to the XBAR. The Nexus controller is identified by setting the MSB in the 4-bit field that supplies the controller ID number.

Table 9-1.XBAR controller ports and logical controller IDs

Module	Physical controller port	Logical controller ID	Comment
Core0 instruction	0	0	
Core0 data	1	0	
Nexus_3_0		8	Nexus_3_0 arbitrates with Core0 data for XBAR port 1
Core1 instruction	2	1	
Core1 data	3	1	
Nexus_3_1		9	Nexus_3_1 arbitrates with Core1 data for XBAR port 3

Table continues on the next page...

Sample Reference Manual

Figure 3. Example of chip-specific information that refers to a different chapter

1.4 Register descriptions

Module chapters present register information in the following:

- Memory maps, which contain:
  - An offset from the module's base address
  - The mnemonic and name of each register
  - The width of each register (in bits)
  - The reset value of each register
- Register figures
- Field-description tables
- Associated text

The following figure shows register figure conventions used throughout the manual.

Access type	Access description	DITA output	Effect of Write on Value	Readback Value
RW	Read/write	R / W: Mnemonic	Changes to Written Value	Current Value
RO	Read-only	R: Mnemonic / W:	No Effect	Current Value
RU	Reserved, unimplemented	R / W: Reserved	No Effect	Value Undefined
ROZ	Reserved, Read-only zero	R: 0 / W:	No Effect	Returns All Zero
ROO	Reserved, Read-only one	R: 1 / W:	No Effect	Returns All Ones
WO	Write-only	R: / W: Mnemonic	Changed to Written Value	Value Undefined
WOZ	Reserved, Write-only zero	R: / W: 0	Write Value Must Be All 0s.	Value Undefined
WOO	Reserved, Write-only one	R: / W: 1	Write Value Must Be All 1s.	Value Undefined
W0C	Write zero to clear	R: Mnemonic / W: w0c	If a Bit in the Written Value is a 0, the Corresponding Bit in the Field is Set to 0. Otherwise, the Field Bit is Not Affected.	Current Value
W1C	Write one to clear	R: Mnemonic / W: w1c	If a Bit in the Written Value is a 1, the Corresponding Bit in the Field is set to 0. Otherwise, the Field Bit is Not Affected.	Current Value
R2C	Read to clear		Value is cleared following the read operation	Current Value
ROWZ	Read-only, writes zero	R: Mnemonic / W: 0	Write Value Must Be All 0s	Current Value
ROWO	Read-only writes one	R: Mnemonic / W: 1	Write Value Must Be All 1s	Current Value
ROWU	Ready-only writes undefined	R: Mnemonic / W: —	Writes Operation Undefine	Current Value
WORZ	Write-only reads zero	R: 0 / W: Mnemonic	Changes to Written Value	Returns All Zero
WORO	Write-only reads one	R: 1 / W: Mnemonic	Changes to Written Value	Returns All Ones
WORU	Write-only reads undefined	R: — / W: Mnemonic	Changes to Written Value	Value Undefined

Figure 4. Register figure conventions

NOTE

Reset values of reserved locations documented in this manual are subject to change and must not be used for diagnostic purposes.

1.5 Conventions

1.5.1 Notes and cautions

Specific information is provided as part of notes and cautions throughout this manual.

NOTE

Emphasizes information that deserves extra attention.

CAUTION

Informs you of situations that could lead to highly undesirable outcomes—such as damage to the chip or irreversible malfunction.

1.5.2 Numbering systems

The following suffixes identify different numbering systems:

Table 1. Numbering systems

This suffix	Identifies a
b	Binary number. For example, the binary equivalent of the number 5 is mentioned as 101b. In some cases, *0b* is prefixed to binary numbers.
d	Decimal number. Decimal numbers are followed by this suffix only when there is a possibility of confusion. In general, decimal numbers are used without a suffix.
h	Hexadecimal number. For example, the hexadecimal equivalent of the number 60 is mentioned as 3Ch. In some cases, *0x* is prefixed to hexadecimal numbers.

1.5.3 Typographic notation

The following typographic notations are used throughout this document:

Table 2. Typographic notation

Example	Description
x and other italicized text	The italicized, lowercase *x* is used as a placeholder for replaceable numbers. In general, italicized text is used for titles of publications and for emphasis. Additionally, italics could be used for metasymbols in syntax descriptions. Plain lowercase letters are used as placeholders for single letters and numbers.
`code font`	Fixed-width font (such as Courier) used for code. It is used for a letter, word, or phrase that you want the user to type. For example, "Type `Read` and press Enter." This type of font is also used for instruction mnemonics, directives, symbols, subcommands, parameters, operators, computer-language elements, code listings, commands that appear in running text, and for sample code. Instruction mnemonics and directives in text and tables are mentioned in all caps; for example, BSR.
SR[SCM]	A mnemonic in square brackets represents the name of a register field. This example refers to the Scaling Mode (SCM) field in the Status Register (SR).
REVNO[6:4], XAD[7:0]	Numbers in brackets that are separated by a colon represent either: • A subset of a register's named field

Table continues on the next page...

Table 2. Typographic notation (continued)

Example	Description
	For example, REVNO[6:4] refers to bits 6-4 that are part of the COREREV field occupying bits 6-0 of the REVNO register. • A continuous range of individual signals of a bus For example, XAD[7:0] refers to signals 7-0 of the XAD bus.
MOD.REG	A period separates the elements of a hierarchy: subsystem.module.register. For example: • SWT.TO means that the TO register is located in the SWT module. • SMU.XRDC.CR means that the CR register is located in the XRDC module within the SMU subsystem.

1.5.4 Special terms

The following terms have special meanings.

Table 3. Special terms

Term	Meaning
Asserted	Refers to the state of a signal as follows: • An active-high signal is asserted when high (1). • An active-low signal is asserted when low (0).
Deasserted	Refers to the state of a signal as follows: • An active-high signal is deasserted when low (0). • An active-low signal is deasserted when high (1). In some cases, deasserted signals are described as *negated*.
Reserved	Refers to memory space, register, field, or programming setting. Writes to a reserved location can result in unpredictable functionality or behavior. You must: • Before writing to a location which contain reserved bits user must make sure the write operation will write the reserved bit with value specified as the reset value in NXP reference manual. • Consider undefined locations in memory to be reserved as reset value 0 shall be assumed. You might get a BERR(transfer error) response on access to undefined locations in memory. • If user reads data from memory area containing reserved bit, the value of reserved bits should be ignored and not used for any functional purposes. **NOTE** BootROM could modify the reserved bit values after reset. Please refer to the BootROM settings attachment.
Write 1 to clear (w1c)	Refers to the access type of a register field that is used to clear the field by writing the value 1 to it.
Undefined (u)	Refers to undefined reset values

1.6 Editorial changes

Each new release of this document includes editorial improvements such as:

- Spelling
- Grammar
- Punctuation
- Voice
- Tense
- Capitalization
- Formatting
- Presentation
- Navigation

1.7 Glossary

The "Glossary" section provides a list of selected terms and definitions used in a chapter. The glossary, if present, is placed at the end of the chapter.

A glossary contains:

- NXP-specific terms, symbols, and notations, with definitions.
- Terms, symbols, and notations that can have different meanings in different contexts. The glossary defines the way they are used in the chapter—especially if the meaning is different from the meaning in standard references.

A glossary does not contain:

- Field mnemonics
- Register mnemonics
- Module mnemonics
- Signal names
- Industry-standard terms

Chapter 2
Introduction

2.1 S32K396 product series

The S32K396 product series further extends the highly scalable portfolio of Arm® Cortex®-M7 K3xx MCUs in the automotive industry. It features:

- The Cortex-M7 core at a higher frequency.
- Advanced motor control coprocessors.
- An extended analog, including a high-resolution PWM.

S32K396 is developed to meet the next generation SiC traction inverter requirements and to enable high efficiency, low latency, and system-level BOM cost savings. Because of its versatile architecture, S32K396 is also well suited to address a wide range of xEV applications.

The S32K39x MCUs extend the high-performance capabilities of S32K37x with two programmable motor control coprocessors. Additionally, S32K36x MCUs are optimized solution targeted at single traction motor control application. The last digit denotes the size of Flash memory size. See the Feature comparison for a detailed overview of the differences between variants. When the S32K396 is referenced in the RM it means the conditions, configurations or features are valid for all the variants of the device.

S32K396 can also be used in combination with powerful 16 nm NXP MCUs or MPUs (S32Z2 and S3E2), in these ways:

- As a companion die: connected locally (same ECU) to S32Z2 and S3E2 through the Zipwire interface to extend 5V I/O and analog capabilities
- As a smart actuator: connected remotely via Ethernet or FlexCAN

2.2 Prominent inclusions

The S32K396 series is equipped with easy-to-use enablement software, application-specific software, and various development tools supported by a broad range of third parties, in different development phases.

The portfolio scalability and future-proof features, such as advanced security and software, tools, and third-party development support, allow developers to standardize the S32K396 series for their end-product platforms, maximizing reuse of hardware and software. This functionality also reduces the time to market of these chips.

The S32K396 chips primarily include the following:

- A 32-bit Cortex-M7 core with IEEE 754-compliant SPFPU, executing at a frequency of up to 320 MHz
- Scalable memory footprints of up to 6 MB flash memory and 800 KB SRAM
- Precision mixed-signal capability with LPCMPs
- Four SDADCs, seven SAR_ADCs, and two SWGs
- Powerful coprocessors supporting advanced motor control applications
- Serial communication interfaces such as LPUART, LPSPI, LPI2C, FlexCAN with ISO CAN-FD support, 10/100 Ethernet, and QuadSPI
- FlexIO configuration that allows other communication options, including SENT
- EVITA full and light functionality that is HSE_B compliant
- Power supply (3.0–5.5 V) with fully functional flash memory program, erase, and read operations
- Functional safety compliance with ISO 26262 levels B or D (features depend on chip specification):
  - Lockstep cores
  - Multiple internal watchdogs

    - Voltage monitors
    - Clock monitors
    - Memory protection
    - Data transport checks
    - ECC on memories
    - CRC
- Ambient operation temperature range: –40°C to 125°C
- Junction temperature range: –40°C to 150°C
- Tools and solutions:
    - S32 Design Studio:
        - Eclipse IDE
        - NXP GNU compilers for the Cortex-M7 core
        - Low-cost debugger with multi-core debug, tracing, and profiling support
        - Pin wizard with a detailed pin configuration report
        - Graphical clock tree for clock configuration
        - Peripheral configuration
- Model-based design toolbox:
    - Integrated Simulink®-embedded target for direct rapid prototyping and PIL development workflows
    - Peripheral chip interface blocks and drivers
    - Target-optimized mathematical and motor control algorithm blocks for efficient execution on the target chip
    - Bit-accurate simulation that results in a Simulink simulation environment
- Software solutions:
    - S32 SDK
        - Communication stacks
        - Middleware
        - Low-level drivers
    - AUTOSAR 4.4 MCAL and OS
    - FreeRTOS
- Design that works in conjunction with NXP SBC FS2600

2.3 Block diagram

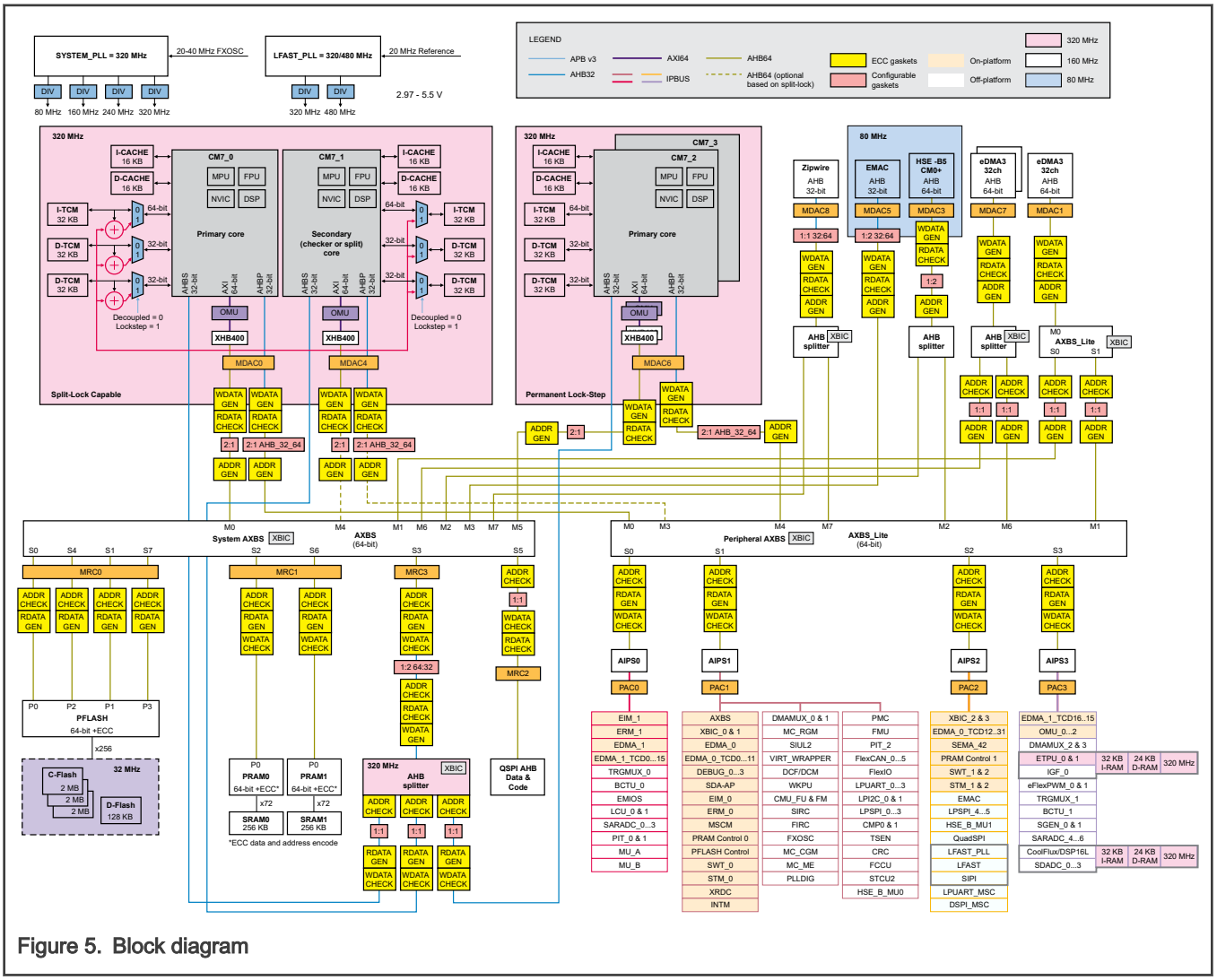


Figure 5. Block diagram

2.4 Feature summary

The following table provides a list of Cortex-M7 core features that the S32K396 product family supports.

Table 4. Feature summary

Feature	Inclusions
Core and architecture	• Cortex-M7 core running up to 320 MHz • Arm core based on the Armv7 architecture and ThumbR-2 ISA • 16 KB D-cache and 16 KB I-cache for optimizing wait state execution from memories • 96 KB TCM associated with each core • On-core MPU for dynamic task protection (16 regions)

Table continues on the next page...

Table 4. Feature summary (continued)

Feature	Inclusions
	• IEEE 754-compliant SPFPU • Harvard bus architecture implementing dedicated instruction and data path • 6-stage pipeline with branch speculation • XRDC integrated with a crossbar switch to provide memory and peripheral protection • DSP and SIMD extension • I/O protection (VIRT_WRAPPER) • ETM supporting instruction trace • Arm third-party ecosystem support: software and tools to help minimize development time and cost
DSP and coprocessors	• CoolFlux DSP16L with: — A frequency of 160 MHz — One core and four threads — 32 KB Instruction RAM and 24 KB Data RAM • Two coprocessor cores at a frequency of 320 MHz each that help with: — Software running independently of the Cortex-M7 CPUs — 32 KB code RAM and 8 KB data RAM — DSP and mathematical capabilities • Extra safety features such as ECC, watchdog, latency monitor, and idle counter
DMA	• 2 x 64-channel DMAMUX per eDMA • 2 x 32-channel eDMAs (1 eDMA implemented as a lock-step pair) • Complex data transfers performed with minimal intervention from a host processor • Programmable support for scatter-gather DMA processing
System and power management	• Support for simplified power modes (Run and Standby) • Support for clock gating of unused modules; specific peripherals continue to work in low-power modes • Support for an external ballast transistor to generate core supply • Fully independent CPU and peripheral clocking scheme • Rapid start-up from a 48 MHz FIRC • Low-power oscillator such as the 32 kHz SIRC • PMC with LVD and selectable trip points

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Table 4. Feature summary (continued)

Feature	Inclusions
	• Support for multiple power modes • NMI
Memory and memory interfaces	• Up to 6 MB program flash memory with an ECC • Up to 128 KB data flash memory with an ECC • Up to 800 KB SRAM with an ECC • 8-bit QuadSPI • 120 MHz DTR
Clocks	• External 8–40 MHz crystal oscillator or resonator • Internal clock references: — 48 MHz FIRC ± 5% — 32 kHz SIRC ± 10% • Up to 640 MHz PLL for divided system clock operation
Security and integrity	• HSE_B: Upgradable firmware that NXP delivers and you can program • Security ciphers: — Symmetric: AES with 128, 192, or 256 bits — Cipher modes: ECB, CBC, CMAC, GMAC, CTR, OFB, CCM, and GCM — Asymmetric: RSA (up to 4096 bytes) and ECC (up to 521 bytes) — Hash: Miyaguchi-Preneel, SHA-2/SHA-3 (up to 512 bytes) — Number of keys that the HSE_B firmware configures and controls — Random number generator • Security use cases supported: — OTA update — Secure boot — Secure communication — Component protection — Secure storage — Key exchange
Safety ISO26262	• Classification up to ASIL D • ERM and EIM support • Watchdog timers with an independent clock source • Voltage monitors

Table continues on the next page...

Table 4. Feature summary (continued)

Feature	Inclusions
	• Bandgap voltage available as ADC input • External clock source monitoring using an independent reference • PLL lock and loss-of-lock protection • XRDC • Access control, memory protection, and peripheral isolation • ECC on code flash memory, data flash memory, and system RAM • ADC self-test feature • Internal analog monitoring of all supplies available • CRC generation module • FCCU failure output
Analog	• 12-bit ADC: — Up to 69 external analog inputs — 1 µs conversion time — Internal bandgap voltage reference channel, supporting automatic compare and an optional hardware trigger — Up to five internal reference inputs — Automatic compare with interrupt — Self-test and self-calibration scheme • SDADC: — Integrated digital filtering (CoolFlux DSP) • SGEN (Sine Wave Generator) — Input clock frequency range: 12 MHz–20 MHz — Output sinusoidal signal frequency range: 1 kHz–50 kHz • LPCMP with an internal 8-bit DAC as a reference: — LPCMP with both positive and negative inputs, with separately selectable interrupts on rising and falling comparator outputs — Ability to cross-trigger the timers from both the ADC and LPCMP outputs • Temperature sensor (TempSense) with an output that ADC measures
I/O timers	• eFlexPWM with NanoEdge (high-resolution PWM): — 16 bits (+5 with NanoEdge) of resolution for center-aligned, edge-aligned, and asymmetrical PWMs — Support for double switching PWM outputs

Table continues on the next page...

Table 4. Feature summary (continued)

Feature	Inclusions
	— Fault inputs that can be assigned to control multiple PWM outputs — Independent top and bottom hardware deadtime insertion — Multiple output trigger events that can be generated per PWM cycle via hardware • 24-bit eMIOS timer, offering up to 24 standard channels: — Input Capture, Output Compare, and PWM modes — Fault input support with global fault control — Multiple features such as deadtime insertion, configurable polarity, quadrature decoding, and so on • Motor control and power conversion using a combination of eTPU, eFlexPWM, eMIOS, LCU, BCTU, and SWG • 3 x STMs, with four channels each • 32-bit RTC • 3 x 32-bit PITs, with four channels for raising interrupts and triggering DMA channels
Communications	• LPSPI supporting DMA with full-duplex or single-wire bidirectional communication in Master or Slave mode • LPI2C modules with: — DMA support — Low-power availability — Master or slave support — System management bus • FlexIO, with an option to configure as different communication peripherals, offering support for SENT • LPUART with DMA support, having: — An optional 13-bit break — Full-duplex NRZ — LIN 2.1 extension support — Low-power availability • FlexCAN modules with ISOCAN-FD and DMA support • EMAC complex (10/100 Ethernet) that supports 1588 timers, MII/RMII interface, and AVB and TSN support • MSC • Zipwire (high-speed SIPI and LFAST)
Debug	• DWT, with four configurable comparators as hardware watch points

Table continues on the next page...

Table 4. Feature summary (continued)

Feature	Inclusions
	• SWO-synchronous trace data support • ITM with software and hardware trace plus timestamping • FPB with an ability to patch code and data from code space to system space • All execution units and bus masters made traceable through TPIU over GPIO pins; a very-low-bandwidth trace option also available via the SWO • ETF: a dedicated trace buffer available for each of the core masters, allowing data to be captured internally before being optionally routed to external trace pins • SWV: trace capability providing displays of: — Reads — Writes — Exceptions — PC samples — Print
I/O and package	• Up to 237 GPIO pins • Up to 144 GPIO pins with interrupt functionality • Up to 77 GPIO pins with wakeup capability • Pseudo open-drain support on LPUART, FlexIO, and LPI2C • Package options of 289 MAPBGA and 176 LQFP-EP

2.5 Feature comparison

The following table compares some of the prominent features of the S32K396 product series.

Table 5. Feature comparison

Feature	S32K396	S32K394	S32K376	S32K374	S32K366	S32K364
Safety/ASIL	ASIL D					
Number of CPU cores	Three Arm® Cortex®-M7 cores				Two Arm® Cortex®-M7 cores	
Core configurations	One lockstep core pair and Two split-lock configurable cores				One lockstep core pair and One Cortex-M7_0 core	
Core frequency (MHz)	320					
Program flash memory (MB)	6	4	6	4	6	4

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Table 5. Feature comparison (continued)

Feature	S32K396	S32K394	S32K376	S32K374	S32K366	S32K364
Data flash memory (KB)	128					
Total RAM (KB)	800 (including 64 KB standby RAM and 288 KB TCM)				704 (including 64 KB standby RAM and 192 KB TCM)	
Standby RAM (KB)	64					
Security	HSE_B					
DMA	2 x 32-channel eDMA (1 eDMA implemented as a lock-step pair)					
Maximum performance (DMIPS)[1]	2218-3101-6509 1 core in lockstep (ASIL D) and 2 cores in split-lock (ASIL B)				1478-2067-4339 1 core in lockstep (ASIL D) and 1 core (ASIL B)	
ASIL D (DMIPS)[1]	1478-2067-4339				739-1034-2170	
Advanced motor control coprocessor configuration	2 x eTPU engines at a frequency of 320 MHz (32 channels each) with an input glitch filter		N/A		2 x eTPU engines at a frequency of 320 MHz (16 channels each) with an input glitch filter	
DSP (CoolFlux) [MHz]	160 (4 threads)				160 (2 threads)	
eFlexPWM configuration	2 x eFlexPWM with NanoEdge (8 channels each)					
FlexCAN instances	6					
EMAC configuration	1 x 10/100 Mbit/s					
LPUART (LIN) instances	4					
Zipwire instances[2]	1					
QuadSPI instances	1					
LPSPI instances	6[3]					
I^2C instances	2					
FlexIO configuration	8 channels, 32 pins Emulating UART, I^2C, SPI, I^2S, SENT, PWM, and camera interface					
MSC instances[4]	1					

Table continues on the next page...

Table 5. Feature comparison (continued)

Feature	S32K396	S32K394	S32K376	S32K374	S32K366	S32K364
SAR_ADC 1-Msps instances	7				4	
SDADC instances	4				2	
SGEN instances	2				1	
LPCMP instances	2				1	
PIT instances	3					
SWT instances	3					
STM instances	3					
LCU instances	2					
BCTU instances	2				1	
TRGMUX instances	2					
eMIOS instances	1 (24 channels)				1 (16 channels)	
RTC instances	1					
289-ball MAPBGA included?	Yes					
176 LQFP-EP included?	Yes					

1. The first result abides by all of the "ground rules" out in Dhrystone documentation, the second permits inlining of functions, not just permitted C strings libraries, while the third additionally permits simultaneous ("multi-file") compilation. All are with the original (K and R) v2.1 of Dhrystone. Arm Compiler 6.17. See https://developer.arm.com/Processors/Cortex-M7 for details.
2. This feature is available for 289 MAPBGA.
3. You can increase the number of channels by using FlexIO emulation.
4. LVDS and single-ended in 289 MAPBGA; single-ended only in 176 LQFP-EP.

2.6 Glossary

ISO CAN-FD	ISO 11898-1 compliant CAN with flexible data-rate (CAN FD)
CCM	Counter with cipher block chaining message authentication code (CBC MAC)
CMAC	Cipher-based message authentication code
CTR	Counter-Based Block Cipher mode
DWT	Debug watchpoint and trace
ECC	Elliptic curve cryptography or error code correction
ETF	Embedded trace FIFO
ETM	Embedded trace macrocell
EVITA	E-safety vehicle intrusion protected applications

GCM	Galois/Counter mode, an encryption algorithm
ITM	Instrumentation trace macrocell
LPCMP	Low-power comparator
MSC	Microsecond channel
OFB	Output-Feedback-Based Block Cipher mode
SENT	Single edge nibble transmission
SPFPU	Single-precision floating-point unit
SWG	Sine wave generator
SWV	Serial wire viewer

Chapter 3
Memory Map

3.1 Introduction

The S32K396 chip contains various memories and memory-mapped peripherals that are placed in a 32-bit contiguous memory space. This chapter describes the memory and peripheral locations within that memory space.

For high-level chip memory map details, see the memory map file attached to this document.

3.2 Memory types

The S32K396 chip has a total of 800 KB available RAM, partitioned as follows:

- ITCMs (96 KB)
- D0TCMs (96 KB)
- D1TCMs (96 KB)
- PRAMC_0 (256 KB)
- PRAMC_1 (256 KB)

PRAMC_0 controls the first 256 KB of RAM that is implemented as follows:

- The first 64 KB of memory supports retention in Standby mode.
- Another set of 64 KB and 128 KB memory is available only in Run mode.

PRAMC_1 controls the next 256 KB of RAM that is partitioned into two sets of 128 KB, and both these sets are available in Run mode.

The memory map file attached to this document provides a complete architectural address space definition for various sections into which the RAM is partitioned. Depending on the physical sizes of the memories and peripherals, the actual address regions used may be smaller.

In addition to ITCM, DTCM, and SRAM, a particular section of the RAM is associated with the Arm Cortex-M7 core internal cache. This chip contains 16 KB of I-cache and 16 KB of D-cache RAM for each Cortex-M7 core.

The cache attributes in the S32K396 cache scheme are defined for a given address range and core, not according to the physical RAM or flash memory block.

3.3 Access-related details of memory types

The Cortex-M7 core can access these memories sequentially:

- ITCM
- DTCM
- I-cache
- D-cache

Any master can access ITCM and DTCM via the 32-bit AHBS interface, for example, different Cortex-M7 cores, eDMA, and so on, to bootload instructions in ITCM. EMAC is another master that can access DTCM. See the "Introduction" chapter for details on the transaction path.

Access to SRAM beyond the RAM available on the chip terminates the bus cycle with an error followed by an appropriate response in the requesting bus master.

3.4 TCM as system memory

In a multicore chip, all enabled core and noncore masters can use TCMs of the disabled core. To allow the use of ITCM and DTCM of the disabled core as system memories, an enabled core master must execute the following steps:

1. Write 1 to the following fields in MC_ME:
   - PRTN2_COFB1_CLKEN[REQ62] for the Cortex-M7_0 core
   - PRTN2_COFB1_CLKEN[REQ63] for the Cortex-M7_1 core
   - PRTN2_COFB2_CLKEN[REQ64] for the Cortex-M7_2 core

   This enables the Cortex-M7 core's TCM controller clock.
2. Write 1 to the following fields in DCM_GPR:
   - DCMRWF4[CM7_0_CPUWAIT] for the Cortex-M7_0 core
   - DCMRWF4[CM7_1_CPUWAIT] for the Cortex-M7_1 core
   - DCMRWF4[CM7_2_CPUWAIT] for the Cortex-M7_2 core

   This configures the core operation in Wait mode.
3. Write 1 to the following fields in MC_ME:
   - PRTN0_CORE0_PCONF[CCE] for the Cortex-M7_0 core
   - PRTN0_CORE1_PCONF[CCE] for the Cortex-M7_1 core
   - PRTN0_CORE4_PCONF[CCE] for the Cortex-M7_2 core

   This enables the Cortex-M7 core's clock.

3.5 TCM mode of operation

The following table provides information on the DCM_GPR and MC_ME control fields, along with the Cortex-M7 core and TCM mode settings.

Table 6. TCM modes of operation

Description	Control field (internal signal)			Cortex-M7 core and TCM mode	
	PRTN2_COFB*i*[1]_CLKEN[REQ62+*n*]	DCMRWF4[CM7_*n*_CPUWAIT]	PRTN0_CORE*n*_PCONF[CCE]	Cortex-M7_*n* mode	Cortex-M7_*n*_TCM backdoor enabled?
Application configurations	—	0	1	Run	Yes
	0	1	1	Wait	Yes
	1	1	1	Wait	Yes
	—	—	0	Disabled	No

1. Where *i* represents the Cortex-M7_0 and Cortex-M7_1 cores and 2 represents the Cortex-M7_2 core.

3.6 TCM implementation: considerations

Before performing read accesses, you must first initialize TCM (ITCM and DTCM) and system RAMs by using 64-bit writes.

You must initialize the system RAM using eDMA and the core.

Only the core can perform ITCM initialization by using either direct or backdoor accesses. ITCM initialization via backdoor can be done by using STM (Store Multiple) with even number of registers. STRD (Store Dual) instruction would not work.

You must initialize the DTCM by using 32-bit writes performed either using the core's direct and backdoor accesses or eDMA. These writes are required to set up the initial ECC code words after chip POR.

Each Cortex-M7 core is equipped with a 32 KB ITCM and 64 KB DTCM with a zero wait-state access. In the lockstep operation, the checker core's TCM is added to the primary core.

See the "Memory and Memory Interfaces" chapter for details on memory ECC initialization.

3.7 Flash memory

For details, see the memory map file attached to this document.

3.8 AIPS_Lite memory map

You can access the peripheral memory map via a crossbar slave port. The following table shows the four regions associated with peripheral space.

Table 7. Regions associated with peripheral space

Address of region (hex)	Region description
4000_0000–401F_FFFF	This 2048 KB region (AIPS_Lite_0) is partitioned into 128 spaces, each 16 KB in size, having 32 on-platform and 96 off-platform spaces. AIPS_Lite generates unique module enables for all the 32 on-platform spaces.
4020_0000–403F_FFFF	This 2048 KB region (AIPS_Lite_1) is partitioned into 128 spaces, each 16 KB in size, having 32 on-platform and 96 off-platform spaces. AIPS_Lite generates unique module enables for all the 32 on-platform spaces.
4040_0000–405F_FFFF	This 2048 KB region (AIPS_Lite_2) is partitioned into 128 spaces, each 16 KB in size, having 32 on-platform and 96 off-platform spaces. AIPS_Lite generates unique module enables for all the 32 on-platform spaces.
4060_0000–407F_FFFF	This 2048 KB region (AIPS_Lite_3) is partitioned into 128 spaces, each 16 KB in size, having 32 on-platform and 96 off-platform spaces. AIPS_Lite generates unique module enables for all the 32 on-platform spaces.

Modules that are disabled via their clock gate control fields in the MC_CGM registers disable the associated AIPS_Lite slots. Access to any address within an unimplemented or disabled peripheral bridge slot results in a transfer error termination.

Multiple instances of the same peripherals are connected to different bridges on the interconnect. For details, see the memory map file attached to this document.

3.9 Serialization of memory operations

In particular cases, you must complete the process of writing to a peripheral before the subsequent action occurs. Examples of such situations include:

- Exiting an interrupt service routine
- Changing a mode
- Configuring a function

In these situations, you must perform a read-after-write sequence to achieve the required serialization of memory operations. The following table provides this sequence.

Table 8. Serialization of memory operations

Step	Action
1	Write to the associated peripheral register.
2	Read the register to verify the write process.
3	Continue the subsequent operations.

3.10 PPB memory map

PPB is a part of the defined Arm bus architecture and provides access to specific processor-local modules. You can access these modules only through the core, and not through other system masters.

Table 9. PPB memory map

Starting hex address	Ending hex address	Size (KB)	Module
E000_0000	E000_0FFF	4	ITM
E000_1000	E000_1FFF	4	DWT
E000_2000	E000_2FFF	4	FPB
E000_3000	E000_DFFF	44	—
E000_E000	E000_EFFF	4	SCS
E000_F000	E003_FFFF	196	Reserved
E004_0000	E004_0FFF	4	TPIU
E004_1000	E004_1FFF	4	ETM
E004_2000	E004_2FFF	4	CTI
E004_3000	E004_3FFF	4	—
E004_4000	E004_4FFF	4	—
E004_5000	E004_5FFF	4	—
E004_6000	E007_FFFF	232	—
E008_0000	E008_0FFF	4	MCM
E008_1000	E008_1FFF	4	—
E008_2000	E008_2FFF	4	—
E008_3000	E00F_EFFF	496	—
E00F_F000	E00F_FFFF	4	Cortex-M7 core PPB ROM table

3.11 Glossary

FPB Flash patch and breakpoints

PPB Private peripheral bus

SCS System control space

Chapter 4
Signal Multiplexing

4.1 Introduction

The signal multiplexing enables the sharing of single pad for multiple functions.

The signal multiplexing unit comprises control signals from SIUL2 and pad interface logic. The signal multiplexing unit consists of several individual sub-units, each handling the signal multiplexing of one pad.

The "SIUL2 Multiplexed Signal Configuration Register (MSCR)" controls the module specific pad settings (pull-up etc) and the signal present on the external pin. See SIUL2_MSCR for the description of control signals. The pad attributes may vary depending on the pad type.

For the pad attributes of each pad type and their reset values per port, see the IOMUX file attached to this document. The pads specific to the packages and their multiplexing is also documented in the IOMUX file attached to this document.

NOTE

The input functions for the protocols which are not to be used should be appropriated configured as 'disabled low'/'disabled high' with appropriate SIUL2.IMCR configurations corresponding for that function.

4.2 Pad description

Following figure shows the basic representation of a GPIO pad.

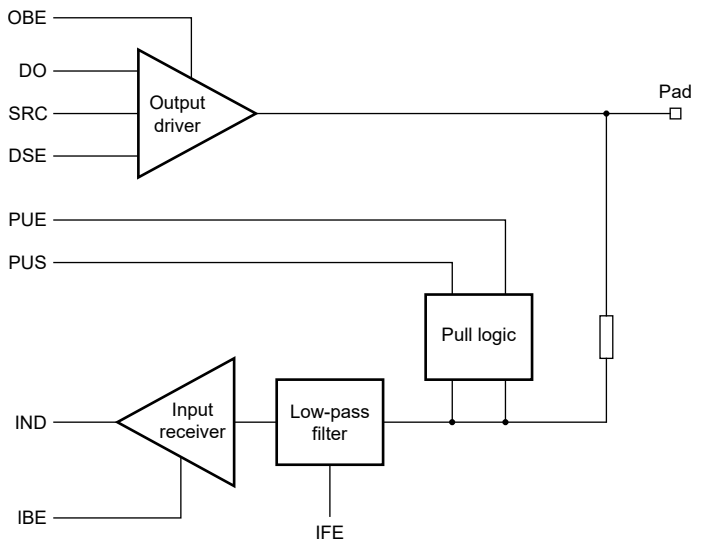

Figure 6. GPIO pad representation

Table 10. Pad Signal description

Signal name	Direction	Description
Pad	I/O	I/O to external world
DO	I	Data coming from the core into the pad
OBE	I	Enable output driver

Table continues on the next page...

Table 10. Pad Signal description (continued)

Signal name	Direction	Description
PUE	I	0: Disable internal pullup or pulldown resistor 1: Enable internal pullup or pulldown resistor
PUS	I	0: Enable internal pulldown resistor if pue is set 1: Enable internal pullup resistor if pue is set
IBE	I	Enable input receiver
IND	O	Data coming out of the pad into the core
SRC	I	Slew Rate Control
PKE	I	Pad keeping enable
IFE	I	Input filter enable
DSE	I	Drive Strength enable

Table 11. Input buffer enable

IBE	Pad	IND	Description
0	X	0	Input buffer disabled, ind gets low
1	0/1	0/1	Input buffer enabled, ind = pad

Table 12. Output buffer enable

OBE	DO	Pad	Description
0	X	Z	Output buffer disabled, pad hi-Z (If not configured as input)
1	0/1	0/1	Output buffer enable, pad = do

Table 13. Input filter enable

IFE	Description
1	Input filter enabled
0	Input filter disabled

Table 14. Pull up/Pull down

PUE	PUS	Pad	Description
0	X	-	Weak pull disabled. Pad retains previous state
1	0	0	Weak pull down enabled
1	1	1	Weak pull up enabled

Table 15. Slew rate control

SRC	Description
0	Slew rate enabled
1	Slew rate disabled

Table 16. Drive strength enable

DSE	Description
1	Drive strength supported
0	Drive strength not supported

Table 17. Pad keeping enable

PKE	Description
0	Pad keeping disabled
1	Pad keeping enabled

4.3 Functional description

The signal multiplexing architectural implementation is as shown in the following figure.

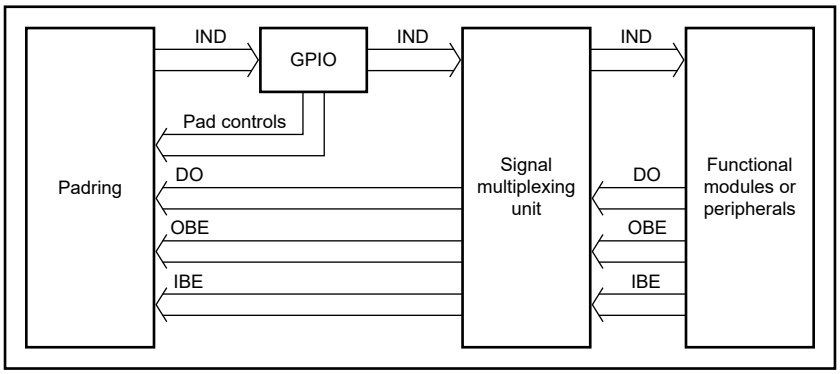

Figure 7. Signal Multiplexing

4.4 Signal Multiplexing sheet

IO Signal Description Input Multiplexing sheet(s) attached to the Reference Manual contains information on pins/balls of this device.

The 'IO Signal Table' and 'Input Muxing' tabs in the sheet correspond to the signal multiplexing information. The 'IO Signal Table' consists of all the pin muxing details and the 'Input Muxing' specifies the priority for the input muxing where an input path is driven by more than one pad.

4.4.1 IO Signal Table

Following is an example snippet of IO Signal Table. For selecting any functionality, the pad MSCR register (refer to SIUL2_MSCRn) needs to be configured accordingly.

Pin	CR	SSS	Function	Module	Description	Direction	Pad Type	32K344_1V2to1p2	32K344_1V2to0p8	I/O Power Domain	Pad State During Destructive Reset	Pad State After Destructive Reset	Pad State During Functional Reset	Pad State After Functional Reset	Pad State After SelfTest	Pad State After FCCU Error	I/O Power Segment	MSCR
PTA0	SIUL_MSCR0	0000_0000	GPIO[0]	SIUL		I/O	GPIO-STANDARD	A13	T13	VDD_HV_A	Hi-Z	Hi-Z	Hi-Z	Hi-Z	Hi-Z	Hi-Z		0
PTA0		0000_0001	LPSPI4_PCS2	LPSPI4	Peripheral Chip Select 2	O												
PTA0		0000_0010	eMIOS_0_CH[17]_Y	eMIOS_0	eMIOS Channel	O												
PTA0		0000_0011	LCU0_OUT4	LCU0	LCU Output	O												
PTA0		0000_0100	FXIO_D2	FXIO	FlexIO Bi-directional Shift/timer I/O	O												
PTA0		0000_0101	eMIOS_1_CH0[0]_X	eMIOS_1	eMIOS Channel	O												
PTA0		0000_0110	LPSPI0_PCS7	LPSPI0	Peripheral Chip Select 7	O												
PTA0		0000_0111	TRGMUX_OUT3	TRGMUX	Trigger Mux Output	O												
PTA0	-	-	ADC0_S8	ADC0	ADC Standard Input	I												
PTA0	-	-	CMP1_IN0	CMP1	Comparator Input Signal	I												
PTA0	SIUL_IMCR32	0000_0000	EIRQ[0]	SIUL	External Interrupt	I												
PTA0	SIUL_IMCR32	0000_0010	eMIOS_0_CH[17]_Y	eMIOS_0	eMIOS Channel	I												
PTA0	SIUL_IMCR32	0000_0011	eMIOS_1_CH0[0]_X	eMIOS_1	eMIOS Channel	I												
PTA0	SIUL_IMCR64	0000_0100	FXIO_D2	FXIO	FlexIO Bi-directional Shift/timer I/O	I												
PTA0	SIUL_IMCR76	0000_0101	LPSPI0_PCS7	LPSPI0	Peripheral Chip Select 7	I												
PTA0	SIUL_IMCR76	0000_0110	LPSPI4_PCS2	LPSPI4	Peripheral Chip Select 2	I												
PTA0	SIUL_IMCR32	0000_0001	LPUART0_CTS	LPUART0	Clear To Send (bar)	I												

Figure 8. IO signal table snippet

The columns of the above figure are described below:

- Port: This field in IO Signal Table specifies the PAD names of the device.
- CR(Control Register): This field specifies the name of MSCR corresponding to the Port field. 'On this device, there are eight port groups (PTA, PTB, PTC, PTD, PTE, PTF, PTG and PTH) that are controlled by SIUL2_MSCRn registers. The below table shows the mapping of ports with respect to SIUL2_MSCRn registers.

Table 18. Port/MSCR mapping

Port	SIUL2_MSCRn index
PortA[0-31]	MSCR0 - MSCR31
PortB[0-31]	MSCR32 - MSCR63
PortC[0-31]	MSCR64 - MSCR95
PortD[0-31]	MSCR96 - MSCR127
PortE[0-31]	MSCR128 - MSCR159
PortF[0-31]	MSCR160 - MSCR191
PortG[0-12]	MSCR192 - MSCR236

See SIUL2_MSCR/IMCR (See following Input Muxing section for details on IMCR) for description of MSCR/IMCR fields.

- SSS: This field specifies the ALT mode of operation as per MSCR[Mux_mode]. Not all pins support all pin muxing slots. Unimplemented pin muxing slots are reserved. The corresponding pin is configured in the following pin muxing slot as follows:
  - 000: Alternative 0 (GPIO)
  - 001: Alternative 1 (chip-specific)
  - 010: Alternative 2 (chip-specific)
  - 011: Alternative 3 (chip-specific)
  - 100: Alternative 4 (chip-specific)
  - 101: Alternative 5 (chip-specific)
  - 110: Alternative 6 (chip-specific)
  - 111: Alternative 7 (chip-specific)

NOTE

The analog functionalities are specified with '-' in this field.

- Function: This field specifies the functionality of the pad as per the corresponding ALT mode specified by SSS field.
- Module: The Module field contains the module which is governing the pad for the ALT mode.
- Description: This field mentions a short description of pad functionality.
- Direction: This field specifies the direction (Input, Output or Input/Output) of the pad for the concerned functionality.
- Pad Type: This field mentions the pad type of the corresponding pad.
  - GPIO-Standard:
    - Switching up to 10MHz
    - High drive-strengh not supported.
    - Slew-rate control not supported.
  - GPIO-Standard plus:

- Switching up to 25MHz
- Supports high drive-strengh.
- Slew-rate control not supported.

— GPIO-Medium:

- Switching up to 50MHz
- Supports high drive-strengh.
- Supports slew-rate control.

— GPIO-Fast:

- Switching up to 120MHz
- Supports high drive-strengh.
- Supports slew-rate control.

- The next columns specify the pin number in the supported packages for the device.
- I/O Power Domain: This field refers to the power domain of associated pad (VDD_HV_A / VDD_HV_B).
- Pad State during/after Reset: These fields represent the pad states during and post different device resets.
- MSCR: This field specifies the default MSCR value for corresponding pad. Refer SIUL2_MSCRn for description of MSCR fields.
- The next two columns specify the reset value and the configurable bit fields of MSCR corresponding to pad.

4.4.2 Input muxing table

As the same function can be multiplexed to several pads by configuring their respective IMCRs, there is priority input muxing. In case of same input being driven from multiple pads, the one with highest priority (1 being the highest) will drive the input. Following is a snippet of Input Muxing Table.

Destination Instance	Destination Function	CR Instance	Input CR#	Input SSS	Source Instance	Source Signal	S32K344_257bga	S32K344_172mqfp_D
CAN0	CAN0_RX	SIUL	SIUL_IMCR512	0000_0000	-	disable low		
				0000_0001	IO_PAD	PTC2	T4	50
				0000_0010	IO_PAD	PTA6	M15	102
				0000_0011	IO_PAD	PTB0	P16	95
				0000_0100	IO_PAD	PTA28	N2	30
				0000_0101	IO_PAD	PTF21	K14	

Figure 9. Input muxing table snippet

The columns of the figure are briefly described below:

- Destination Instance: This field contains the instance name of the input path to where the signal will propagate from padring.
- Destination Function: This field mentions the function name of the input path.
- Input SSS: This field specifies the IMCR[Mux_mode] value corresponding to the pad specified in source signal column.
- Source Instance: This field specifies the source pad type. A blank is mentioned for the default source when no pad is driving the input path.
- Source Signal: This field mentions the pad name. A ‘disable low’/’disable high’ specifies the signal behavior when none of the pads are driving the input path.
- The next columns specify the pin number in the supported packages for the device.

4.4.3 MSCR/IMCR description/explanation

MSCR assignments

The Implemented SIUL2 Multiplexed Single Configuration Register details is provided in the I/O Signal Description Table attached as excel.

Example:

If user wants to configure PTB0 as CAN0RX and PTB1 as CAN0TX, then the following configuration can be used in SIUL2 registers:

```
//.CAN0.RX.(PTB0):
SIUL2.IMCR0.B.SSS.=.0b011;.//.Select.CAN0-RX
SIUL2.MSCR32.B.IBE.=.1;....//.Enable.the.input.buffer

//.CAN0.TX.(PTB1):
SIUL2.MSCR33.B.SSS.=.0b101;.//.Select.CAN0-TX
SIUL2.MSCR33.B.OBE.=.1;.//.Enable.the.output.buffer
```

MSCR bit fields correspond to pin/pad basis, these are independent of muxing implemented on that specific pin/pad. As an example, pad PTA31 has SSS, SMC, DSE, PUS, PKE, INV, IBE and OBE are implemented with the reset value 0 and SRC is implemented with reset value 1.

In the 'IO Signal Table' tab of the IOMUX file attached, the MSCR register bits shows ‘0’, ‘1’, and ‘-’ for state of all bits associated with different ports. ‘0’ or ’1’ represents the reset state and ‘-’ represents the bit is not supported on the respective port.

NOTE

The GPIOs 38 and 39 are used for direct connections and FXOSC.

4.4.4 Pinout diagrams

See IO Signal Description Input Multiplexing sheet(s) attached to the Reference Manual for pinout diagrams corresponding to available packages.

4.5 Pin States

The tables in the upcoming sections mention the state of pins of the device under various conditions/event like Functional Reset, Destructive Reset, Power Up condition, during Selftest Phase etc. The details of the Reset events can be found in the Reset overview Chapter. The Details of Selftest can be found in the STCU chapter.

4.5.1 Pin numbers

The pin numbers which have been referenced to the tables are explicitly mentioned here

- RESET_B: PTA5 = GPIO5. The pad state tables below assume RESET_B configured as Reset pin (See UTEST DCF record 'dcf_client_reset_pad_dedicated' in the DCF clients file attached to this document for Reset pin control as dedicated/muxed GPIO'.
- JTAG_TMS : PTA4 = GPIO4
- JTAG_TCK : PTC4 = GPIO68
- JTAG_TDI : PTC5 = GPIO69
- JTAG_TDO : PTA10 = GPIO10
- TRACE_ETM_CLKOUT : PTG6 = GPIO[198] (Slow pad trace), PTC1=GPIO[65] (Fast pad trace), PTC2=GPIO[66] (Fast pad trace)

- TRACE_ETM_D0 : PTG7 = GPIO[199] (Slow pad trace), PTC0=GPIO[64] (Fast pad trace), PTD7=GPIO[103] (Fast pad trace)
- TRACE_ETM_D1 : PTG15 = GPIO[207] (Slow pad trace), PTD9=GPIO[105] (Fast pad trace), PTD12=GPIO[108] (Fast pad trace)
- TRACE_ETM_D2 : PTG16 = GPIO[208] (Slow pad trace), PTD8=GPIO[104] (Fast pad trace), PTD11=GPIO[107] (Fast pad trace)
- TRACE_ETM_D3 : PTF31 = GPIO[191] (Slow pad trace), PTC17=GPIO[81] (Fast pad trace), PTD10=GPIO[106] (Fast pad trace)
- TRACE_ETM_D4 : PTG17 = GPIO[209] (Slow pad trace)
- TRACE_ETM_D5 : PTF28 = GPIO[188] (Slow pad trace)
- TRACE_ETM_D[6:15] : PTG18:PTG27 = GPIO[210]:GPIO[219] (Slow pad trace)
- CLKOUT_STANDBY : PTA22:PTE10 = GPIO[22]:GPIO[138]
- FCCU_ERR[0:1] : PTA2:PTA3:PTE15:PTE16:PTF14:PTF15 = GPIO[2]:GPIO[3], GPIO[143]:GPIO[144], GPIO[174]:GPIO[175]

4.5.2 Power up

This table mentions the pin behavior on power up condition of the device.

Table 19. Power up

Pin function	POWER UP until SW comes up[1]
RESET_B	LOW
JTAG_TMS,JTAG_TCK,JTAG_TDI,JTAG_TDO as JTAG	PULLED Values: (TMS = HIGH, TCK = LOW, TDI =HIGH) TDO: HIGH Z
ETM_TRACE	HIGH Z
FCCU_ERR	HIGH Z
CLKOUT_STANDBY	HIGH Z
GPIOs	HIGH Z
EXTAL	HIGH Z till extal is connected
XTAL	HIGH Z till xtal is connected

1. The IO pad states are undefined until Supply rises sufficiently to enable the POR circuits.

4.5.3 Destructive Reset

This table mentions the Pin behavior when any Destructive Reset event is triggered.

Table 20. Destructive Reset

Pins	ON Destructive Reset until SW comes up
RESET_B	LOW
TMS,TCK,TDI,TDO as JTAG	PULLED Values:

Table continues on the next page...

Table 20. Destructive Reset (continued)

Pins	ON Destructive Reset until SW comes up
	(TMS = HIGH TCK = LOW, TDI =HIGH) TDO: HIGH Z
ETM_TRACE (Only on 17trace Pins)	HIGH Z
FCCU_ERR	HIGH Z
CLKOUT_STANDBY	Clkout expose if CLKOUT_STANDBY is configured to be Enabled Else HIGH Z
GPIOs	HIGH Z

4.5.4 Functional Reset including Functional entry sequence

This table mentions the Pin behavior when any functional Reset event is triggered. Also, when the FCCU reaction is configured as Functional Reset , then also the same behavior is achieved.

Table 21. Functional Reset including Functional entry sequence

Pins	Functional Reset Entry	Reset until SW comes up
RESET_B	LOW	LOW
TMS,TCK,TDI,TDO as JTAG	TMS,TCK,TDI: PULLED Values if configured as JTAG (TMS = HIGH TCK = LOW, TDI =HIGH) HIGH Z if configured as GPIO TDO: HIGH Z	PULLED Values (TMS = HIGH TCK = LOW, TDI =HIGH) TDO: HIGH Z
ETM_TRACE	Trace if MDMAPCTL[DBGRSTSLOWPAD] or MDMAPCTL[DBGRSTFASTPAD] is configured to be Enabled Else HIGH Z	Trace if MDMAPCTL[DBGRSTSLOWPAD] or MDMAPCTL[DBGRSTFASTPAD] is configured to be Enabled Else HIGH Z
FCCU_ERR	ERR from FCCU if UTEST_MISC[FCCU_EOUT_DEDICATED] is configured to be Enabled Else HIGH Z	ERR from FCCU if UTEST_MISC[FCCU_EOUT_DEDICATED] is configured to be Enabled. Else HIGH Z
CLKOUT_STANDBY	Clkout expose if DCMRWP1[CLKOUT_STANDBY] is configured to be Enabled Else HIGH Z	Clkout expose if DCMRWP1[CLKOUT_STANDBY] is configured to be Enabled Else HIGH Z
GPIOs	HIGH Z	HIGH Z

4.5.5 SELFTEST(MC_RGM.ERCTRL[ERASSERT] configured as 1)

Table 22. SELFTEST(MC_RGM.ERCTRL[ERASSERT] configured as 1)

Pins	Selftest	Reset until SW comes up
RESET_B	LOW if configured as Reset Pin High Z if configured as GPIO	LOW if configured as Reset Pin High Z if configured as GPIO
TMS,TCK,TDI,TDO as JTAG	PULLED Values if configured as JTAG (TMS = HIGH, TCK = LOW, TDI = HIGH) TDO: HIGH Z	PULLED Values (TMS = HIGH, TCK = LOW, TDI = HIGH) TDO: HIGH Z
ETM_TRACE	Trace if MDMAPCTL[DBGRSTSLOWPAD] or MDMAPCTL[DBGRSTFASTPAD] is configured to be Enabled. Else HIGH Z	Trace if MDMAPCTL[DBGRSTSLOWPAD] or MDMAPCTL[DBGRSTFASTPAD] is configured to be Enabled. Else HIGH Z
FCCU_ERR	FCCU Error State if UTEST_MISC[FCCU_EOUT_DEDICATED] is Enabled and DCMRWD2[EOUT_STAT_DUR_STEST] is Enabled Else HIGH Z	FCCU Error State if UTEST_MISC[FCCU_EOUT_DEDICATED] is Enabled and DCMRWD2[EOUT_STAT_DUR_STEST] is Enabled Else HIGH Z
CLKOUT_STANDBY	Clkout expose if DCMRWP1[CLKOUT_STANDBY] is configured to be Enabled Else HIGH Z	Clkout expose if DCMRWP1[CLKOUT_STANDBY] is configured to be Enabled Else HIGH Z
GPIOs	HIGH Z	HIGH Z

4.5.6 SELFTEST (RGM_ERCTRL[ERASSERT]=0 and RGM_FRBE[ST_DONE] =0)

Table 23. SELFTEST (RGM_ERCTRL[ERASSERT]=0 and RGM_FRBE[ST_DONE] =0)

Pins	Selftest	Reset after Selftest until SW comes up
RESET_B	Same state as before selftest	Same state as before selftest
TMS,TCK,TDI,TDO as JTAG	Same state as before selftest	PULLED Values (TMS = HIGH, TCK = LOW, TDI = HIGH) TDO: No change
ETM_TRACE	Same state as before selftest	Same state as before selftest
FCCU_ERR	FCCU Error State if UTEST_MISC[FCCU_EOUT_DEDICATED] is Enabled and DCMRWD2[EOUT_STAT_DUR_STEST] is Enabled	FCCU Error State if UTEST_MISC[FCCU_EOUT_DEDICATED] is Enabled and DCMRWD2[EOUT_STAT_DUR_STEST] is Enabled

Table continues on the next page...

Table 23. SELFTEST (RGM_ERCTRL[ERASSERT]=0 and RGM_FRBE[ST_DONE] =0) (continued)

Pins	Selftest	Reset after Selftest until SW comes up
	Else No change	Else No change
CLKOUT_STANDBY	Same state as before selftest	Same state as before selftest
GPIOs	Same state as before selftest	Same state as before selftest

4.5.7 FCCU fault in RUN mode when the fault reaction is not Reset

NOTE

All GPIO pins output buffers are controlled by the corresponding MSCR[SMC] bit when the FCCU is in the fault state. If MSCR[SMC] is cleared then the pin output buffer is disabled (high Z) else if MSCR[SMC] is set then the pin output buffer configuration is retained.

Table 24. FCCU fault in RUN mode, fault reaction not Reset

Pins	ON FCCU Fault
RESET_B	If RESET_B is assigned as a dedicated PAD then no change in the state of the PAD else if RESET_B is configured as GPIO then it would behave as per the SMC configuration. • Case 1: If dcf_client_reset_pad_dedicated[reset pad dedicated] is configured as 1'b1, the pad functions as per the reset state machine. • Case 2: If dcf_client_reset_pad_dedicated[reset pad dedicated] is configured as 1'b0 and SIUL2.MSCR5[SMC] is configured as 1'b1, the pad functions as per the configured protocol status, the protocol being configured via SIUL2.MSCR5[SSS]. • Case 3: If dcf_client_reset_pad_dedicated[reset pad dedicated] is configured as 1'b0 and SIUL2.MSCR5[SMC] is configured as 1'b0, the pin gets tristated (high-Z).
TMS, TCK, TDI, TDO as JTAG	If the PAD is configured as a JTAG PAD then no change and the pad would continue performing the operation else if it is a GPIO PAD then it would behave as per the SMC configuration. • Case 1: If the pad is configured for JTAG mode and SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b1, the pad functions as per the JTAGC state machine or protocol. • Case 2: If the pad is configured for non-JTAG mode and SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b0, the pins get tristated (high-Z).
ETM_TRACE	If the PAD is configured as a dedicated PAD then no change and the pad would continue performing the operation else if it is a GPIO PAD then it would behave as per the SMC configuration. • Case 1: If the pad is configured for ETM_TRACE functionality and SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b1, the pad functions as per the ETM trace control logic. • Case 2: If the pad is configured for non-ETM_TRACE mode and SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b0, the pins get tristated (high-Z).
FCCU_ERR	If the PAD is configured as a dedicated PAD by programming the UTEST_MISC[FCCU_EOUT_DEDICATED] as well as Eout indication is enabled then it would be indicating error state else if it is a GPIO PAD then it would behave as per the SMC configuration.

Table continues on the next page...

Table 24. FCCU fault in RUN mode, fault reaction not Reset (continued)

Pins	ON FCCU Fault
	• Case 1: If dcf_client_utest_misc[FCCU_EOUT_DEDICATED] is configured as 1'b1, the FCCU_ERR pins indicate the error state. • Case 2: If dcf_client_utest_misc[FCCU_EOUT_DEDICATED] is configured as 1'b0 and SMC bit of the SIUL2's corresponding MSCR register is configured as 1'b1, the pin retains its state. • Case 3: If dcf_client_utest_misc[FCCU_EOUT_DEDICATED] is configured as 1'b0 and SIUL2.MSCR5[SMC] is configured as 1'b0, the pin gets tristated (high-Z).
CLKOUT_STANDBY	If the PAD is configured as a dedicated PAD then no change and the pad would continue performing the operation else if it is a GPIO PAD then it would behave as per the SMC configuration. • Case 1: If the pad is configured for CLKOUT_STANDBY functionality and SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b1, the pin continues functioning as the CLKOUT_STANDBY pin. • Case 2: If the SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b0, the pin gets tristated (high-Z).
GPIOs	If the PAD is configured as a dedicated PAD then no change and the pad would continue performing the operation else if it is a GPIO PAD then it would behave as per the SMC configuration. • Case 1: If the SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b1, the pin continues its operation. • Case 2: If the SMC bit of SIUL2's MSCR register of the corresponding pin is configured as 1'b0, the pins get tristated (high-Z).

4.5.8 STANDBY (DCMRWF1[STANDBY_IO_CONFIG] must be configured as 1)

- Please refer to Padkeeping Section for steps to configure the various pad states during standby

Table 25. STANDBY

Pins	Standby until SW comes up
RESET_B	Alive / HighZ /LOW/HIGH (Depends on Software configuration before entering STANDBY)
TMS,TCK,TDI,TDO as JTAG	HighZ /LOW/HIGH (Depends on Software configuration before entering STANDBY)
ETM_TRACE	HighZ /LOW/HIGH (Depends on Software configuration before entering STANDBY)
FCUU_ERR	HighZ /LOW/HIGH (Depends on Software configuration before entering STANDBY)
CLKOUT_STANDBY	Alive / HighZ /LOW/HIGH (Depends on Software configuration before entering STANDBY)
GPIOs	HighZ /LOW/HIGH (Depends on Software configuration before entering STANDBY)

4.6 Glossary

DSE Drive strength enable

EXTAL	External crystal input
GPIO	General purpose input/output
IBE	Input buffer enable
INV	Invert enable
JTAG_TMS	JTAG test mode select
JTAG_TCK	JTAG test clock input
JTAG_TDI	JTAG test data input
JTAG_TDO	JTAG test data output
OBE	Output buffer enable
PUS	Pullup and pulldown select
PKE	Pad keeping enable
SMC	Safe mode control
SRC	Slew rate control
SSS	Solid-state storage
XTAL	External crystal output

Chapter 5
Cortex-M7 Overview

5.1 Introduction

The Cortex-M7 core is a high-performance embedded processor designed for use in deeply embedded applications that require fast interrupt response features. The configuration of the processor is based on the little-endian format, and you must also compile the execution testbench tests in this format.

Cortex-M7 supports four cores:

- Cortex-M7_0 and Cortex-M7_1 in Split-lock mode
- Cortex-M7_2 and Cortex-M7_3 in Permanent Lockstep mode

NOTE

- TCM cannot be initialized using backdoor path.
- Cortex-M7_1 is not available in S32K36x.

5.1.1 Features

- Low interrupt latency
- Low-cost debug
- Backward compatibility with existing Cortex-M profile processors
- In-order superscalar pipeline
- Dual-issue support for load/load and load/store instruction pairs to multiple memory interfaces
- An MPU that you could configure to protect regions of memory
- An NVIC
- A debug and trace unit (CoreSight components)
- Floating-point arithmetic functionality, with support for single-precision arithmetic
- The ability to perform speculative load from any normal memory space through its AXIM bus, if D-cache is enabled
- Several memory interfaces that include:
  - I-caches and D-caches based on the Harvard architecture.
  - An AXIM interface.
  - A dedicated low-latency AHBP interface.
  - A 64-bit AXI AMBA4 memory interface with a 16 KB I-cache and a 16 KB D-cache for efficient access to external resources. The I-caches and D-caches are ECC protected.
  - A 32-bit AHBS for interfacing with slaves such as DMA.
  - 64-bit and 32-bit memory interfaces for a connection with local tightly coupled memories called ITCM and DTCM. Each Cortex-M7 core interfaces with low-latency 32 KB ITCM, 32 KB DTCM0, and 32 KB DTCM1.

5.1.2 Related information

See the following resources for detailed information:

- Arm Cortex-M7 Processor Technical Reference Manual (for more on the Cortex-M7 core).
- Arm Cortex-M7 Devices Generic User Guide (for more on the Cortex-M7 core peripherals and control).

- The memory map file attached for this document (for more on system memory map).

5.1.3 Buses and associated information

The following table discusses the buses and associated interconnects and interfaces of the Cortex-M7 core.

Table 26. Buses and associated information

Bus name	Description
AXIM	Using the XHB400 module, this bus first translates to the AHB-Lite bus that interfaces with the AXBS crossbar switch, providing high-bandwidth access to on-chip memories and peripherals.
AHBP	This bus connects to the AXBS crossbar switch, providing high-bandwidth access to on-chip peripherals.
AHBS	The 32-bit AHB slave (AHBS) interface provides system access to the ITCM, D1TCM, and D0TCM.
PPB	This bus provides access to the following modules: • Arm modules, such as NVIC, ETM, ITM, DWT, and ROM tables

NOTE

S32K396 AHBP bus is enabled after reset. Therefore, accesses of all cores to on-chip peripherals are performed exclusively through this bus.

5.1.4 Core configuration

The following table describes parameter settings of the Cortex-M7 core.

Table 27. Core configuration

Parameter	Configuration[1]
FPU	Single precision
DSP extension instructions	• Single-cycle 16/32-bit MAC • Single-cycle dual 16-bit MAC • 8/16-bit SIMD arithmetic • Hardware divide (2–12 cycles)
ARMv8-M security extensions	Not implemented
I-cache	Implemented
D-cache	Implemented
ECC caches	Implemented
On-core MPU region	16
Number of IRQs	240
IRQ priority width configuration	4 (16 interrupt priority levels)
Debug (breakpoint/watchpoint)	Full comparator set: 4 DWT and 8 FPB comparators
Internal trace support	ITM and DWT trace functionality implemented

Table continues on the next page...

Table 27. Core configuration (continued)

Parameter	Configuration[1]
ETM support	Instruction and data ETM interface implemented
CTI	Implemented
WIC support	Not implemented[2]
Dual-redundant core (lockstep) CPU functionality	Not implemented
RAR[3]	All asynchronously reset
I-cache size	16 KB
D-cache size	16 KB
ITCM	32 KB
DTCM0	32 KB
DTCM1	32 KB

1. ARMv7-M (Harvard architecture), six-stage superscalar plus branch prediction.
2. The WIC parameter is set to 1 to the core, but the WIC ports are not used. Therefore, the logic related to it optimizes at synthesis.
3. RAR is set to 2 for all registers, including ETM, to reset asynchronously. The Arm Cortex-M7 processor is synthesized using the RAR integration parameter set to 2.

5.2 Speculative accesses

The Cortex-M7 core can issue speculative read accesses that may access any location within the complete memory address range. This behavior can be controlled, but not disabled. For a proper operation of your system, consider the corresponding effects.

Speculative accesses do not cause any processor faults. The processor is aware whether an access is speculative and ignores any error response the system signals because of speculative accesses. However, the system that is integrating the processor cannot distinguish between speculative and non-speculative accesses: The addresses that speculative accesses use are not validated against the memory map of the chip. They may also attempt to access non-existing memory regions or hardware elements having side effects. See Related information for more on the corresponding behavior of the Cortex-M7 core. Important processing aspects are listed in the “Memory Model” section of the *Generic User Guide*.

Speculative accesses can result in improved performance when the related memory regions are properly characterized. It is imperative to properly set up the attributes within the MPU to avoid any unwanted impact of a speculative access. Examples of possible, corresponding issues are usually the result of side effects unknown to the processor:

- Speculative access to an uninitialized RAM memory location that causes a double-bit error (FCCU performs the related fault processing independently of the processor).
- Speculative access to a peripheral that causes an unwanted operation; for example, a FIFO read (the corresponding data may be removed from the FIFO without being processed).
- Speculative access to a peripheral that is not clocked, powered down, or cannot respond (the access may not be terminated, resulting into an access that is stalled, leading to system blockage).
- Speculative access to an address range that causes an unexpected error being reported; for example, a read-while-write error of the embedded flash memory (that writing 1 to MCRS[RWE] indicates) during a flash memory erase or program operation, which may hide real errors.
- A proper assignment of memory regions within the MPU can control speculative accesses.
- Speculative instruction fetches are never made to memory addresses in an Execute Never region.
- Speculative data reads are never made to memory addresses marked as non-accessible in the MPU.

- Speculative cache line fills are never made to noncacheable memory addresses.
- Speculative data reads and speculative cache line fills are never made to memory addresses in a region having a Device or Strongly-ordered memory attribute.
- Speculative reads are never made on the AHBP interface.
- Speculative writes are never made.

Memory regions mapped to a TCM are always treated as normal memory (equivalent to the MPU attribute) and are therefore always subject to speculation. You can avoid related issues by properly initializing any TCM memory before a corresponding access may occur.

When no speculative accesses should be initiated to a memory region, NXP recommends you to set the following attributes within the MPU for this region:

- Device or Strongly-ordered
- Execute Never

These attributes are often also used for address ranges associated with peripherals.

You can also prevent unwanted side effects that a speculative access causes by disabling related events when a speculative access occurs. For example, you can enable FCCU after the ECC of the RAM memories is initialized. Another example is that you can inhibit read accesses to a flash memory block by configuring an MPU region when it is being erased.

5.3 Debug facilities

This chip has extensive debug capabilities such as run control and tracing. It includes the standard Arm debug port that supports the JTAG and SWD interfaces.

5.4 Vector fetch behavior on the Cortex-M7 core

For the Cortex-M7 core, vector fetches are looked up into the I-cache. If the vector table is located in a region of memory that is cacheable, you must treat any load or store to the vector as self-modifying code. Cache maintenance instructions must also be used to synchronize updates to both D-caches and I-caches. See the "Cache maintenance design hints and tips" chapter in the *Cortex-M7 Devices Generic User Guide* that recommends you to synchronize D-cache and I-cache.

If cache maintenance is to be avoided each time when the vector table is updated, the vector table must be allocated in the ITCM or DTCM because those are noncacheable regions. Alternatively, you must enable the I-cache after the vector table initializes.

5.5 Glossary

AHBP	AHB-Lite peripheral interface
AHBS	AHB-Lite slave interface
AXIM	Advanced extensible interface master
DWT	Data watchpoint and trace unit
ETM	Embedded trace macrocell
FPU	Floating-point unit
FPB	Flash patch and breakpoint
ITM	Instrumentation trace macrocell
MAC	Multiplier accumulator (refers to a multiplier accumulator unit as well as multiplier accumulator operation)
NVIC	Nested vectored interrupt controller
RAR	Reset-all-registers
SIMD	Single instruction multiple data

Chapter 6
Overlay Management Unit (OMU)

6.1 Chip-specific OMU information

6.1.1 OMU configuration

S32K396 does not support the region size 8192 KB.

6.1.2 OMU features

Table 28. OMU features

Parameters	Details	Value
NUM_ORD	Sets the number of overlay region descriptors	16

6.1.3 Calibration

In the S32K396, the OMU is used to overlay memory. The OMU is added between CM7 and XHB400, with CM7 on upper side and XHB400 on the lower side of OMU. The OMUs are connected to the peripheral bus to allow access to the registers. Following are the OMUs used:

- Two are in permanent lockstep mode for the two cores in permanent lockstep mode.
- Two in split-lock mode, for the 2 cores in split-lock mode.

By default the OMU is enabled. The DCF can be programmed to disable the OMU using the dcf_client_caldis.

The OMU dynamic bypass feature is implemented. It will dynamically bypass all addresses except 0x0840_0000-0x08bF_FFFF when OMU is enabled and when disabled all addresses are passed without any delay (bypass mode for all addresses). 0x0840_0000-0x08bF_FFFF is mirrored flash area and is translated to 0x0040_0000-0x00bF_FFFF. Note that remapping takes place only between mirrored Flash Area and QSPI.

NOTE

OMU requires its corresponding core to be active. It must be ensured that the Core CM7_x is not clock gated while accessing its OMU, OMU_CM7_x, else the system might enter a hang state.

NOTE

Split-lock mode is not available in S32K36x.

6.1.4 OMU Bypass Control

The OMU supports two modes as described in the 'Operating Modes' section.

- Normal (bypass) mode
  - All OMU address relocation services are disabled in normal mode. Normal mode is enabled when OER[OE] is cleared.
- Development mode
  - OMU address relocation services are enabled in development mode. Development mode is enabled when OER[OE] is set.

The operating mode is configured using OMUx.OER[OE] field.

Configuring OMUx.OER[OE] field as 1’b0 configures the OMUx into bypass mode, i.e., the AXI address relocation services get disabled.

Besides this, the OMU can be configured into bypass mode using dcf_client_caldis record in the UTEST memory space. Refer device DCF record information in the attached S32K39_and_S32K37_DCF_clients.xlsx

Configuring the CALDIS bit(s) as 1'b1 within the dcf_client_caldis record, the corresponding OMU gets configured into the bypass mode. This record can be used by application if the AXI address relocation services are not required. In such a case the record can be configured to result in OMU bypass mode.

NOTE

The dcf_client_caldis record is write once client.

6.2 Overview

OMU is a hardware block that controls overlay mapping. It has 16 regions that you can configure to perform specific and global relocation services. OMU is a basic building block to enable calibration during development as well as in a production module.

6.2.1 Block diagram

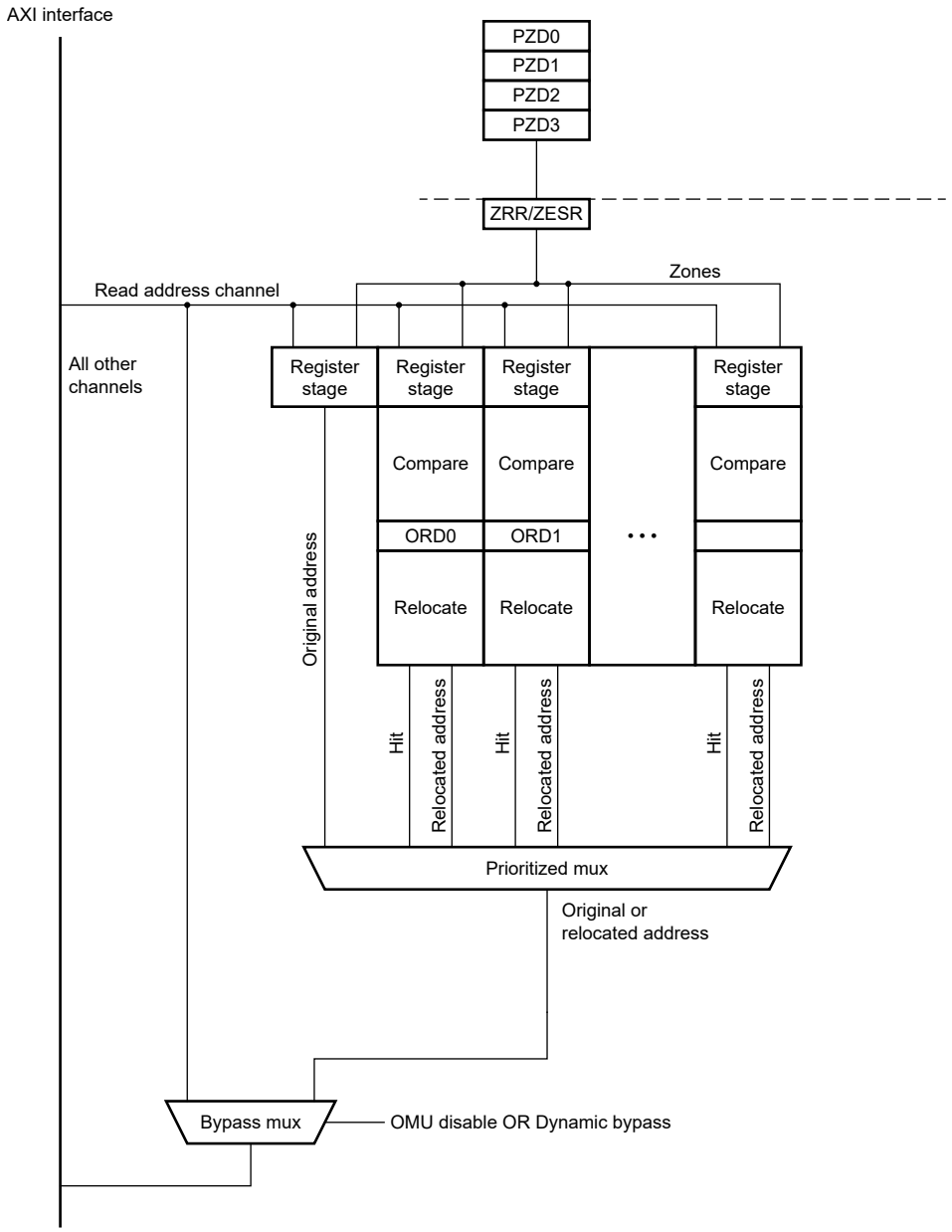

Figure 10. Block diagram

6.2.2 Features

- Multipurpose use of processor code and constant memory to support repurposing of constants data and code segments for calibration
- Eight simultaneous virtual calibration processes processes (four for each processor)
- Possible secure protection for each process zone descriptor for a software-assignable processor
- Possible control of two software-assigned process zones via each processor (these zones can use tools to generate up to two in-process calibration tables)

- Address relocation services enabled for all masters that access the code/constant memory through the OMU path (only reads receive address relocation services)
- Each region descriptor consists of:
  - Logical starting address
  - Physical starting address
  - Region size
  - Zone assign
- Data read latency not incurred when you disable OMU
- Automatic hardware triggered Dynamic Bypass mode when accessing memory regions ineligible for OMU address relocation services (additional read latency because of OMU address lookup and remapping is incurred when accessing the flash memory mirror address range)
- Hardware synchronization of the Zone Request registers across multiple OMU instances

6.3 Functional description

The following sections describe functional details of the OMU module.

When you write 0 to OER[OE], OMU logic is bypassed. There is no latency impact to the AXI read address channel. When you write 1 to OER[OE], the address relocation services are enabled on the AXI read address channel, thereby incurring three extra cycles of latency. OMU does not affect the latency of all other AXI channels.

The 16 OMU regions are prioritized in a way that the lowest order region hit wins if there are region hits in more than one region. A global region must be the lowest priority active region.

Each OMU consists of 16 overlay regions, which when enabled, simultaneously compare the following attributes for a valid AXI read address channel transaction:

- The AXI read address field is simultaneously compared to each region's logical address range, as defined by ORD*n*LSA[LSA] and ORD*n*RS[RS].
- Comparisons occur only when a region is enabled via ORD*n*RZA[RZA] and ZER*n*[Z*n*E].

If all conditions and comparisons are true, it is considered a region hit. For a region hit, the upper logical read address bits, as determined by ORD*n*LSA[LSA] and ORD*n*RS[RS], are replaced by the associated ORD*n*PSA[PSA]. The lower logical read address bits are ORed to form a full 32-bit address.

NOTE

The appropriate number of lower order bits must be set to zero in the description of ORD*n*LSA[LSA] and ORD*n*PSA[PSA].

If there is no region hit, then the original address is not relocated. When enabled, OMU performs address relocation services to any read access, for software constants, data segments, and code segments. For overlay regions that have a size programmed less than 4 KB, the AXI burst length must not exceed the region size.

During development, the external tool reads the OMU configuration to ensure that a functionally safe operation takes place. During development, the external tool reads one or more values from a calibration set and reference set to ensure that a functionally safe operation takes place. During normal operation, FCCU monitors the OMU enable signal to ensure that OMU is always disabled. During normal operation, OMU compares the input AXI read address channel and output AXI read channel to ensure they are equal (for example, EXOR of each latched each AXI clock). FCCU monitors the compared result signals to ensure that there is no AXI read channel corruption.

6.3.1 Operating modes

Table 29. Operating modes

Mode	Description	Mode enabling condition
Normal (Bypass) mode	OMU address relocation services are disabled.	When you write 0 to OER[OE].
Development mode	OMU address relocation services are enabled.	When you write 1 to OER[OE].

6.3.2 Clocking

Clock	Description
System clock	AXI clock of the system bus interconnect that is used for the AXI controller and target interfaces of OMU
Peripheral clock	Peripheral clock that is used for accessing the programming model of OMU

6.3.3 Reset

OMU is reset by the common asynchronous system reset.

6.3.4 Interrupts

This module has no interrupts.

6.3.5 Dynamic Bypass function

Dynamic Bypass mode is triggered on a per bus transactions basis, based on the address of the transaction. When this mode is triggered, the associated bus transaction bypasses the OMU lookup logic and is not eligible for OMU address relocation services. For details, see the chip-level memory map for information on the flash memory mirror address range that does not trigger Dynamic Bypass mode.

The chip-level memory map provides the flash memory mirror address range, which indicates that the range is eligible for OMU address relocation services. All other addresses trigger Dynamic Bypass mode based on the hardware configuration.

6.3.6 Local and global zone requests

OMU supports both local and global zone requests for supporting systems with multiple OMU instances that may require synchronized zone request updates.

You can use OER[ZRGUE] to enable global zone request updates from other OMU instances for automatically updating the local ZRR. When you write 1 to OER[ZRGUE], the local ZRR is automatically updated to match any GZRR updates in the remote OMU instances, thereby allowing synchronized updates to ZRR for each OMU instance. When you write 0 to OER[ZRGUE] for a particular OMU instance, that instance does not receive GZRR updates from other OMU instances.

Table 30. Types of request registers

Types of request registers	Description
Zone Request Register (ZRR)	Requests zones 0-7 to be enabled or disabled for the local OMU instance

Table continues on the next page...

Table 30. Types of request registers (continued)

Types of request registers	Description
Global Zone Request Register (GZRR)	Requests zones to 0-7 be enabled or disabled for all OMU instances, including the local instance

6.4 External signals

This module has no external signals.

6.5 Initialization

OMU does not provide any relocation services until it is properly initialized. Perform the following procedure to initialize OMU.

Table 31. OMU configuration procedure

Step	Purpose	Programming
1	Configure one or more region descriptors.	Write to ORD*n*LSA, ORD*n*PSA, ORD*n*RS, and ORD*n*RZA.
2	Enable one or more zones.	Write 1 to ZER0, ZER1, ZER2, or ZER3 zone enable control bits.
3	Enable OMU.	Write 1 to OER[OE].

6.6 Application information

This section provides a brief overview for the calibration and measurement processes. The expected use case is to configure OMU or remap the flash memory mirror address range to QSPI.

6.6.1 Calibration application 1

This example has one calibration process in progress on core 0 for a 1 MB reference set in code/constant (CC) memory. In this session, all core data read accesses to the 1 MB block reference set in code/constant memory (on-chip reference) are relocated to one of two 1 MB writable calibration sets in flash memory bank 2. When you enable one of the two process zones, it selects the online calibration set while the other remains offline for adjustments.

The development tool alternately adjusts these writable calibration sets to achieve production-worthy calibrated data. However, when only core 0 is undergoing a calibration process, only its exclusive data constants are adjusted during the session.

To enable the aforementioned scenario, the development tool provides the following configuration:

1. Set up the first OMU region where all core data reads to the first logical address range in the code/constant memory (on-die reference set) are relocated to the first 1 MB calibration set in flash memory bank 2. Associate it to process zone 0.
2. Set up the second OMU region where all core data reads to the first logical address range in the code/constant memory (on-die reference set) are relocated to the second 1 MB calibration set in flash memory bank 2. Associate it to process zone 1.
3. The development tool alternately requests a zone enable for one of the two 1 MB calibration sets, or the reference set, to be brought online at an appropriate synchronization point for core 0. Offline calibration sets are adjusted and then used online to qualitatively compare against each other to achieve production-worthy calibrated data.

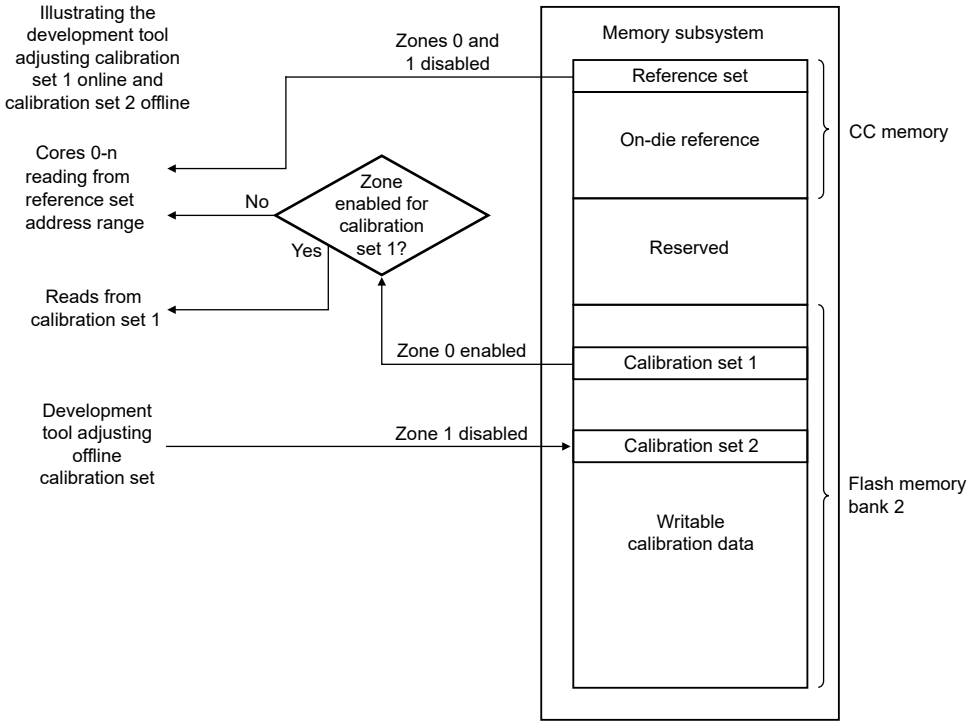

Figure 11. Calibration application 1

6.6.2 Calibration application 2

This example is identical to the first, except that a 1 MB reference set in flash memory bank 1 is used. This example achieves the same objective as the first, but in a more complex way. Importantly, it allows for a way to mitigate the limited number of program and erase cycles for flash memory bank 2.

The development tool alternately adjusts these writable calibration sets to achieve production-worthy calibrated data. However, when only core 0 is undergoing a calibration process, only the exclusive data constants for core 0 are adjusted during the session.

To enable the aforementioned scenario, the development tool provides the following configuration:

1. Set up a global OMU region for the 2 x 1 MB calibration because software accesses of calibrated data pertain to the code/constant (CC) memory.

   A global OMU region contains the information that is used to direct that for all core data reads to the 2 x 1 MB logical address range of the calibration sets, the address is relocated to an associated 2 x 1 MB address range in flash memory bank 1 (off-die reference). This is done to free up the code/constant memory for calibration sets when allowing cores to access the calibrated data from the off-die reference.

   The global regions have the lowest priority and are overridden by specific regions and associated process zones in the following steps. The global OMU region is not associated with any process zones and it is always enabled.

2. Set up the first OMU region where core data reads to the first logical address range in the code/constant memory (on-die reference set) are relocated to the first 1 MB calibration set in the code/constant memory.

   No actual address translation is configured here, but it is necessary to override the global relocation. Associate it to process zone 0.

3. Set up the second OMU region where core data reads to the first logical address range in the code/constant memory (on-die reference set) are relocated to the second 1 MB calibration set in the code/constant memory. Associate it to process zone 1.

4. The development tool alternately requests zone enable for one of the two 1 MB calibration sets, or the reference set, to be brought online at an appropriate synchronization point for core 0. Offline calibration sets are adjusted and then used online to qualitatively compare against each other to achieve production-worthy calibrated data.

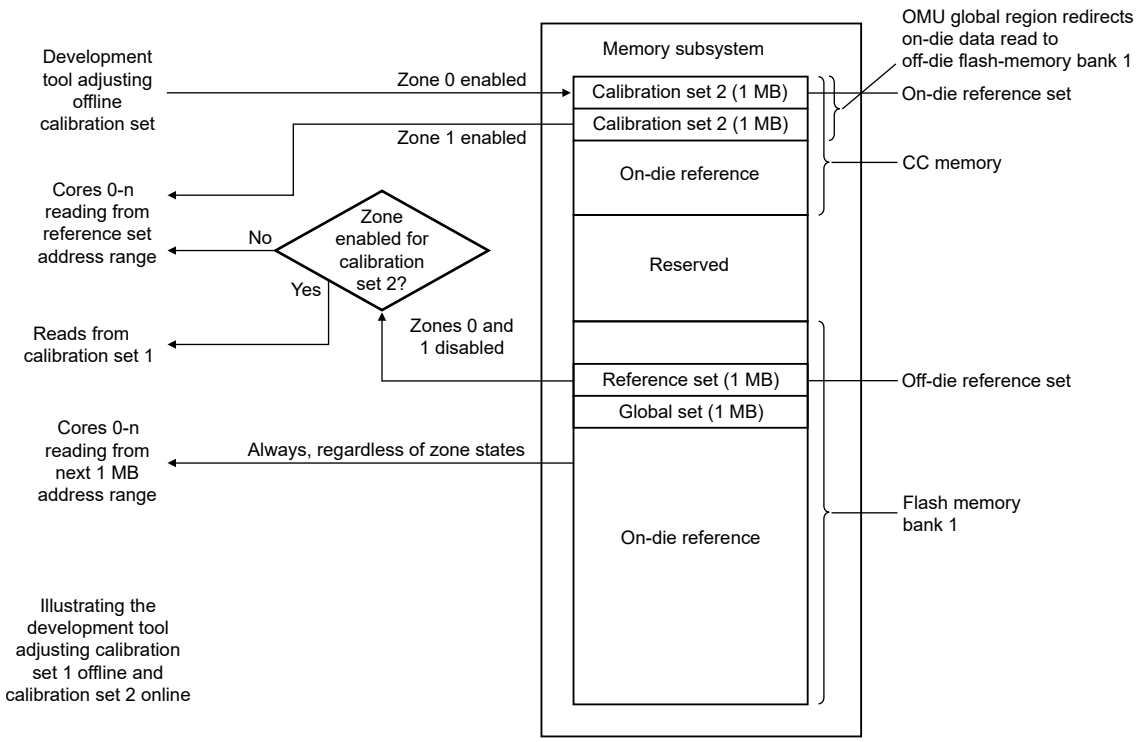

Figure 12. Calibration application 2

6.6.3 Calibration application 3

This calibration example deploys a small portion of the unused code/constant (CC) memory or system memory for calibration. Because the software application does not use this small memory portion, there is no need to create global overlays to reference off-die constants, as in example 2.

This example of calibration session has two calibration processes in progress on cores 0 and 1, with 4 KB and 8 KB reference sets respectively in code/constant memory. In the session, core 0 data read accesses to its 4 KB block reference set in the code/constant memory (on-die reference) are relocated to one of the two 4 KB writable calibration sets in the unused code/constant memory or system memory locations. Likewise, core 1 data read accesses to its 8 KB block reference set in code/constant memory (on-die reference) are relocated to one of the two 8 KB writable calibration sets in the unused code/constant memory or system memory locations. The development tool alternately adjusts these writable calibration sets to achieve production-worthy calibrated data.

When core 0 is undergoing a calibration process, only its exclusive data constants are adjusted during the session. Likewise, when core 1 is undergoing a calibration process, only its exclusive data constants are adjusted during the session.

To enable the aforementioned scenario, the development tool provides the following configuration:

1. Set up the first OMU region where core 0 data reads to the first logical address range in the code/constant memory (on-die reference set) are relocated to the first 4 KB calibration set in the unused code/constant or system memory.
2. Set up the second OMU region where core 0 data reads to the first logical address range in the code/constant memory (on-die reference set) are relocated to the second 4 KB calibration set in the unused code/constant or system memory.
3. Set up the third OMU region where core 1 data reads to the second logical address range in the code/constant memory (on-die reference set) are relocated to the first 8 KB calibration set in the unused code/constant or system memory.

4. Set up the fourth OMU region where core 1 data reads to a second logical address range in the code/constant memory (on-die reference set) are relocated to the second 8 KB calibration set in the unused code/constant or system memory.
5. For each virtual calibration process executing on cores 0 and 1, the development tool manages each one of them independently. For each calibration process, the development tool alternately requests for one of the two associated calibration sets, or the reference set, to be brought online at an appropriate synchronization point for the respective cores. Offline calibration sets are adjusted and then used online to qualitatively compare against each other to achieve production-worthy calibrated data.

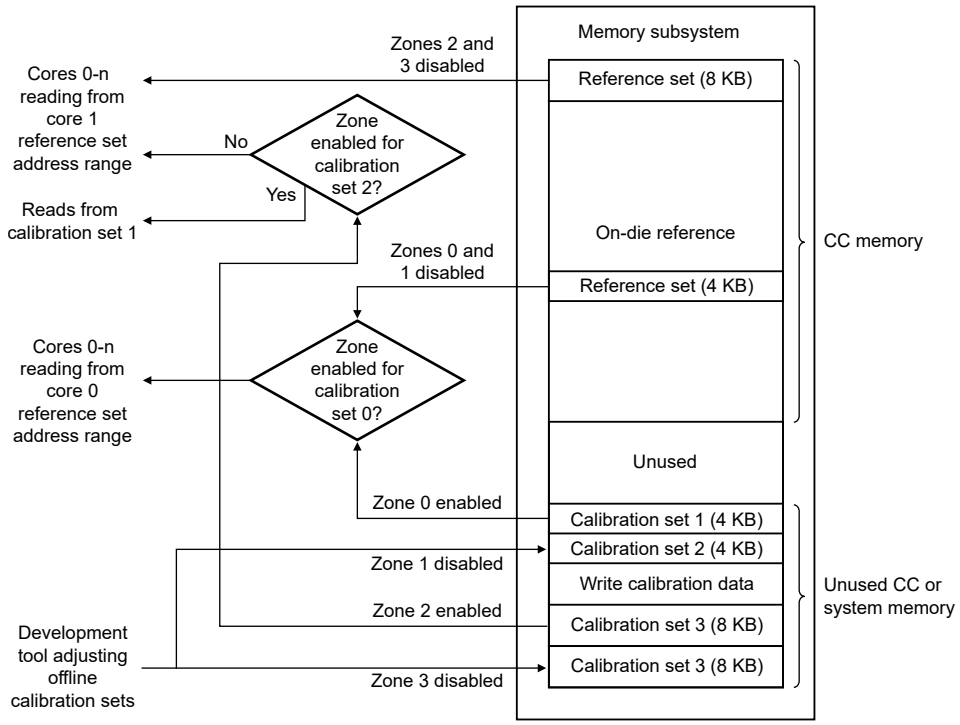

Figure 13. Calibration application 3

6.6.4 Measurement application

Measurement data that is collected in customer-specified locations in the code/constant memory or system memory during runtime is used for in-depth analysis of embedded algorithmic variables. This analysis occurs during the development phase, and may be a part of the process quantification of operational metrics. For example, measurement data can be used to develop realtime graphical information per cylinder for fuel injector on-duration, spark angle advance, and mass air flow information, which are then used to measure and adjust to achieve optimal fuel economy.

The following are the conditions to use measurement data during a session:

- You have incorporated software instrumentation during the development phase for pertinent embedded algorithmic variables that are to be measured. The instrumented software continually writes measurement data to the locations that you specify in the code/constant memory or system memory via the memory map.
- A development tool connected to the chip via ZipWire continually reads the intended measurement data via the memory map. The ZipWire read commands that the chip receives are converted to internal AMBA bus transactions, and they access the locations that you specify in the code/constant memory or system memory through system buses.

The development tool may provide digested views of the realtime measurement data collected (for example, graphical chart, minimum and maximum values, and so on) for in-depth analysis.

6.7 OMU register descriptions

You can access the programming model registers via 8-, 16-, or 32-bit reads and 32-bit write references. Attempted accesses using unsupported write data sizes and writes to read-only resources or to reserved spaces are terminated with an error.

6.7.1 OMU memory map

OMU_CM7_0 base address: 4051_8000h

OMU_CM7_1 base address: 4052_0000h

OMU_CM7_2 base address: 4052_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Zone Request Status 0 (z0ZRSR)	32	R	0000_0000h
4h	Zone Enable 0 (ZER0)	32	RW	0000_0000h
1000h	Zone Request Status 1 (z1ZRSR)	32	R	0000_0000h
1004h	Zone Enable 1 (ZER1)	32	RW	0000_0000h
2000h	Zone Request Status 2 (z2ZRSR)	32	R	0000_0000h
2004h	Zone Enable 2 (ZER2)	32	RW	0000_0000h
3000h	Zone Request Status 3 (z3ZRSR)	32	R	0000_0000h
3004h	Zone Enable 3 (ZER3)	32	RW	0000_0000h
4000h	OMU Enable (OER)	32	RW	0000_0000h
4004h	Zone Request (ZRR)	32	RW	0000_0000h
4008h	Zone Enable Status (ZESR)	32	R	0000_0000h
400Ch	Global Zone Request (GZRR)	32	RW	0000_0000h
4010h	Global Zone Request Update Delay (GZRUDR)	32	RW	0000_0000h
4400h	ORD0 Logical Start Address (ORD0LSA)	32	RW	0000_0000h
4404h	ORD0 Physical Start Address (ORD0PSA)	32	RW	0000_0000h
4408h	ORD0 Region Size (ORD0RS)	32	RW	0000_0000h
440Ch	ORD0 Region Zone Assignment (ORD0RZA)	32	RW	0000_0000h
4410h	ORD1 Logical Start Address (ORD1LSA)	32	RW	0000_0000h
4414h	ORD1 Physical Start Address (ORD1PSA)	32	RW	0000_0000h
4418h	ORD1 Region Size (ORD1RS)	32	RW	0000_0000h
441Ch	ORD1 Region Zone Assignment (ORD1RZA)	32	RW	0000_0000h
4420h	ORD2 Logical Start Address (ORD2LSA)	32	RW	0000_0000h
4424h	ORD2 Physical Start Address (ORD2PSA)	32	RW	0000_0000h
4428h	ORD2 Region Size (ORD2RS)	32	RW	0000_0000h
442Ch	ORD2 Region Zone Assignment (ORD2RZA)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
4430h	ORD3 Logical Start Address (ORD3LSA)	32	RW	0000_0000h
4434h	ORD3 Physical Start Address (ORD3PSA)	32	RW	0000_0000h
4438h	ORD3 Region Size (ORD3RS)	32	RW	0000_0000h
443Ch	ORD3 Region Zone Assignment (ORD3RZA)	32	RW	0000_0000h
4440h	ORD4 Logical Start Address (ORD4LSA)	32	RW	0000_0000h
4444h	ORD4 Physical Start Address (ORD4PSA)	32	RW	0000_0000h
4448h	ORD4 Region Size (ORD4RS)	32	RW	0000_0000h
444Ch	ORD4 Region Zone Assignment (ORD4RZA)	32	RW	0000_0000h
4450h	ORD5 Logical Start Address (ORD5LSA)	32	RW	0000_0000h
4454h	ORD5 Physical Start Address (ORD5PSA)	32	RW	0000_0000h
4458h	ORD5 Region Size (ORD5RS)	32	RW	0000_0000h
445Ch	ORD5 Region Zone Assignment (ORD5RZA)	32	RW	0000_0000h
4460h	ORD6 Logical Start Address (ORD6LSA)	32	RW	0000_0000h
4464h	ORD6 Physical Start Address (ORD6PSA)	32	RW	0000_0000h
4468h	ORD6 Region Size (ORD6RS)	32	RW	0000_0000h
446Ch	ORD6 Region Zone Assignment (ORD6RZA)	32	RW	0000_0000h
4470h	ORD7 Logical Start Address (ORD7LSA)	32	RW	0000_0000h
4474h	ORD7 Physical Start Address (ORD7PSA)	32	RW	0000_0000h
4478h	ORD7 Region Size (ORD7RS)	32	RW	0000_0000h
447Ch	ORD7 Region Zone Assignment (ORD7RZA)	32	RW	0000_0000h
4480h	ORD8 Logical Start Address (ORD8LSA)	32	RW	0000_0000h
4484h	ORD8 Physical Start Address (ORD8PSA)	32	RW	0000_0000h
4488h	ORD8 Region Size (ORD8RS)	32	RW	0000_0000h
448Ch	ORD8 Region Zone Assignment (ORD8RZA)	32	RW	0000_0000h
4490h	ORD9 Logical Start Address (ORD9LSA)	32	RW	0000_0000h
4494h	ORD9 Physical Start Address (ORD9PSA)	32	RW	0000_0000h
4498h	ORD9 Region Size (ORD9RS)	32	RW	0000_0000h
449Ch	ORD9 Region Zone Assignment (ORD9RZA)	32	RW	0000_0000h
44A0h	ORD10 Logical Start Address (ORD10LSA)	32	RW	0000_0000h
44A4h	ORD10 Physical Start Address (ORD10PSA)	32	RW	0000_0000h
44A8h	ORD10 Region Size (ORD10RS)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
44ACh	ORD10 Region Zone Assignment (ORD10RZA)	32	RW	0000_0000h
44B0h	ORD11 Logical Start Address (ORD11LSA)	32	RW	0000_0000h
44B4h	ORD11 Physical Start Address (ORD11PSA)	32	RW	0000_0000h
44B8h	ORD11 Region Size (ORD11RS)	32	RW	0000_0000h
44BCh	ORD11 Region Zone Assignment (ORD11RZA)	32	RW	0000_0000h
44C0h	ORD12 Logical Start Address (ORD12LSA)	32	RW	0000_0000h
44C4h	ORD12 Physical Start Address (ORD12PSA)	32	RW	0000_0000h
44C8h	ORD12 Region Size (ORD12RS)	32	RW	0000_0000h
44CCh	ORD12 Region Zone Assignment (ORD12RZA)	32	RW	0000_0000h
44D0h	ORD13 Logical Start Address (ORD13LSA)	32	RW	0000_0000h
44D4h	ORD13 Physical Start Address (ORD13PSA)	32	RW	0000_0000h
44D8h	ORD13 Region Size (ORD13RS)	32	RW	0000_0000h
44DCh	ORD13 Region Zone Assignment (ORD13RZA)	32	RW	0000_0000h
44E0h	ORD14 Logical Start Address (ORD14LSA)	32	RW	0000_0000h
44E4h	ORD14 Physical Start Address (ORD14PSA)	32	RW	0000_0000h
44E8h	ORD14 Region Size (ORD14RS)	32	RW	0000_0000h
44ECh	ORD14 Region Zone Assignment (ORD14RZA)	32	RW	0000_0000h
44F0h	ORD15 Logical Start Address (ORD15LSA)	32	RW	0000_0000h
44F4h	ORD15 Physical Start Address (ORD15PSA)	32	RW	0000_0000h
44F8h	ORD15 Region Size (ORD15RS)	32	RW	0000_0000h
44FCh	ORD15 Region Zone Assignment (ORD15RZA)	32	RW	0000_0000h

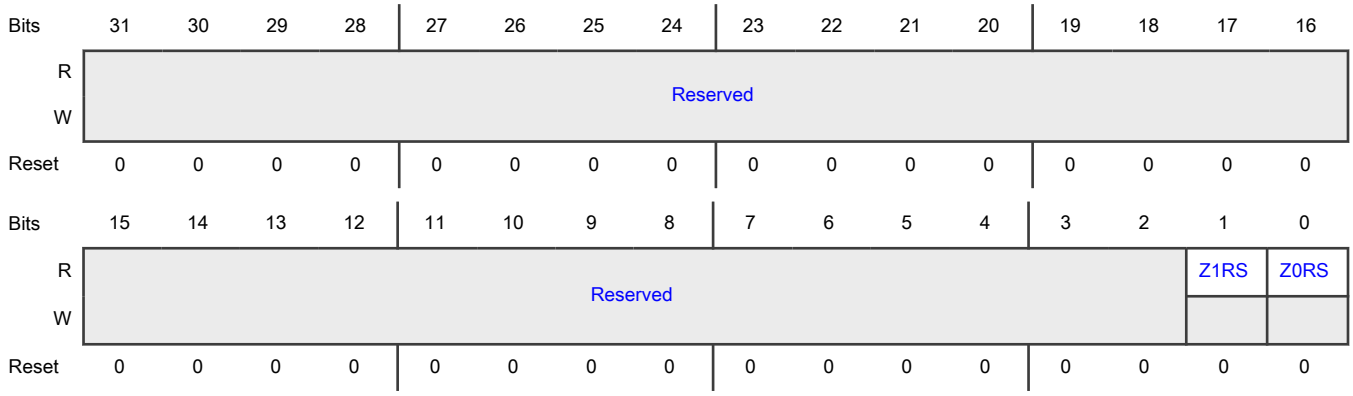
6.7.2 Zone Request Status 0 (z0ZRSR)

Offset

Register	Offset
z0ZRSR	0h

Function
Indicates zone request status 0.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z1RS	Zone 1 Request Status Indicates the value of ZRR[Z1R].
0 Z0RS	Zone 0 Request Status Indicates the value of ZRR[Z0R].

6.7.3 Zone Enable 0 (ZER0)

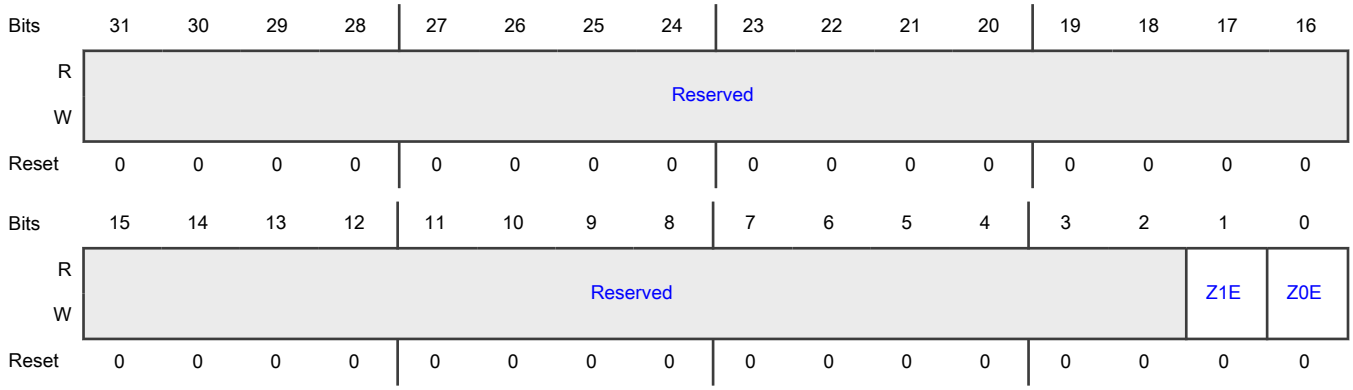
Offset

Register	Offset
ZER0	4h

Function

Enables all OMU regions assigned to the concerned zone.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z1E	Zone 1 Enable Enables all OMU regions assigned to zone 1. 0b - Disable 1b - Enable
0 Z0E	Zone 0 Enable Enables all OMU regions assigned to zone 0. 0b - Disable 1b - Enable

6.7.4 Zone Request Status 1 (z1ZRSR)

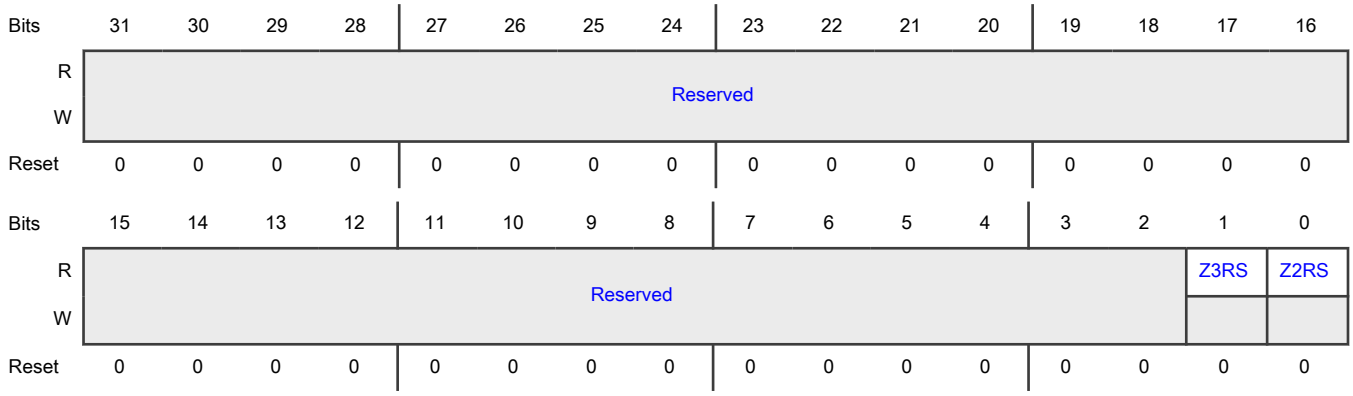
Offset

Register	Offset
z1ZRSR	1000h

Function

Indicates zone request status 1.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z3RS	Zone 3 Request Status Indicates the value of ZRR[Z3R].
0 Z2RS	Zone 2 Request Status Indicates the value of ZRR[Z2R].

6.7.5 Zone Enable 1 (ZER1)

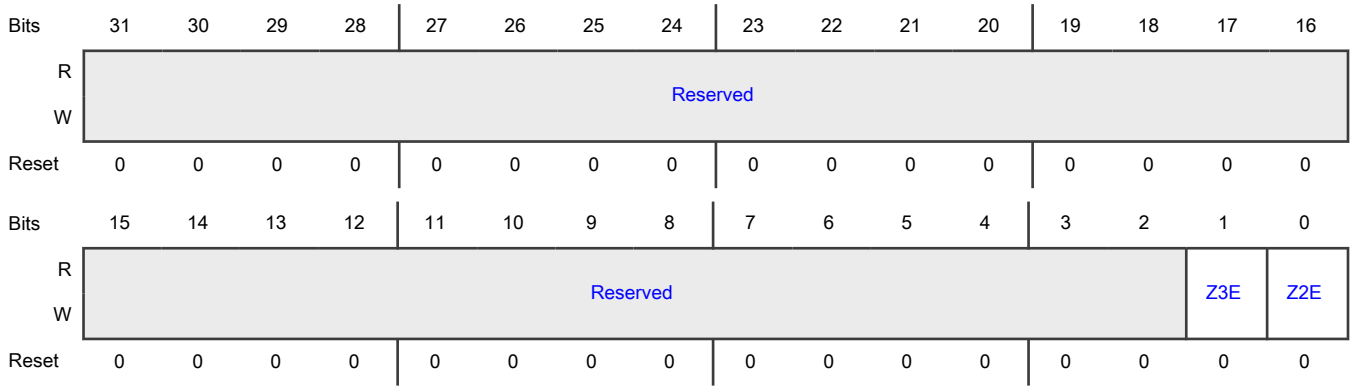
Offset

Register	Offset
ZER1	1004h

Function

Enables all OMU regions assigned to the concerned zone.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z3E	Zone 3 Enable Enables all OMU regions assigned to zone 3. 0b - Disable 1b - Enable
0 Z2E	Zone 2 Enable Enables all OMU regions assigned to zone 2. 0b - Disable 1b - Enable

6.7.6 Zone Request Status 2 (z2ZRSR)

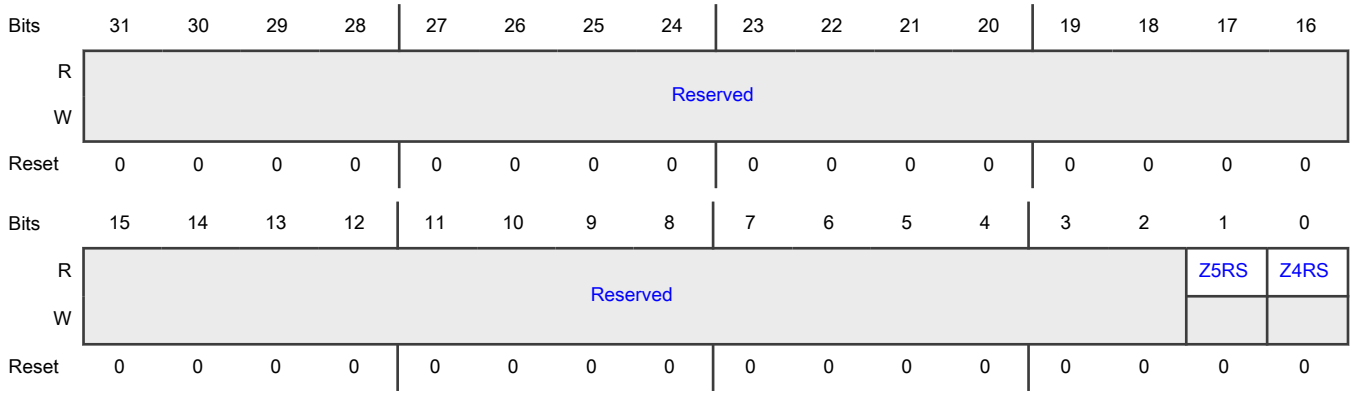
Offset

Register	Offset
z2ZRSR	2000h

Function

Indicates zone request status 2.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z5RS	Zone 5 Request Status Indicates the value of ZRR[Z5R].
0 Z4RS	Zone 4 Request Status Indicates the value of ZRR[Z4R].

6.7.7 Zone Enable 2 (ZER2)

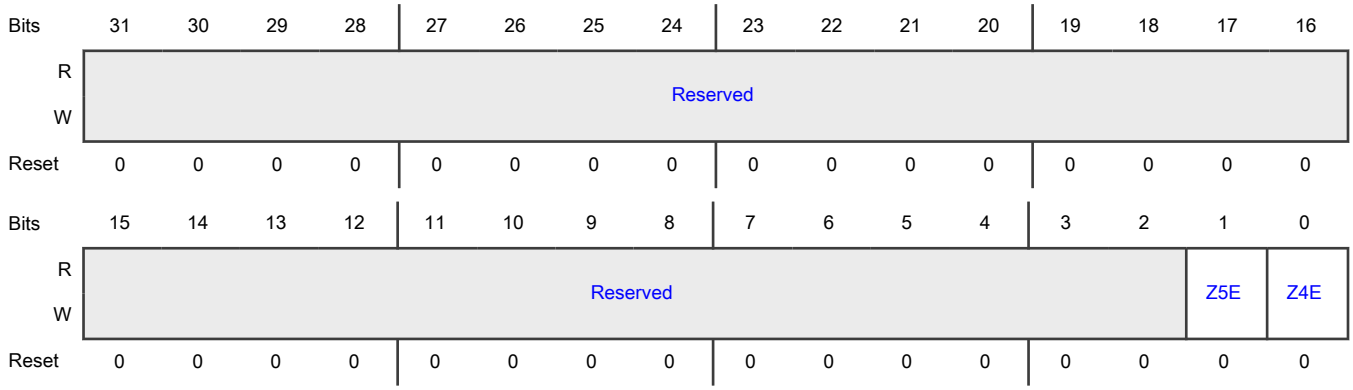
Offset

Register	Offset
ZER2	2004h

Function

Enables all OMU regions assigned to the concerned zone.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z5E	Zone 5 Enable Enables all OMU regions assigned to zone 5. 0b - Disable 1b - Enable
0 Z4E	Zone 4 Enable Enables all OMU regions assigned to zone 4. 0b - Disable 1b - Enable

6.7.8 Zone Request Status 3 (z3ZRSR)

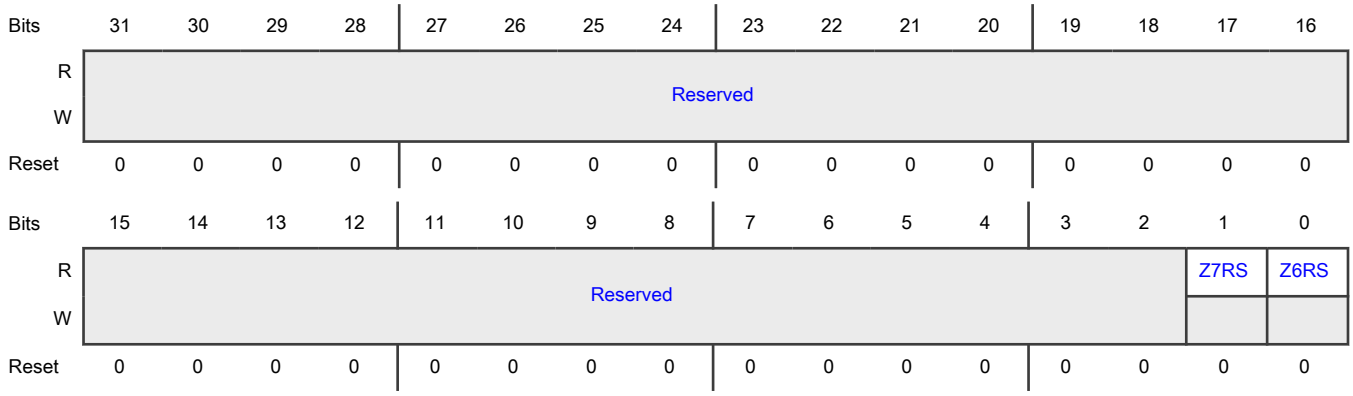
Offset

Register	Offset
z3ZRSR	3000h

Function

Indicates zone request status 3.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z7RS	Zone 7 Request Status Indicates the value of ZRR[Z7R].
0 Z6RS	Zone 6 Request Status Indicates the value of ZRR[Z6R].

6.7.9 Zone Enable 3 (ZER3)

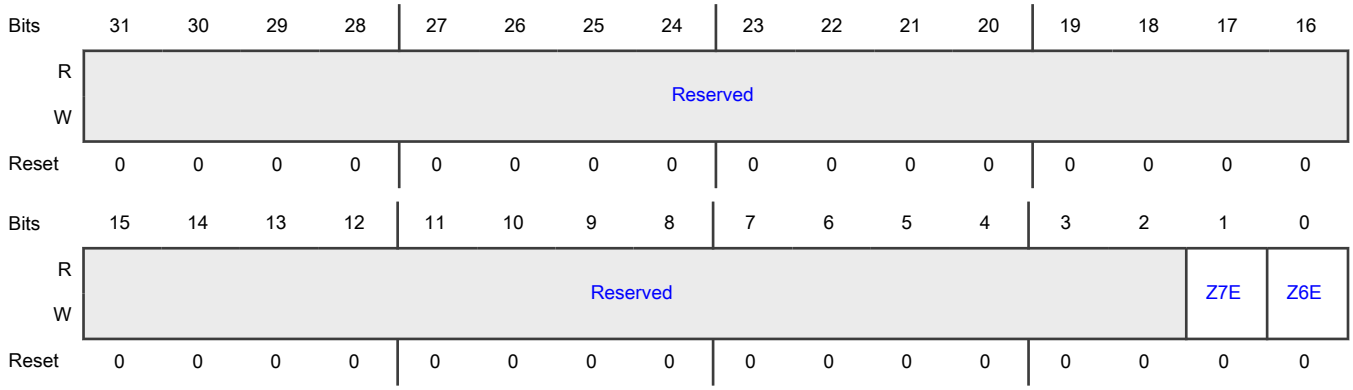
Offset

Register	Offset
ZER3	3004h

Function

Enables all OMU regions assigned to the concerned zone.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 Z7E	Zone 7 Enable Enables all OMU regions assigned to zone 7. 0b - Disable 1b - Enable
0 Z6E	Zone 6 Enable Enables all OMU regions assigned to zone 6. 0b - Disable 1b - Enable

6.7.10 OMU Enable (OER)

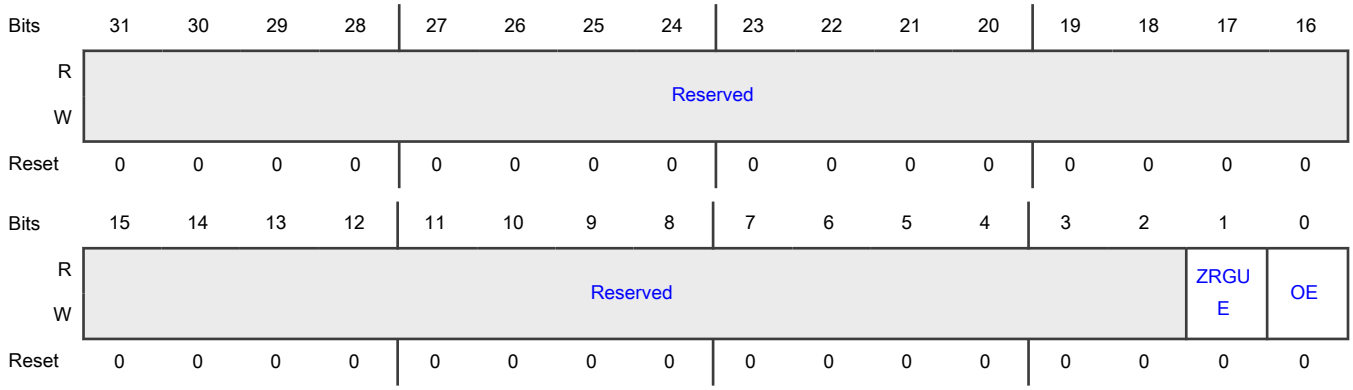
Offset

Register	Offset
OER	4000h

Function

Enables AXI address relocation services.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 ZRGUE	OMU Zone Request Global Update Enable Controls whether the global zone request synchronization interface updates the OMU Zone Request registers. 0b - Update 1b - Do not update
0 OE	OMU Enable Enables AXI address relocation services. When you write 0 to this field, Bypass mode is enabled. 0b - Disable 1b - Enable

6.7.11 Zone Request (ZRR)

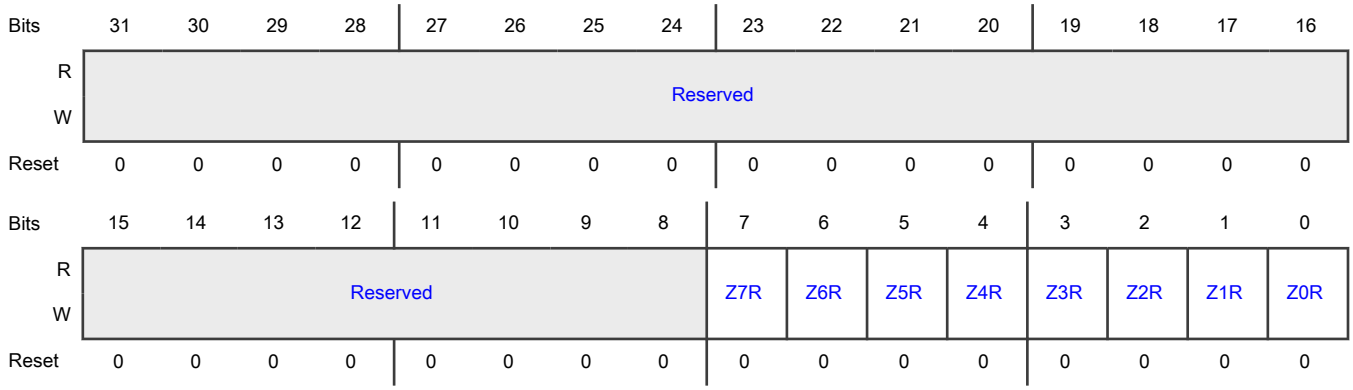
Offset

Register	Offset
ZRR	4004h

Function

Requests the concerned zone to be enabled.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 ZnR	Zone n Request Requests Zone *n* to be enabled. 0b - Disable 1b - Enable

6.7.12 Zone Enable Status (ZESR)

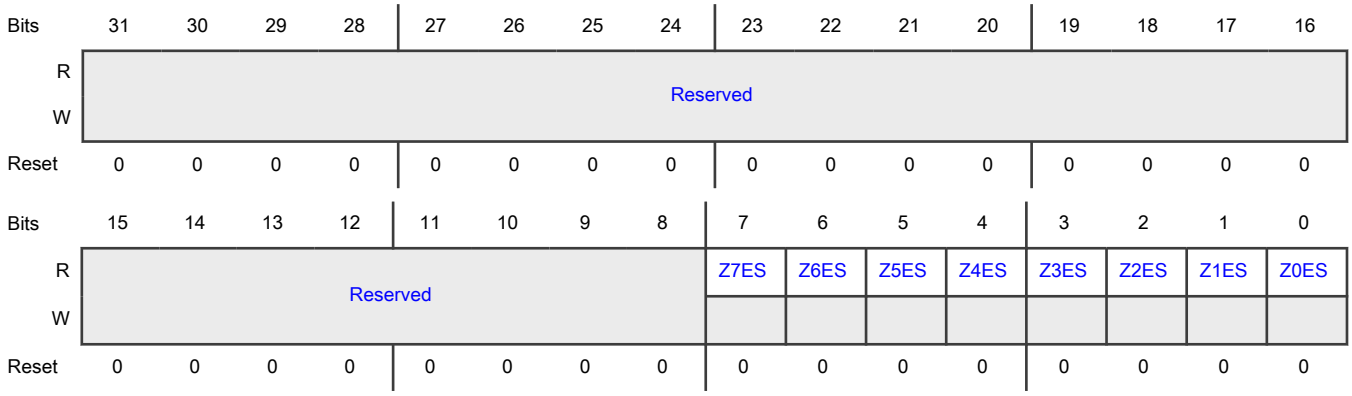
Offset

Register	Offset
ZESR	4008h

Function

Indicates the value of the corresponding field in the Zone Enable register.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 ZnES	Zone n Enable Status Indicates the value of the corresponding ZER*n*[Z*n*E] field. 0b - Disabled 1b - Enabled

6.7.13 Global Zone Request (GZRR)

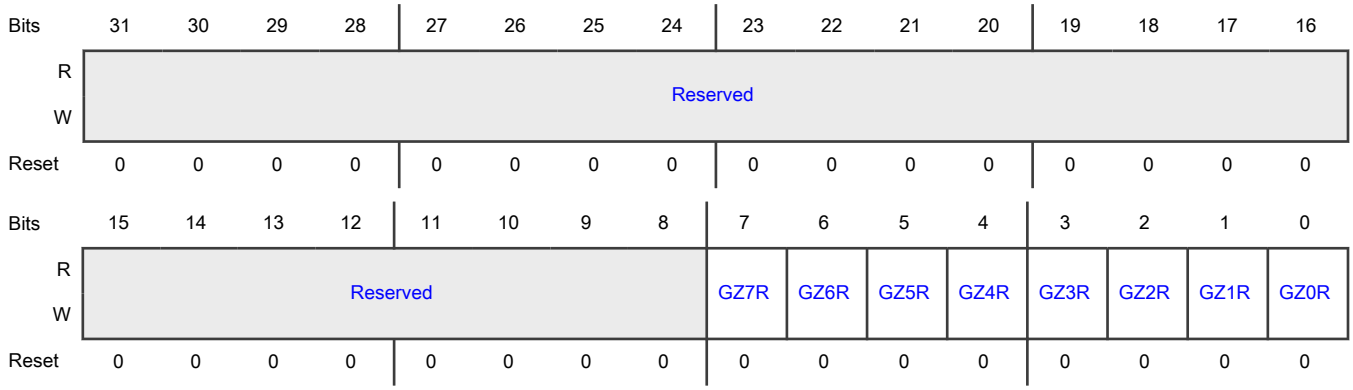
Offset

Register	Offset
GZRR	400Ch

Function

Enables global requests for the concerned zone.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 GZnR	Global Zone n Request Enables global request for zone *n*. 0b - Disable 1b - Enable

6.7.14 Global Zone Request Update Delay (GZRUDR)

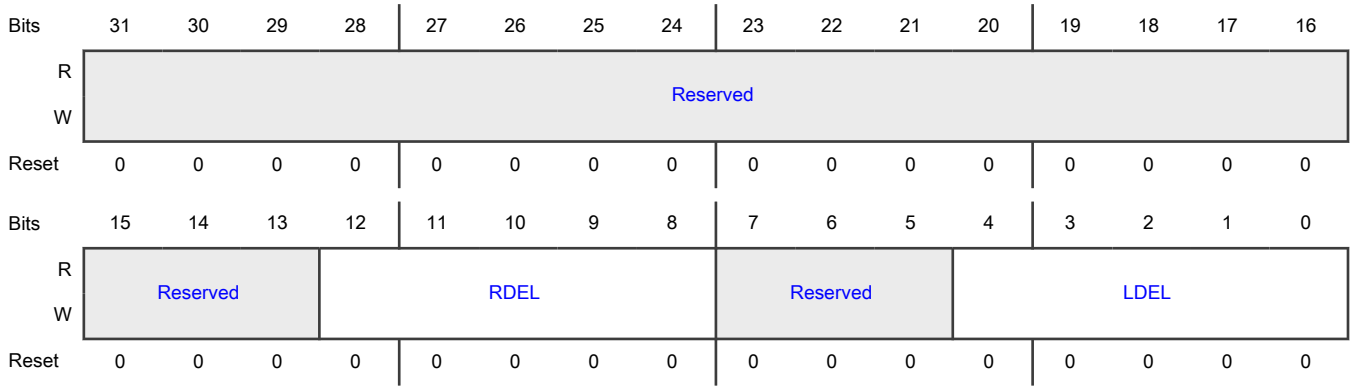
Offset

Register	Offset
GZRUDR	4010h

Function

Indicates the delay in clock cycles post updation of GZRR in local or remote OMU.

Diagram



Fields

Field	Function
31-13 —	Reserved
12-8 RDEL	Remote Delay Specifies the delay in terms of clock cycles incurred after a hardware global zone request update is received from a remote OMU, prior to when the update is reflected in the local OMU Zone Request Status 0-3 registers.
7-5 —	Reserved
4-0 LDEL	Local Delay Specifies the delay in terms of clock cycles incurred after you update GZRR in the local OMU, prior to when the update is reflected in the local OMU Zone Request Status 0-3 registers.

6.7.15 ORDa Logical Start Address (ORD0LSA - ORD15LSA)

Offset

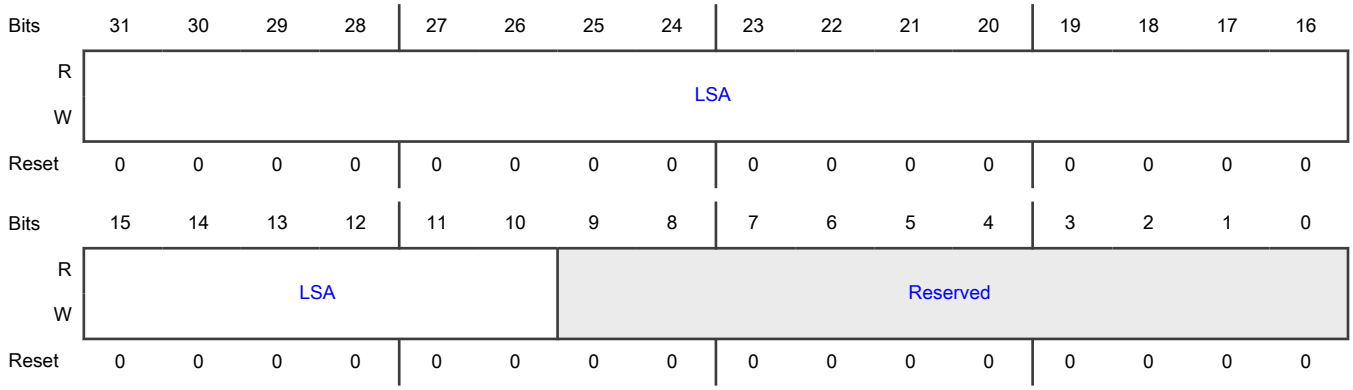
For a = 0 to 15:

Register	Offset
ORDaLSA	4400h + (a × 10h)

Function

Qualifies address relocation services on data reads from the selected controller.

Diagram



Fields

Field	Function
31-10 LSA	Logical Start Address Qualifies address relocation services on data reads from the selected controller, if you enable the associated region. If you disable the associated region, LSA is ignored. Associated LSA, ORD*n*RS[RS], and ORD*n*RZA[RZA] are used to define a logical address region that is compared to incoming read addresses from the selected controller. If there is a successful region hit, the associated PSA register is used for address relocation services. It is used to relocate the input data read logical address to an output data read physical address for transaction completion. There are certain restrictions on LSA settings, as described in ORD*n*RS[RS].
9-0 —	Reserved

6.7.16 ORDa Physical Start Address (ORD0PSA - ORD15PSA)

Offset

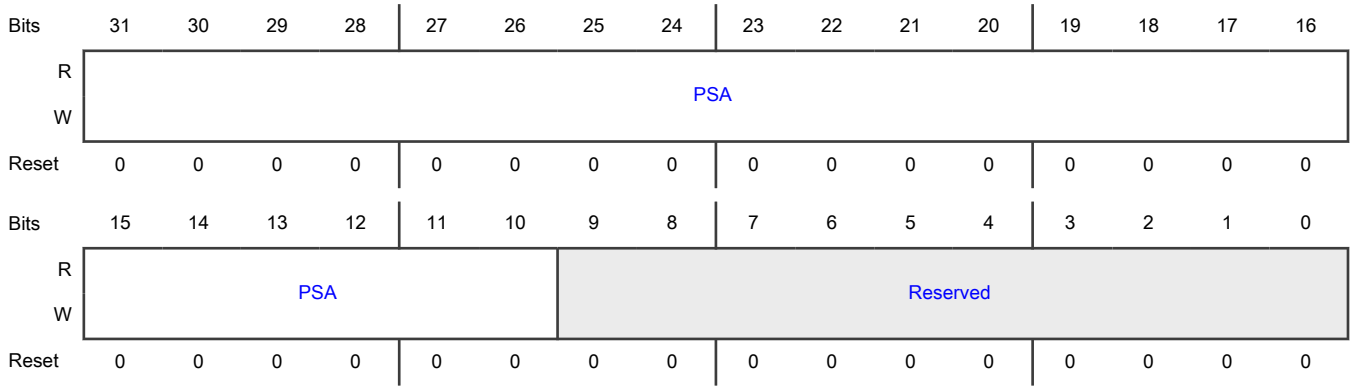
For a = 0 to 15:

Register	Offset
ORDaPSA	4404h + (a × 10h)

Function

Qualifies address relocation services.

Diagram



Fields

Field	Function
31-10 PSA	Physical Start Address Qualifies address relocation services, if you enable the associated region. If you disable the associated region, then PSA is ignored. Associated ORD*n*LSA[LSA] and ORD*n*RS[RS] fields are used to define a logical address region that is compared to incoming read addresses from the selected controller. If there is a successful region hit, the associated PSA register is used for address relocation services. It is used to relocate the input data read logical address to an output data read physical address for transaction completion. There are restrictions on PSA settings, as described in ORD*n*RS[RS].
9-0 —	Reserved

6.7.17 ORDa Region Size (ORD0RS - ORD15RS)

Offset

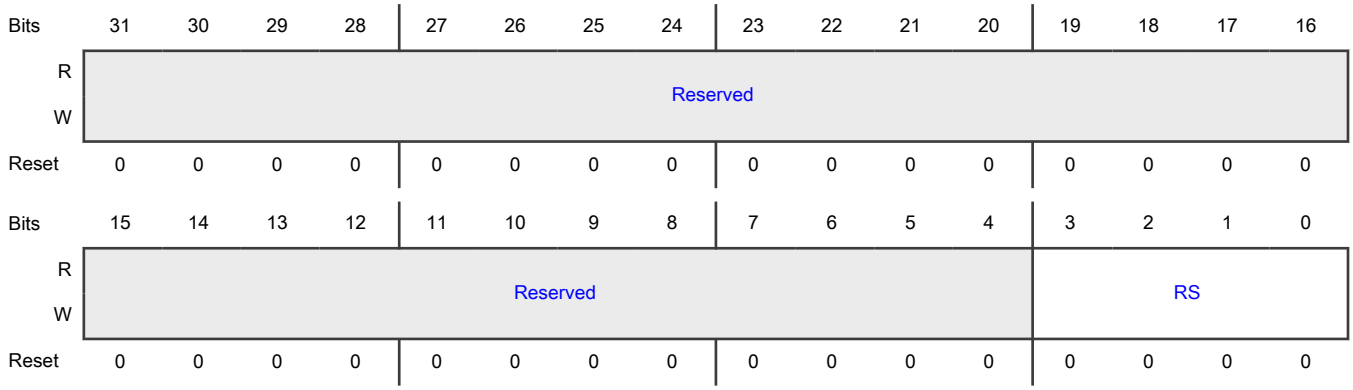
For a = 0 to 15:

Register	Offset
ORDaRS	4408h + (a × 10h)

Function

Specifies the ORD region size.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 RS	Region Size Specifies the ORD region size. 0000b - 1 KB 0001b - 2 KB—Low-order 1 bit of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 0010b - 4 KB—Low-order 2 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 0011b - 8 KB—Low-order 3 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 0100b - 16 KB—Low-order 4 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 0101b - 32 KB—Low-order 5 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 0110b - 64 KB—Low-order 6 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 0111b - 128 KB—Low-order 7 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 1000b - 256 KB—Low-order 8 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 1001b - 512 KB—Low-order 9 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 1010b - 1024 KB—Low-order 10 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 1011b - 2048 KB—Low-order 11 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 1100b - 4096 KB—Low-order 12 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 1101b - 8192 KB—Low-order 13 bits of ORDnLSA[LSA] and ORDnPSA[PSA] must be zero 1110b - Reserved 1111b - Reserved

6.7.18 ORDa Region Zone Assignment (ORD0RZA - ORD15RZA)

Offset

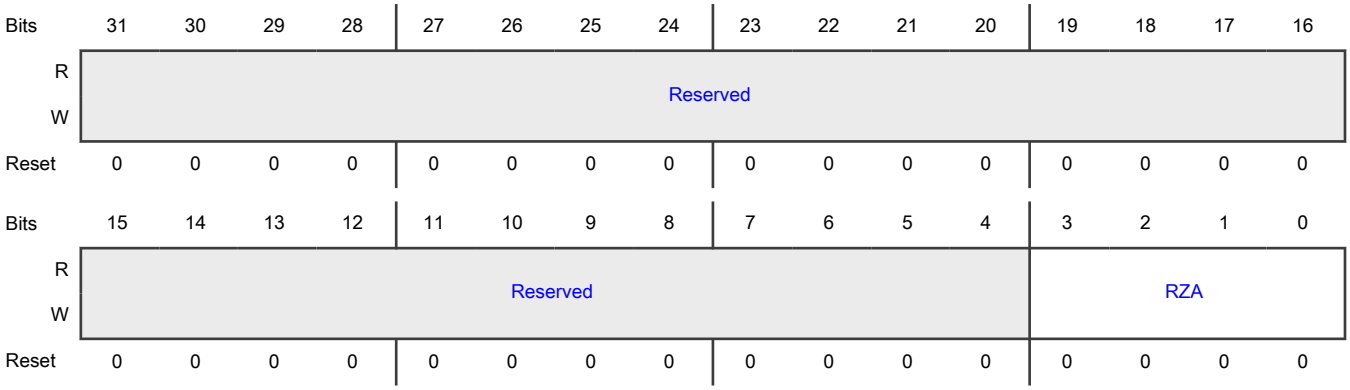
For a = 0 to 15:

Register	Offset
ORDaRZA	440Ch + (a × 10h)

Function

Controls enablement of the associated region.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 RZA	Region Zone Assignment Controls enablement of the associated region. 0000b - Disabled 0001b - Disabled 0010b - Disabled 0011b - Disabled 0100b - Always enabled 0101b - Always enabled 0110b - Always enabled 0111b - Always enabled 1000b - Enabled when zone 0 is enabled 1001b - Enabled when zone 1 is enabled 1010b - Enabled when zone 2 is enabled 1011b - Enabled when zone 3 is enabled 1100b - Enabled when zone 4 is enabled

Table continues on the next page...

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Field	Function
	1101b - Enabled when zone 5 is enabled 1110b - Enabled when zone 6 is enabled 1111b - Enabled when zone 7 is enabled

Chapter 7
Miscellaneous Control Module (MCM)

7.1 Chip-specific MCM information

7.1.1 MCM instances and configuration

This chip supports one instance per core:

- MCM_0
- MCM_1
- MCM_2
- MCM_3

Table 32. Memories

Memory	single core	Dual core	Lockstep for CM7_0 and CM7_1	Lockstep for CM7_2 and CM7_3
Icache	16 KB	16 KB (per core)	16 KB	16 KB
Dcache	16 KB	16 KB (per core)	16 KB	16 KB
ITCM	32 KB	32 KB (per core)	64 KB	32 KB
DTCM	64 KB	64 KB (per core)	128 KB	64 KB

7.2 Introduction

MCM provides miscellaneous control functions and contains local memory descriptors for the Cortex-M7 core. For more information about core-related registers, see the Cortex-M7 core overview chapter.

7.2.1 Features

The MCM includes the following features:

- Program-visible information on the platform configuration and revision
- Floating Point Exception monitor and interrupt control
- Local memory descriptors:
  - ITCM
  - D0TCM
  - D1TCM
  - I-cache
  - D-cache

7.3 Functional description

7.3.1 Interrupts

MCM generates an interrupt if any of the following are true:

- FPU input denormal interrupt is enabled (FIDCE) and an input is denormalized (FIDC).

- FPU inexact interrupt is enabled (FIXCE) and a number is inexact (FIXC).
- FPU underflow interrupt is enabled (FUFCE) and an underflow occurs (FUFC).
- FPU overflow interrupt is enabled (FOFCE) and an overflow occurs (FOFC).
- FPU divide-by-zero interrupt is enabled (FDZCE) and a divide-by-zero occurs (FDZC).
- FPU invalid operation interrupt is enabled (FIOCE) and an invalid operation occurs (FIOC).
- Write abort interrupt is enabled (WABE) and a write abort occurs (CORTEX-M7 WABORTS INDICATOR).

Determining interrupt source

To determine the exact source of the interrupt for Cortex-M7 core, qualify the interrupt status flags with the corresponding interrupt enable fields.

- MCM_ISCR[31:16] && MCM_ISCR[15:0]
- Search the result for asserted flags, which indicate the exact interrupt sources.

7.4 Memory map and register descriptions

The memory map and register descriptions below describe the registers using byte addresses.

NOTE

The following actions result in bus errors:

- Writing to read-only registers at 0x0.
- Reading from or writing to an address from offset 480h and above.
- Accessing any MCM register while in User mode. These registers are only accessible while in Supervisor mode.

7.4.1 MCM register descriptions

7.4.1.1 MCM memory map

MCM_0_CM7 base address: E008_0000h

MCM_1_CM7 base address: E008_0000h

MCM_2_CM7 base address: E008_0000h

MCM_3_CM7 base address: E008_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	SoC-defined Platform Revision (PLREV)	16	R	0000h
2h	Processor Core Type (PCT)	16	R	AC70h
Ch	Core Platform Control (CPCR)	32	RW	0000_0200h
10h	Interrupt Status and Control (ISCR)	32	RW	0000_0000h
30h	Process Identifier (PID)	8	RW	00h
400h	Local Memory Descriptor 0 (LMEM_DESC_0)	32	RW	8606_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
404h - 408h	Local Memory Descriptor a (LMEM_DESC_1 - LMEM_DESC_2)	32	RW	8604_2000h
40Ch	Local Memory Descriptor 3 (LMEM_DESC_3)	32	RW	8526_4000h
410h	Local Memory Descriptor 4 (LMEM_DESC_4)	32	RW	8544_6000h

7.4.1.2 SoC-defined Platform Revision (PLREV)

Offset

Register	Offset
PLREV	0h

Function

Specifies a chip-defined platform revision number. A platform input signal defines the state of this register; it can only be read from the IPS programming model. Any attempted write is ignored.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PLREV															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-0 PLREV	Defines the software-visible revision number, specified by a platform input signal.

7.4.1.3 Processor Core Type (PCT)

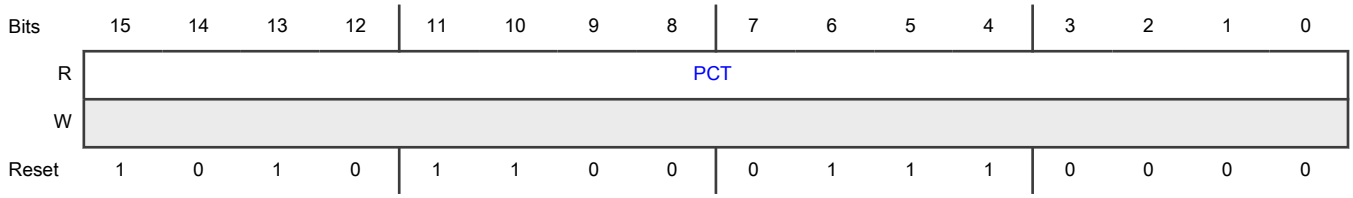
Offset

Register	Offset
PCT	2h

Function

Specifies the architecture of the processor core within the platform on the chip. A module input signal defines the state of this register, which can only be read from the IPS programming model. Any attempted write is ignored.

Diagram



Fields

Field	Function
15-0 PCT	Core Complex Identifier Identifies the core complex. This MCM design supports the Arm Cortex M7 core. 1010_1100_0111_0000b - Arm Cortex-M7

7.4.1.4 Core Platform Control (CPCR)

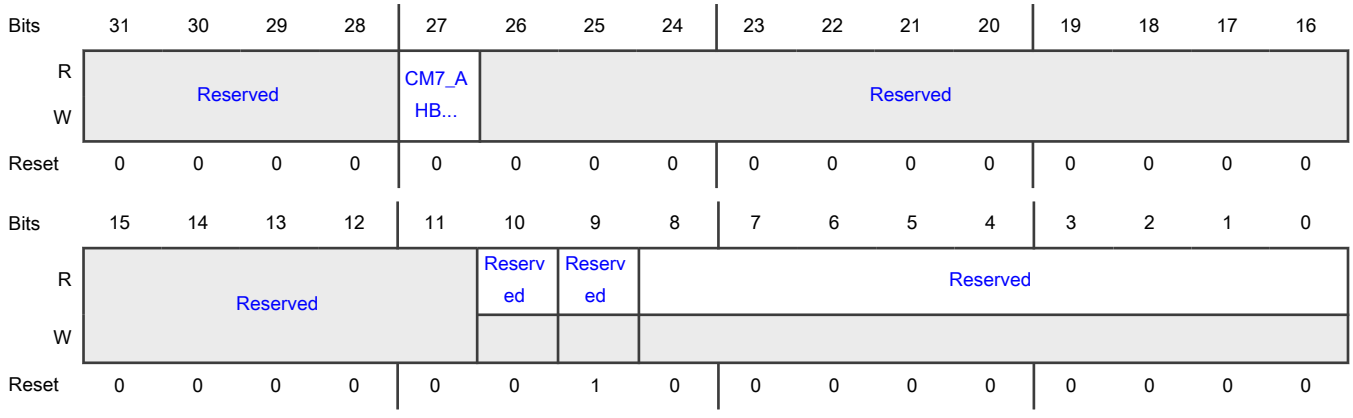
Offset

Register	Offset
CPCR	Ch

Function

Defines the arbitration and protection schemes for the two system RAM arrays.

Diagram



Fields

Field	Function
31-28 —	Reserved
27 CM7_AHBSPRI	AHB Slave Priority Indicates the access priority on the AHBS port of the Cortex-M7. **NOTE** This setting has no effect unless enabled by AHBSCR[CTL][1] of the Cortex-M7 core. 0b - Uses a round-robin arbitration scheme 1b - AHB-slave access has priority over a core access
26-11 —	Reserved
10 —	Reserved
9 —	Reserved
8-0 —	Reserved

1. For more information see Cortex-M7 documentation: Arm Cortex-M7 Processor Technical Reference Manual at www.arm.com.

7.4.1.5 Interrupt Status and Control (ISCR)

Offset

Register	Offset
ISCR	10h

Function

Defines the configuration and reports the status for a number of core-related interrupt exception conditions. It includes:

- Enable and status fields associated with the core's floating-point exceptions
- Bus errors associated with the core's cache write buffer

The individual event indicators are first qualified with their exception enables, and then logically summed to form an interrupt request sent to the core's NVIC.

Bits 15-8 are read-only indicator flags based on the processor's FPSCR register. Attempted writes to these fields are ignored. When these flags are 1, they retain this value until software clears the corresponding FPSCR field. For more information see Cortex-M7 documentation: Arm Cortex-M7 Processor Technical Reference Manual at www.arm.com.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	FIDCE	0		FIXCE	FUFCE	FOFCE	FDZCE	FIOCE	0		WABE	0				
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	FIDC	0		FIXC	FUFC	FOFC	FDZC	FIOC	0	WABSO	WABS	0				
W											W1C					
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 FIDCE	FPU Input Denormal Interrupt Enable 0b - Disable 1b - Enable
30-29 —	Reserved
28 FIXCE	FPU Inexact Interrupt Enable 0b - Disable 1b - Enable
27 FUFCE	FPU Underflow Interrupt Enable 0b - Disable 1b - Enable
26 FOFCE	FPU Overflow Interrupt Enable 0b - Disable 1b - Enable
25 FDZCE	FPU Divide-by-Zero Interrupt Enable 0b - Disable 1b - Enable
24 FIOCE	FPU Invalid Operation Interrupt Enable 0b - Disable 1b - Enable
23-22	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
21 WABE	TCM Write Abort Interrupt Enable 0b - Disable 1b - Enable
20-16 —	Reserved
15 FIDC	FPU Input Denormal Interrupt Status Indicates that an input denormalized number has been detected in the processor's FPU. This field is a copy of the core's FPSCR[IDC] field. When this field is 1, it retains this value until software clears the FPSCR[IDC] field. 0b - No interrupt 1b - Interrupt occurred
14-13 —	Reserved
12 FIXC	FPU Inexact Interrupt Status Indicates that an inexact number has been detected in the processor's FPU. This field is a copy of the core's FPSCR[IXC] field. When this field is 1, it retains this value until software clears the FPSCR[IXC] field. 0b - No interrupt 1b - Interrupt occurred
11 FUFC	FPU Underflow Interrupt Status Indicates that an underflow has been detected in the processor's FPU. This field is a copy of the core's FPSCR[UFC] field. When this field is 1, it retains this value until software clears the FPSCR[UFC] field. 0b - No interrupt 1b - Interrupt occurred
10 FOFC	FPU Overflow Interrupt Status Indicates that an overflow has been detected in the processor's FPU. This field is a copy of the core's FPSCR[OFC] field. When this field is 1, it retains this value until software clears the FPSCR[OFC] field. 0b - No interrupt 1b - Interrupt occurred
9 FDZC	FPU Divide-by-Zero Interrupt Status Indicates that a divide-by-zero operation has been detected in the processor's FPU. This field is a copy of the core's FPSCR[DZC] field. When this field is 1, it retains this value until software clears the FPSCR[DZC] field.

Table continues on the next page...

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Field	Function
	0b - No interrupt 1b - Interrupt occurred
8 FIOC	FPU Invalid Operation Interrupt Status Indicates that an illegal operation has been detected in the processor's FPU. This field is a copy of the core's FPSCR[IOC] field. When this field is 1, it retains this value until software clears the FPSCR[IOC] field. 0b - No interrupt 1b - Interrupt occurred
7 —	Reserved
6 WABSO	Write Abort on Slave Overrun The overrun conditions are reported only if WABE=1. 0b - No write abort overrun 1b - Write abort overrun occurred
5 WABS	Write Abort on Slave Indicates when a write abort has occurred on the AHBS interface. 0b - No write abort occurred on AHBS interface 1b - Write abort occurred on AHBS interface
4-0 —	Reserved

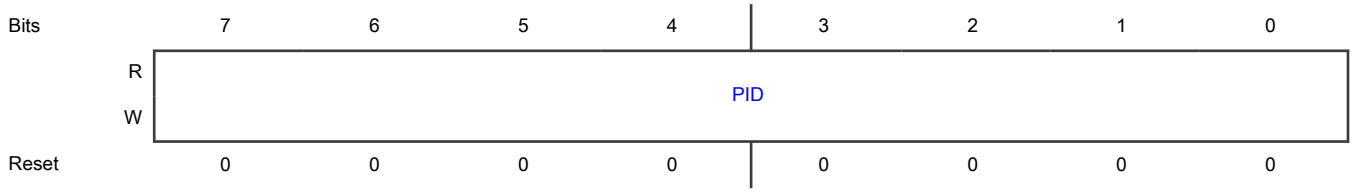
7.4.1.6 Process Identifier (PID)

Offset

Register	Offset
PID	30h

Function
Contains the CPU process ID.

Diagram



Fields

Field	Function
7-0 PID	Process Identifier Identifies the CPU process.

7.4.1.7 Local Memory Descriptor 0 (LMEM_DESC_0)

Offset

Register	Offset
LMEM_DESC_0	400h

Function

NOTE

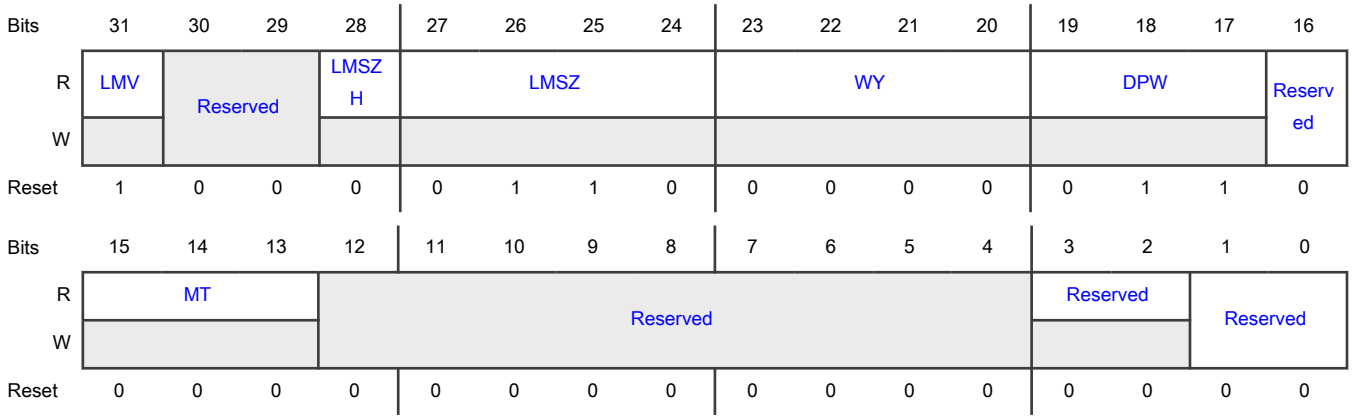
The DESC_a registers map to the LMEMs in this way:

- DESC_0: ITCM
- DESC_1: D0TCM
- DESC_2: D1TCM
- DESC_3: I-cache
- DESC_4: D-cache

NOTE

You can read and write to the reserved fields (instead of read as zero and write ignored). Writing to any of these fields has no functional impact.

Diagram



Fields

Field	Function
31 LMV	Local Memory Valid This read-only field defines the validity (presence) of the local memory. 0b - LMEM*n* not present 1b - LMEM*n* present
30-29 —	Reserved
28 LMSZH	LMEM Size Hole Used for local memories that are not fully populated (that is, local memories that include a memory "hole" in the upper 25 % of the address range). 0b - LMEM*n* is a power-of-2 capacity 1b - LMEM*n* is not a power-of-2, with capacity of 0.75 × LMSZ
27-24 LMSZ	Local Memory Size 0000b - 0 KB 0001b - 1 KB 0010b - 2 KB 0011b - 4 KB 0100b - 8 KB 0101b - 16 KB 0110b - 32 KB 0111b - 64 KB 1000b - 128 KB 1001b - 256 KB

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1010b - 512 KB 1011b - 1024 KB 1100b - 2048 KB 1101b - 4096 KB 1110b - 8192 KB 1111b - 16384 KB
23-20 WY	Level 1 Cache Ways 0000b - No cache 0010b - 2-way set associative 0100b - 4-way set associative
19-17 DPW	Data Path Width Defines the LMEM*n* data path width, which is the width of the local memory. 000b-001b - Reserved 010b - 32 bits 011b - 64 bits 100b-111b - Reserved
16 —	Reserved
15-13 MT	Memory Type 000b - ITCM 001b - DTCM 010b - I-cache 011b - D-cache
12-4 —	Reserved
3-2 —	Reserved
1-0 —	Reserved

7.4.1.8 Local Memory Descriptor a (LMEM_DESC_1 - LMEM_DESC_2)

Offset

Register	Offset
LMEM_DESC_1	404h
LMEM_DESC_2	408h

Function

NOTE

The DESC_a registers map to the LMEMs in this way:

- DESC_0: ITCM
- DESC_1: D0TCM
- DESC_2: D1TCM
- DESC_3: I-cache
- DESC_4: D-cache

NOTE

You can read and write to the reserved fields (instead of read as zero and write ignored). Writing to any of these fields has no functional impact.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LMV	Reserved		LMSZH	LMSZ				WY				DPW			Reserved
W																
Reset	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MT			Reserved									Reserved		Reserved	
W																
Reset	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LMV	Local Memory Valid This read-only field defines the validity (presence) of the local memory. 0b - LMEM*n* not present 1b - LMEM*n* present

Table continues on the next page...

Table continued from the previous page...

Field	Function
30-29 —	Reserved
28 LMSZH	LMEM Size Hole Used for local memories that are not fully populated (that is, local memories that include a memory "hole" in the upper 25 % of the address range). 0b - LMEM*n* is a power-of-2 capacity 1b - LMEM*n* is not a power-of-2, with capacity of 0.75 × LMSZ
27-24 LMSZ	Local Memory Size 0000b - 0 KB 0001b - 1 KB 0010b - 2 KB 0011b - 4 KB 0100b - 8 KB 0101b - 16 KB 0110b - 32 KB 0111b - 64 KB 1000b - 128 KB 1001b - 256 KB 1010b - 512 KB 1011b - 1024 KB 1100b - 2048 KB 1101b - 4096 KB 1110b - 8192 KB 1111b - 16384 KB
23-20 WY	Level 1 Cache Ways 0000b - No cache 0010b - 2-way set associative 0100b - 4-way set associative
19-17 DPW	Data Path Width Defines the LMEM*n* data path width, which is the width of the local memory. 000b-001b - Reserved 010b - 32 bits

Table continues on the next page...

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Field	Function
	011b - 64 bits 100b-111b - Reserved
16 —	Reserved
15-13 MT	Memory Type 000b - ITCM 001b - DTCM 010b - I-cache 011b - D-cache
12-4 —	Reserved
3-2 —	Reserved
1-0 —	Reserved

7.4.1.9 Local Memory Descriptor 3 (LMEM_DESC_3)

Offset

Register	Offset
LMEM_DESC_3	40Ch

Function

NOTE

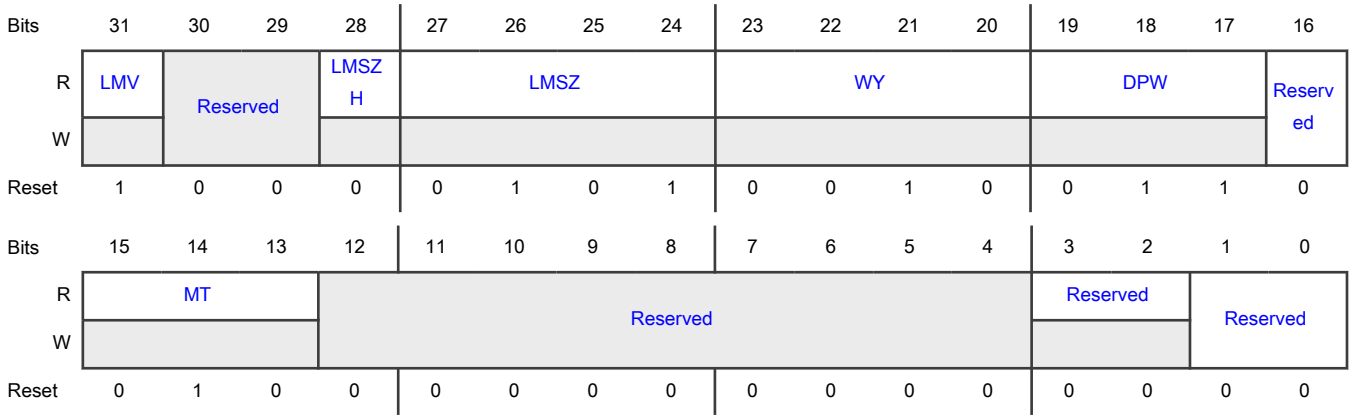
The DESC_a registers map to the LMEMs in this way:

- DESC_0: ITCM
- DESC_1: D0TCM
- DESC_2: D1TCM
- DESC_3: I-cache
- DESC_4: D-cache

NOTE

You can read and write to the reserved fields (instead of read as zero and write ignored). Writing to any of these fields has no functional impact.

Diagram



Fields

Field	Function
31 LMV	Local Memory Valid This read-only field defines the validity (presence) of the local memory. 0b - LMEM*n* not present 1b - LMEM*n* present
30-29 —	Reserved
28 LMSZH	LMEM Size Hole Used for local memories that are not fully populated (that is, local memories that include a memory "hole" in the upper 25 % of the address range). 0b - LMEM*n* is a power-of-2 capacity 1b - LMEM*n* is not a power-of-2, with capacity of 0.75 × LMSZ
27-24 LMSZ	Local Memory Size 0000b - 0 KB 0001b - 1 KB 0010b - 2 KB 0011b - 4 KB 0100b - 8 KB 0101b - 16 KB 0110b - 32 KB 0111b - 64 KB 1000b - 128 KB 1001b - 256 KB

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Field	Function
	1010b - 512 KB 1011b - 1024 KB 1100b - 2048 KB 1101b - 4096 KB 1110b - 8192 KB 1111b - 16384 KB
23-20 WY	Level 1 Cache Ways 0000b - No cache 0010b - 2-way set associative 0100b - 4-way set associative
19-17 DPW	Data Path Width Defines the LMEM*n* data path width, which is the width of the local memory. 000b-001b - Reserved 010b - 32 bits 011b - 64 bits 100b-111b - Reserved
16 —	Reserved
15-13 MT	Memory Type 000b - ITCM 001b - DTCM 010b - I-cache 011b - D-cache
12-4 —	Reserved
3-2 —	Reserved
1-0 —	Reserved

7.4.1.10 Local Memory Descriptor 4 (LMEM_DESC_4)

Offset

Register	Offset
LMEM_DESC_4	410h

Function

NOTE

The DESC_a registers map to the LMEMs in this way:

- DESC_0: ITCM
- DESC_1: D0TCM
- DESC_2: D1TCM
- DESC_3: I-cache
- DESC_4: D-cache

NOTE

You can read and write to the reserved fields (instead of read as zero and write ignored). Writing to any of these fields has no functional impact.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LMV	Reserved		LMSZH	LMSZ				WY				DPW			Reserved
W																
Reset	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MT			Reserved									Reserved		Reserved	
W																
Reset	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LMV	Local Memory Valid This read-only field defines the validity (presence) of the local memory. 0b - LMEM*n* not present 1b - LMEM*n* present
30-29	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
28 LMSZH	LMEM Size Hole Used for local memories that are not fully populated (that is, local memories that include a memory "hole" in the upper 25 % of the address range). 0b - LMEM*n* is a power-of-2 capacity 1b - LMEM*n* is not a power-of-2, with capacity of 0.75 × LMSZ
27-24 LMSZ	Local Memory Size 0000b - 0 KB 0001b - 1 KB 0010b - 2 KB 0011b - 4 KB 0100b - 8 KB 0101b - 16 KB 0110b - 32 KB 0111b - 64 KB 1000b - 128 KB 1001b - 256 KB 1010b - 512 KB 1011b - 1024 KB 1100b - 2048 KB 1101b - 4096 KB 1110b - 8192 KB 1111b - 16384 KB
23-20 WY	Level 1 Cache Ways 0000b - No cache 0010b - 2-way set associative 0100b - 4-way set associative
19-17 DPW	Data Path Width Defines the LMEM*n* data path width, which is the width of the local memory. 000b-001b - Reserved 010b - 32 bits 011b - 64 bits 100b-111b - Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
16 —	Reserved
15-13 MT	Memory Type 000b - ITCM 001b - DTCM 010b - I-cache 011b - D-cache
12-4 —	Reserved
3-2 —	Reserved
1-0 —	Reserved

7.5 Glossary

ITCM	Instruction Tightly-Coupled Memory
DTCM	Data Tightly Coupled Memory
I-cache	Instruction Cache Memory
D-cache	Data Cache Memory

Chapter 8
Miscellaneous System Control Module (MSCM)

8.1 Chip-specific MSCM information

8.1.1 MSCM instance

This chip has one instance of MSCM.

8.2 Overview

MSCM contains registers for:

- CPU configuration
- On-chip memory control
- Interrupt router control
- Message-based interrupt configuration
- Virtual management

8.2.1 Features

- Software-accessible processor core configuration information
- Support for interrupt router control
- Support for message-based interrupt configuration

8.3 Functional description

MSCM provides information of the system cores and can identify the core that is running currently.

8.3.1 MSI routing

MSIs are interrupts that are indirectly broadcast to a target core by writing configuration bits in MSCM. These MSIs can be initiated by one core targeting another core in the system (known as core-to-core interrupts). These MSIs are initiated via writes to the IRCP0IGR0 register and managed through the IRCP0ISR0 register, where *n* indicates the logical core number (0-1) and *m* represents the interrupt number (0-3). The Cortex-M7 cores can support up to four outstanding core-to-core interrupts.

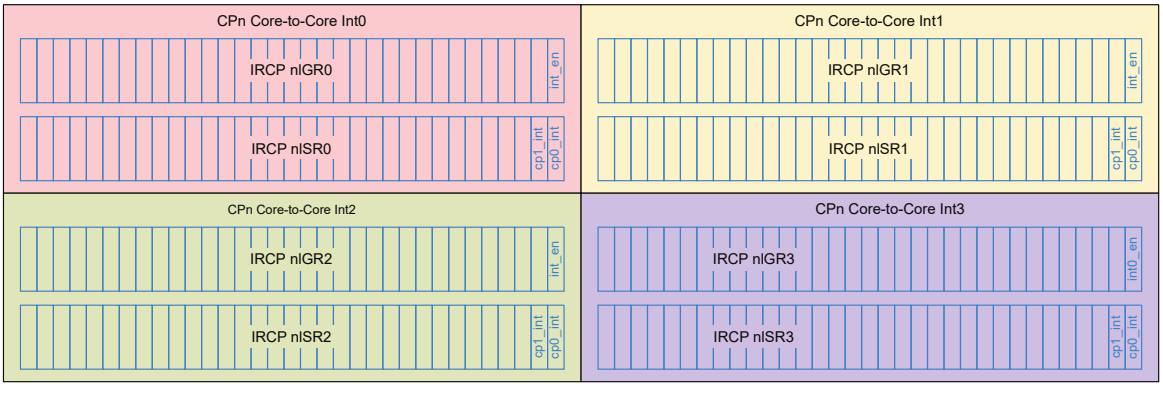

Figure 14. IRCP*n*IGR*m*/IRCP*n*ISR*m* pairs for one core

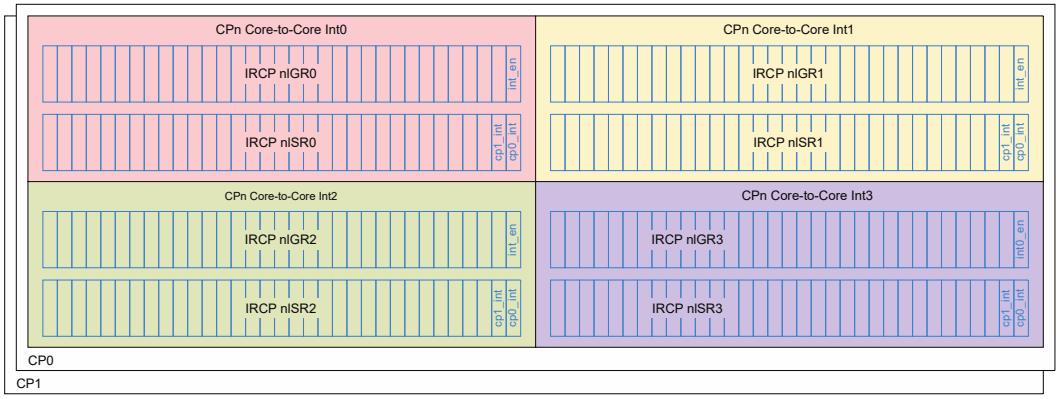

Figure 15. IRCP*n*IGR*m*/IRCP*n*ISR*m* pairs per core

8.3.1.1 Core-to-core MSIs

The next figure depicts the sequence for initiating a core-to-core MSI, in which *m* represents the initiating core, *n* represents the target core, and *x* indicates the MSI number. CP*m* writes to IRCP*n*IGR*x* to initiate an MSI. The outstanding MSI that CP*m* initiates, targeting CP*n*, is reflected in the corresponding bit-mapped field in IRCP*n*ISR*x*.

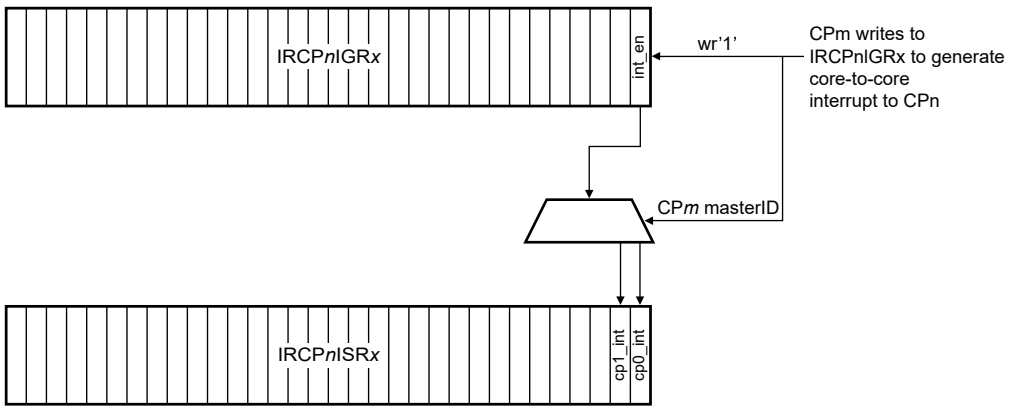

Figure 16. Initiating a core-to-core MSI via IRCP*n*IGR*x*/IRCP*n*ISR*x*

8.3.2 Interrupt steering and semaphores

8.3.2.1 Interrupt handling overview

The interrupt handling mechanisms of the Cortex-M7 cores are very similar. These cores have an NVIC tightly coupled to the processor core. The real-time performance of the cores means the NVIC directly provides an appropriate interrupt vector, in the form of the starting instruction address for the interrupt service routine, to the core. These core architectural features directly translate into a faster ISR entry and exit capabilities, coupled with an improved runtime performance. See the Arm modules and Arm core technical reference manuals for details.

In this architecture, a total of 240 IRQs are supported, where this parameter is defined by the realistic limits of the NVIC implementation, both in terms of silicon size and supported frequency of operation. These 240 IRQs are split into a total of four directed requests and 236 shared peripheral requests. Unless noted otherwise, let the directed requests be defined as IRQ[3:0] and the shared peripheral requests as IRQ[239:4]. See the interrupt map file attached to this document for details.

8.3.2.2 MSCM interrupt router functional description

As described in MSCM register descriptions, the interrupt routing registers enable the steering of requests to the processor cores.

8.3.3 Clocking

This module has no clocking considerations.

8.4 External signals

This module has no external signals.

8.5 Initialization

This module does not require initialization.

8.6 Memory map and register definition

8.6.1 Core configuration registers

These read-only registers contain data that defines the core setup for this chip. You can access the registers using 32-bit read references; other access sizes terminate with an error. Attempted write accesses to the read-only core configuration registers also terminate with an error.

The core configuration portion of the MSCM programming model map is organized based on the logical core number, and not on any type of physical port number. The following table shows how the configuration is partitioned.

Table 33. MSCM core configuration partitioning

Offset address range	Purpose
0h–018h	Defines the generic core x configuration information. Only the MSCM associated controllers can access this region in either User or Privileged mode; reads by noncore bus controllers (including the debugger) are treated as read as zero (RAZ) accesses. Write attempts are not permitted and terminate with a system bus error.
020h–038h	Defines the configuration information for core 0 (CP0). Any bus controller can access this region in either User or Privileged mode. Write attempts are not permitted and terminate with a system bus error.
040h–058h	Defines the configuration information for core 1 (CP1). A bus controller can access this region in either User or Privileged mode. Write attempts are not permitted and terminate with a system bus error.
060h–078h	Defines the configuration information for core 2 (CP2). Any bus controller can access this region in either User or Privileged mode. Write attempts are not permitted and terminate with a system bus error.

NOTE

Attempted accesses to reserved locations are not permitted and terminate with a system bus error.

8.6.2 Shared peripheral interrupt (SPI) routing

The SPI router portion of MSCM provides a set of memory-mapped registers defining the interrupt routing for all the SPIs on this chip.

8.6.3 MSCM register descriptions

8.6.3.1 MSCM memory map

MSCM base address: 4026_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Processor X Type (CPXTYPE)	32	R	See section
4h	Processor X Number (CPXNUM)	32	R	See section
8h	Processor X Revision (CPXREV)	32	R	See section
Ch	Processor X Configuration 0 (CPXCFG0)	32	R	0602_0604h
10h	Processor X Configuration 1 (CPXCFG1)	32	R	See section
14h	Processor X Configuration 2 (CPXCFG2)	32	R	See section
20h	Processor 0 Type (CP0TYPE)	32	R	434D_3730h
24h	Processor 0 Number (CP0NUM)	32	R	See section
28h	Processor 0 Count (CP0REV)	32	R	See section
2Ch	Processor 0 Configuration 0 (CP0CFG0)	32	R	0602_0604h
30h	Processor 0 Configuration 1 (CP0CFG1)	32	R	0000_0000h
34h	Processor 0 Configuration 2 (CP0CFG2)	32	R	See section
40h	Processor 1 Type (CP1TYPE)	32	R	434D_3731h
44h	Processor 1 Number (CP1NUM)	32	R	0000_0001h
48h	Processor 1 Count (CP1REV)	32	R	See section
4Ch	Processor 1 Configuration 0 (CP1CFG0)	32	R	0602_0604h
50h	Processor 1 Configuration 1 (CP1CFG1)	32	R	See section
54h	Processor 1 Configuration 2 (CP1CFG2)	32	R	See section
58h	Processor 1 Configuration 3 (CP1CFG3)	32	R	0000_000Bh
60h	Processor 2 Type (CP2TYPE)	32	R	434D_3732h
64h	Processor 2 Number (CP2NUM)	32	R	0000_0002h
68h	Processor 2 Count (CP2REV)	32	R	See section
6Ch	Processor 2 Configuration 0 (CP2CFG0)	32	R	0602_0604h
70h	Processor 2 Configuration 1 (CP2CFG1)	32	R	See section
74h	Processor 2 Configuration 2 (CP2CFG2)	32	R	See section
78h	Processor 2 Configuration 3 (CP2CFG3)	32	R	0000_000Bh
200h	Interrupt Router CP0 Interrupt Status (IRCP0ISR0)	32	RW	0000_0000h
204h	Interrupt Router CP0 Interrupt Generation (IRCP0IGR0)	32	RW	0000_0000h
208h	Interrupt Router CP0 Interrupt Status (IRCP0ISR1)	32	RW	0000_0000h
20Ch	Interrupt Router CP0 Interrupt Generation (IRCP0IGR1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
210h	Interrupt Router CP0 Interrupt Status (IRCP0ISR2)	32	RW	0000_0000h
214h	Interrupt Router CP0 Interrupt Generation (IRCP0IGR2)	32	RW	0000_0000h
218h	Interrupt Router CP0 Interrupt Status (IRCP0ISR3)	32	RW	0000_0000h
21Ch	Interrupt Router CP0 Interrupt Generation (IRCP0IGR3)	32	RW	0000_0000h
220h	Interrupt Router CP1 Interrupt Status (IRCP1ISR0)	32	RW	0000_0000h
224h	Interrupt Router CP1 Interrupt Generation (IRCP1IGR0)	32	RW	0000_0000h
228h	Interrupt Router CP1 Interrupt Status (IRCP1ISR1)	32	RW	0000_0000h
22Ch	Interrupt Router CP1 Interrupt Generation (IRCP1IGR1)	32	RW	0000_0000h
230h	Interrupt Router CP1 Interrupt Status (IRCP1ISR2)	32	RW	0000_0000h
234h	Interrupt Router CP1 Interrupt Generation (IRCP1IGR2)	32	RW	0000_0000h
238h	Interrupt Router CP1 Interrupt Status (IRCP1ISR3)	32	RW	0000_0000h
23Ch	Interrupt Router CP1 Interrupt Generation (IRCP1IGR3)	32	RW	0000_0000h
240h	Interrupt Router CP2 Interrupt Status (IRCP2ISR0)	32	RW	0000_0000h
244h	Interrupt Router CP2 Interrupt Generation (IRCP2IGR0)	32	RW	0000_0000h
248h	Interrupt Router CP2 Interrupt Status (IRCP2ISR1)	32	RW	0000_0000h
24Ch	Interrupt Router CP2 Interrupt Generation (IRCP2IGR1)	32	RW	0000_0000h
250h	Interrupt Router CP2 Interrupt Status (IRCP2ISR2)	32	RW	0000_0000h
254h	Interrupt Router CP2 Interrupt Generation (IRCP2IGR2)	32	RW	0000_0000h
258h	Interrupt Router CP2 Interrupt Status (IRCP2ISR3)	32	RW	0000_0000h
25Ch	Interrupt Router CP2 Interrupt Generation (IRCP2IGR3)	32	RW	0000_0000h
400h	Interrupt Router Configuration (IRCPCFG)	32	RW	0000_0000h
500h	Memory Execution Control (XN_CTRL)	32	RW	4000_0000h
600h	Enable Interconnect Error Detection (ENEDC)	32	RW	0000_0000h
604h	Enable Interconnect Error Detection (ENEDC1)	32	RW	0000_0000h
880h - A5Eh	Interrupt Router Shared Peripheral Routing Control (IRSPRC0 - IRSPRC239)	16	RW	000Fh

8.6.3.2 Processor X Type (CPXTYPE)

Offset

Register	Offset
CPXTYPE	0h

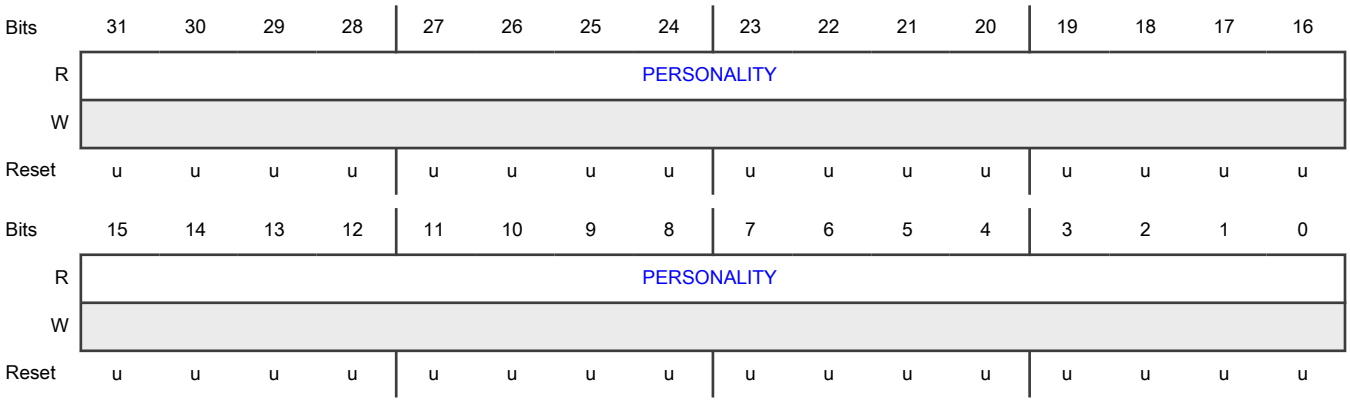
Function

Provides a CPU-specific response indicating the personality of the core making the access. The 32-bit response includes four ASCII characters defining the CPU type (Cortex-M7 cores) along with a byte defining the logical revision number and a byte defining the instance number of the core.

A read from Cortex-M7 returns the appropriate processor information. Reads from any other bus controller return all 0s and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-0 PERSONALITY	Personality of CPx Defines the processor personality for CP*x*.

Processor	Personality
CP*x* = Cortex-M7_0	43_4D_37_30h
CP*x* = Cortex-M7_1	43_4D_37_31h
CP*x* = Cortex-M7_2	43_4D_37_32h
CP*x* = Cortex-M7_3	43_4D_37_33h

8.6.3.3 Processor X Number (CPXNUM)

Offset

Register	Offset
CPXNUM	4h

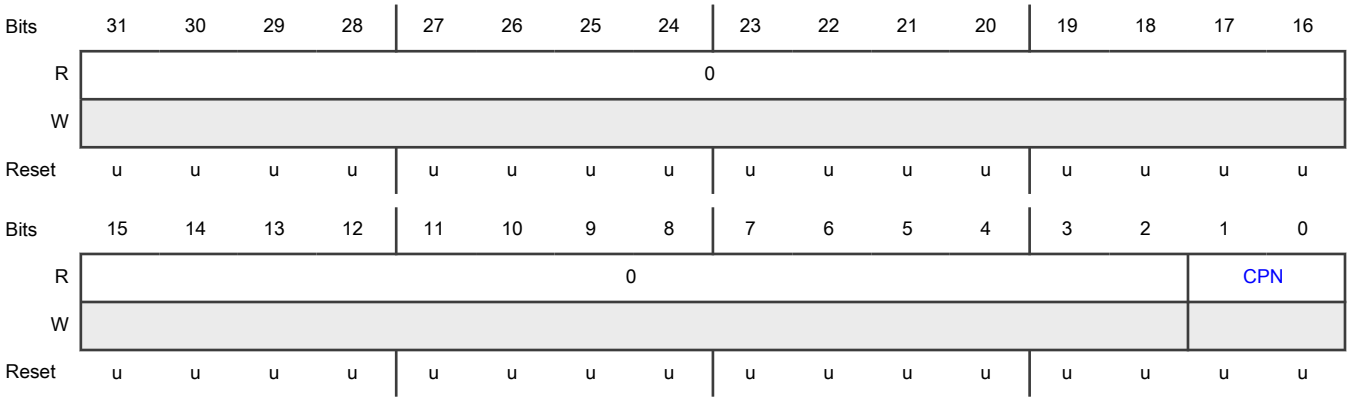
Function

Provides a CPU-specific response indicating the logical processor number of the core making the access.

A read from the Cortex-M7 cores returns the appropriate processor information. Reads from any other bus controller return all 0s and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-2 —	Reserved
1-0 CPN	Processor Number Defines the logical processor number for CP*x*. **NOTE** CPN in MSCM indicates only the on-platform cores and not the HSE_B core. CPN = 0 represents Cortex-M7_0 if it is a lockstep or dual core. In Lockstep mode, CPN = 1 does not read from Processor X Number (CPXNUM). 00b - Cortex-M7 core 0 01b - Cortex-M7 core 1 10b - Cortex-M7 core 2

8.6.3.4 Processor X Revision (CPXREV)

Offset

Register	Offset
CPXREV	8h

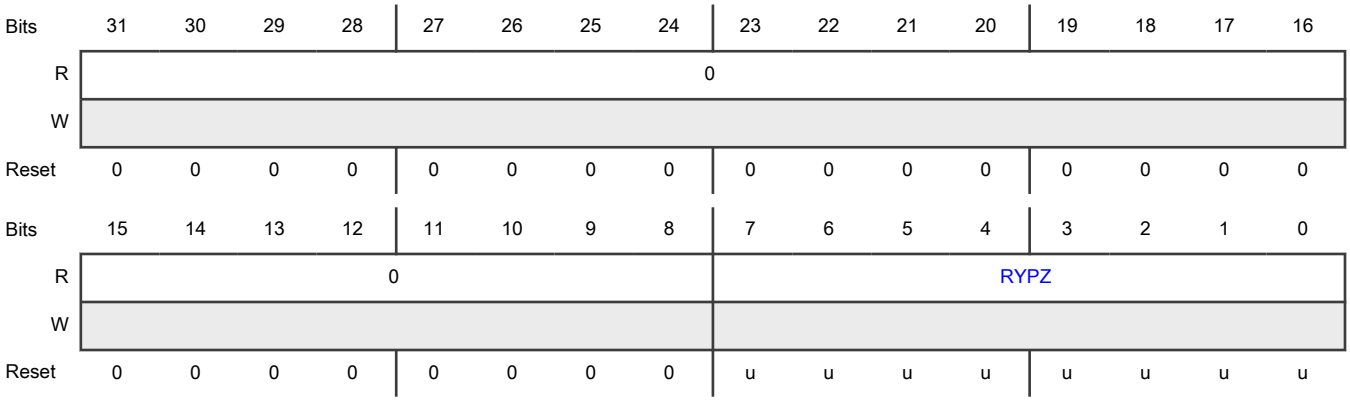
Function

Provides a CPU-specific response indicating the logical revision number of the core.

A read from the Cortex-M7 cores returns the appropriate processor information. Reads from any other bus controller return all 0s and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 RYPZ	Processor Revision Defines the processor revision for CP*x*. For the Cortex-M7 cores in this chip, RYPZ = 12h corresponding to the r1p2 core release.

8.6.3.5 Processor X Configuration 0 (CPXCFG0)

Offset

Register	Offset
CPXCFG0	Ch

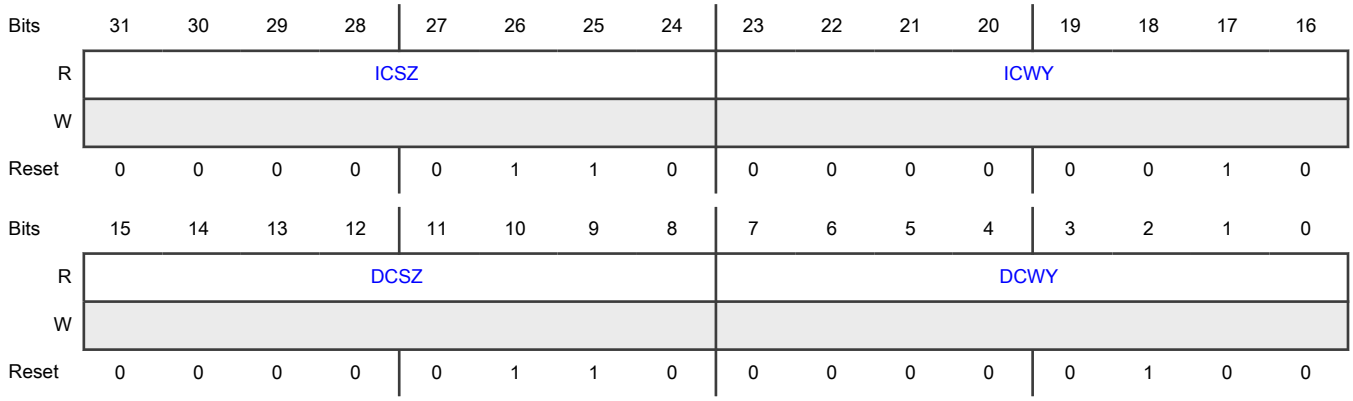
Function

Provides a CPU-specific response detailing configuration information. In this case, it is information on Level 1 (L1) cache, if present.

A read from Cortex-M7 returns the appropriate processor information. Reads from any other bus controller return all 0s and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 ICSZ	Level 1 Instruction Cache Size Provides an encoded value of the instruction cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, ICSZ is a nonzero value and ICSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
23-16 ICWY	L1 Instruction Cache Ways Provides the number of cache ways for the instruction cache. For the Cortex-M7 cores in this chip, ICWY = 2h (2-way set-associative).
15-8 DCSZ	L1 Data Cache Size Provides an encoded value of the data cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, DCSZ is a nonzero value and DCSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
7-0 DCWY	L1 Data Cache Ways Provides the number of cache ways for the data cache. For the Cortex-M7 cores in this chip, DCWY = 4h (4-way set-associative).

8.6.3.6 Processor X Configuration 1 (CPXCFG1)

Offset

Register	Offset
CPXCFG1	10h

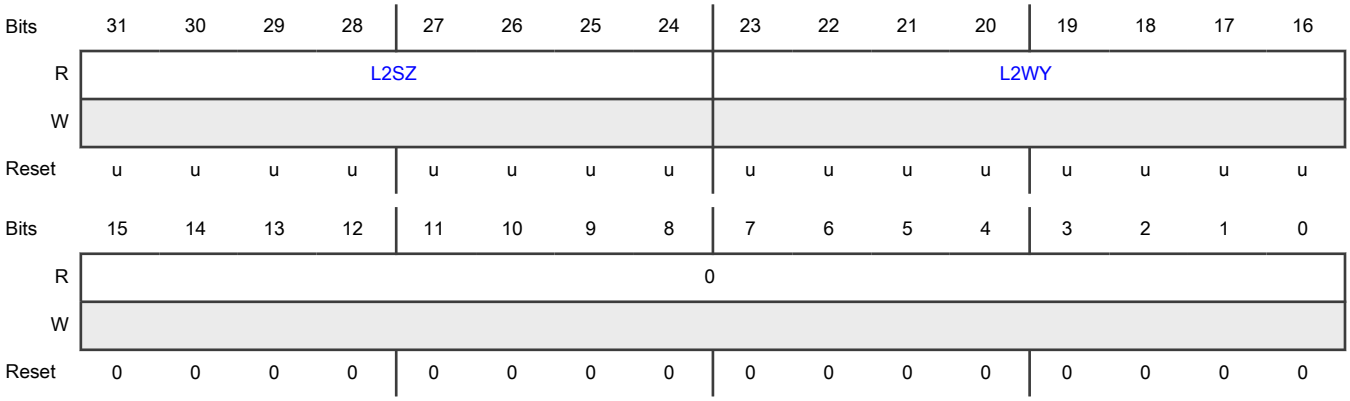
Function

Provides a CPU-specific response detailing configuration information. In this case, it is information on Level 2 (L2) cache, if present.

A read from the Cortex-M7 cores returns the appropriate processor information. Reads from any other bus controller return all 0s and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 L2SZ	L2 Cache Size Provides an encoded value of the L2 cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, L2SZ is a nonzero value, and L2SZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, L2SZ = 0h (not present).
23-16 L2WY	L2 Cache Ways Provides the number of cache ways for the L2 cache. For the Cortex-M7 cores in this chip, L2WY = 0h (not present).
15-0 —	Reserved

8.6.3.7 Processor X Configuration 2 (CPXCFG2)

Offset

Register	Offset
CPXCFG2	14h

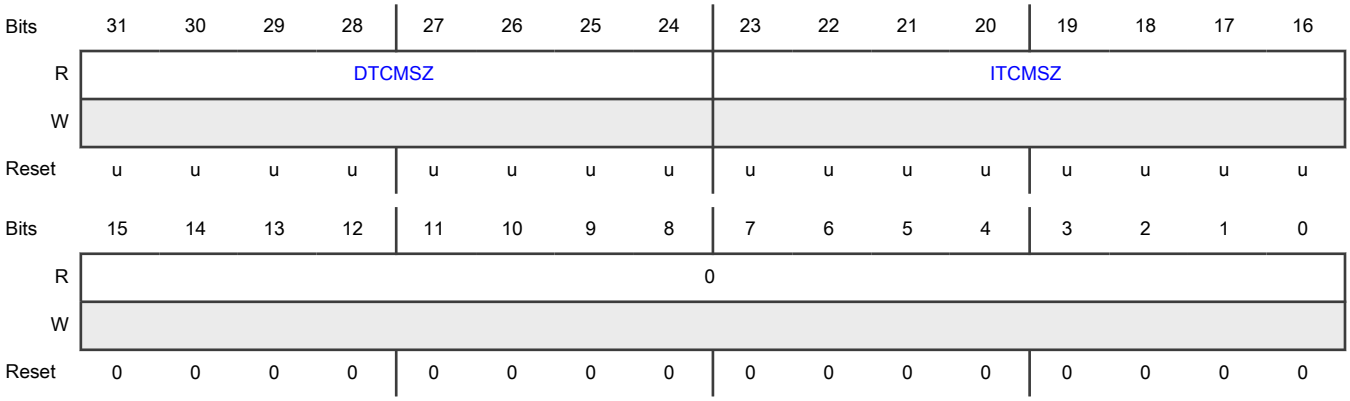
Function

Provides a CPU-specific response detailing configuration information. In this case, it is information on tightly coupled local memories, if present.

A read from the Cortex-M7 cores returns the appropriate processor information. Reads from any other bus controller return all 0s and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 DTCMSZ	Tightly Coupled Data Memory Size Provides an encoded value of the tightly coupled local data memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, DTCMSZ is a nonzero value and DTCMSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip: • DTCMSZ = 08 in Decoupled mode (64 KB) • DTCMSZ = 09 for Cortex-M7_0 in Lockstep mode (128 KB)
23-16 ITCMSZ	Instruction Tightly Coupled Memory Size Provides an encoded value of the tightly coupled local instruction memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, ITCMSZ is a nonzero value, and ITCMSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip: • ITCMSZ = 07 in Decoupled mode (32 KB) • ITCMSZ = 08 for Cortex-M7_0 in Lockstep mode (64 KB)
15-0 —	Reserved

8.6.3.8 Processor 0 Type (CP0TYPE)

Offset

Register	Offset
CP0TYPE	20h

Function

Defines the configuration information for processor 0 (CP0). It has the same field definitions and functionality as provided in Processor X Type (CPXTYPE).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PERSONALITY															
W																
Reset	0	1	0	0	0	0	1	1	0	1	0	0	1	1	0	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PERSONALITY															
W																
Reset	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	0

Fields

Field	Function
31-0 PERSONALITY	Processor Personality Defines the processor personality for CP0. For Cortex-M7 core 0, personality = 43_4D_37_30h.

8.6.3.9 Processor 0 Number (CP0NUM)

Offset

Register	Offset
CP0NUM	24h

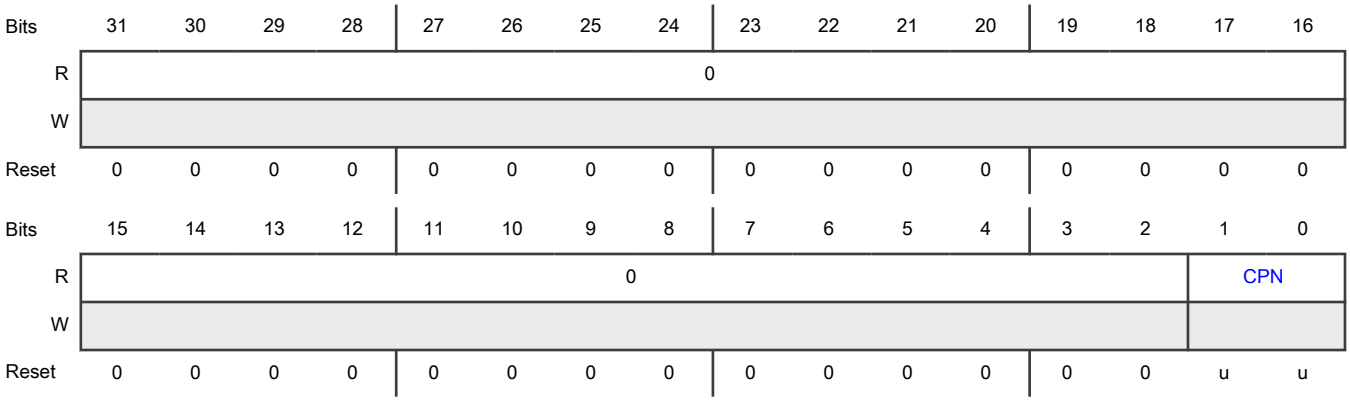
Function

Defines the configuration information for processor 0 (CP0). It has the same field definitions and functionality as provided in Processor X Number (CPXNUM).

A privileged read from any bus controllers returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-2 —	Reserved
1-0 CPN	Processor Number Defines the logical processor number for CP0. For processor Cortex-M7 core 0, processor number = 0.

8.6.3.10 Processor 0 Count (CP0REV)

Offset

Register	Offset
CP0REV	28h

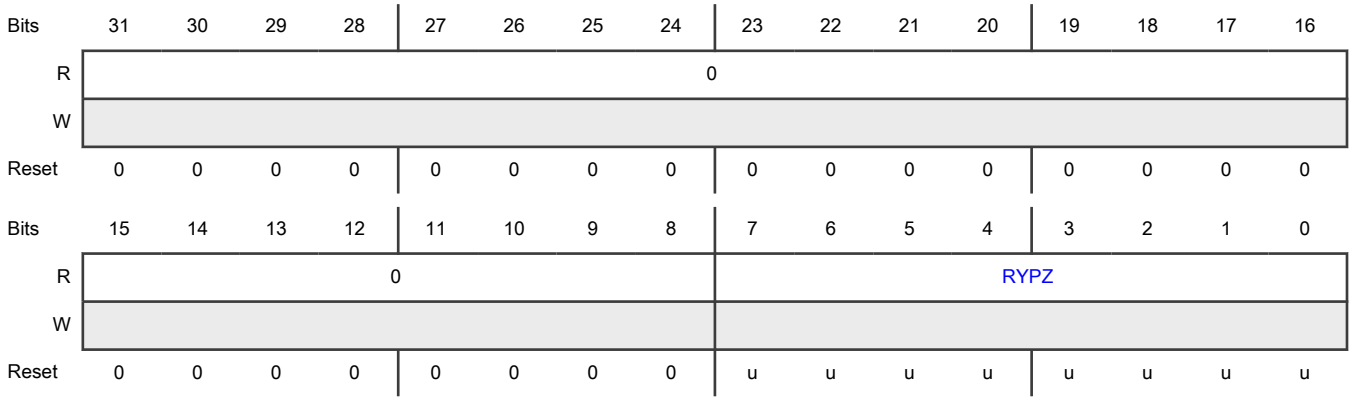
Function

Defines the configuration information for processor 0 (CP0). It has the same field definitions and functionality as provided in Processor X Revision (CPXREV).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 RYPZ	Processor Revision Defines the processor revision for CP0. For the Cortex-M7 processor, RYPZ = 12h corresponding to the r1p2 core release.

8.6.3.11 Processor 0 Configuration 0 (CP0CFG0)

Offset

Register	Offset
CP0CFG0	2Ch

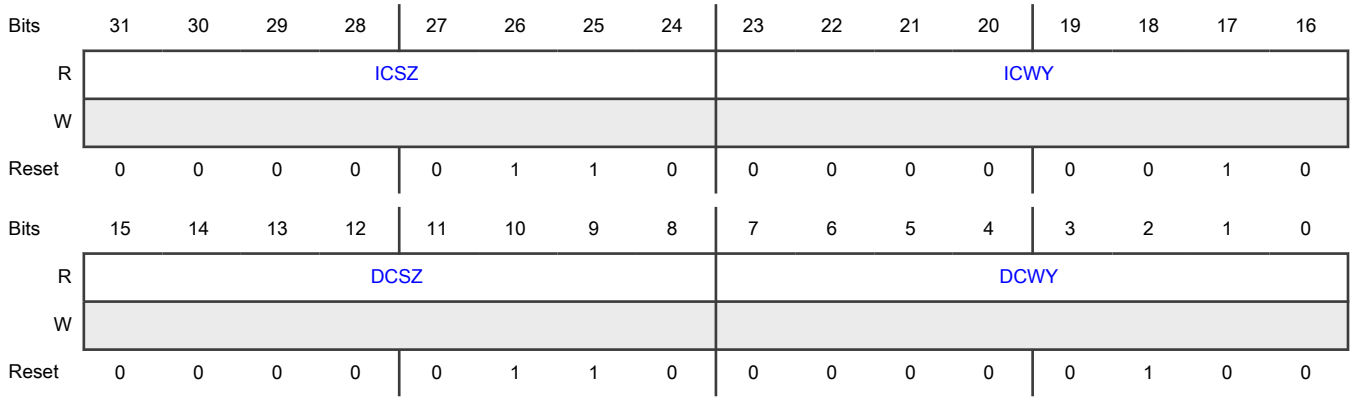
Function

Defines the configuration information for processor 0 (CP0). It has the same field definitions and functionality as provided in Processor X Configuration 0 (CPXCFG0).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 ICSZ	Level 1 Instruction Cache Size Provides an encoded value of the instruction cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, ICSZ is a nonzero value, and ICSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
23-16 ICWY	L1 Instruction Cache Ways Provides the number of cache ways for the instruction cache. For the Cortex-M7 cores in this chip, ICWY = 2h (2-way set-associative).
15-8 DCSZ	L1 Data Cache Size Provides an encoded value of the data cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, DCSZ is a nonzero value, and DCSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
7-0 DCWY	L1 Data Cache Ways Provides the number of cache ways for the data cache. For the Cortex-M7 cores in this chip, DCWY = 4h (4-way set-associative).

8.6.3.12 Processor 0 Configuration 1 (CP0CFG1)

Offset

Register	Offset
CP0CFG1	30h

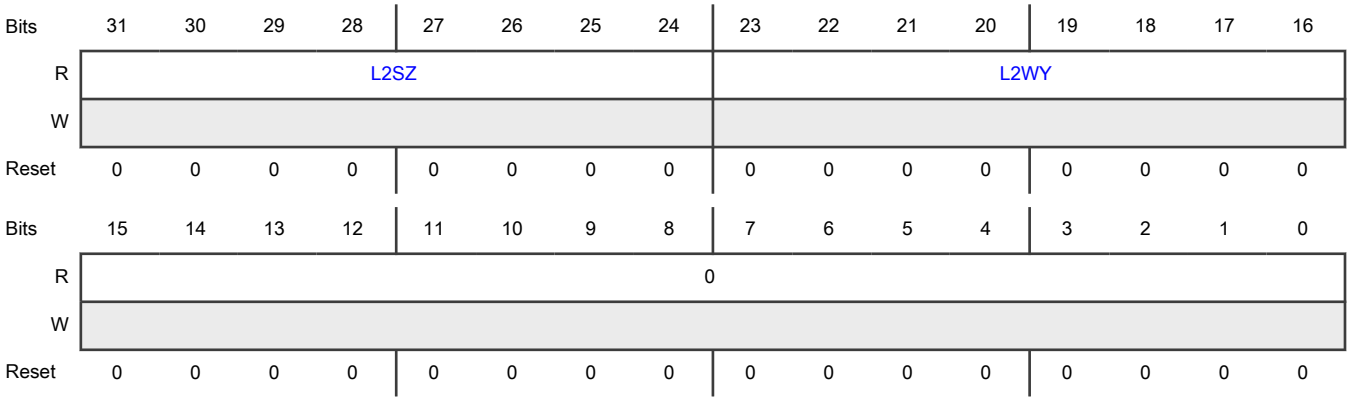
Function

Defines the configuration information for processor 0 (CP0). It has the same field definitions and functionality as provided in Processor X Configuration 1 (CPXCFG1).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 L2SZ	L2 Cache Size Provides an encoded value of the L2 cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, L2SZ is a nonzero value, and L2SZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, L2SZ = 0h (not present).
23-16 L2WY	L2 Cache Ways Provides the number of cache ways for the L2 cache. For the Cortex-M7 cores in this chip, L2WY = 0h (not present).
15-0 —	Reserved

8.6.3.13 Processor 0 Configuration 2 (CP0CFG2)

Offset

Register	Offset
CP0CFG2	34h

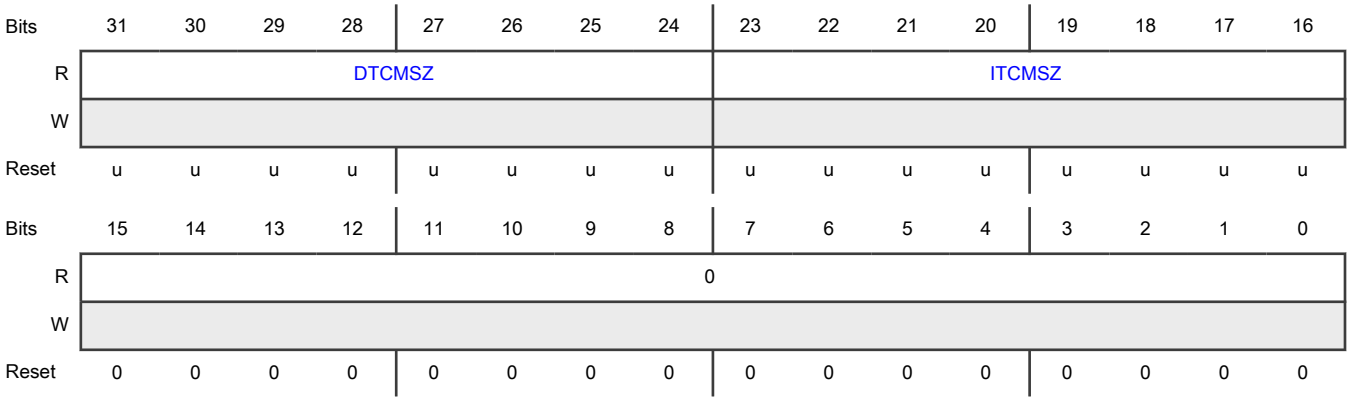
Function

Defines the configuration information for processor 0 (CP0). It has the same field definitions and functionality as provided in Processor X Configuration 2 (CPXCFG2).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 DTCMSZ	Tightly Coupled Data Memory Size Provides an encoded value of the tightly coupled local data memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, TMLSZ is a nonzero value, and TMLSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip: • DTCMSZ = 8h in Decoupled mode (64 KB) • DTCMSZ = 9h in Lockstep mode (128 KB)
23-16 ITCMSZ	Instruction Tightly Coupled Memory Size Provides an encoded value of the tightly coupled local instruction memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, TMUSZ is a nonzero value, and TMUSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip: • ITCMSZ = 7h in Decoupled mode (32 KB) • ITCMSZ = 8h in Lockstep mode (64 KB)
15-0 —	Reserved

8.6.3.14 Processor 1 Type (CP1TYPE)

Offset

Register	Offset
CP1TYPE	40h

Function

Defines the configuration information for processor 1 (CP1). It has the same field definitions and functionality as provided in Processor X Type (CPXTYPE).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PERSONALITY															
W																
Reset	0	1	0	0	0	0	1	1	0	1	0	0	1	1	0	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PERSONALITY															
W																
Reset	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1

Fields

Field	Function
31-0 PERSONALITY	Personality Processor Defines the processor personality for CP1. CP1 = Cortex-M7 core 1 and processor personality = 43_4D_37_31h.

8.6.3.15 Processor 1 Number (CP1NUM)

Offset

Register	Offset
CP1NUM	44h

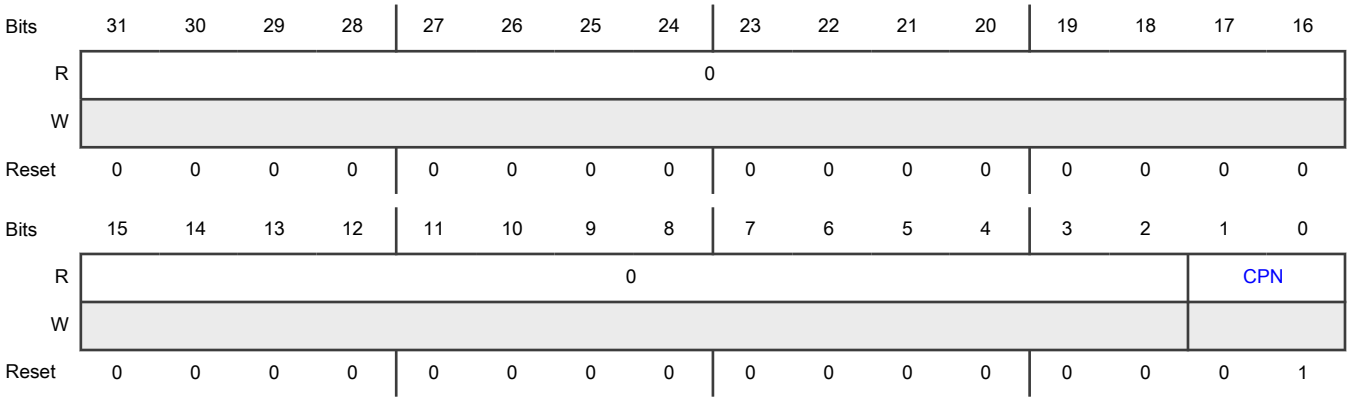
Function

Defines the configuration information for processor 1 (CP1). It has the same field definitions and functionality as provided in Processor X Number (CPXNUM).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-2 —	Reserved
1-0 CPN	Processor Number Defines the logical processor number for CP1. For the Cortex-M7 core 1 processor, the processor number = 1.

8.6.3.16 Processor 1 Count (CP1REV)

Offset

Register	Offset
CP1REV	48h

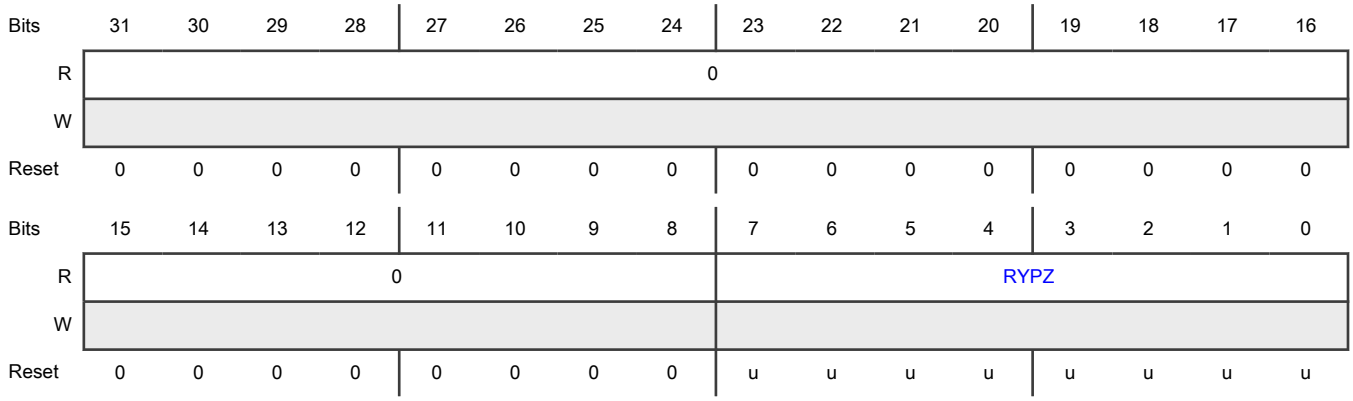
Function

Defines the configuration information for processor 1 (CP1). It has the same field definitions and functionality as provided in Processor X Revision (CPXREV).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 RYPZ	Processor Revision Defines the processor revision for CP1. For the Cortex-M7 processor, RYPZ = 12h corresponding to the r1p2 core release.

8.6.3.17 Processor 1 Configuration 0 (CP1CFG0)

Offset

Register	Offset
CP1CFG0	4Ch

Function

Defines the configuration information for processor 1 (CP1). It has the same field definitions and functionality as provided in Processor X Configuration 0 (CPXCFG0).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ICSZ								ICWY							
W																
Reset	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCSZ								DCWY							
W																
Reset	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0

Fields

Field	Function
31-24 ICSZ	Level 1 Instruction Cache Size Provides an encoded value of the instruction cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, ICSZ is a nonzero value, and ICSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
23-16 ICWY	Level 1 Instruction Cache Ways Provides the number of cache ways for the instruction cache. For the Cortex-M7 cores in this chip, ICWY = 2h (2-way set-associative).
15-8 DCSZ	L1 Data Cache Size Provides an encoded value of the data cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, DCSZ is a nonzero value, and DCSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
7-0 DCWY	L1 Data Cache Ways Provides the number of cache ways for the data cache. For the Cortex-M7 cores in this chip, DCWY = 4h (4-way set-associative).

8.6.3.18 Processor 1 Configuration 1 (CP1CFG1)

Offset

Register	Offset
CP1CFG1	50h

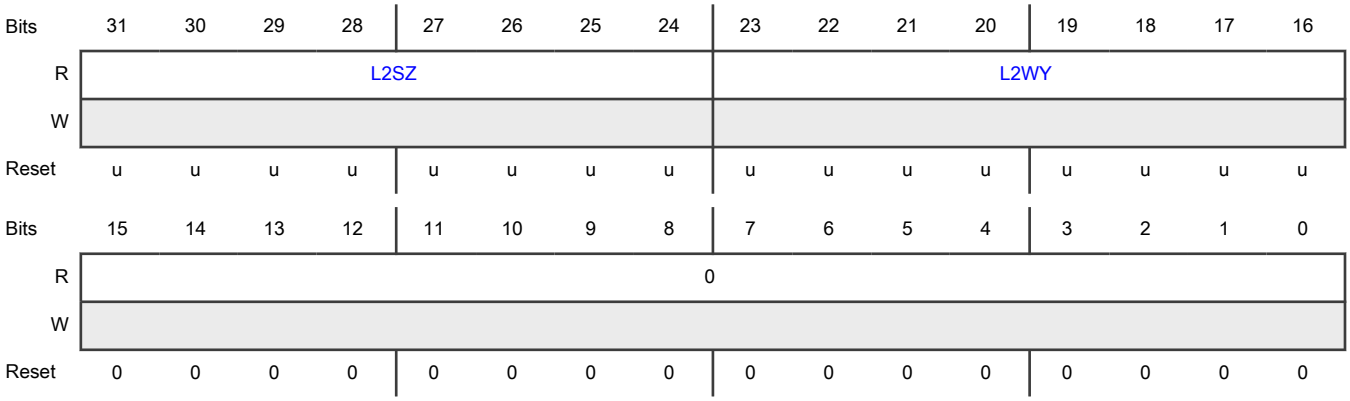
Function

Defines the configuration information for processor 1 (CP1). It has the same field definitions and functionality as provided in Processor X Configuration 1 (CPXCFG1).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 L2SZ	L2 Cache Size Provides an encoded value of the L2 cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, L2SZ is a nonzero value, and L2SZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, L2SZ = 0h (not present).
23-16 L2WY	L2 Cache Ways Provides the number of cache ways for the L2 cache. For the Cortex-M7 cores in this chip, L2WY = 0h (not present).
15-0 —	Reserved

8.6.3.19 Processor 1 Configuration 2 (CP1CFG2)

Offset

Register	Offset
CP1CFG2	54h

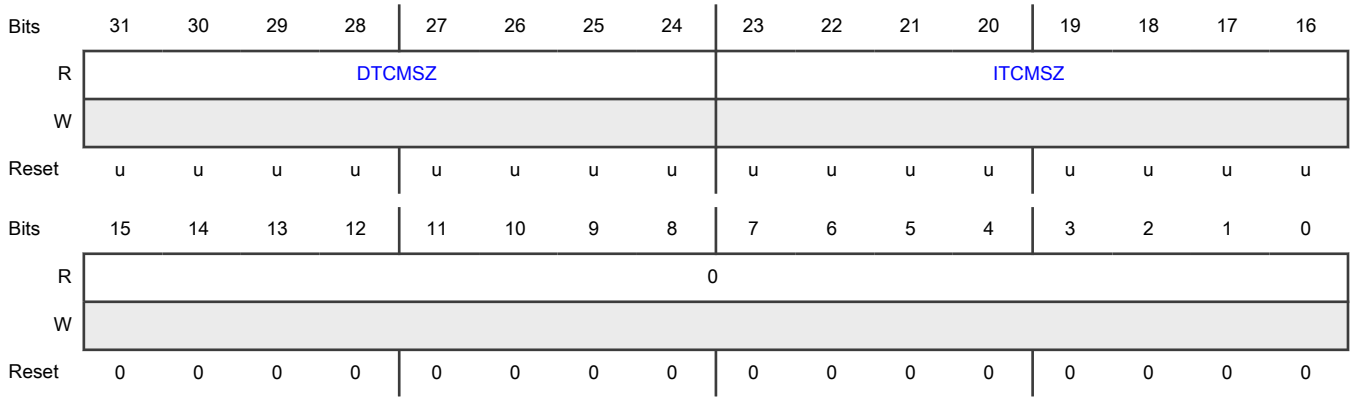
Function

Defines the configuration information for processor 1 (CP1). It has the same field definitions and functionality as provided in Processor X Configuration 2 (CPXCFG2).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 DTCMSZ	Tightly Coupled Data Memory Size Provides an encoded value of the tightly coupled local data memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, TMLSZ is a nonzero value, and TMLSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, DTCMSZ = 8h in Decoupled mode (64 KB), and this value is not applicable in Lockstep mode.
23-16 ITCMSZ	Instruction Tightly Coupled Memory Size Provides an encoded value of the tightly coupled local instruction memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, TMUSZ is a nonzero value, and TMUSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, ITCMSZ = 7h in Decoupled mode (32 KB); this value is not applicable in Lockstep mode.
15-0 —	Reserved

8.6.3.20 Processor 1 Configuration 3 (CP1CFG3)

Offset

Register	Offset
CP1CFG3	58h

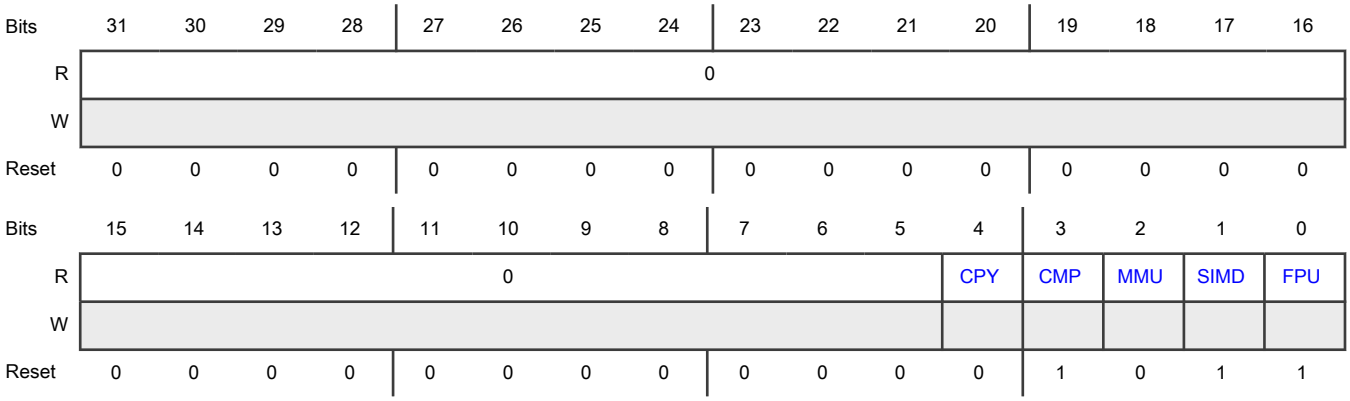
Function

Defines the configuration information for processor 1 (CP1). It has the same field definitions and functionality as provided in the CPXCFG3 register.

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-5 —	Reserved
4 CPY	Cryptography Indicates whether cryptography extensions are supported in the core. For the Cortex-M7 cores in this chip, CPY = 0h. 0b - Not supported 1b - Supported
3 CMP	Core Memory Protection Unit Indicates whether the core memory protection hardware is included in this core. For the Cortex-M7 cores in this chip, CMP = 1h.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not included 1b - Included
2 MMU	Memory Management Unit Indicates whether virtual management capabilities are supported in this core. For the Cortex-M7 cores in this chip, MMU = 0h. 0b - Not supported 1b - Supported
1 SIMD	SIMD/NEON Instruction Support Indicates whether the instruction set extensions supporting SIMD and/or NEON capabilities are included in the processor. For the Cortex-M7 cores in this chip, SIMD = 1h. 0b - Not included 1b - Included
0 FPU	Floating Point Unit Indicates whether the processor includes hardware support for floating point capabilities. For the Cortex-M7 cores in this chip, FPU = 1h. 0b - Not included 1b - Included

8.6.3.21 Processor 2 Type (CP2TYPE)

Offset

Register	Offset
CP2TYPE	60h

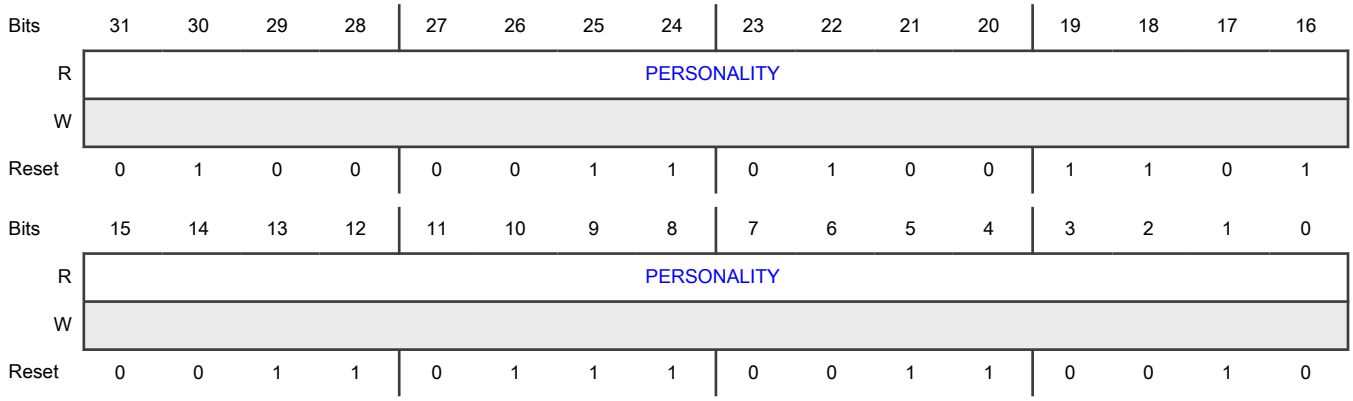
Function

Defines the configuration information for processor 2 (CP2). It has the same field definitions and functionality as provided in Processor X Type (CPXTYPE).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-0 PERSONALITY	Processor Personality Defines the processor personality for CP2. CP2 = Cortex-M7 core 2 and processor personality = 43_4D_37_32h.

8.6.3.22 Processor 2 Number (CP2NUM)

Offset

Register	Offset
CP2NUM	64h

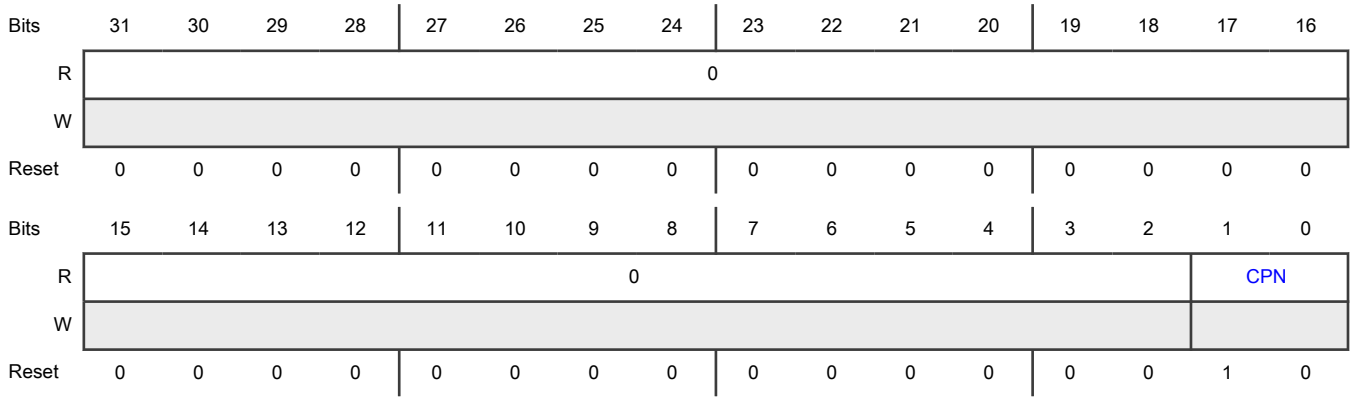
Function

Defines the configuration information for processor 2 (CP2). It has the same field definitions and functionality as provided in Processor X Number (CPXNUM).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-2 —	Reserved
1-0 CPN	Processor Number Defines the logical processor number for CP2. For Cortex-M7 core 2, processor number = 2.

8.6.3.23 Processor 2 Count (CP2REV)

Offset

Register	Offset
CP2REV	68h

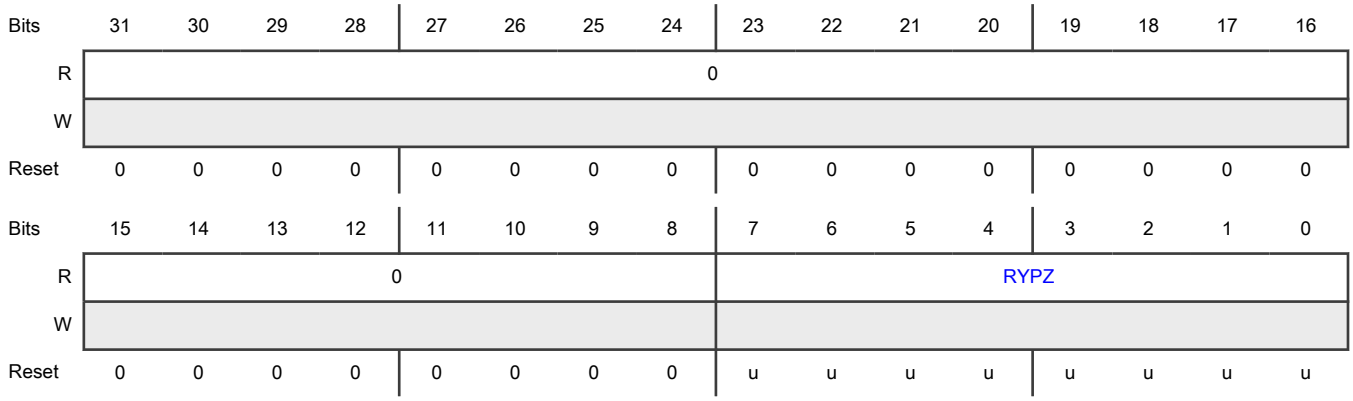
Function

Defines the configuration information for processor 2 (CP2). It has the same field definitions and functionality as provided in Processor X Revision (CPXREV).

A read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 RYPZ	Processor Revision Defines the processor revision for CP2. For the Cortex-M7 processor, RYPZ = 12h corresponding to the r1p2 core release.

8.6.3.24 Processor 2 Configuration 0 (CP2CFG0)

Offset

Register	Offset
CP2CFG0	6Ch

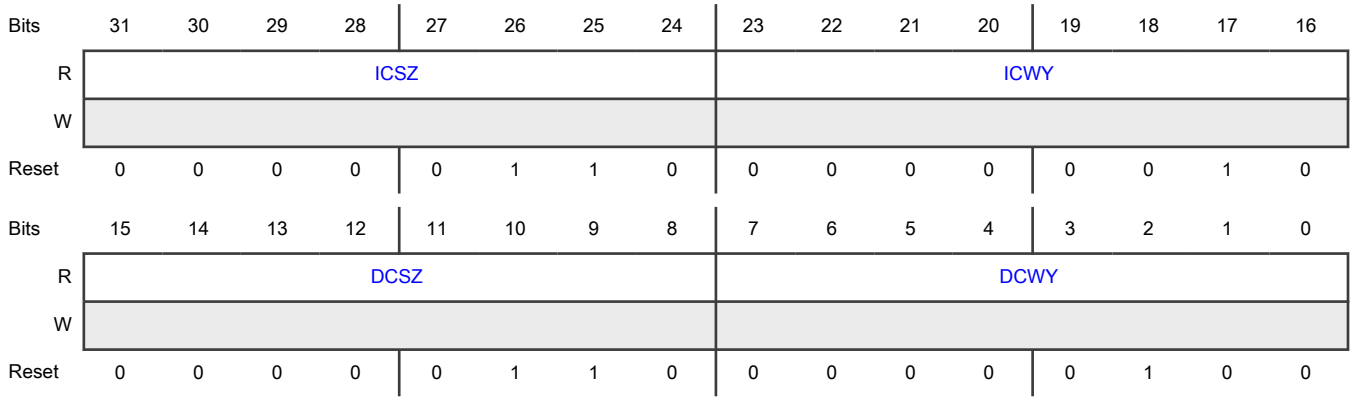
Function

Defines the configuration information for processor 2 (CP2). It has the same field definitions and functionality as provided in Processor X Configuration 0 (CPXCFG0).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 ICSZ	Level 1 Instruction Cache Size Provides an encoded value of the instruction cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, ICSZ is a nonzero value, and ICSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
23-16 ICWY	Level 1 Instruction Cache Ways Provides the number of cache ways for the instruction cache. For the Cortex-M7 cores in this chip, ICWY = 2h (2-way set-associative).
15-8 DCSZ	L1 Data Cache Size Provides an encoded value of the data cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, DCSZ is a nonzero value, and DCSZ = 0 indicates that the memory is not present. For information about cache sizes, see the "Miscellaneous Control Module (MCM)" chapter.
7-0 DCWY	L1 Data Cache Ways Provides the number of cache ways for the data cache. For the Cortex-M7 cores in this chip, DCWY = 4h (4-way set-associative).

8.6.3.25 Processor 2 Configuration 1 (CP2CFG1)

Offset

Register	Offset
CP2CFG1	70h

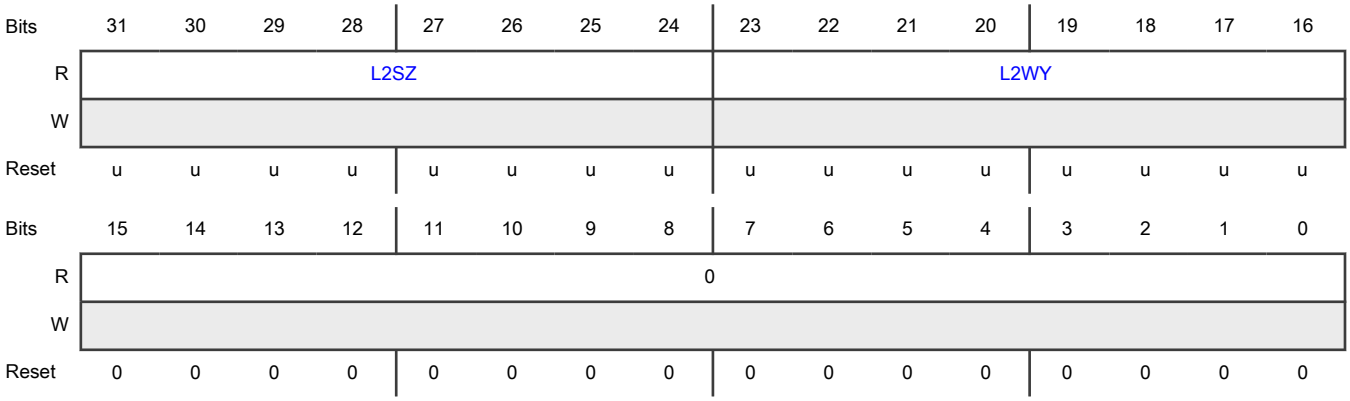
Function

Defines the configuration information for processor 2 (CP2). It has the same field definitions and functionality as provided in Processor X Configuration 1 (CPXCFG1).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 L2SZ	L2 Cache Size Provides an encoded value of the L2 cache size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, L2SZ is a nonzero value, and L2SZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, L2SZ = 0h (not present).
23-16 L2WY	L2 Cache Ways Provides the number of cache ways for the L2 cache. For the Cortex-M7 cores in this chip, L2WY = 0h (not present).
15-0 —	Reserved

8.6.3.26 Processor 2 Configuration 2 (CP2CFG2)

Offset

Register	Offset
CP2CFG2	74h

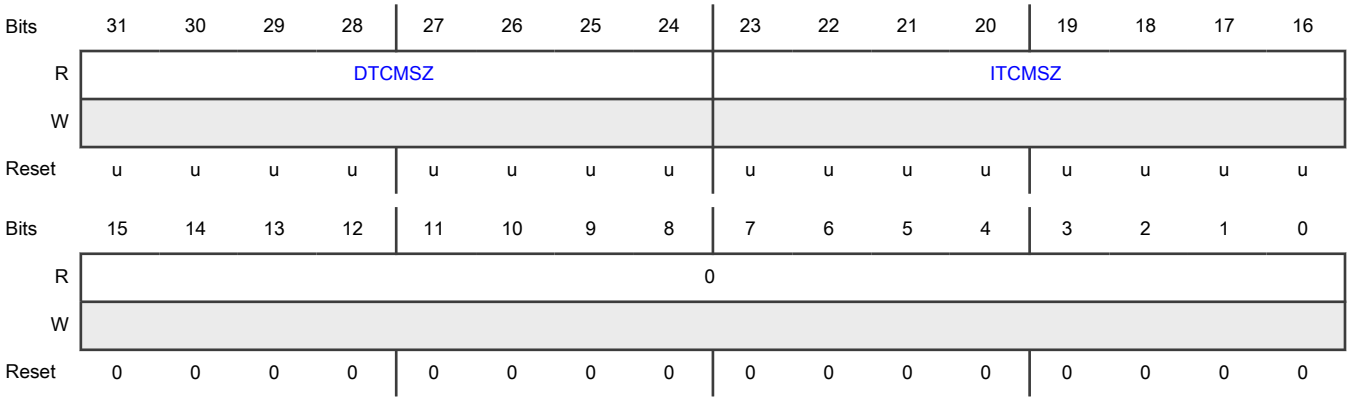
Function

Defines the configuration information for processor 2 (CP2). It has the same field definitions and functionality as provided in Processor X Configuration 2 (CPXCFG2).

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-24 DTCMSZ	Tightly Coupled Data Memory Size Provides an encoded value of the tightly coupled local data memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, TMLSZ is a nonzero value, and TMLSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, DTCMSZ = 8h in Decoupled mode (64 KB), and this value is not applicable in Lockstep mode.
23-16 ITCMSZ	Instruction Tightly Coupled Memory Size Provides an encoded value of the tightly coupled local instruction memory size. The capacity of the memory is derived using the formula $2^{(8+SZ)}$ and expressed as bytes. Here, TMUSZ is a nonzero value, and TMUSZ = 0 indicates that the memory is not present. For the Cortex-M7 cores in this chip, ITCMSZ = 7h in Decoupled mode (32 KB); this value is not applicable in Lockstep mode.
15-0 —	Reserved

8.6.3.27 Processor 2 Configuration 3 (CP2CFG3)

Offset

Register	Offset
CP2CFG3	78h

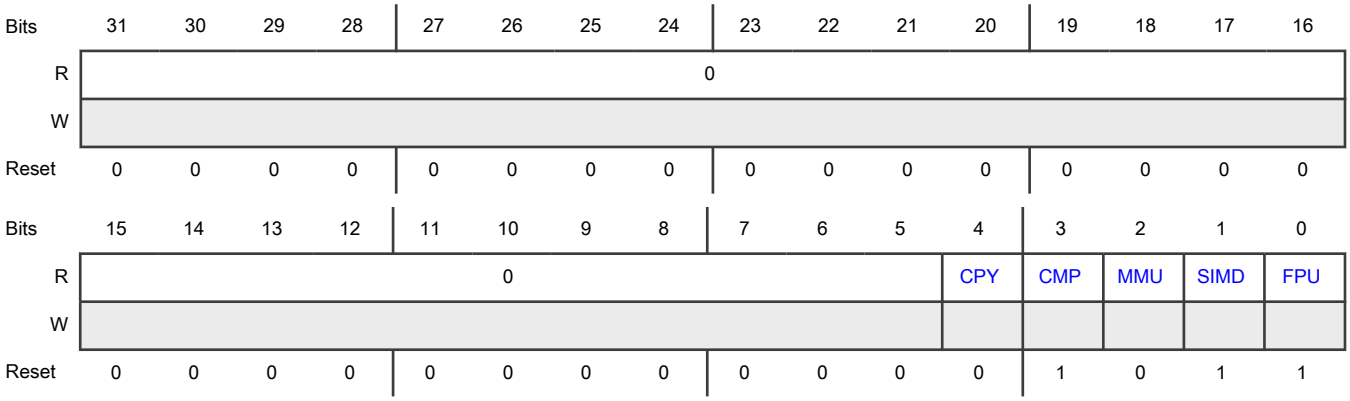
Function

Defines the configuration information for processor 2 (CP2). It has the same field definitions and functionality as provided in the CPXCFG3 register.

A privileged read from any bus controller returns the appropriate processor information and attempted write accesses terminate with an error.

Access: User or privileged read-only

Diagram



Fields

Field	Function
31-5 —	Reserved
4 CPY	Cryptography Indicates whether cryptography extensions are supported in the core. For the Cortex-M7 cores in this chip, CPY = 0h. 0b - Not supported 1b - Supported
3 CMP	Core Memory Protection Unit Indicates whether the core memory protection hardware is included in this core. For the Cortex-M7 cores in this chip, CMP = 1h.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not included 1b - Included
2 MMU	Memory Management Unit Indicates whether virtual management capabilities are supported in this core. For the Cortex-M7 cores in this chip, MMU = 0h. 0b - Not supported 1b - Supported
1 SIMD	SIMD/NEON Instruction Support Indicates whether the instruction set extensions supporting SIMD and/or NEON capabilities are included in the processor. For the Cortex-M7 cores in this chip, SIMD = 1h. 0b - Not included 1b - Included
0 FPU	Floating Point Unit Indicates whether the processor includes hardware support for floating point capabilities. For the Cortex-M7 cores in this chip, FPU = 1h. 0b - Not included 1b - Included

8.6.3.28 Interrupt Router CPn Interrupt Status (IRCP0ISR0 - IRCP2ISR3)

Offset

For n = 0 to 2; m = 0 to 3:

Register	Offset
IRCPnISRm	200h + (n × 20h) + (m × 8h)

Function

Provides an interrupt bit map, where each bit defines the state of a unique MSI based on the initiating core. An MSI interrupt clears in an interrupt service routine by writing 1 to the appropriate field in IRCP*n*ISR*m*.

In this discussion, CP*m* represents the initiating core and CP*n* represents the target core for a core-to-core interrupt. For more information on interrupt source mapping, see the interrupt map file attached to this document.

For read access:

- Reads to IRCP*n*ISR*m* are only accessible in Privileged mode using 32-bit (word) accesses.
- Privileged 32-bit read accesses from noncore (and nondebugger) bus controllers are treated as RAZ.

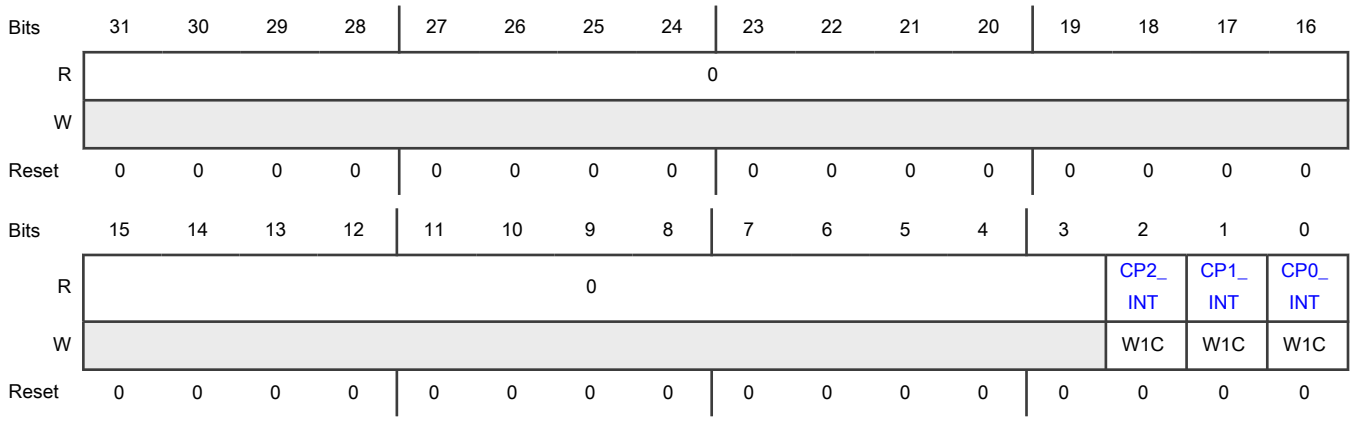
- Attempted accesses in User mode or the ones using a size other than 32 bits are not permitted. They terminate with an error.
- When CP*n* requests to read IRCP*n*ISR*m*, MSCM returns the entire content of IRCP*n*ISR*m*.
- When a trusted core, as the IRCPCFG register indicates, requests to read IRCP*n*ISR*m*, MSCM returns the entire content of IRCP*n*ISR*m*.
- When the debugger requests to read IRCP*n*ISR*m*, MSCM returns the entire content of IRCP*n*ISR*m*.
- When CP*m* requests to read IRCP*n*ISR*m*, MSCM returns the value of the corresponding status, CP*m*_INT, while not exposing all the other pending interrupts that the cores initiated.
- When CP*m* requests to read IRCP*n*ISR*m*, MSCM returns the value of the corresponding status, CP*m*_INT, in bit position 0, reflecting how CP*m* set the MSI when it wrote to IRCP*n*IGR*m*. All the other fields on the returned read value are zero-filled.

For write access:

- Writes to IRCP*n*ISR*m* are only accessible in Privileged mode using 32-bit (word) accesses.
- Attempted accesses in User mode or the ones using a size other than 32 bits are not permitted. They terminate with an error.
- Writes to IRCP*n*ISR*m* follow the Write 1 to Clear (W1C) protocol, whereby writing 1 causes the corresponding field to become 0, and writing 0 is ignored.
- The target core, CP*n*, has full access to write to all the fields of IRCP*n*ISR*m*.
- A trusted core, as the IRCPCFG register indicates, has full access to write to all the fields of IRCP*n*ISR*m*.
- When CP*m* is different from CP*n*, the W1C action by CP*m* only clears IRCP*n*ISR*m*[CP*m*_INT].
- The CP*m* field must present W1C in bit position 0 to clear its corresponding interrupt. Write data bits 1-31 that CP*m* presents are ignored.
- Privileged write accesses from the noncore (and nondebugger) bus controllers are treated as Writes Ignored (WI).
- Privileged write accesses from the debugger are treated as WI.

Access: Privileged mode only

Diagram



Fields

Field	Function
31-3	Reserved

Table continues on the next page...

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Field	Function
—	
2 CP2_INT	CP2-to-CPn Interrupt Generates a directed interrupt initiated by core 2 targeting core *n*, if the appropriate interrupt routing bit is enabled. The interrupt is negated when the target core, a trusted core, or core 2 writes 1 to clear the field. 0b - No interrupt is asserted to CPn 1b - Interrupt to CPn is asserted
1 CP1_INT	CP1-to-CPn Interrupt Generates a directed interrupt initiated by core 1 targeting core *n*, if the appropriate interrupt routing bit is enabled. The interrupt is negated when the target core, a trusted core, or core 1 writes 1 to clear the field. 0b - No interrupt is asserted to CPn 1b - Interrupt to CPn is asserted
0 CP0_INT	CP0-to-CPn Interrupt Generates a directed interrupt initiated by core 0 targeting core *n*, if the appropriate interrupt routing bit is enabled. The interrupt is negated when the target core, a trusted core, or core 0 writes 1 to clear the field. 0b - No interrupt asserted to CPn 1b - Interrupt to CPn asserted

8.6.3.29 Interrupt Router CPn Interrupt Generation (IRCP0IGR0 - IRCP2IGR3)

Offset

For n = 0 to 2; m = 0 to 3:

Register	Offset
IRCPnIGRm	204h + (n × 20h) + (m × 8h)

Function

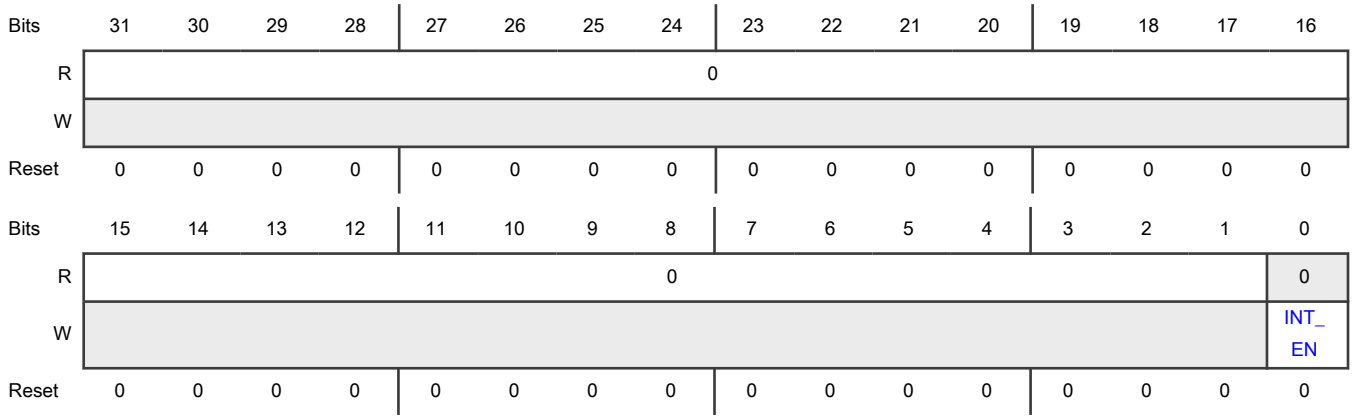
Provides a mechanism for cores to initiate an MSI to another core in the system.

Privileged, 32-bit accesses from the:

- Cortex-M7 cores are treated as RAZ/W.
- Debugger are treated as RAZ/WI.
- Noncore (and nondebugger) bus controllers are treated as RAZ/WI.

Access: Privileged mode only. Attempted accesses in User mode or the ones using a size other than 32 bits are not permitted and terminate with an error.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 INT_EN	Interrupt Enable Initiates a core-to-core interrupt targeting CP*n*, if CP*m* writes to this field. See MSI routing.

8.6.3.30 Interrupt Router Configuration (IRCPCFG)

Offset

Register	Offset
IRCPCFG	400h

Function

Provides a mechanism to designate specific cores in the system as trusted. These trusted cores are allowed to access and manage outstanding MSIs.

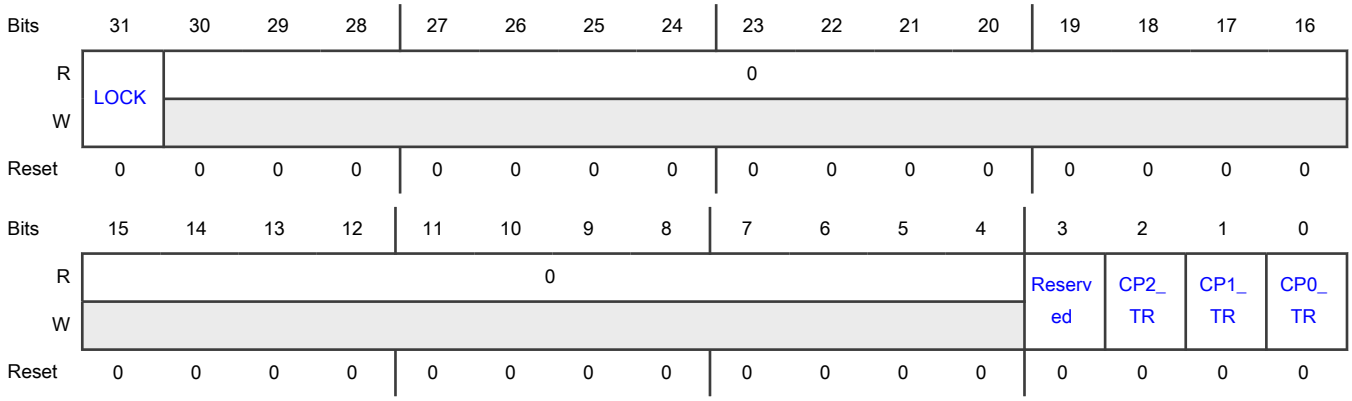
Privileged, 32-bit accesses from the:

- Cortex-M7 cores are treated as R/W.
- Debugger are treated as R/WI.
- Noncore (and nondebugger) bus controllers are treated as RAZ/WI.

Attempted accesses in User mode or the ones using a size other than 32 bits are not permitted. They terminate with an error.

Access: Privileged mode only

Diagram



Fields

Field	Function
31 LOCK	Lock Provides a locking mechanism that can be used to limit the ability to write to the register. After you write 1 to this field, it remains 1 until the next reset. 0b - Register can be written by any privileged write 1b - Register is locked (read-only) until the next reset
30-4 —	Reserved
3 —	Reserved
2 CP2_TR	CP2 as Trusted Core Indicates whether CP2 is a trusted core with access to read the full contents of IRCP*n*ISR*m*. 0b - Not trusted 1b - Trusted
1 CP1_TR	CP1 as Trusted Core Indicates whether CP1 is a trusted core with access to read the full contents of IRCP*n*ISR*m*. 0b - Not trusted 1b - Trusted
0 CP0_TR	CP0 as Trusted Core Indicates whether CP0 is a trusted core with access to read the full contents of IRCP*n*ISR*m*. 0b - Not trusted 1b - Trusted

8.6.3.31 Memory Execution Control (XN_CTRL)

Offset

Register	Offset
XN_CTRL	500h

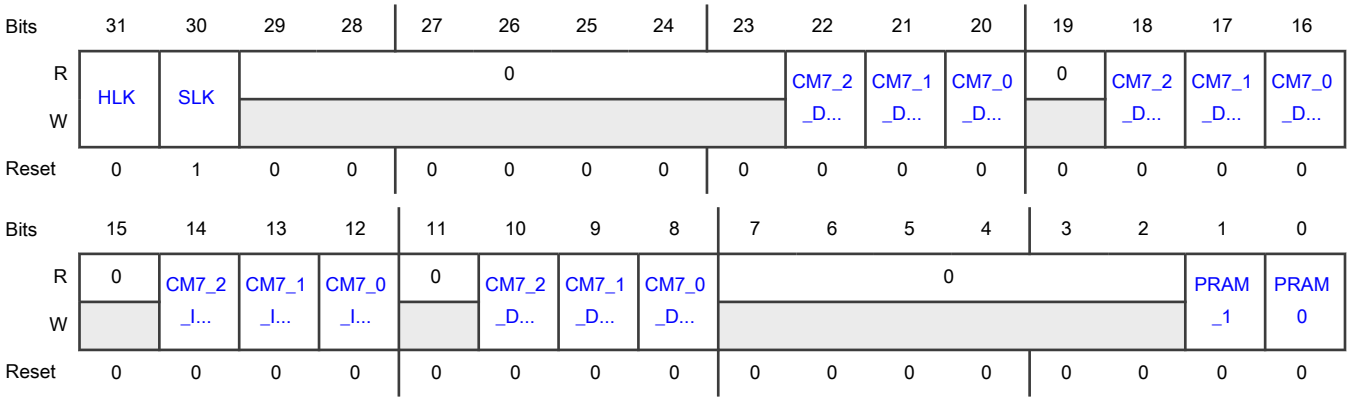
Function

Controls whether an instruction fetch, also known as a code fetch or executable fetch, is allowed for SRAM and TCM.

NOTE

This register does not inhibit HSE_B instruction accesses.

Diagram



Fields

Field	Function
31 HLK	Hard Lock Enables hard lock. This field locks the register to disable writes until the next hardware reset. 0b - Disable 1b - Enable
30 SLK	Soft Lock Enables soft lock. This field locks the register to disable writes until this field becomes 0. 0b - Disable 1b - Enable
29-23	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
22 CM7_2_DTCM	Transaction Control For Cortex-M7_2 DTCM Does not select Cortex-M7_2 as target. All code fetch or executable fetch transactions to Cortex-M7_2 DTCM are not generated because Cortex-M7_2 DTCM is not selected (backdoor access). 0b - Transaction enabled 1b - Transaction disabled
21 CM7_1_DTCM	Transaction Control For Cortex-M7_1 DTCM Does not select Cortex-M7_1 as target. All code fetch or executable fetch transactions to Cortex-M7_1 DTCM are not generated because Cortex-M7_1 DTCM is not selected (backdoor access). 0b - Transaction enabled 1b - Transaction disabled
20 CM7_0_DTCM	Transaction Control For Cortex-M7_0 DTCM Specifies the transaction status. This field does not select Cortex-M7_0 as target. All code fetch or executable fetch transactions to Cortex-M7_0 DTCM are not generated because Cortex-M7_0 DTCM is not selected (backdoor access). 0b - Transaction enabled 1b - Transaction disabled
19 —	Reserved
18 CM7_2_DIS_D0_D1TCM_EXEC	Disable D0 and D1 TCM Execution For Cortex-M7_2 Disables D0 and D1 TCM execution for Cortex-M7_2. It is provided to the core. If execution is disabled, it is taken as illegal access by the core. 0b - Enable 1b - Disable
17 CM7_1_DIS_D0_D1TCM_EXEC	D0 and D1 TCM Execution For Cortex-M7_1 Disables D0 and D1 TCM execution for Cortex-M7_1. It is provided to the core. If execution is disabled, it is taken as illegal access by the core. 0b - Enable 1b - Disable
16 CM7_0_DIS_D0_D1TCM_EXEC	D0 And D1 TCM Execution For Cortex-M7_0 Disables D0 and D1 TCM execution for Cortex-M7_0. It is provided to the core. If execution is disabled, it is taken as illegal access by the core. 0b - Enable

Table continues on the next page...

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Field	Function
	1b - Disable
15 —	Reserved
14 CM7_2_ITCM	Transaction Control For Cortex-M7_2 ITCM Does not select Cortex-M7_2 ITCM as target. All code fetch or executable fetch transactions to Cortex-M7_2 ITCM are not generated because Cortex-M7_2 ITCM is not selected (backdoor access). 0b - Execution enabled 1b - Execution disabled
13 CM7_1_ITCM	Transaction Control For Cortex-M7_1 ITCM Does not select Cortex-M7_1 ITCM as target. All code fetch or executable fetch transactions to Cortex-M7_1 ITCM are not generated because Cortex-M7_1 ITCM is not selected (backdoor access). 0b - Execution enabled 1b - Execution disabled
12 CM7_0_ITCM	Transaction Control For Cortex-M7_0 ITCM Does not select Cortex-M7_0 ITCM as target. All code fetch or executable fetch transactions to Cortex-M7_0 ITCM are not generated because Cortex-M7_0 ITCM is not selected (backdoor access). 0b - Execution enabled 1b - Execution disabled
11 —	Reserved
10 CM7_2_DIS_ITCM_EXEC	ITCM Execution for Cortex-M7_2 Disables ITCM execution for Cortex-M7_2. It is provided to the core. If execution is disabled, it is considered an illegal access by the core. 0b - Enable 1b - Disable
9 CM7_1_DIS_ITCM_EXEC	ITCM Execution For Cortex-M7_1 Disables ITCM execution for Cortex-M7_1. It is provided to the core. If execution is disabled, it is considered an illegal access by the core. 0b - Enable 1b - Disable
8 CM7_0_DIS_ITCM_EXEC	ITCM Execution For Cortex-M7_0 Disables ITCM execution for Cortex-M7_0. It is provided to the core. If execution is disabled, it is considered an illegal access by the core.

Table continues on the next page...

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Field	Function
	0b - Enable 1b - Disable
7-2 —	Reserved
1 PRAM_1	Transaction Control For PRAM 1 Does not select PRAM1 as target. All code fetch or executable fetch transactions to PRAM1 are not generated because PRAM1 is not selected. 0b - Transaction enabled 1b - Transaction disabled
0 PRAM0	Transaction Control For PRAM 0 Does not select PRAM0 as target. All code fetch or executable fetch transactions to PRAM0 are not generated because PRAM0 is not selected. 0b - Transaction enabled 1b - Transaction disabled

8.6.3.32 Enable Interconnect Error Detection (ENEDC)

Offset

Register	Offset
ENEDC	600h

Function

Enables interconnect error detection.

For more information, see the FCCU file attached to this document.

Access: Privileged mode only

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		ADD_CM7...	CM7_1_T...	ADD_CM7...	CM7_0_T...	ADD_AIP...	AIPS2	ADD_AIP...	AIPS1	ADD_AIP...	AIPS0	ADD_QSPI	QSPI	ADD_TCM...	TCM_BAC...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ADD_PRA...	PRAM1	ADD_PRA...	PRAM0	ADD_PF2	ADD_PF1	ADD_PF0	TCM	CM7_1_A...	CM7_1_A...	ENET	HSE	0	EDMA	CM7_0_A...	CM7_0_A...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29 ADD_CM7_1_TCM	Address Check For Cortex-M7_1_TCM Enables address check for the Cortex-M7_1_TCM backdoor path. 0b - Disable 1b - Enable
28 CM7_1_TCM	Write Data Check For Cortex-M7_1_TCM Enables write data check for the Cortex-M7_1_TCM backdoor path. 0b - Disable 1b - Enable
27 ADD_CM7_0_TCM	Address Check For Cortex-M7_0_TCM Enables address check for the Cortex-M7_0_TCM backdoor path. 0b - Disable 1b - Enable
26 CM7_0_TCM	Write Data Check For Cortex-M7_0_TCM Enables write data check for the Cortex-M7_0_TCM backdoor path. 0b - Disable 1b - Enable
25 ADD_AIPS2	Address Check For AIPS2 Enables address check for the AIPS2 path. 0b - Disable 1b - Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
24 AIPS2	Write Data Check For AIPS2 Enables write data check for the AIPS2 path. 0b - Disable 1b - Enable
23 ADD_AIPS1	Address Check For AIPS1 Enables address check for the AIPS1 path. 0b - Disable 1b - Enable
22 AIPS1	Write Data Check For AIPS1 Enables write data check for the AIPS1 path. 0b - Disable 1b - Enable
21 ADD_AIPS0	Address Check For AIPS0 Enables address check for the AIPS0 path. 0b - Disable 1b - Enable
20 AIPS0	Write Data Check For AIPS0 Enables write data check for the AIPS0 path. 0b - Disable 1b - Enable
19 ADD_QSPI	Address Check For QuadSPI Enables address check for the QuadSPI path. 0b - Disable 1b - Enable
18 QSPI	Write Data Check For QuadSPI Enables write data check for the QuadSPI path. 0b - Disable 1b - Enable
17 ADD_TCM_BACKDOOR	Write Data Check For TCM Backdoor Enables the address check for the TCM backdoor path. 0b - Disable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Enable
16 TCM_BACKDOOR	Write Data Check For TCM Backdoor Enables write data check for the TCM backdoor path. 0b - Disable 1b - Enable
15 ADD_PRAM1	Address Check For PRAM1 Enables address check for the PRAM1 path. 0b - Disable 1b - Enable
14 PRAM1	Write Data Check For PRAM1 Enables write data check for the PRAM1 path. 0b - Disable 1b - Enable
13 ADD_PRAM0	Address Check For PRAM0 Enables address check for the PRAM0 path. 0b - Disable 1b - Enable
12 PRAM0	Write Data Check For PRAM0 Enables write data check for the PRAM0 path. 0b - Disable 1b - Enable
11 ADD_PF2	Enable Address Check For PF2 Enables address check for the PF2 path. 0b - Disable 1b - Enable
10 ADD_PF1	Address Check For PF1 Enables address check for the PF1 path. 0b - Disable 1b - Enable
9 ADD_PF0	Address Check For PF0 Enables address check for the PF0 path.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
8 TCM	Read Data Check For TCM Enables read data check for the TCM 32-bit path. 0b - Disable 1b - Enable
7 CM7_1_AHBP	Read Data Check For Cortex-M7_1_AHBP Enables read data check for the Cortex-M7_1_AHBP path. 0b - Disable 1b - Enable
6 CM7_1_AHBM	Read Data Check For Cortex-M7_1_AHBM Enables read data check for the Cortex-M7_1_AHBM path. 0b - Disable 1b - Enable
5 ENET	Read Data Check For ENET Enables read data check for the ENET path. 0b - Disable 1b - Enable
4 HSE	Read Data Check For HSE_B Enables read data check for the HSE_B path. 0b - Disable 1b - Enable
3 —	Reserved
2 EDMA	Read Data Check For eDMA Enables read data check for the eDMA path. 0b - Disable 1b - Enable
1 CM7_0_AHBP	Read Data Check For Cortex-M7_0_AHBP Enables read data check for the Cortex-M7_0_AHBP path.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
0 CM7_0_AHBM	Read Data Check For Cortex-M7_0_AHBM Enables read data check for the Cortex-M7_0_AHBM path. 0b - Disable 1b - Enable

8.6.3.33 Enable Interconnect Error Detection (ENEDC1)

Offset

Register	Offset
ENEDC1	604h

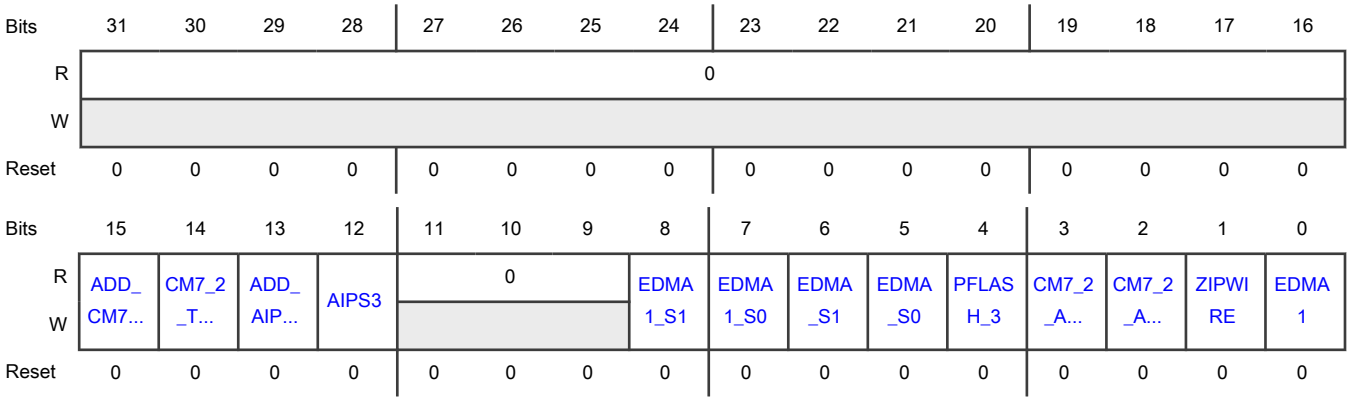
Function

Enables interconnect error detection.

For more information, see the FCCU file attached to this document.

Access: Privileged mode only

Diagram



Fields

Field	Function
31-16 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
15 ADD_CM7_2_TCM	Enable Address Check Cortex-M7_2_TCM Enables the address data check for Cortex-M7_2_TCM backdoor path. 0b - Disable 1b - Enable
14 CM7_2_TCM	Enable Write Data Check Cortex-M7_2_TCM Enables the write data check for Cortex-M7_2_TCM backdoor path. 0b - Disable 1b - Enable
13 ADD_AIPS3	Enable Address Check AIPS3 Enables address data check for the AIPS3 path. 0b - Disable 1b - Enable
12 AIPS3	Enable Write Data Check AIPS3 Enables write data check for the AIPS3 path. 0b - Disable 1b - Enable
11-9 —	Reserved
8 EDMA1_S1	Enable Address Check eDMA1 S1 Enables the address check for the eDMA1 S1 path. 0b - Disable 1b - Enable
7 EDMA1_S0	Enable Address Check eDMA1 S0 Enables the address check for the eDMA1 S0 path. 0b - Disable 1b - Enable
6 EDMA_S1	Enable Address Check eDMA S1 Enables the address check for the eDMA S1 path. 0b - Disable 1b - Enable
5	Enable Address Check eDMA S0

Table continues on the next page...

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Field	Function
EDMA_S0	Enables address check for the eDMA S0 path. 0b - Disable 1b - Enable
4 PFLASH_3	Enable Address Check PFlash3 Enables address check for the PFlash3 path. 0b - Disable 1b - Enable
3 CM7_2_AHBP	Enable Read Data Check Cortex-M7_2_AHBP Enables read data check for the Cortex-M7_2_AHBP path. 0b - Disable 1b - Enable
2 CM7_2_AHBM	Enable Read Data Check Cortex-M7_2_AHBM Enables read data check for the Cortex-M7_2_AHBM path. 0b - Disable 1b - Enable
1 ZIPWIRE	Enable Read Data Check Zipwire Enables read data check for the Zipwire path. 0b - Disable 1b - Enable
0 EDMA1	Enable Read Data Check eDMA1 Enables read data check for the eDMA1 path. 0b - Disable 1b - Enable

8.6.3.34 Interrupt Router Shared Peripheral Routing Control (IRSPRC0 - IRSPRC239)

Offset

For n = 0 to 239:

Register	Offset
IRSPRCn	880h + (n × 2h)

Function

Provides an array of 16-bit registers, where each register defines the routing control for the corresponding interrupt request, starting from IRQ = 0 (first on-platform interrupt vector). See the interrupt map file attached to this document for details.

For this chip, each interrupt request can be either routed to a subset or to all the cores using the bit-mapped fields in IRSPRC*n*. If all the CP*x*E*n* fields are cleared, the interrupt request is disabled. Each routing control halfword can be locked by writing 1 to the LOCK field.

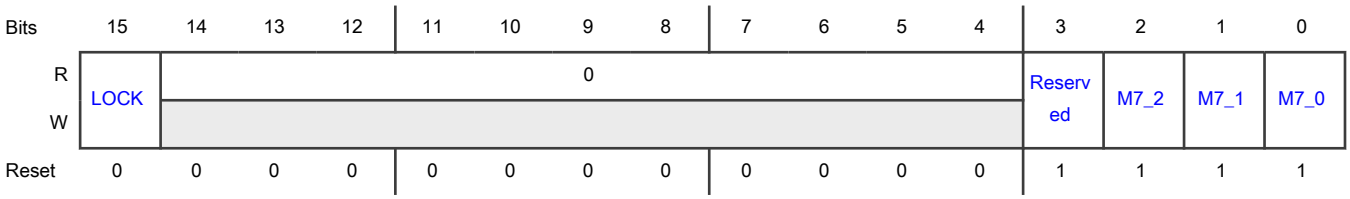
Privileged accesses from noncore (and nondebug) bus controllers are treated as RAZ/WI, and any attempted User mode reference terminates with an error. Attempted accesses using a size other than a 16-bit halfword also terminate with an error.

If you write 1 to all the CP*x*En bits, all the cores service the interrupt. You must ensure that no conflicts arise from this setup either via the interrupt handler or through programming core level interrupt routing (NVIC/GIC).

Reads and writes to this register beyond IRSPRC207 lead to unpredictable results.

Access: Privileged mode only

Diagram



Fields

Field	Function
15 LOCK	Lock Provides a mechanism to lock the routing of the corresponding interrupt request. After you write 1 to this field, attempted writes to IRSPRC*n* are ignored until the next reset writes 0 to the field. 0b - Writes to IRSPRCn allowed 1b - Writes to IRSPRCn ignored
14-4 —	Reserved
3 —	Reserved
2 M7_2	Enable Cortex-M7_2 Interrupt Steering Enables the corresponding interrupt request to route to Cortex-M7_2. 0b - Routing disabled 1b - Routing enabled
1 M7_1	Enable Cortex-M7_1 Interrupt Steering Enables the corresponding interrupt request to route to Cortex-M7_1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Routing disabled 1b - Routing enabled
0 M7_0	Enable Cortex-M7_0 Interrupt Steering Enables the corresponding interrupt request to route to Cortex-M7_0. 0b - Routing disabled 1b - Routing enabled

8.7 Glossary

GIC	Generic interrupt controller
IRQs	Interrupt requests
ISR	Interrupt service routine
MSI	Message signal interface
NVIC	Nested vector interrupt controller

Chapter 9
Virtualization Wrapper (VIRT_WRAPPER)

9.1 Chip-specific VIRT_WRAPPER information

9.1.1 System overview of PDAC scheme

This figure shows the interaction of XRDC (containing PDACs), related to different cores (domain IDs), with VIRT_WRAPPER.

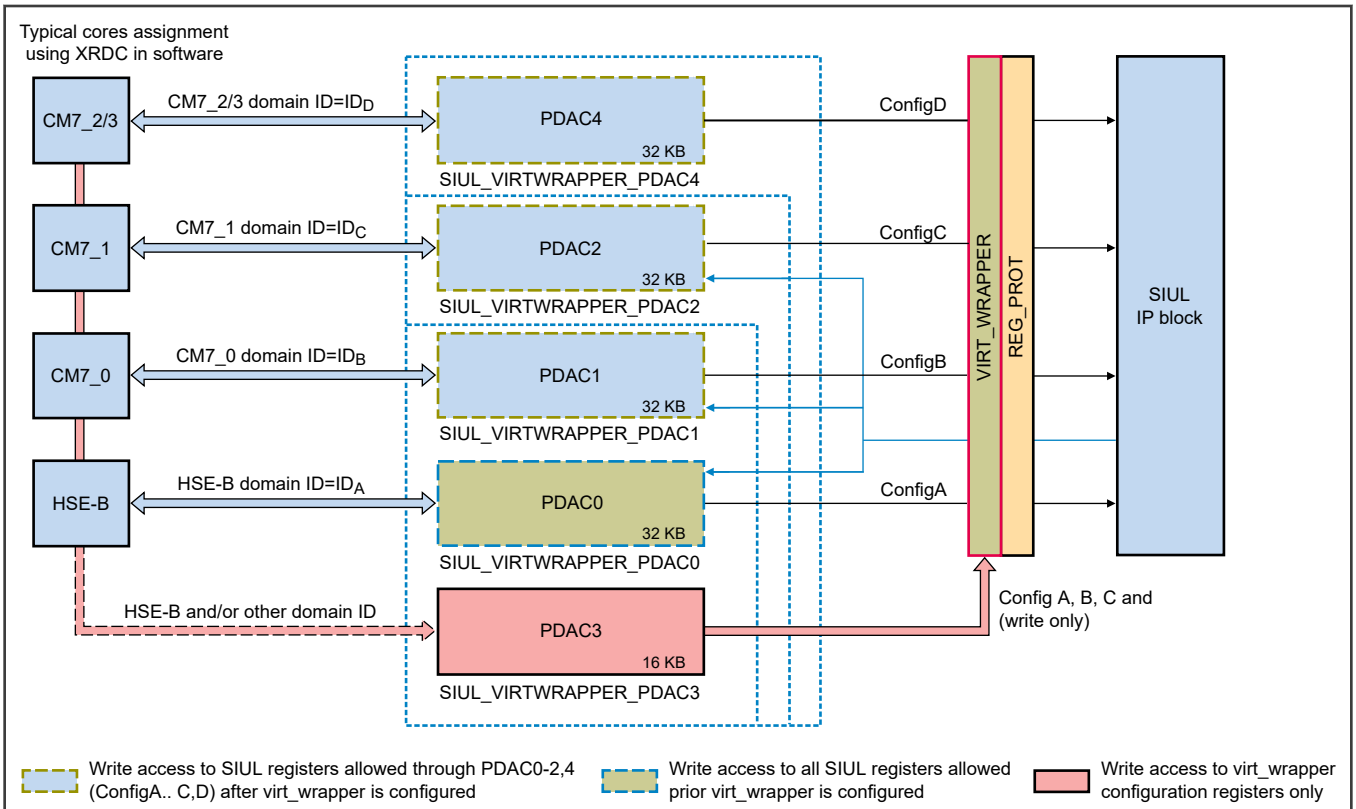


Figure 17. System overview of PDAC scheme

9.1.2 Initial VIRT_WRAPPER operation

Initially, VIRT_WRAPPER:

- Protects the "ConfigB-D" paths to SIUL2. You must configure VIRT_WRAPPER to define the SIUL2 R/W control registers that you can access through the "ConfigB-D" VIRT_WRAPPER access paths.
- Does not protect the direct path to SIUL2. It allows write accesses to all the SIUL2 R/W control registers. If PDAC0 is set to allow write access only to master core, for example HSE-B core (variant supported by the chip), then other masters cannot program the SIUL2 register. However, if these non-HSE_B masters program SIUL2 registers using other PDAC slots, a transfer error occurs. Any core can act as master core.

9.1.3 Additional VIRT_WRAPPER details

See the "SIUL2 memory map overview and protection" table, later in this chapter, for an overview of the SIUL2 registers and their protection attributes.

By default, any core can access SIUL2 registers through PDAC0. This process is called ANY_MASTER. However, after XRDC configuration, HSE_B:

- Assigns PDACs to the respective cores or domain IDs
- Locks the XRDC configuration
- Programs VIRT_WRAPPER registers for pad assignments

HSE_B accesses PDAC0 solely for the pads having 11b as the value in their corresponding registers. Also, HSE_B retains the same value for the pads that it stores. In case HSE_B needs to take control of some pins, it can still configure PDAC*n* to be accessible not only from a specific core master, but also from HSE_B, before it allows other cores to execute.

PDAC3 protects the IPS register portal of VIRT_WRAPPER configuration registers that any master can access but only via the memory slot assigned to PDAC3. The configuration via IPS register portal can be locked to prevent any further changes until the next functional reset. PDAC3 implements this locking.

The protection information of the parallel port output registers is inherited from the protection information of the included pads, according to these rules:

- When all the pads assigned to a GPIO port share the same protection information, the corresponding parallel port output register for this port inherits the same protection information.
- When at least one of the pads assigned to a GPIO port has different protection information than the other pads assigned to this GPIO port, access to the corresponding parallel port output register for this port is disabled for all the masters. Because of the aforementioned protection group mapping, the data bits of a register encode the protection control information related to one full GPIO port, or a chunk of 16 pads.
- You can assign the following SIUL2 registers to individual PDAC control:
  - DISR0
  - DIRER0
  - DIRSR0
  - IREER0
  - IFEER0
  - IFER0
  - IFMCR0–31
  - IFCPR

  Then, you can access all these registers only through the assigned PDAC because the VIRT_WRAPPER_REG_C1039_1024 register controls the SIUL2 interrupt registers.
- You cannot access the SIUL2 R/W control registers configured through PDAC3 to be accessible through the ConfigA VIRT_WRAPPER access path, using the ConfigB VIRT_WRAPPER access path.
- You cannot access any of the SIUL2 R/W control registers through ConfigB-D VIRT_WRAPPER access paths prior to VIRT_WRAPPER configuration. By default, any core can access SIUL2 registers through PDAC0 after reset.
- The same PDAC that accesses the main SIUL2 registers is used to access the SIUL2-mirrored registers and soft-lock-bit registers. This is because these registers are a part of the same 16 KB space.
- Access to mirrored SIUL2 registers sets the bit in Soft lock bit as an inherent property of register protection. See the "Register Protection" chapter for details on the soft lock bit behavior, when accessing the mirrored region.

9.2 Introduction

Virtualization refers to the various techniques, methods, or approaches of creating a virtual (rather than actual) version of something, such as a virtual hardware platform, operating system (OS), storage device, or network resources. The term "hardware virtualization" refers to the creation of a virtual machine that acts like a real computer with an operating system. The underlying hardware resources separate the software executed on these virtual machines (named "guest program"). In many cases, the specifically modified guest programs are required to run in such a virtual environment.

There are different types of hardware virtualization. One of them is para-virtualization. The para-virtualization is a non-simulated hardware environment. However, a guest program is executed in its own isolated domain, as if it is running on a separate system. Such a behavior is especially beneficial for the software targeted toward functional safety, because it allows freedom of interference for certain aspects of this software.

The hardware-assisted virtualization is a way of improving the efficiency of hardware virtualization. It involves employing specially designed CPUs and hardware components that help improve the performance of a guest environment. VIRT_WRAPPER, described in this chapter, is such a hardware component.

9.2.1 Overview

VIRT_WRAPPER is an extension of the Register Protection (REG_PROT) wrapper methodology. It works in parallel with an existing REG_PROT wrapper by virtualizing registers within the virtualized module. In this chip, SIUL2 is the virtualized module. Virtualized module is the module instance associated with VIRT_WRAPPER. Virtualization is implemented by protecting (for example, granting or inhibiting) the access to a register within the virtualized module, dependent on the specific criteria. It also virtualizes registers within REG_PROT when associated with registers within the virtualized module.

Registers within virtualized module or the REG_PROT wrapper are virtualized by granting, or inhibiting the access to different PDACs as encoded within virtualization pad assignments in VIRT_WRAPPER configuration registers. For this purpose, the virtualization information is programmed into VIRT_WRAPPER configuration registers that specify the grouping of registers within virtualized module. Upon an access to virtualized module through the peripheral interface, the grouping information is exercised to identify whether the corresponding transaction should be granted, or inhibited. A corresponding signal is forwarded to the REG_PROT wrapper that then grants, or inhibits the transaction. The following figure depicts the usage of VIRT_WRAPPER in combination with the REG_PROT wrapper and virtualized module.

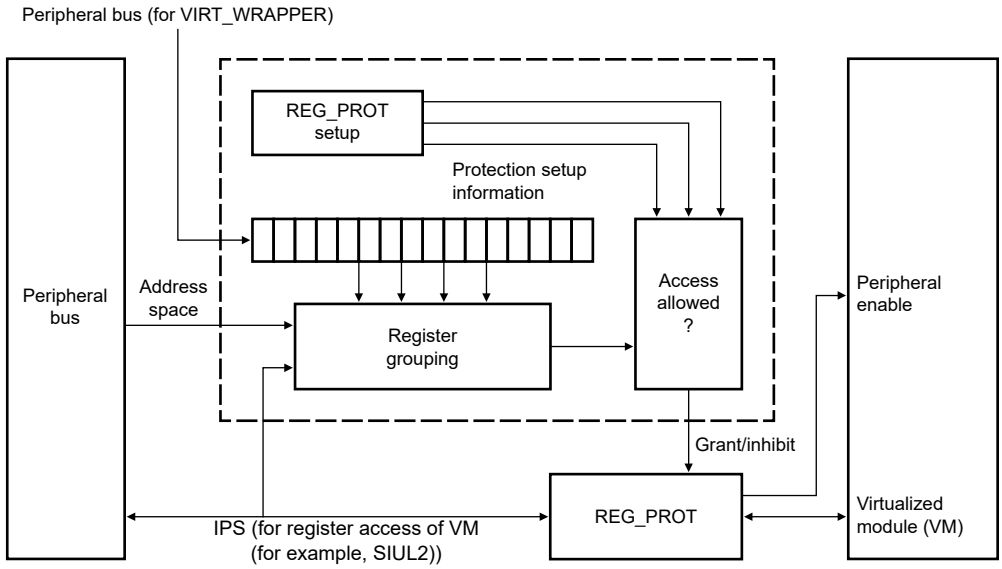


Figure 18. VIRT_WRAPPER block diagram

On a high level, VIRT_WRAPPER is an extension of the REG_PROT wrapper along those lines:

- There is a set of GPRs that receive data over peripheral bus of the VIRT_WRAPPER module. The output of these clients is a quasi-static bus providing the "Protection Control Information" to the remaining logic; this information is kept stable, that is programmed by PDAC4 after boot-up. PDAC4 should be accessed only by that master(s) that is accessing PDAC0. This is taken care by XRDC programming at the SoC.
- The remaining functionality added by VIRT_WRAPPER module consists of two sub-blocks:
  - A first sub-block (the "Grouping PLA") defines the grouping of the registers within the virtualized module. This sub-block is module specific and generated, since this information is specific for the virtualized module, It receives the address information from the peripheral bus and selects the corresponding data from the "Protection Control Information".

— A second sub-block (the "Protection" sub-block) encodes the previously selected "Protection Control Information" and combines it with the information about the received access request. The current protection methodology allows to inhibit only write accesses for a specific master or set of masters. For this purpose, this sub-block evaluates the received access information; especially the byte enables and the PDAC of the accessing master. The output of this sub-block is an internal signal "access granted" that is used to flag an access inhibited by the virtualization information.

9.2.2 Features

VIRT_WRAPPER includes these features:

- A programmable chip-specific virtualization setup, capable to select a subset of the available masters in combination with up to four available address spaces
- Virtualizing accesses to the registers within a VM by inhibiting accesses to a subset of these registers under control of the specified virtualization information. Only write accesses can be inhibited for a specific master or set of masters.
- Inhibiting accesses to registers within REG_PROT associated with VM; in cases, these registers are associated with a register in the VM to which the access is also inhibited. Additionally, accesses to the global control register (GCR) within REG_PROT can be protected separately.

9.2.3 Modes of operation

VIRT_WRAPPER is operable when the VM is operable. For details about the availability of the VM, see the chapter of the corresponding module. When there is no virtualization information specified for the VIRT_WRAPPER module, if XRDC is not configured, PDAC slot 0 is open as the default value of configuration register is 11b that is assigned with PDAC slot 0 and any master can access through it.

For more details, see "Chip specific VIRT_WRAPPER information".

9.3 Functional description

This section describes the following topics:

- PDAC-based protection scheme
- Register group mapping considering SIUL2
- Access errors

9.3.1 PDAC-based protection scheme

VIRT_WRAPPER uses a protection scheme of the PDACs sub-blocks of XRDC. Each PDAC slot is assigned to one or more cores (by domain ID assignment in XRDC) as shown in Chip-specific VIRT_WRAPPER information section. Only the write accesses are protected by the virtualization feature. Read accesses are not impacted.

For any protection group defined within the register, two bits specify the protection control information according to the following table.

Table 34. Protection control information for a single group

Value	Mnemonic	Protection	Description
00	PDAC1	Restricted access of registers, MSCR, IMCR, and INTINT, and GCR to PDAC slot 1	Protection setup information for PDAC slot 1 is used.
01	PDAC2	Restricted access of registers, MSCR, IMCR, and INTINT, and GCR to PDAC slot 2	Protection setup information for PDAC slot 2 is used.

Table continues on the next page...

Table 34. Protection control information for a single group (continued)

Value	Mnemonic	Protection	Description
10	PDAC3	Restricted access of registers, MSCR, IMCR, and INT INT, and GCR to PDAC slot 3	Protection setup information for PDAC slot 3 is used.
11	PDAC0	By default, any core can access SIUL2 registers through PDAC slot 0. This process is called ANY_MASTER.	Protection setup information for PDAC slot 0 is used.

9.3.2 Clocking

This module has no major clocking considerations.

9.3.3 Register group mapping for SIUL2

For the SIUL2 instance, the corresponding virtualization information within the VIRT_WRAPPER module is defined on a per-pad basis. Additionally, the virtualization information protects the control registers (controlling the input multiplexing scheme).

9.3.3.1 Virtualization of pad output registers

Any functional pad (controlled by the SIUL2 instance) is assigned to a separate protection group. This scheme excludes the pads that an MSCR register does not control within an SIUL2 instance (for example, power supply pads). As a result, the protection granularity defined by the virtualization information is a single pad. The control information associated with this protection group affects all the registers related to this pad.

The protection control information for pad *i* is specified within the protection group *i*; thus, it enables a very simple assignment scheme for the related protection control data that is hard-coded. The protection control information for pad *i* affects all the registers related to this pad, in the MSCR*i* and the GPDO*i* registers (in case such registers exist).

SIUL2 can control up to 512 pads that the MSCR, GPDO, and GPDI registers can access individually. The actual number of pads associated with a SIUL2 instance is specific to implementation. GPIO pads are also organized in GPIO ports consisting of a maximum of 16 pads that the parallel port registers (PGPDO, PGPDI, MPGPDO) can access.

Only the pad control and pad output registers are protected. Accesses to the read-only registers GPDI and PGPDI are not affected by virtualization.

As the protection granularity is a single pad, any virtualization information associated with this pad affects the corresponding MCSR and GPDO registers directly. Additionally, any consequence that an illegal access has on the registers implemented within the REG_PROT wrapper is inhibited. For this purpose, any access to the mirrored address space and the corresponding Soft Lock Bit Register (SLBR) is also observed.

The parallel port output registers (PGPDO, MPGPDO) inherit the protection information from the protection information of the included pads according to the following rules:

- When all pads assigned to a GPIO port share the same protection information, the corresponding parallel port output register for this port inherits the same protection information.
- When at least one of the pads assigned to a GPIO port has a different protection information than the other pads assigned to this GPIO port, the write access to the corresponding parallel port output register (PGPDO and MPGPDO) for this port is disabled for all the masters through all the PDAC slots and a transfer error is generated.

Due to the aforementioned protection group mapping, the data bits of a register encode the protection control information related to one full GPIO port, or a chunk of 16 pads.

9.3.3.2 Virtualization of input multiplexing control registers

Additionally, the SIUL2 instance supports the control of an input multiplexer (INMUX) scheme. This scheme provides the capability to select one of a set of the input pads to be the source of an input function for some of the peripheral modules. Any INMUX controlled by the SIUL2 instance is assigned to a separate protection group. It therefore provides an equivalent protection granularity within the virtualization information.

The protection group 512+*i* specifies the protection control information for the input multiplexer INMUX *i*. This enables a very simple assignment scheme for the related protection control data that is hard-coded. The protection control information for INMUX *i* affects the input multiplexing control register related to this input—namely, IMCR*i*.

SIUL2 can control up to 512 MSCRs and 512 IMCRs input multiplexers that the IMCRs can access individually. GPIO inputs are not affected by the input multiplexer scheme. Therefore, the associated virtualization information does not affect the corresponding pad input registers.

As the protection granularity is a single INMUX, any virtualization information associated with this INMUX affects the corresponding IMCR directly. Additionally, any consequence that an illegal access has on the registers implemented within the REG_PROT wrapper is inhibited. For this purpose, any access to the mirrored address space and the corresponding SLBR is also observed.

9.3.3.3 Virtualization of interrupt control registers

Additionally, the complete set of interrupt control registers within SIUL2 (address offset range 0010h–00C3h) can be protected as a separate group (protection group #1024).

Another additional protection group (protection group #1055) is defined for the global control register (GCR) of the related REG_PROT wrapper.

The PDAC that accesses the main SIUL2 registers is used to access the SIUL2-mirrored registers and soft-lock-bit registers. This is because these registers are a part of the same 16 KB space.

Access to mirrored SIUL2 registers sets the bit in Soft lock bit as an inherent property of register protection. See the "Register Protection" chapter for details on the soft lock bit behavior, when accessing the mirrored region.

The following table shows an overview of the SIUL2 registers and their protection attributes.

Table 35. SIUL2 memory map overview and protection

Offset range	Register	Size (bits)	Protected	Description
0000–000Fh	MIDR1, MIDR2	32	N	Read-only registers, not protected
0010–00C3h	Interrupt registers	32	Y	Protected as a single group—no individual protection of related registers
0240–A3Fh [1]	MSCR	32	Y	Amount of registers defines maximum number of PADs to be controlled and protected
0A40–0123Fh	IMCR	32	Y	Amount of registers defines maximum number of INMUXes to be controlled and protected
1300–14FFh	GPDO GPDO[0] (8-bit) register controls single PAD[0] pad means that if PAD[0] is assigned to PDAC slot 1 then PDAC slot 1 can write to GPDO[0] (8-bit).	8	Y	There are fewer GPDO registers than MSCR registers, as some PADs are not made available as GPIO PADs, but their electrical characteristics can still be programmed

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Table 35. SIUL2 memory map overview and protection (continued)

Offset range	Register	Size (bits)	Protected	Description
1500–16FFh	GPDI	8	N	PAD input register, not protected
1700–173Fh	PGPDO PGPDO[0] (16-bit) register controls PAD[0-15] pads meaning if only all the PADs[0-15] are assigned to PDAC slot 1, then PDAC slot 1 can write to PGPDO[0] (16-bit).	16	Y	Writable with 8-, 16-, and as a pair with 32-bit accesses
1740–177Fh	PGPDI	16	N	PAD input register, not protected
1780–17FFh	MPGPDO MPGPDO[0] (32-bit) register controls PAD[0-15] pads meaning if only all the PADs[0-15] are assigned to PDAC slot 1, then PDAC slot 1 can write to MPGPDO[0] (32-bit).	32	Y	Only writable with 32-bit accesses
2010–20C3h	Interrupt registers (mirror) The DISR0 DIRER0 DIRSR0 IREER0 IFEER0 IFER0 IFMCR0-31 IFCPR0 can be assigned to individual PDAC control, then all these registers are only accessible through assigned PDAC.[2]	32	Y	Mirrored access to interrupt registers in SIUL2 instance
2240–2A3Fh	MSCR (mirror)[3]	32	Y	Mirrored access to MSCRs in SIUL2 instance
2A40–323Fh	IMCR (mirror)[3]	32	Y	Mirrored access to IMCRs in SIUL2 instance
3300–34FFh	GPDO (mirror)[4]	8	Y	Mirrored access to GPDOs in SIUL2 instance
4000–47FFh	SLBR[5]	8	Y	Soft lock bit registers within REG_PROT wrapper for this SIUL2 instance
4800–48FFh	GCR	32	Y	Global configuration register within REG_PROT wrapper for this SIUL2 instance. There is a single

Table continues on the next page...

Table 35. SIUL2 memory map overview and protection (continued)

Offset range	Register	Size (bits)	Protected	Description
				register in configuration space that is area 4 of REG_PROT. The size mentioned is to make the whole area a multiple of 4 kB. See the table "Address accesses as a function of PROT_MEM" in the REG_PROT chapter to know the exact area for GCRs.

1. The SIUL2 block guide specifies the support of a maximum of 512 MSCRs.
2. Access to mirrored register address range results in a change of the related SLBR within the REG_PROT wrapper if REG_PROT protects the register. For registers unprotected by REG_PROT, a write to a register mirror has the same impact as a write to the register.
3. Access to mirrored register address range results in a change of the related SLBR within the REG_PROT wrapper if REG_PROT protects the register. For registers unprotected by REG_PROT, write to register mirror has the same impact as write to register.
4. Access to mirrored register address range results in a change of the related SLBR within the REG_PROT wrapper if REG_PROT protects the register. For registers unprotected by REG_PROT, a write to a register mirror has the same impact as a write to the register.
5. Only SLBRs protecting accesses to the interrupt registers, IMCRs, and the MSCR registers are protected. See the register protection sheet attached to the reference manual for a complete list of SIUL2 registers that REG_PROT protects.

9.4 External signals

This module has no external signals.

9.5 Initialization

This module does not require initialization.

9.6 Application Information

This module supports virtualization of accesses to the registers within a SIUL2 by inhibiting or granting accesses to a subset of these registers under control of the specified master(core) information.

9.7 VIRT_WRAPPER memory map register descriptions

NOTE

Access to reserved spaces outside the register bank and holes (unimplemented registers) within register bank generates the transfer error.

9.7.1 VIRT_WRAPPER memory map

VIRT_WRAPPER base address: 402A_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Parameter_n Register (REG_A15_0)	32	RW	FFFF_FFFFh
4h	Parameter_n Register (REG_A31_16)	32	RW	FFFF_FFFFh
8h	Parameter_n Register (REG_A47_32)	32	RW	FFFF_FFFFh

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Offset	Register	Width (In bits)	Access	Reset value
Ch	Parameter_n Register (REG_A63_48)	32	RW	FFFF_FFFFh
10h	Parameter_n Register (REG_A79_64)	32	RW	FFFF_FFFFh
14h	Parameter_n Register (REG_A95_80)	32	RW	FFFF_FFFFh
18h	Parameter_n Register (REG_A111_96)	32	RW	FFFF_FFFFh
1Ch	Parameter_n Register (REG_A127_112)	32	RW	FFFF_FFFFh
20h	Parameter_n Register (REG_A143_128)	32	RW	FFFF_FFFFh
24h	Parameter_n Register (REG_A159_144)	32	RW	FFFF_FFFFh
28h	Parameter_n Register (REG_A175_160)	32	RW	FFFF_FFFFh
2Ch	Parameter_n Register (REG_A191_176)	32	RW	FFFF_FFFFh
30h	Parameter_n Register (REG_A207_192)	32	RW	FFFF_FFFFh
34h	Parameter_n Register (REG_A223_208)	32	RW	FFFF_FFFFh
38h	Parameter_n Register (REG_A239_224)	32	RW	FFFF_FFFFh
3Ch	Parameter_n Register (REG_A255_240)	32	RW	FFFF_FFFFh
40h	Parameter_n Register (REG_A271_256)	32	RW	FFFF_FFFFh
44h	Parameter_n Register (REG_A287_272)	32	RW	FFFF_FFFFh
48h	Parameter_n Register (REG_A303_288)	32	RW	FFFF_FFFFh
4Ch	Parameter_n Register (REG_A319_304)	32	RW	FFFF_FFFFh
50h	Parameter_n Register (REG_A335_320)	32	RW	FFFF_FFFFh
54h	Parameter_n Register (REG_A351_336)	32	RW	FFFF_FFFFh
58h	Parameter_n Register (REG_A367_352)	32	RW	FFFF_FFFFh
5Ch	Parameter_n Register (REG_A383_368)	32	RW	FFFF_FFFFh
60h	Parameter_n Register (REG_A399_384)	32	RW	FFFF_FFFFh
64h	Parameter_n Register (REG_A415_400)	32	RW	FFFF_FFFFh
68h	Parameter_n Register (REG_A431_416)	32	RW	FFFF_FFFFh
6Ch	Parameter_n Register (REG_A447_432)	32	RW	FFFF_FFFFh
70h	Parameter_n Register (REG_A463_448)	32	RW	FFFF_FFFFh
74h	Parameter_n Register (REG_A479_464)	32	RW	FFFF_FFFFh
78h	Parameter_n Register (REG_A495_480)	32	RW	FFFF_FFFFh
7Ch	Parameter_n Register (REG_A511_496)	32	RW	FFFF_FFFFh
80h	Parameter_n Register (REG_B527_512)	32	RW	FFFF_FFFFh
84h	Parameter_n Register (REG_B543_528)	32	RW	FFFF_FFFFh

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Offset	Register	Width (In bits)	Access	Reset value
88h	Parameter_n Register (REG_B559_544)	32	RW	FFFF_FFFFh
8Ch	Parameter_n Register (REG_B575_560)	32	RW	FFFF_FFFFh
90h	Parameter_n Register (REG_B591_576)	32	RW	FFFF_FFFFh
94h	Parameter_n Register (REG_B607_592)	32	RW	FFFF_FFFFh
98h	Parameter_n Register (REG_B623_608)	32	RW	FFFF_FFFFh
9Ch	Parameter_n Register (REG_B639_624)	32	RW	FFFF_FFFFh
A0h	Parameter_n Register (REG_B655_640)	32	RW	FFFF_FFFFh
A4h	Parameter_n Register (REG_B671_656)	32	RW	FFFF_FFFFh
A8h	Parameter_n Register (REG_B687_672)	32	RW	FFFF_FFFFh
ACh	Parameter_n Register (REG_B703_688)	32	RW	FFFF_FFFFh
B0h	Parameter_n Register (REG_B719_704)	32	RW	FFFF_FFFFh
B4h	Parameter_n Register (REG_B735_720)	32	RW	FFFF_FFFFh
B8h	Parameter_n Register (REG_B751_736)	32	RW	FFFF_FFFFh
BCh	Parameter_n Register (REG_B767_752)	32	RW	FFFF_FFFFh
C0h	Parameter_n Register (REG_B783_768)	32	RW	FFFF_FFFFh
C4h	Parameter_n Register (REG_B799_784)	32	RW	FFFF_FFFFh
C8h	Parameter_n Register (REG_B815_800)	32	RW	FFFF_FFFFh
CCh	Parameter_n Register (REG_B831_816)	32	RW	FFFF_FFFFh
D0h	Parameter_n Register (REG_B847_832)	32	RW	FFFF_FFFFh
D4h	Parameter_n Register (REG_B863_848)	32	RW	FFFF_FFFFh
D8h	Parameter_n Register (REG_B879_864)	32	RW	FFFF_FFFFh
DCh	Parameter_n Register (REG_B895_880)	32	RW	FFFF_FFFFh
E0h	Parameter_n Register (REG_B911_896)	32	RW	FFFF_FFFFh
E4h	Parameter_n Register (REG_B927_912)	32	RW	FFFF_FFFFh
E8h	Parameter_n Register (REG_B943_928)	32	RW	FFFF_FFFFh
ECh	Parameter_n Register (REG_B959_944)	32	RW	FFFF_FFFFh
F0h	Parameter_n Register (REG_B975_960)	32	RW	FFFF_FFFFh
F4h	Parameter_n Register (REG_B991_976)	32	RW	FFFF_FFFFh
F8h	Parameter_n Register (REG_B1007_992)	32	RW	FFFF_FFFFh
FCh	Parameter_n Register (REG_B1023_1008)	32	RW	FFFF_FFFFh
100h	Parameter_n Register (REG_C1039_1024)	32	RW	FFFF_FFFFh

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Offset	Register	Width (In bits)	Access	Reset value
104h	Parameter_n Register (REG_D1055_1040)	32	RW	FFFF_FFFFh

9.7.2 Parameter_n Register (REG_A15_0 - REG_A511_496)

Offset

Register	Offset
REG_A15_0	0h
REG_A31_16	4h
REG_A47_32	8h
REG_A63_48	Ch
REG_A79_64	10h
REG_A95_80	14h
REG_A111_96	18h
REG_A127_112	1Ch
REG_A143_128	20h
REG_A159_144	24h
REG_A175_160	28h
REG_A191_176	2Ch
REG_A207_192	30h
REG_A223_208	34h
REG_A239_224	38h
REG_A255_240	3Ch
REG_A271_256	40h
REG_A287_272	44h
REG_A303_288	48h
REG_A319_304	4Ch
REG_A335_320	50h
REG_A351_336	54h
REG_A367_352	58h
REG_A383_368	5Ch
REG_A399_384	60h

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Register	Offset
REG_A415_400	64h
REG_A431_416	68h
REG_A447_432	6Ch
REG_A463_448	70h
REG_A479_464	74h
REG_A495_480	78h
REG_A511_496	7Ch

Function

This register set is for PAD0-511. They control MSCR, GPDO, PGPDO, and MPGPDO. Two bits assigned per PDAC have attributes of one of the implemented PDACs:

- 00-SIUL2_VIRTWRAPPER_PDAC1
- 01-SIUL2_VIRTWRAPPER_PDAC2
- 10-SIUL2_VIRTWRAPPER_PDAC4
- 11-SIUL2_VIRTWRAPPER_PDAC0

NOTE

- Any master can access holes (unimplemented registers) of SIUL2 through PDAC0.
- After reset, when XRDC is not configured, any master can access SIUL2 registers through PDAC0 without getting transfer error. However, if SIUL2 registers are accessed through other PDAC slots, a transfer error will be generated.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PAD_15		PAD_14		PAD_13		PAD_12		PAD_11		PAD_10		PAD_9		PAD_8	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PAD_7		PAD_6		PAD_5		PAD_4		PAD_3		PAD_2		PAD_1		PAD_0	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-30	PAD_15

Table continues on the next page...

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Field	Function
PAD_15	00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
29-28 PAD_14	PAD_14 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
27-26 PAD_13	PAD_13 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
25-24 PAD_12	PAD_12 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
23-22 PAD_11	PAD_11 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
21-20 PAD_10	PAD_10 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
19-18 PAD_9	PAD_9 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2

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Field	Function
	10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
17-16 PAD_8	PAD_8 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
15-14 PAD_7	PAD_7 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
13-12 PAD_6	PAD_6 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
11-10 PAD_5	PAD_5 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
9-8 PAD_4	PAD_4 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
7-6 PAD_3	PAD_3 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0

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Field	Function
5-4 PAD_2	PAD_2 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
3-2 PAD_1	PAD_1 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
1-0 PAD_0	PAD_0 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0

9.7.3 Parameter_n Register (REG_B527_512 - REG_B1023_1008)

Offset

Register	Offset
REG_B527_512	80h
REG_B543_528	84h
REG_B559_544	88h
REG_B575_560	8Ch
REG_B591_576	90h
REG_B607_592	94h
REG_B623_608	98h
REG_B639_624	9Ch
REG_B655_640	A0h
REG_B671_656	A4h
REG_B687_672	A8h
REG_B703_688	ACh

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Register	Offset
REG_B719_704	B0h
REG_B735_720	B4h
REG_B751_736	B8h
REG_B767_752	BCh
REG_B783_768	C0h
REG_B799_784	C4h
REG_B815_800	C8h
REG_B831_816	CCh
REG_B847_832	D0h
REG_B863_848	D4h
REG_B879_864	D8h
REG_B895_880	DCh
REG_B911_896	E0h
REG_B927_912	E4h
REG_B943_928	E8h
REG_B959_944	ECh
REG_B975_960	F0h
REG_B991_976	F4h
REG_B1007_992	F8h
REG_B1023_1008	FCh

Function

Controls access to pads 0 to 255 specific for IMCR registers. Two bits assigned per IMCR register have attributes of one of the implemented PDACs:

- 00-SIUL2_VIRTWRAPPER_PDAC1
- 01-SIUL2_VIRTWRAPPER_PDAC2
- 10-SIUL2_VIRTWRAPPER_PDAC4
- 11-SIUL2_VIRTWRAPPER_PDAC0

NOTE

- Any master can access holes (unimplemented registers) of SIUL2 through PDAC0.
- After reset, when XRDC is not configured, any master can access SIUL2 registers through PDAC0 without getting transfer error. However, if SIUL2 registers are accessed through other PDAC slots, a transfer error will be generated.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	INMUX_15		INMUX_14		INMUX_13		INMUX_12		INMUX_11		INMUX_10		INMUX_9		INMUX_8	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	INMUX_7		INMUX_6		INMUX_5		INMUX_4		INMUX_3		INMUX_2		INMUX_1		INMUX_0	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-30 INMUX_15	INMUX_15 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
29-28 INMUX_14	INMUX_14 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
27-26 INMUX_13	INMUX_13 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
25-24 INMUX_12	INMUX_12 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
23-22 INMUX_11	INMUX_11 00b - SIUL2_VIRTWRAPPER_PDAC1

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Field	Function
	01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
21-20 INMUX_10	INMUX_10 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
19-18 INMUX_9	INMUX_9 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
17-16 INMUX_8	INMUX_8 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
15-14 INMUX_7	INMUX_7 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
13-12 INMUX_6	INMUX_6 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
11-10 INMUX_5	INMUX_5 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4

Table continues on the next page...

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Field	Function
	11b - SIUL2_VIRTWRAPPER_PDAC0
9-8 INMUX_4	INMUX_4 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
7-6 INMUX_3	INMUX_3 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
5-4 INMUX_2	INMUX_2 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
3-2 INMUX_1	INMUX_1 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0
1-0 INMUX_0	INMUX_0 00b - SIUL2_VIRTWRAPPER_PDAC1 01b - SIUL2_VIRTWRAPPER_PDAC2 10b - SIUL2_VIRTWRAPPER_PDAC4 11b - SIUL2_VIRTWRAPPER_PDAC0

9.7.4 Parameter_n Register (REG_C1039_1024)

Offset

Register	Offset
REG_C1039_1024	100h

Function

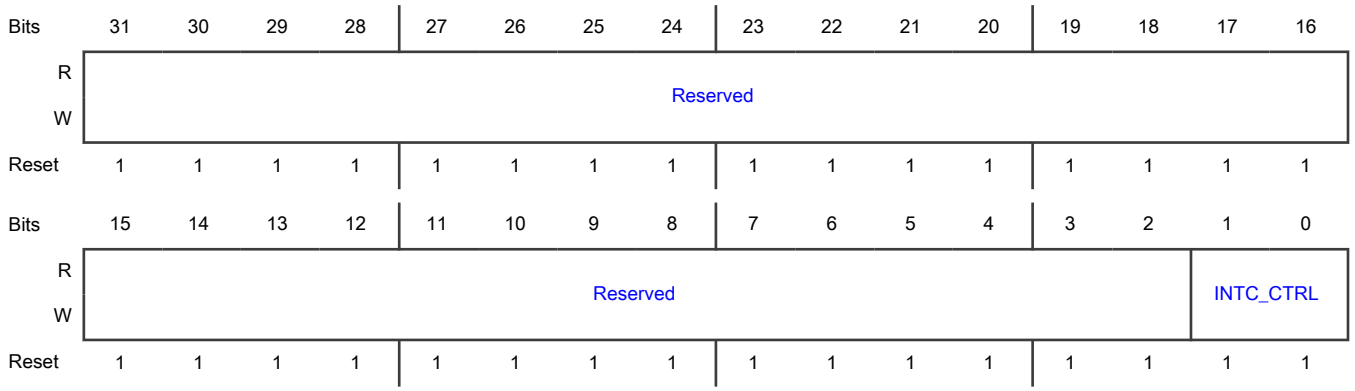
Controls access to DISR0, DIRER0, DIRSR0, IREER0, IFEER0, IFER0, IFMCR, and IFCPR0 interrupt registers. Two bits assigned per PDAC have attributes of one of the implemented PDACs:

- 00-SIUL2_VIRTWRAPPER_PDAC1
- 01-SIUL2_VIRTWRAPPER_PDAC2
- 10-SIUL2_VIRTWRAPPER_PDAC4
- 11-SIUL2_VIRTWRAPPER_PDAC0

NOTE

After reset, when XRDC is not configured, any master can access SIUL2 registers through PDAC0 without getting transfer error. However, if SIUL2 registers are accessed through other PDAC slots, a transfer error will be generated.

Diagram



Fields

Field	Function
31-2 —	Reserved
1-0 INTC_CTRL	Interrupt register control This bit controls the interrupt register.

9.7.5 Parameter_n Register (REG_D1055_1040)

Offset

Register	Offset
REG_D1055_1040	104h

Function

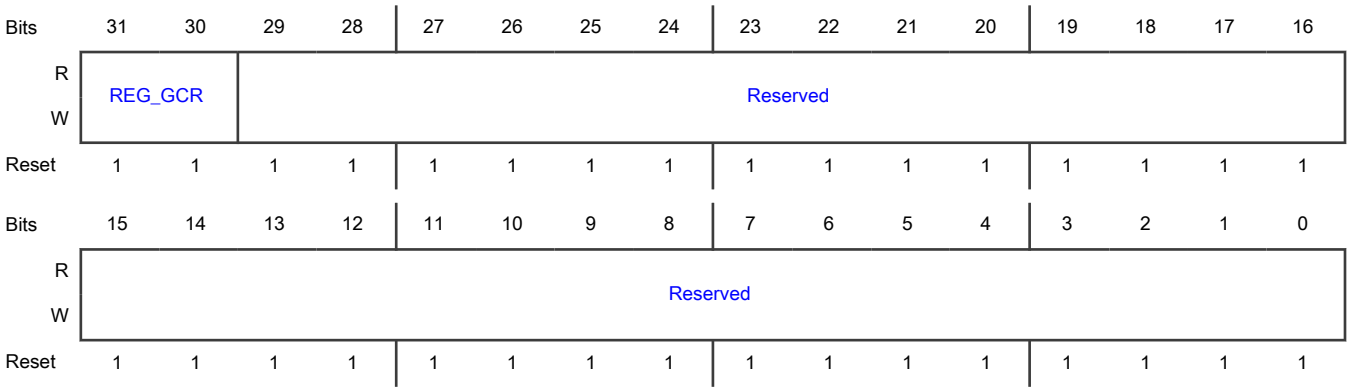
Controls access to GCR protection wrapper registers. Two bits assigned per PDAC have attributes of one of the implemented PDACs:

- 00-SIUL2_VIRTWRAPPER_PDAC1
- 01-SIUL2_VIRTWRAPPER_PDAC2
- 10-SIUL2_VIRTWRAPPER_PDAC4
- 11-SIUL2_VIRTWRAPPER_PDAC0

NOTE

After reset, when XRDC is not configured, any master can access SIUL2 registers through PDAC0 without getting transfer error. However, if SIUL2 registers are accessed through other PDAC slots, a transfer error will be generated.

Diagram



Fields

Field	Function
31-30 REG_GCR	GCR Register Of REG_PROT Controls access to GCR protection wrapper registers.
29-0 —	Reserved

9.8 Glossary

VM Virtualized module, such as SIUL2.

PDAC Peripheral domain access control. PDAC and PDAC slot are interchangeable terms.

Chapter 10
System Integration Unit Lite2 (SIUL2)

10.1 Chip-specific SIUL2 information

10.1.1 Feature availability

This chip:

- Supports input filter enable (MSCR5[IFE]) only for the reset pad (PTA5). For details, see the "Pad signal description" table in the "Signal Multiplexing" chapter.
- Does not implement the open-drain feature. LPI2C directly configures only the pads related to the I2C and LPUART functions in pseudo open-drain when these functions are muxed to the pads. See the LPI2C and LPUART chapters for more information.

NOTE

EIRQ[0-15] can be used either for interrupt or DMA request. EIRQ[16-31] can only be used for interrupt request.

10.1.2 Mapping of MSCR and IMCR instances

- CR numbers 0-511 correspond to the MSCR instances.
- CR numbers 512-1023 correspond to the IMCR instances. IMCRs defined in the attached IOMUX file have an offset of 512 with respect to the IMCR number defined in SIUL2 memory map section.

NOTE

IMCR register only supports 32 bit access, any other access might result in unexpected data. See IOMUX file attached to this document for the exact number of IMCR and MSCR register instances.

10.1.3 SIUL registers reset values

You can read the reset values of the following registers after they come out of reset.

Table 36. SIUL registers reset values

Registers	Reset values
SIUL2 GPIO Pad Data Input Register (GPDI4)	0x01
SIUL2 GPIO Pad Data Input Register (GPDI5)	0x01
SIUL2 GPIO Pad Data Input Register (GPDI69)	0x01
SIUL2 Parallel GPIO Pad Data In Register (PGPDI0)	0x0C00
SIUL2 Parallel GPIO Pad Data In Register (PGPDI4)	0x0400

10.2 Overview

SIUL2 provides control over all electrical pin controls and ports with 16 bits of bidirectional, general-purpose input and output signals. SIUL2 enables you to select the functions and electrical characteristics that appear on external chip pins. It also controls the multiplexing of internal signals from one module to another and controls chip I/O. It supports as many as 32 external interrupts with trigger event configuration.

10.2.1 Block diagram

The following diagram shows the functional blocks of the module and its interfaces to other system components.

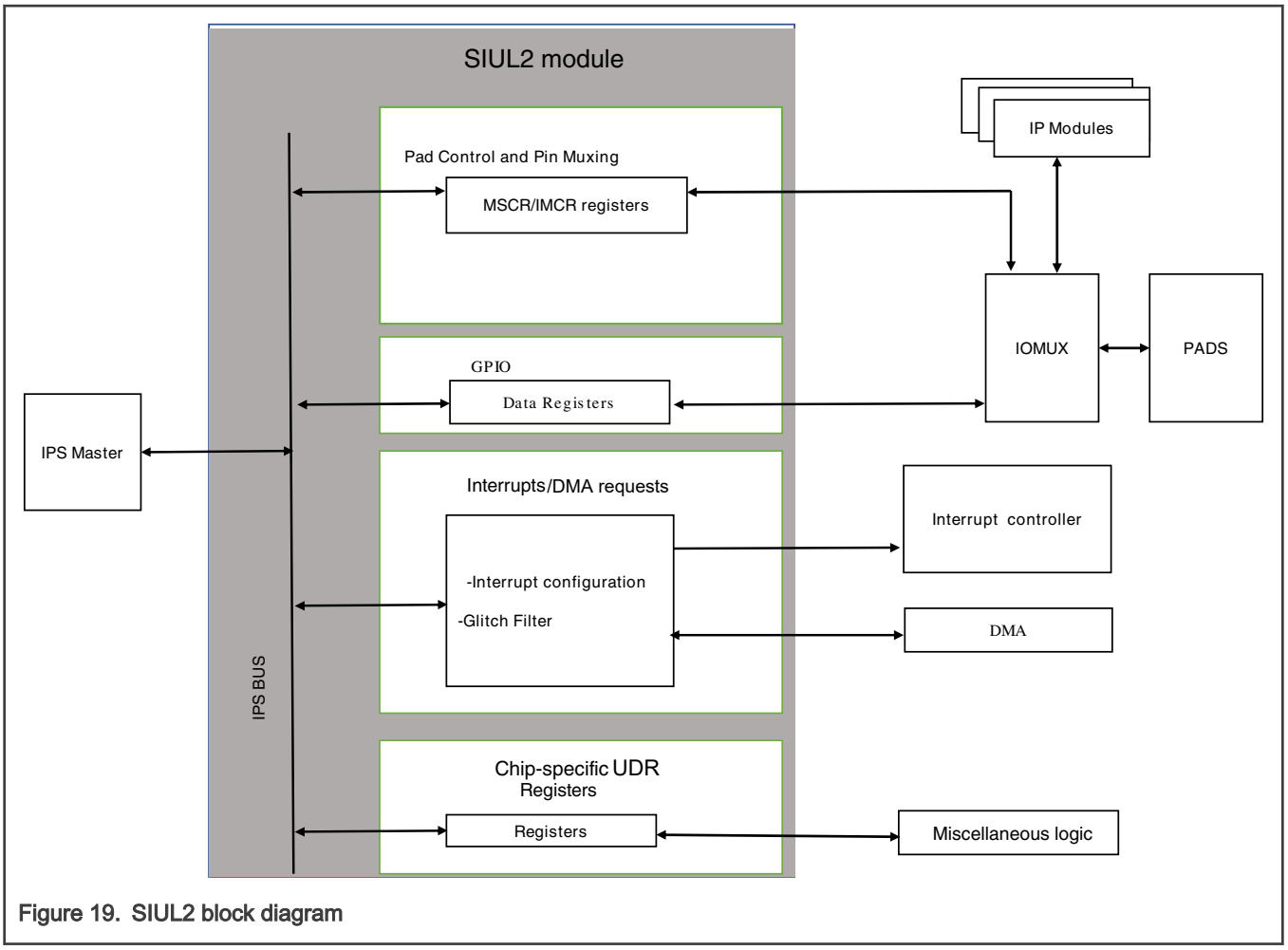


Figure 19. SIUL2 block diagram

SIUL2 provides dedicated pad control to general-purpose pads that can be configured as either inputs or outputs. It provides registers for you to read values from GPIO pads configured as inputs and to write values to GPIO pads configured as outputs:

- When configured as output, you can write to an internal register to control the state driven on the associated output pad.
- When configured as input, you can detect the state of the associated pad by reading the value from an internal register.
- When configured as input and output, the pad value can be read back to check if the written value appeared on the pad.

You can access GPIO data registers in various ways to allow port access and bit manipulation without read-modify-write operations:

- Access to two 16-bit ports in one access
- Read/write access to a single bit
- A 16-bit port write with a bit mask using single 32-bit access

You can configure external interrupt sources at the chip level to be used with any chip pad. You can configure interrupt sources to have a digital filter to reject short glitches on the inputs. The external interrupt/DMA requests map to the interrupt request pins (REQ) in the chip packages. The User Defined Registers (UDRs) contain miscellaneous control and status bits.

10.2.2 Features

SIUL2 supports:

- One to 32 GPIO ports with data control
  - Drives data to as many as 16 independent I/O channels

— Samples data from as many as 16 independent I/O channels

- Read or write of two 16-bit registers with one access for a 32-bit port
- External interrupt/DMA requests:
  — One to 32 programmable digital glitch filters, one for each interrupt REQ pin
  — Edge detection
- Multiplexed Signal Configuration Registers (MSCR) to configure the electrical parameters and settings for as many as 512 functional pads.

See the interrupt map file and the DMAMUX map file attached to this document for mapping of interrupt and DMA sources to interrupt vectors and DMA channels.

10.3 Functional description

10.3.1 Pad Control

SIUL2 can control the electrical characteristics of as many as 512 pads. It provides a consistent interface for all pads, both on a by-port and a by-bit basis.

The setting of each pad out of reset is fixed per chip but can be configured individually. This way you can select special pull settings or peripheral pad ownership.

You can configure each pad independently of all other pads on the chip or other pads grouped within a single port. Thus you can group different pad types together in ports and operate the pads individually. Grouping the various functions for each pad into a single register allows you to configure each pad with a single write to a register, which further allows you to duplicate software for similar pads with index changes.

10.3.2 General Purpose Input and Output pads (GPIO)

SIUL2 allows each pad to be configured as either of the following:

- General Purpose Input or Output pad (GPIO)
- A pad for one or more alternate functions (input or output) determined by the peripheral that uses the pad

GPIO pads can also be implemented without any alternate function.

SIUL2 can manage as many as 512 GPIO pads organized as ports that can be accessed for data reads and writes as 8-bit, 16-bit, or 32-bit.

All port accesses are identical, with each read or write performed only at a different location to access a different port width:

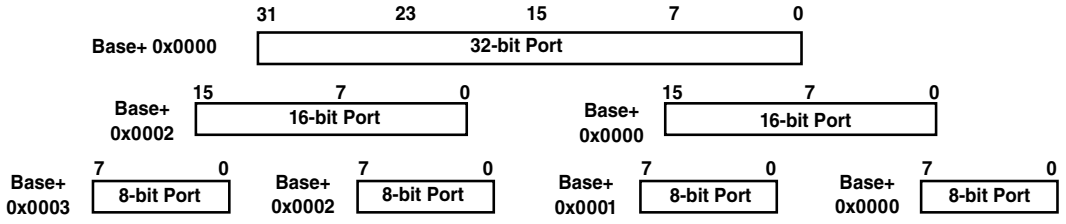


Figure 20. Data Port example arrangement showing configuration for different port width accesses

SIUL2 has separate data input and data output registers for all pads. You can thus directly read back an input or output value of a pad to validate what is actually present on the pad instead of confirming the value that was written to the data input registers.

- The data output registers support both read and write operations.
- The data input registers support read access only.

When a pad is configured to use one of its alternate functions, the data input values reflect the respective value of the pad. If a write operation is performed to the data output register for a pad configured as an alternate function (non-GPIO), this write will not be reflected by the pad value until re-configured to GPIO. All general purpose pads are implemented as bidirectional.

If bidirectional operation impacts performance or is not required for a pad function, you can limit the functionality of the pad to input only.

10.3.3 Clocking

This module has no clocking considerations.

10.3.4 External interrupts

SIUL2 supports one to 32 external interrupts allocated to pads by the chip.

See the interrupt map file and the DMAMUX map file attached to this document (device reference manual) for mapping of interrupt and DMA sources to interrupt vectors and DMA channels.

SIUL2 supports one to four interrupt vectors to the interrupt controller of the chip .Each interrupt vector can support as many as eight external interrupt sources from the chip pads.

All the external interrupt pads within a single group have equal priority. You are responsible for searching through the group of sources in the appropriate way for the application.

NOTE

Glitch filters applied to external interrupts require a running internal oscillator clock. If such a clock is not available, enabling the glitch filter on an external interrupt will disable the interrupt.

The external interrupt signals from a pad have internal synchronizers. Therefore, the width of the interrupt signals should be at least 2.5 or 3 times the Internal RC Oscillator (IRC) clock cycles to correctly capture the interrupts.

10.3.4.1 External interrupt initialization

Follow these steps to enable external interrupts:

NOTE

If you do not follow these steps you may get a false interrupt flag during interrupt initialization.

1. Set the appropriate IFER[IFE*n*] fields to enable the glitch filter.
2. Write 0 to DIRER0[EIRE*n*] to mask interrupts.
3. Write 1 to the appropriate IREE*n* fields in the IREER0 register and IFEE*n* fields in the IFEER0 register as needed to select the pin polarity.
4. Configure the appropriate bits in the MSCR register instances for the external interrupt pin(s):
    a. Clear the OBE and ODE bits to disable output.
    b. Set the IBE bit to enable the input buffer of the pin.
    c. If you are using the internal pull-up or pull-down, configure the appropriate PUE and PUS fields.

    NOTE

    When you chose external interrupt inputs for external interrupt pins, do not configure them as outputs (that is, MSCR[OBE] bits must not be to 0) because it can cause false interrupts detection (such as from a GPIO configuration).
5. Write the appropriate DIRSR0[DIRS*n*] bits to select a request between DMA or interrupt.
6. Select the desired glitch filter setup for the pins:
    a. Write the appropriate value to IFMCR*n*[MAXCNT] register for the respective external interrupt to the filter counter.

b. Write the appropriate value to IFCPR[IFCP] to set the filter clock prescaler.

c. Set the appropriate IFER0[IFE*n*] bits to enable the glitch filter for the external interrupt pins.

7. Write to the appropriate DISR0[EIF*n*] bits to clear any flags.
8. Set the appropriate DIRER0[EIRE*n*] bits to enable the interrupt pins.

10.3.4.2 External interrupt management

You can enable or disable each interrupt independently using a single rolled up register, DIRER0.

You can configure a pad defined as an external interrupt to recognize interrupts with an active rising edge, an active falling edge, or both, using the IREER and IFEER registers.

NOTE

You must not disable both edge events of a given interrupt.

Each external interrupt has an individual flag, held in the DISR0 register. DISR0 is a clear-by-write-1 register, which prevents inadvertent overwriting of other flags in the same register.

This figure provides an overview of the external interrupt implementation:

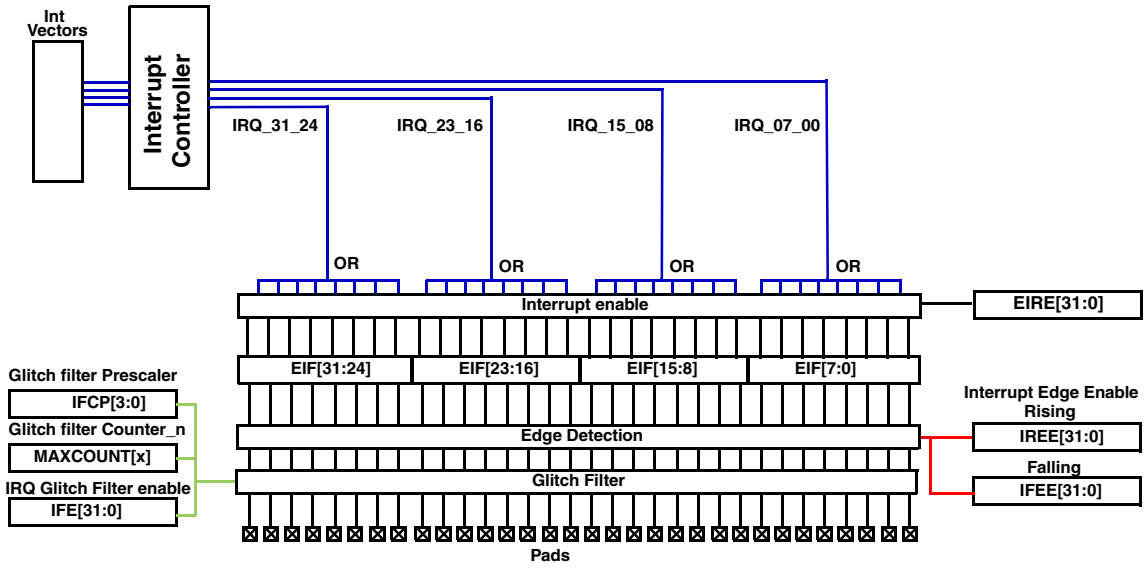


Figure 21. External interrupt pad diagram

10.3.4.3 External interrupt request

The REQ input pins on the chip are sources for interrupt or DMA requests. The chip provides one possible interrupt vector for SIUL2. The 32 interrupt request sources map to vectors and channels as follows:

Table 37. Interrupt source mapping to SIUL2 interrupt request output for 32 interrupt sources

Vector/Channel #	Interrupt vector source
0	REQ[07] | REQ[06] | REQ[05] | REQ[04] | REQ[03] | REQ[02] | REQ[01] | REQ[00]
1	REQ[15] | REQ[14] | REQ[13] | REQ[12] | REQ[11] | REQ[10] | REQ[09] | REQ[08]

Table continues on the next page...

Table 37. Interrupt source mapping to SIUL2 interrupt request output for 32 interrupt sources (continued)

Vector/Channel #	Interrupt vector source
2	REQ[23] | REQ[22] | REQ[21] | REQ[20] | REQ[19] | REQ[18] | REQ[17] | REQ[16]
3	REQ[31] | REQ[30] | REQ[29] | REQ[28] | REQ[27] | REQ[26] | REQ[25] | REQ[24]

10.3.5 DMA requests

The REQ pins on the chip map to independent DMA request channels in the DMA controller. See DMAMUX map file attached to this document for mapping of DMA sources to DMA channels.

DISR0 and DIRSR0 registers manage DMA requests in the following way:

- Servicing a DMA request clears the DISR0 register flags.
- Writing the appropriate DIRSR0[DIRSn] field, selects a request between DMA or interrupt.
- If DMA is selected in DIRSR0 and the corresponding DISR0 flag is set for that, SIUL2 sends DMA request signal as an output.

10.4 External signal description

See the IOMUX file attached to this document for more information.

10.5 Initialization

This module does not require initialization.

10.6 SIUL2 register descriptions

This section describes the SIUL2 registers.

NOTE

- Undocumented register spaces in the SIUL2 memory map, including addresses shown as blanks, are Reserved.
  - Reserved registers or spaces are read as 0.
  - Writes to Reserved registers or spaces generate a transfer error.
- Writes to read-only registers generate a transfer error.

NOTE

- For the array of 8-bit registers GPDO*n* and GPDI*n*:
  - An 8-bit access to an unimplemented address (a "hole") within the array region will generate a transfer error.
  - However, if you do a 16-bit or a 32-bit access and if any register instance is implemented within the accessed range, a transfer error will not be generated even if the range includes a hole.
- For the array of 16-bit registers PGPDO*n* and PGPDI*n*:
  - A 16-bit access to an unimplemented address (a "hole") within the array region will generate a transfer error.
  - However, a 32-bit access does not generate a transfer error for a hole irrespective of whether or not the other 16-bit range includes a register instance.

10.6.1 SIUL2 memory map

SIUL2 base address: 4029_0000h

Offset	Register	Width (In bits)	Access	Reset value
4h	SIUL2 MCU ID Register #1 (MIDR1)	32	R	See section
8h	SIUL2 MCU ID Register #2 (MIDR2)	32	R	See section
10h	SIUL2 DMA/Interrupt Status Flag 0 (DISR0)	32	RW	0000_0000h
18h	SIUL2 DMA/Interrupt Request Enable 0 (DIRER0)	32	RW	0000_0000h
20h	SIUL2 DMA/Interrupt Request Select 0 (DIRSR0)	32	RW	0000_0000h
28h	SIUL2 Interrupt Rising-Edge Event Enable 0 (IREER0)	32	RW	0000_0000h
30h	SIUL2 Interrupt Falling-Edge Event Enable 0 (IFEER0)	32	RW	0000_0000h
38h	SIUL2 Interrupt Filter Enable 0 (IFER0)	32	RW	0000_0000h
40h - BCh	SIUL2 Interrupt Filter Maximum Counter (IFMCR0 - IFMCR31)	32	RW	0000_0000h
C0h	SIUL2 Interrupt Filter Clock Prescaler (IFCPR)	32	RW	0000_0000h
100h	MUX0_TIMER_EN1 (MUX0_TIMER_EN1)	32	RW	See section
104h	MUX0_BCTU1_EN (MUX0_BCTU1_EN)	32	RW	See section
108h	MUX1_TIMER_EN0 (MUX1_TIMER_EN0)	32	RW	See section
10Ch	MUX1_BCTU0_EN (MUX1_BCTU0_EN)	32	RW	See section
110h	MUX1_MISC_EN (MUX1_MISC_EN)	32	RW	See section
114h	MUX2_TIMER_EN1 (MUX2_TIMER_EN1)	32	RW	See section
118h	MUX2_BCTU1_EN (MUX2_BCTU1_EN)	32	RW	See section
11Ch	MUX2_MISC_EN (MUX2_MISC_EN)	32	RW	See section
200h	SIUL2 MCU ID Register #3 (MIDR3)	32	R	See section
204h	SIUL2 MCU ID Register #4 (MIDR4)	32	R	See section
240h	SIUL2 Multiplexed Signal Configuration Register (MSCR0)	32	RW	0000_0000h
244h	SIUL2 Multiplexed Signal Configuration Register (MSCR1)	32	RW	0000_0000h
248h	SIUL2 Multiplexed Signal Configuration Register (MSCR2)	32	RW	0000_0000h
24Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR3)	32	RW	0000_0000h
250h	SIUL2 Multiplexed Signal Configuration Register (MSCR4)	32	RW	0008_2827h
254h	SIUL2 Multiplexed Signal Configuration Register (MSCR5)	32	RW	0000_0000h
258h	SIUL2 Multiplexed Signal Configuration Register (MSCR6)	32	RW	0000_0000h
25Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR7)	32	RW	0000_0000h
260h	SIUL2 Multiplexed Signal Configuration Register (MSCR8)	32	RW	0000_0000h
264h	SIUL2 Multiplexed Signal Configuration Register (MSCR9)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
268h	SIUL2 Multiplexed Signal Configuration Register (MSCR10)	32	RW	0000_0127h
278h	SIUL2 Multiplexed Signal Configuration Register (MSCR14)	32	RW	0000_0000h
27Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR15)	32	RW	0000_0000h
280h	SIUL2 Multiplexed Signal Configuration Register (MSCR16)	32	RW	0000_0000h
284h	SIUL2 Multiplexed Signal Configuration Register (MSCR17)	32	RW	0000_0000h
288h	SIUL2 Multiplexed Signal Configuration Register (MSCR18)	32	RW	0000_0000h
28Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR19)	32	RW	0000_0000h
290h	SIUL2 Multiplexed Signal Configuration Register (MSCR20)	32	RW	0000_0000h
294h	SIUL2 Multiplexed Signal Configuration Register (MSCR21)	32	RW	0000_0000h
298h	SIUL2 Multiplexed Signal Configuration Register (MSCR22)	32	RW	0000_0009h
29Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR23)	32	RW	0000_0000h
2A0h	SIUL2 Multiplexed Signal Configuration Register (MSCR24)	32	RW	0000_0000h
2A4h	SIUL2 Multiplexed Signal Configuration Register (MSCR25)	32	RW	0000_0000h
2A8h	SIUL2 Multiplexed Signal Configuration Register (MSCR26)	32	RW	0000_0000h
2B0h	SIUL2 Multiplexed Signal Configuration Register (MSCR28)	32	RW	0000_0000h
2B4h	SIUL2 Multiplexed Signal Configuration Register (MSCR29)	32	RW	0000_0000h
2B8h	SIUL2 Multiplexed Signal Configuration Register (MSCR30)	32	RW	0000_0000h
2BCh	SIUL2 Multiplexed Signal Configuration Register (MSCR31)	32	RW	0000_0000h
2C0h	SIUL2 Multiplexed Signal Configuration Register (MSCR32)	32	RW	0000_0000h
2C4h	SIUL2 Multiplexed Signal Configuration Register (MSCR33)	32	RW	0000_0000h
2C8h	SIUL2 Multiplexed Signal Configuration Register (MSCR34)	32	RW	0000_0000h
2CCh	SIUL2 Multiplexed Signal Configuration Register (MSCR35)	32	RW	0000_4000h
2D0h	SIUL2 Multiplexed Signal Configuration Register (MSCR36)	32	RW	0000_0000h
2D4h	SIUL2 Multiplexed Signal Configuration Register (MSCR37)	32	RW	0000_0000h
2E0h	SIUL2 Multiplexed Signal Configuration Register (MSCR40)	32	RW	0000_0000h
2E4h	SIUL2 Multiplexed Signal Configuration Register (MSCR41)	32	RW	0000_0000h
2E8h	SIUL2 Multiplexed Signal Configuration Register (MSCR42)	32	RW	0000_0000h
2ECh	SIUL2 Multiplexed Signal Configuration Register (MSCR43)	32	RW	0000_0000h
2F0h	SIUL2 Multiplexed Signal Configuration Register (MSCR44)	32	RW	0000_0000h
2F4h	SIUL2 Multiplexed Signal Configuration Register (MSCR45)	32	RW	0000_0000h
2F8h	SIUL2 Multiplexed Signal Configuration Register (MSCR46)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
2FCh	SIUL2 Multiplexed Signal Configuration Register (MSCR47)	32	RW	0000_0000h
300h	SIUL2 Multiplexed Signal Configuration Register (MSCR48)	32	RW	0000_0000h
304h	SIUL2 Multiplexed Signal Configuration Register (MSCR49)	32	RW	0000_0000h
308h	SIUL2 Multiplexed Signal Configuration Register (MSCR50)	32	RW	0000_0000h
30Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR51)	32	RW	0000_0000h
310h	SIUL2 Multiplexed Signal Configuration Register (MSCR52)	32	RW	0000_4000h
314h	SIUL2 Multiplexed Signal Configuration Register (MSCR53)	32	RW	0000_0000h
318h	SIUL2 Multiplexed Signal Configuration Register (MSCR54)	32	RW	0000_0000h
31Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR55)	32	RW	0000_0000h
320h	SIUL2 Multiplexed Signal Configuration Register (MSCR56)	32	RW	0000_0000h
324h	SIUL2 Multiplexed Signal Configuration Register (MSCR57)	32	RW	0000_4000h
328h	SIUL2 Multiplexed Signal Configuration Register (MSCR58)	32	RW	0000_0000h
32Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR59)	32	RW	0000_0000h
330h	SIUL2 Multiplexed Signal Configuration Register (MSCR60)	32	RW	0000_4000h
334h	SIUL2 Multiplexed Signal Configuration Register (MSCR61)	32	RW	0000_4000h
340h	SIUL2 Multiplexed Signal Configuration Register (MSCR64)	32	RW	0000_4000h
344h	SIUL2 Multiplexed Signal Configuration Register (MSCR65)	32	RW	0000_4000h
348h	SIUL2 Multiplexed Signal Configuration Register (MSCR66)	32	RW	0000_4000h
34Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR67)	32	RW	0000_4000h
350h	SIUL2 Multiplexed Signal Configuration Register (MSCR68)	32	RW	0008_2000h
354h	SIUL2 Multiplexed Signal Configuration Register (MSCR69)	32	RW	0008_2800h
358h	SIUL2 Multiplexed Signal Configuration Register (MSCR70)	32	RW	0000_0000h
35Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR71)	32	RW	0000_0000h
360h	SIUL2 Multiplexed Signal Configuration Register (MSCR72)	32	RW	0000_0000h
364h	SIUL2 Multiplexed Signal Configuration Register (MSCR73)	32	RW	0000_0000h
368h	SIUL2 Multiplexed Signal Configuration Register (MSCR74)	32	RW	0000_0000h
36Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR75)	32	RW	0000_0000h
370h	SIUL2 Multiplexed Signal Configuration Register (MSCR76)	32	RW	0000_4000h
374h	SIUL2 Multiplexed Signal Configuration Register (MSCR77)	32	RW	0000_0000h
378h	SIUL2 Multiplexed Signal Configuration Register (MSCR78)	32	RW	0000_0000h
37Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR79)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
380h	SIUL2 Multiplexed Signal Configuration Register (MSCR80)	32	RW	0000_4000h
384h	SIUL2 Multiplexed Signal Configuration Register (MSCR81)	32	RW	0000_4000h
388h	SIUL2 Multiplexed Signal Configuration Register (MSCR82)	32	RW	0000_4000h
38Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR83)	32	RW	0000_4000h
390h	SIUL2 Multiplexed Signal Configuration Register (MSCR84)	32	RW	0000_0000h
394h	SIUL2 Multiplexed Signal Configuration Register (MSCR85)	32	RW	0000_0000h
39Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR87)	32	RW	0000_0000h
3A0h	SIUL2 Multiplexed Signal Configuration Register (MSCR88)	32	RW	0000_0000h
3A4h	SIUL2 Multiplexed Signal Configuration Register (MSCR89)	32	RW	0000_0000h
3A8h	SIUL2 Multiplexed Signal Configuration Register (MSCR90)	32	RW	0000_0000h
3ACh	SIUL2 Multiplexed Signal Configuration Register (MSCR91)	32	RW	0000_0000h
3B0h	SIUL2 Multiplexed Signal Configuration Register (MSCR92)	32	RW	0000_0000h
3B4h	SIUL2 Multiplexed Signal Configuration Register (MSCR93)	32	RW	0000_0000h
3B8h	SIUL2 Multiplexed Signal Configuration Register (MSCR94)	32	RW	0000_0000h
3BCh	SIUL2 Multiplexed Signal Configuration Register (MSCR95)	32	RW	0000_0000h
3C0h	SIUL2 Multiplexed Signal Configuration Register (MSCR96)	32	RW	0000_0000h
3C4h	SIUL2 Multiplexed Signal Configuration Register (MSCR97)	32	RW	0000_0000h
3C8h	SIUL2 Multiplexed Signal Configuration Register (MSCR98)	32	RW	0000_0000h
3CCh	SIUL2 Multiplexed Signal Configuration Register (MSCR99)	32	RW	0000_0000h
3D0h	SIUL2 Multiplexed Signal Configuration Register (MSCR100)	32	RW	0000_0000h
3D4h	SIUL2 Multiplexed Signal Configuration Register (MSCR101)	32	RW	0000_4000h
3D8h	SIUL2 Multiplexed Signal Configuration Register (MSCR102)	32	RW	0000_4000h
3DCh	SIUL2 Multiplexed Signal Configuration Register (MSCR103)	32	RW	0000_4000h
3E0h	SIUL2 Multiplexed Signal Configuration Register (MSCR104)	32	RW	0000_4000h
3E4h	SIUL2 Multiplexed Signal Configuration Register (MSCR105)	32	RW	0000_4000h
3E8h	SIUL2 Multiplexed Signal Configuration Register (MSCR106)	32	RW	0000_4000h
3ECh	SIUL2 Multiplexed Signal Configuration Register (MSCR107)	32	RW	0000_4000h
3F0h	SIUL2 Multiplexed Signal Configuration Register (MSCR108)	32	RW	0000_4000h
3F4h	SIUL2 Multiplexed Signal Configuration Register (MSCR109)	32	RW	0000_0000h
3F8h	SIUL2 Multiplexed Signal Configuration Register (MSCR110)	32	RW	0000_0000h
3FCh	SIUL2 Multiplexed Signal Configuration Register (MSCR111)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
400h	SIUL2 Multiplexed Signal Configuration Register (MSCR112)	32	RW	0000_0000h
404h	SIUL2 Multiplexed Signal Configuration Register (MSCR113)	32	RW	0000_0000h
408h	SIUL2 Multiplexed Signal Configuration Register (MSCR114)	32	RW	0000_0000h
40Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR115)	32	RW	0000_0000h
410h	SIUL2 Multiplexed Signal Configuration Register (MSCR116)	32	RW	0000_0000h
414h	SIUL2 Multiplexed Signal Configuration Register (MSCR117)	32	RW	0000_0000h
418h	SIUL2 Multiplexed Signal Configuration Register (MSCR118)	32	RW	0000_0000h
41Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR119)	32	RW	0000_0000h
420h	SIUL2 Multiplexed Signal Configuration Register (MSCR120)	32	RW	0000_0000h
424h	SIUL2 Multiplexed Signal Configuration Register (MSCR121)	32	RW	0000_0000h
428h	SIUL2 Multiplexed Signal Configuration Register (MSCR122)	32	RW	0000_0000h
42Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR123)	32	RW	0000_0000h
430h	SIUL2 Multiplexed Signal Configuration Register (MSCR124)	32	RW	0000_0000h
434h	SIUL2 Multiplexed Signal Configuration Register (MSCR125)	32	RW	0000_0000h
438h	SIUL2 Multiplexed Signal Configuration Register (MSCR126)	32	RW	0000_0000h
43Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR127)	32	RW	0000_0000h
440h	SIUL2 Multiplexed Signal Configuration Register (MSCR128)	32	RW	0000_0000h
444h	SIUL2 Multiplexed Signal Configuration Register (MSCR129)	32	RW	0000_0000h
448h	SIUL2 Multiplexed Signal Configuration Register (MSCR130)	32	RW	0000_0000h
450h	SIUL2 Multiplexed Signal Configuration Register (MSCR132)	32	RW	0000_0000h
454h	SIUL2 Multiplexed Signal Configuration Register (MSCR133)	32	RW	0000_0000h
458h	SIUL2 Multiplexed Signal Configuration Register (MSCR134)	32	RW	0000_0000h
45Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR135)	32	RW	0000_0000h
460h	SIUL2 Multiplexed Signal Configuration Register (MSCR136)	32	RW	0000_4000h
464h	SIUL2 Multiplexed Signal Configuration Register (MSCR137)	32	RW	0000_0000h
468h	SIUL2 Multiplexed Signal Configuration Register (MSCR138)	32	RW	0000_0000h
46Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR139)	32	RW	0000_0000h
470h	SIUL2 Multiplexed Signal Configuration Register (MSCR140)	32	RW	0000_0000h
478h	SIUL2 Multiplexed Signal Configuration Register (MSCR142)	32	RW	0000_0000h
47Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR143)	32	RW	0000_0000h
480h	SIUL2 Multiplexed Signal Configuration Register (MSCR144)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
484h	SIUL2 Multiplexed Signal Configuration Register (MSCR145)	32	RW	0000_0000h
488h	SIUL2 Multiplexed Signal Configuration Register (MSCR146)	32	RW	0000_0000h
48Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR147)	32	RW	0000_0000h
490h	SIUL2 Multiplexed Signal Configuration Register (MSCR148)	32	RW	0000_0000h
494h	SIUL2 Multiplexed Signal Configuration Register (MSCR149)	32	RW	0000_0000h
49Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR151)	32	RW	0000_0000h
4A8h	SIUL2 Multiplexed Signal Configuration Register (MSCR154)	32	RW	0000_0000h
4ACh	SIUL2 Multiplexed Signal Configuration Register (MSCR155)	32	RW	0000_0000h
4B0h	SIUL2 Multiplexed Signal Configuration Register (MSCR156)	32	RW	0000_0000h
4B4h	SIUL2 Multiplexed Signal Configuration Register (MSCR157)	32	RW	0000_0000h
4B8h	SIUL2 Multiplexed Signal Configuration Register (MSCR158)	32	RW	0000_0000h
4BCh	SIUL2 Multiplexed Signal Configuration Register (MSCR159)	32	RW	0000_0000h
4C0h	SIUL2 Multiplexed Signal Configuration Register (MSCR160)	32	RW	0000_0000h
4C4h	SIUL2 Multiplexed Signal Configuration Register (MSCR161)	32	RW	0000_0000h
4C8h	SIUL2 Multiplexed Signal Configuration Register (MSCR162)	32	RW	0000_0000h
4CCh	SIUL2 Multiplexed Signal Configuration Register (MSCR163)	32	RW	0000_0000h
4D0h	SIUL2 Multiplexed Signal Configuration Register (MSCR164)	32	RW	0000_0000h
4D4h	SIUL2 Multiplexed Signal Configuration Register (MSCR165)	32	RW	0000_0000h
4D8h	SIUL2 Multiplexed Signal Configuration Register (MSCR166)	32	RW	0000_0000h
4DCh	SIUL2 Multiplexed Signal Configuration Register (MSCR167)	32	RW	0000_0000h
4E0h	SIUL2 Multiplexed Signal Configuration Register (MSCR168)	32	RW	0000_0000h
4E4h	SIUL2 Multiplexed Signal Configuration Register (MSCR169)	32	RW	0000_0000h
4E8h	SIUL2 Multiplexed Signal Configuration Register (MSCR170)	32	RW	0000_0000h
4ECh	SIUL2 Multiplexed Signal Configuration Register (MSCR171)	32	RW	0000_0000h
4F0h	SIUL2 Multiplexed Signal Configuration Register (MSCR172)	32	RW	0000_0000h
4F4h	SIUL2 Multiplexed Signal Configuration Register (MSCR173)	32	RW	0000_0000h
4F8h	SIUL2 Multiplexed Signal Configuration Register (MSCR174)	32	RW	0000_0000h
4FCh	SIUL2 Multiplexed Signal Configuration Register (MSCR175)	32	RW	0000_0000h
500h	SIUL2 Multiplexed Signal Configuration Register (MSCR176)	32	RW	0000_0000h
504h	SIUL2 Multiplexed Signal Configuration Register (MSCR177)	32	RW	0000_0000h
508h	SIUL2 Multiplexed Signal Configuration Register (MSCR178)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
50Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR179)	32	RW	0000_0000h
510h	SIUL2 Multiplexed Signal Configuration Register (MSCR180)	32	RW	0000_0000h
514h	SIUL2 Multiplexed Signal Configuration Register (MSCR181)	32	RW	0000_0000h
51Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR183)	32	RW	0000_0000h
520h	SIUL2 Multiplexed Signal Configuration Register (MSCR184)	32	RW	0000_0000h
524h	SIUL2 Multiplexed Signal Configuration Register (MSCR185)	32	RW	0000_0000h
528h	SIUL2 Multiplexed Signal Configuration Register (MSCR186)	32	RW	0000_0000h
52Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR187)	32	RW	0000_0000h
530h	SIUL2 Multiplexed Signal Configuration Register (MSCR188)	32	RW	0000_0000h
534h	SIUL2 Multiplexed Signal Configuration Register (MSCR189)	32	RW	0000_0000h
538h	SIUL2 Multiplexed Signal Configuration Register (MSCR190)	32	RW	0000_0000h
53Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR191)	32	RW	0000_0000h
540h	SIUL2 Multiplexed Signal Configuration Register (MSCR192)	32	RW	0000_0000h
544h	SIUL2 Multiplexed Signal Configuration Register (MSCR193)	32	RW	0000_0000h
548h	SIUL2 Multiplexed Signal Configuration Register (MSCR194)	32	RW	0000_0000h
54Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR195)	32	RW	0000_0000h
550h	SIUL2 Multiplexed Signal Configuration Register (MSCR196)	32	RW	0000_0000h
554h	SIUL2 Multiplexed Signal Configuration Register (MSCR197)	32	RW	0000_0000h
558h	SIUL2 Multiplexed Signal Configuration Register (MSCR198)	32	RW	0000_0000h
55Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR199)	32	RW	0000_0000h
560h	SIUL2 Multiplexed Signal Configuration Register (MSCR200)	32	RW	0000_0000h
564h	SIUL2 Multiplexed Signal Configuration Register (MSCR201)	32	RW	0000_0000h
568h	SIUL2 Multiplexed Signal Configuration Register (MSCR202)	32	RW	0000_0000h
56Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR203)	32	RW	0000_0000h
570h	SIUL2 Multiplexed Signal Configuration Register (MSCR204)	32	RW	0000_0000h
574h	SIUL2 Multiplexed Signal Configuration Register (MSCR205)	32	RW	0000_0000h
578h	SIUL2 Multiplexed Signal Configuration Register (MSCR206)	32	RW	0000_0000h
57Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR207)	32	RW	0000_0000h
580h	SIUL2 Multiplexed Signal Configuration Register (MSCR208)	32	RW	0000_0000h
584h	SIUL2 Multiplexed Signal Configuration Register (MSCR209)	32	RW	0000_0000h
588h	SIUL2 Multiplexed Signal Configuration Register (MSCR210)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
58Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR211)	32	RW	0000_0000h
590h	SIUL2 Multiplexed Signal Configuration Register (MSCR212)	32	RW	0000_0000h
594h	SIUL2 Multiplexed Signal Configuration Register (MSCR213)	32	RW	0000_0000h
598h	SIUL2 Multiplexed Signal Configuration Register (MSCR214)	32	RW	0000_0000h
59Ch	SIUL2 Multiplexed Signal Configuration Register (MSCR215)	32	RW	0000_0000h
5A0h	SIUL2 Multiplexed Signal Configuration Register (MSCR216)	32	RW	0000_0000h
5A4h	SIUL2 Multiplexed Signal Configuration Register (MSCR217)	32	RW	0000_0000h
5A8h	SIUL2 Multiplexed Signal Configuration Register (MSCR218)	32	RW	0000_0000h
5ACh	SIUL2 Multiplexed Signal Configuration Register (MSCR219)	32	RW	0000_0000h
5DCh	SIUL2 Multiplexed Signal Configuration Register (MSCR231)	32	RW	0000_0000h
5E0h	SIUL2 Multiplexed Signal Configuration Register (MSCR232)	32	RW	0000_0000h
5E4h	SIUL2 Multiplexed Signal Configuration Register (MSCR233)	32	RW	0000_0000h
5E8h	SIUL2 Multiplexed Signal Configuration Register (MSCR234)	32	RW	0000_0000h
5ECh	SIUL2 Multiplexed Signal Configuration Register (MSCR235)	32	RW	0000_0000h
5F0h	SIUL2 Multiplexed Signal Configuration Register (MSCR236)	32	RW	0000_0000h
A40h	SIUL2 Input Multiplexed Signal Configuration (IMCR0)	32	RW	0000_0000h
A44h	SIUL2 Input Multiplexed Signal Configuration (IMCR1)	32	RW	0000_0000h
A48h	SIUL2 Input Multiplexed Signal Configuration (IMCR2)	32	RW	0000_0000h
A4Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR3)	32	RW	0000_0000h
A50h	SIUL2 Input Multiplexed Signal Configuration (IMCR4)	32	RW	0000_0000h
A54h	SIUL2 Input Multiplexed Signal Configuration (IMCR5)	32	RW	0000_0000h
A80h	SIUL2 Input Multiplexed Signal Configuration (IMCR16)	32	RW	0000_0000h
A84h	SIUL2 Input Multiplexed Signal Configuration (IMCR17)	32	RW	0000_0000h
A88h	SIUL2 Input Multiplexed Signal Configuration (IMCR18)	32	RW	0000_0000h
A8Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR19)	32	RW	0000_0000h
A90h	SIUL2 Input Multiplexed Signal Configuration (IMCR20)	32	RW	0000_0000h
A94h	SIUL2 Input Multiplexed Signal Configuration (IMCR21)	32	RW	0000_0000h
A98h	SIUL2 Input Multiplexed Signal Configuration (IMCR22)	32	RW	0000_0000h
A9Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR23)	32	RW	0000_0000h
AA0h	SIUL2 Input Multiplexed Signal Configuration (IMCR24)	32	RW	0000_0000h
AA4h	SIUL2 Input Multiplexed Signal Configuration (IMCR25)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
AA8h	SIUL2 Input Multiplexed Signal Configuration (IMCR26)	32	RW	0000_0000h
AACh	SIUL2 Input Multiplexed Signal Configuration (IMCR27)	32	RW	0000_0000h
AB0h	SIUL2 Input Multiplexed Signal Configuration (IMCR28)	32	RW	0000_0000h
AB4h	SIUL2 Input Multiplexed Signal Configuration (IMCR29)	32	RW	0000_0000h
AB8h	SIUL2 Input Multiplexed Signal Configuration (IMCR30)	32	RW	0000_0000h
ABCh	SIUL2 Input Multiplexed Signal Configuration (IMCR31)	32	RW	0000_0000h
AC0h	SIUL2 Input Multiplexed Signal Configuration (IMCR32)	32	RW	0000_0000h
AC4h	SIUL2 Input Multiplexed Signal Configuration (IMCR33)	32	RW	0000_0000h
AC8h	SIUL2 Input Multiplexed Signal Configuration (IMCR34)	32	RW	0000_0000h
ACCh	SIUL2 Input Multiplexed Signal Configuration (IMCR35)	32	RW	0000_0000h
AD0h	SIUL2 Input Multiplexed Signal Configuration (IMCR36)	32	RW	0000_0000h
AD4h	SIUL2 Input Multiplexed Signal Configuration (IMCR37)	32	RW	0000_0000h
AD8h	SIUL2 Input Multiplexed Signal Configuration (IMCR38)	32	RW	0000_0000h
ADCh	SIUL2 Input Multiplexed Signal Configuration (IMCR39)	32	RW	0000_0000h
AE0h	SIUL2 Input Multiplexed Signal Configuration (IMCR40)	32	RW	0000_0000h
AE4h	SIUL2 Input Multiplexed Signal Configuration (IMCR41)	32	RW	0000_0000h
AE8h	SIUL2 Input Multiplexed Signal Configuration (IMCR42)	32	RW	0000_0000h
AECh	SIUL2 Input Multiplexed Signal Configuration (IMCR43)	32	RW	0000_0000h
AF0h	SIUL2 Input Multiplexed Signal Configuration (IMCR44)	32	RW	0000_0000h
AF4h	SIUL2 Input Multiplexed Signal Configuration (IMCR45)	32	RW	0000_0000h
AF8h	SIUL2 Input Multiplexed Signal Configuration (IMCR46)	32	RW	0000_0000h
AFCh	SIUL2 Input Multiplexed Signal Configuration (IMCR47)	32	RW	0000_0000h
B00h	SIUL2 Input Multiplexed Signal Configuration (IMCR48)	32	RW	0000_0000h
B04h	SIUL2 Input Multiplexed Signal Configuration (IMCR49)	32	RW	0000_0000h
B08h	SIUL2 Input Multiplexed Signal Configuration (IMCR50)	32	RW	0000_0000h
B0Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR51)	32	RW	0000_0000h
B10h	SIUL2 Input Multiplexed Signal Configuration (IMCR52)	32	RW	0000_0000h
B14h	SIUL2 Input Multiplexed Signal Configuration (IMCR53)	32	RW	0000_0000h
B18h	SIUL2 Input Multiplexed Signal Configuration (IMCR54)	32	RW	0000_0000h
B1Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR55)	32	RW	0000_0000h
B20h	SIUL2 Input Multiplexed Signal Configuration (IMCR56)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
B24h	SIUL2 Input Multiplexed Signal Configuration (IMCR57)	32	RW	0000_0000h
B28h	SIUL2 Input Multiplexed Signal Configuration (IMCR58)	32	RW	0000_0000h
B2Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR59)	32	RW	0000_0000h
B30h	SIUL2 Input Multiplexed Signal Configuration (IMCR60)	32	RW	0000_0000h
B34h	SIUL2 Input Multiplexed Signal Configuration (IMCR61)	32	RW	0000_0000h
B38h	SIUL2 Input Multiplexed Signal Configuration (IMCR62)	32	RW	0000_0000h
B3Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR63)	32	RW	0000_0000h
B40h	SIUL2 Input Multiplexed Signal Configuration (IMCR64)	32	RW	0000_0000h
B44h	SIUL2 Input Multiplexed Signal Configuration (IMCR65)	32	RW	0000_0000h
B48h	SIUL2 Input Multiplexed Signal Configuration (IMCR66)	32	RW	0000_0000h
B4Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR67)	32	RW	0000_0000h
B50h	SIUL2 Input Multiplexed Signal Configuration (IMCR68)	32	RW	0000_0000h
B54h	SIUL2 Input Multiplexed Signal Configuration (IMCR69)	32	RW	0000_0000h
B58h	SIUL2 Input Multiplexed Signal Configuration (IMCR70)	32	RW	0000_0000h
B5Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR71)	32	RW	0000_0000h
C80h	SIUL2 Input Multiplexed Signal Configuration (IMCR144)	32	RW	0000_0000h
C84h	SIUL2 Input Multiplexed Signal Configuration (IMCR145)	32	RW	0000_0000h
C88h	SIUL2 Input Multiplexed Signal Configuration (IMCR146)	32	RW	0000_0000h
C8Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR147)	32	RW	0000_0000h
C90h	SIUL2 Input Multiplexed Signal Configuration (IMCR148)	32	RW	0000_0000h
C94h	SIUL2 Input Multiplexed Signal Configuration (IMCR149)	32	RW	0000_0000h
CA0h	SIUL2 Input Multiplexed Signal Configuration (IMCR152)	32	RW	0000_0000h
CA4h	SIUL2 Input Multiplexed Signal Configuration (IMCR153)	32	RW	0000_0000h
CA8h	SIUL2 Input Multiplexed Signal Configuration (IMCR154)	32	RW	0000_0000h
CACh	SIUL2 Input Multiplexed Signal Configuration (IMCR155)	32	RW	0000_0000h
CB0h	SIUL2 Input Multiplexed Signal Configuration (IMCR156)	32	RW	0000_0000h
CB4h	SIUL2 Input Multiplexed Signal Configuration (IMCR157)	32	RW	0000_0000h
CB8h	SIUL2 Input Multiplexed Signal Configuration (IMCR158)	32	RW	0000_0000h
CBCh	SIUL2 Input Multiplexed Signal Configuration (IMCR159)	32	RW	0000_0000h
CC0h	SIUL2 Input Multiplexed Signal Configuration (IMCR160)	32	RW	0000_0000h
CC4h	SIUL2 Input Multiplexed Signal Configuration (IMCR161)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
CC8h	SIUL2 Input Multiplexed Signal Configuration (IMCR162)	32	RW	0000_0000h
CCCh	SIUL2 Input Multiplexed Signal Configuration (IMCR163)	32	RW	0000_0000h
CD0h	SIUL2 Input Multiplexed Signal Configuration (IMCR164)	32	RW	0000_0000h
CD4h	SIUL2 Input Multiplexed Signal Configuration (IMCR165)	32	RW	0000_0000h
CD8h	SIUL2 Input Multiplexed Signal Configuration (IMCR166)	32	RW	0000_0000h
CDCh	SIUL2 Input Multiplexed Signal Configuration (IMCR167)	32	RW	0000_0000h
CE0h	SIUL2 Input Multiplexed Signal Configuration (IMCR168)	32	RW	0000_0000h
CE4h	SIUL2 Input Multiplexed Signal Configuration (IMCR169)	32	RW	0000_0000h
CE8h	SIUL2 Input Multiplexed Signal Configuration (IMCR170)	32	RW	0000_0000h
CECh	SIUL2 Input Multiplexed Signal Configuration (IMCR171)	32	RW	0000_0000h
CF0h	SIUL2 Input Multiplexed Signal Configuration (IMCR172)	32	RW	0000_0000h
CF4h	SIUL2 Input Multiplexed Signal Configuration (IMCR173)	32	RW	0000_0000h
CF8h	SIUL2 Input Multiplexed Signal Configuration (IMCR174)	32	RW	0000_0000h
CFCh	SIUL2 Input Multiplexed Signal Configuration (IMCR175)	32	RW	0000_0000h
D00h	SIUL2 Input Multiplexed Signal Configuration (IMCR176)	32	RW	0000_0000h
D04h	SIUL2 Input Multiplexed Signal Configuration (IMCR177)	32	RW	0000_0000h
D08h	SIUL2 Input Multiplexed Signal Configuration (IMCR178)	32	RW	0000_0000h
D0Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR179)	32	RW	0000_0000h
D10h	SIUL2 Input Multiplexed Signal Configuration (IMCR180)	32	RW	0000_0000h
D14h	SIUL2 Input Multiplexed Signal Configuration (IMCR181)	32	RW	0000_0000h
D18h	SIUL2 Input Multiplexed Signal Configuration (IMCR182)	32	RW	0000_0000h
D1Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR183)	32	RW	0000_0000h
D20h	SIUL2 Input Multiplexed Signal Configuration (IMCR184)	32	RW	0000_0000h
D24h	SIUL2 Input Multiplexed Signal Configuration (IMCR185)	32	RW	0000_0000h
D28h	SIUL2 Input Multiplexed Signal Configuration (IMCR186)	32	RW	0000_0000h
D2Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR187)	32	RW	0000_0000h
D30h	SIUL2 Input Multiplexed Signal Configuration (IMCR188)	32	RW	0000_0000h
D34h	SIUL2 Input Multiplexed Signal Configuration (IMCR189)	32	RW	0000_0000h
D38h	SIUL2 Input Multiplexed Signal Configuration (IMCR190)	32	RW	0000_0000h
D8Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR211)	32	RW	0000_0000h
D90h	SIUL2 Input Multiplexed Signal Configuration (IMCR212)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
D94h	SIUL2 Input Multiplexed Signal Configuration (IMCR213)	32	RW	0000_0000h
D98h	SIUL2 Input Multiplexed Signal Configuration (IMCR214)	32	RW	0000_0000h
D9Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR215)	32	RW	0000_0000h
DA0h	SIUL2 Input Multiplexed Signal Configuration (IMCR216)	32	RW	0000_0000h
DA4h	SIUL2 Input Multiplexed Signal Configuration (IMCR217)	32	RW	0000_0000h
DA8h	SIUL2 Input Multiplexed Signal Configuration (IMCR218)	32	RW	0000_0000h
DACh	SIUL2 Input Multiplexed Signal Configuration (IMCR219)	32	RW	0000_0000h
DB0h	SIUL2 Input Multiplexed Signal Configuration (IMCR220)	32	RW	0000_0000h
DB4h	SIUL2 Input Multiplexed Signal Configuration (IMCR221)	32	RW	0000_0000h
DB8h	SIUL2 Input Multiplexed Signal Configuration (IMCR222)	32	RW	0000_0000h
DBCh	SIUL2 Input Multiplexed Signal Configuration (IMCR223)	32	RW	0000_0000h
DC0h	SIUL2 Input Multiplexed Signal Configuration (IMCR224)	32	RW	0000_0000h
DC4h	SIUL2 Input Multiplexed Signal Configuration (IMCR225)	32	RW	0000_0000h
DC8h	SIUL2 Input Multiplexed Signal Configuration (IMCR226)	32	RW	0000_0000h
DCCh	SIUL2 Input Multiplexed Signal Configuration (IMCR227)	32	RW	0000_0000h
DD0h	SIUL2 Input Multiplexed Signal Configuration (IMCR228)	32	RW	0000_0000h
DD4h	SIUL2 Input Multiplexed Signal Configuration (IMCR229)	32	RW	0000_0000h
DD8h	SIUL2 Input Multiplexed Signal Configuration (IMCR230)	32	RW	0000_0000h
DDCh	SIUL2 Input Multiplexed Signal Configuration (IMCR231)	32	RW	0000_0000h
DE0h	SIUL2 Input Multiplexed Signal Configuration (IMCR232)	32	RW	0000_0000h
DE4h	SIUL2 Input Multiplexed Signal Configuration (IMCR233)	32	RW	0000_0000h
DE8h	SIUL2 Input Multiplexed Signal Configuration (IMCR234)	32	RW	0000_0000h
DECh	SIUL2 Input Multiplexed Signal Configuration (IMCR235)	32	RW	0000_0000h
DF0h	SIUL2 Input Multiplexed Signal Configuration (IMCR236)	32	RW	0000_0000h
DF4h	SIUL2 Input Multiplexed Signal Configuration (IMCR237)	32	RW	0000_0000h
DF8h	SIUL2 Input Multiplexed Signal Configuration (IMCR238)	32	RW	0000_0000h
DFCh	SIUL2 Input Multiplexed Signal Configuration (IMCR239)	32	RW	0000_0000h
E00h	SIUL2 Input Multiplexed Signal Configuration (IMCR240)	32	RW	0000_0000h
E04h	SIUL2 Input Multiplexed Signal Configuration (IMCR241)	32	RW	0000_0000h
E08h	SIUL2 Input Multiplexed Signal Configuration (IMCR242)	32	RW	0000_0000h
E0Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR243)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
E10h	SIUL2 Input Multiplexed Signal Configuration (IMCR244)	32	RW	0000_0000h
E14h	SIUL2 Input Multiplexed Signal Configuration (IMCR245)	32	RW	0000_0000h
E18h	SIUL2 Input Multiplexed Signal Configuration (IMCR246)	32	RW	0000_0000h
E1Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR247)	32	RW	0000_0000h
E20h	SIUL2 Input Multiplexed Signal Configuration (IMCR248)	32	RW	0000_0000h
E24h	SIUL2 Input Multiplexed Signal Configuration (IMCR249)	32	RW	0000_0000h
E28h	SIUL2 Input Multiplexed Signal Configuration (IMCR250)	32	RW	0000_0000h
E2Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR251)	32	RW	0000_0000h
E30h	SIUL2 Input Multiplexed Signal Configuration (IMCR252)	32	RW	0000_0000h
E34h	SIUL2 Input Multiplexed Signal Configuration (IMCR253)	32	RW	0000_0000h
E38h	SIUL2 Input Multiplexed Signal Configuration (IMCR254)	32	RW	0000_0000h
E3Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR255)	32	RW	0000_0000h
E40h	SIUL2 Input Multiplexed Signal Configuration (IMCR256)	32	RW	0000_0000h
E44h	SIUL2 Input Multiplexed Signal Configuration (IMCR257)	32	RW	0000_0000h
E48h	SIUL2 Input Multiplexed Signal Configuration (IMCR258)	32	RW	0000_0000h
E4Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR259)	32	RW	0000_0000h
E50h	SIUL2 Input Multiplexed Signal Configuration (IMCR260)	32	RW	0000_0000h
E54h	SIUL2 Input Multiplexed Signal Configuration (IMCR261)	32	RW	0000_0000h
E58h	SIUL2 Input Multiplexed Signal Configuration (IMCR262)	32	RW	0000_0000h
E5Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR263)	32	RW	0000_0000h
E60h	SIUL2 Input Multiplexed Signal Configuration (IMCR264)	32	RW	0000_0000h
E64h	SIUL2 Input Multiplexed Signal Configuration (IMCR265)	32	RW	0000_0000h
E68h	SIUL2 Input Multiplexed Signal Configuration (IMCR266)	32	RW	0000_0000h
E6Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR267)	32	RW	0000_0000h
E70h	SIUL2 Input Multiplexed Signal Configuration (IMCR268)	32	RW	0000_0000h
EC4h	SIUL2 Input Multiplexed Signal Configuration (IMCR289)	32	RW	0000_0000h
EC8h	SIUL2 Input Multiplexed Signal Configuration (IMCR290)	32	RW	0000_0000h
ECCh	SIUL2 Input Multiplexed Signal Configuration (IMCR291)	32	RW	0000_0000h
ED0h	SIUL2 Input Multiplexed Signal Configuration (IMCR292)	32	RW	0000_0000h
ED4h	SIUL2 Input Multiplexed Signal Configuration (IMCR293)	32	RW	0000_0000h
ED8h	SIUL2 Input Multiplexed Signal Configuration (IMCR294)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
EDCh	SIUL2 Input Multiplexed Signal Configuration (IMCR295)	32	RW	0000_0000h
EE0h	SIUL2 Input Multiplexed Signal Configuration (IMCR296)	32	RW	0000_0000h
EE4h	SIUL2 Input Multiplexed Signal Configuration (IMCR297)	32	RW	0000_0000h
EE8h	SIUL2 Input Multiplexed Signal Configuration (IMCR298)	32	RW	0000_0000h
EECh	SIUL2 Input Multiplexed Signal Configuration (IMCR299)	32	RW	0000_0000h
EF0h	SIUL2 Input Multiplexed Signal Configuration (IMCR300)	32	RW	0000_0000h
EF4h	SIUL2 Input Multiplexed Signal Configuration (IMCR301)	32	RW	0000_0000h
EF8h	SIUL2 Input Multiplexed Signal Configuration (IMCR302)	32	RW	0000_0000h
EFCh	SIUL2 Input Multiplexed Signal Configuration (IMCR303)	32	RW	0000_0000h
F00h	SIUL2 Input Multiplexed Signal Configuration (IMCR304)	32	RW	0000_0000h
F04h	SIUL2 Input Multiplexed Signal Configuration (IMCR305)	32	RW	0000_0000h
F08h	SIUL2 Input Multiplexed Signal Configuration (IMCR306)	32	RW	0000_0000h
F0Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR307)	32	RW	0000_0000h
F10h	SIUL2 Input Multiplexed Signal Configuration (IMCR308)	32	RW	0000_0000h
F14h	SIUL2 Input Multiplexed Signal Configuration (IMCR309)	32	RW	0000_0000h
F9Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR343)	32	RW	0000_0000h
FA0h	SIUL2 Input Multiplexed Signal Configuration (IMCR344)	32	RW	0000_0000h
FA4h	SIUL2 Input Multiplexed Signal Configuration (IMCR345)	32	RW	0000_0000h
FA8h	SIUL2 Input Multiplexed Signal Configuration (IMCR346)	32	RW	0000_0000h
FACh	SIUL2 Input Multiplexed Signal Configuration (IMCR347)	32	RW	0000_0000h
FB0h	SIUL2 Input Multiplexed Signal Configuration (IMCR348)	32	RW	0000_0000h
FB4h	SIUL2 Input Multiplexed Signal Configuration (IMCR349)	32	RW	0000_0000h
FB8h	SIUL2 Input Multiplexed Signal Configuration (IMCR350)	32	RW	0000_0000h
FBCh	SIUL2 Input Multiplexed Signal Configuration (IMCR351)	32	RW	0000_0000h
FC0h	SIUL2 Input Multiplexed Signal Configuration (IMCR352)	32	RW	0000_0000h
FC4h	SIUL2 Input Multiplexed Signal Configuration (IMCR353)	32	RW	0000_0000h
FE0h	SIUL2 Input Multiplexed Signal Configuration (IMCR360)	32	RW	0000_0000h
FE4h	SIUL2 Input Multiplexed Signal Configuration (IMCR361)	32	RW	0000_0000h
FE8h	SIUL2 Input Multiplexed Signal Configuration (IMCR362)	32	RW	0000_0000h
FECh	SIUL2 Input Multiplexed Signal Configuration (IMCR363)	32	RW	0000_0000h
FF0h	SIUL2 Input Multiplexed Signal Configuration (IMCR364)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
FF4h	SIUL2 Input Multiplexed Signal Configuration (IMCR365)	32	RW	0000_0000h
FF8h	SIUL2 Input Multiplexed Signal Configuration (IMCR366)	32	RW	0000_0000h
100Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR371)	32	RW	0000_0000h
1010h	SIUL2 Input Multiplexed Signal Configuration (IMCR372)	32	RW	0000_0000h
1014h	SIUL2 Input Multiplexed Signal Configuration (IMCR373)	32	RW	0000_0000h
1018h	SIUL2 Input Multiplexed Signal Configuration (IMCR374)	32	RW	0000_0000h
101Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR375)	32	RW	0000_0000h
1020h	SIUL2 Input Multiplexed Signal Configuration (IMCR376)	32	RW	0000_0000h
1024h	SIUL2 Input Multiplexed Signal Configuration (IMCR377)	32	RW	0000_0000h
1028h	SIUL2 Input Multiplexed Signal Configuration (IMCR378)	32	RW	0000_0000h
102Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR379)	32	RW	0000_0000h
1030h	SIUL2 Input Multiplexed Signal Configuration (IMCR380)	32	RW	0000_0000h
1034h	SIUL2 Input Multiplexed Signal Configuration (IMCR381)	32	RW	0000_0000h
1038h	SIUL2 Input Multiplexed Signal Configuration (IMCR382)	32	RW	0000_0000h
103Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR383)	32	RW	0000_0000h
1040h	SIUL2 Input Multiplexed Signal Configuration (IMCR384)	32	RW	0000_0000h
1044h	SIUL2 Input Multiplexed Signal Configuration (IMCR385)	32	RW	0000_0000h
1048h	SIUL2 Input Multiplexed Signal Configuration (IMCR386)	32	RW	0000_0000h
104Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR387)	32	RW	0000_0000h
1050h	SIUL2 Input Multiplexed Signal Configuration (IMCR388)	32	RW	0000_0000h
1054h	SIUL2 Input Multiplexed Signal Configuration (IMCR389)	32	RW	0000_0000h
1058h	SIUL2 Input Multiplexed Signal Configuration (IMCR390)	32	RW	0000_0000h
105Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR391)	32	RW	0000_0000h
1060h	SIUL2 Input Multiplexed Signal Configuration (IMCR392)	32	RW	0000_0000h
1064h	SIUL2 Input Multiplexed Signal Configuration (IMCR393)	32	RW	0000_0000h
1068h	SIUL2 Input Multiplexed Signal Configuration (IMCR394)	32	RW	0000_0000h
106Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR395)	32	RW	0000_0000h
1070h	SIUL2 Input Multiplexed Signal Configuration (IMCR396)	32	RW	0000_0000h
1074h	SIUL2 Input Multiplexed Signal Configuration (IMCR397)	32	RW	0000_0000h
1078h	SIUL2 Input Multiplexed Signal Configuration (IMCR398)	32	RW	0000_0000h
107Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR399)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1080h	SIUL2 Input Multiplexed Signal Configuration (IMCR400)	32	RW	0000_0000h
1084h	SIUL2 Input Multiplexed Signal Configuration (IMCR401)	32	RW	0000_0000h
1088h	SIUL2 Input Multiplexed Signal Configuration (IMCR402)	32	RW	0000_0000h
108Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR403)	32	RW	0000_0000h
1090h	SIUL2 Input Multiplexed Signal Configuration (IMCR404)	32	RW	0000_0000h
1094h	SIUL2 Input Multiplexed Signal Configuration (IMCR405)	32	RW	0000_0000h
1098h	SIUL2 Input Multiplexed Signal Configuration (IMCR406)	32	RW	0000_0000h
109Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR407)	32	RW	0000_0000h
10A0h	SIUL2 Input Multiplexed Signal Configuration (IMCR408)	32	RW	0000_0000h
10A4h	SIUL2 Input Multiplexed Signal Configuration (IMCR409)	32	RW	0000_0000h
10A8h	SIUL2 Input Multiplexed Signal Configuration (IMCR410)	32	RW	0000_0000h
10ACh	SIUL2 Input Multiplexed Signal Configuration (IMCR411)	32	RW	0000_0000h
10B4h	SIUL2 Input Multiplexed Signal Configuration (IMCR413)	32	RW	0000_0000h
10B8h	SIUL2 Input Multiplexed Signal Configuration (IMCR414)	32	RW	0000_0000h
10BCh	SIUL2 Input Multiplexed Signal Configuration (IMCR415)	32	RW	0000_0000h
10C0h	SIUL2 Input Multiplexed Signal Configuration (IMCR416)	32	RW	0000_0000h
10C4h	SIUL2 Input Multiplexed Signal Configuration (IMCR417)	32	RW	0000_0000h
10C8h	SIUL2 Input Multiplexed Signal Configuration (IMCR418)	32	RW	0000_0000h
10CCh	SIUL2 Input Multiplexed Signal Configuration (IMCR419)	32	RW	0000_0000h
10D0h	SIUL2 Input Multiplexed Signal Configuration (IMCR420)	32	RW	0000_0000h
10D4h	SIUL2 Input Multiplexed Signal Configuration (IMCR421)	32	RW	0000_0000h
10D8h	SIUL2 Input Multiplexed Signal Configuration (IMCR422)	32	RW	0000_0000h
10DCh	SIUL2 Input Multiplexed Signal Configuration (IMCR423)	32	RW	0000_0000h
10E0h	SIUL2 Input Multiplexed Signal Configuration (IMCR424)	32	RW	0000_0000h
10E4h	SIUL2 Input Multiplexed Signal Configuration (IMCR425)	32	RW	0000_0000h
10E8h	SIUL2 Input Multiplexed Signal Configuration (IMCR426)	32	RW	0000_0000h
10ECh	SIUL2 Input Multiplexed Signal Configuration (IMCR427)	32	RW	0000_0000h
10F0h	SIUL2 Input Multiplexed Signal Configuration (IMCR428)	32	RW	0000_0000h
10F4h	SIUL2 Input Multiplexed Signal Configuration (IMCR429)	32	RW	0000_0000h
10F8h	SIUL2 Input Multiplexed Signal Configuration (IMCR430)	32	RW	0000_0000h
10FCh	SIUL2 Input Multiplexed Signal Configuration (IMCR431)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1100h	SIUL2 Input Multiplexed Signal Configuration (IMCR432)	32	RW	0000_0000h
1104h	SIUL2 Input Multiplexed Signal Configuration (IMCR433)	32	RW	0000_0000h
1108h	SIUL2 Input Multiplexed Signal Configuration (IMCR434)	32	RW	0000_0000h
110Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR435)	32	RW	0000_0000h
1110h	SIUL2 Input Multiplexed Signal Configuration (IMCR436)	32	RW	0000_0000h
1114h	SIUL2 Input Multiplexed Signal Configuration (IMCR437)	32	RW	0000_0000h
1118h	SIUL2 Input Multiplexed Signal Configuration (IMCR438)	32	RW	0000_0000h
111Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR439)	32	RW	0000_0000h
1120h	SIUL2 Input Multiplexed Signal Configuration (IMCR440)	32	RW	0000_0000h
1124h	SIUL2 Input Multiplexed Signal Configuration (IMCR441)	32	RW	0000_0000h
1128h	SIUL2 Input Multiplexed Signal Configuration (IMCR442)	32	RW	0000_0000h
112Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR443)	32	RW	0000_0000h
1130h	SIUL2 Input Multiplexed Signal Configuration (IMCR444)	32	RW	0000_0000h
1134h	SIUL2 Input Multiplexed Signal Configuration (IMCR445)	32	RW	0000_0000h
1138h	SIUL2 Input Multiplexed Signal Configuration (IMCR446)	32	RW	0000_0000h
113Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR447)	32	RW	0000_0000h
1140h	SIUL2 Input Multiplexed Signal Configuration (IMCR448)	32	RW	0000_0000h
1144h	SIUL2 Input Multiplexed Signal Configuration (IMCR449)	32	RW	0000_0000h
1148h	SIUL2 Input Multiplexed Signal Configuration (IMCR450)	32	RW	0000_0000h
114Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR451)	32	RW	0000_0000h
1150h	SIUL2 Input Multiplexed Signal Configuration (IMCR452)	32	RW	0000_0000h
1154h	SIUL2 Input Multiplexed Signal Configuration (IMCR453)	32	RW	0000_0000h
1158h	SIUL2 Input Multiplexed Signal Configuration (IMCR454)	32	RW	0000_0000h
115Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR455)	32	RW	0000_0000h
1160h	SIUL2 Input Multiplexed Signal Configuration (IMCR456)	32	RW	0000_0000h
1164h	SIUL2 Input Multiplexed Signal Configuration (IMCR457)	32	RW	0000_0000h
1168h	SIUL2 Input Multiplexed Signal Configuration (IMCR458)	32	RW	0000_0000h
116Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR459)	32	RW	0000_0000h
1170h	SIUL2 Input Multiplexed Signal Configuration (IMCR460)	32	RW	0000_0000h
1174h	SIUL2 Input Multiplexed Signal Configuration (IMCR461)	32	RW	0000_0000h
1178h	SIUL2 Input Multiplexed Signal Configuration (IMCR462)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
117Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR463)	32	RW	0000_0000h
1180h	SIUL2 Input Multiplexed Signal Configuration (IMCR464)	32	RW	0000_0000h
1184h	SIUL2 Input Multiplexed Signal Configuration (IMCR465)	32	RW	0000_0000h
1188h	SIUL2 Input Multiplexed Signal Configuration (IMCR466)	32	RW	0000_0000h
118Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR467)	32	RW	0000_0000h
1190h	SIUL2 Input Multiplexed Signal Configuration (IMCR468)	32	RW	0000_0000h
1194h	SIUL2 Input Multiplexed Signal Configuration (IMCR469)	32	RW	0000_0000h
1198h	SIUL2 Input Multiplexed Signal Configuration (IMCR470)	32	RW	0000_0000h
119Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR471)	32	RW	0000_0000h
11A0h	SIUL2 Input Multiplexed Signal Configuration (IMCR472)	32	RW	0000_0000h
11A4h	SIUL2 Input Multiplexed Signal Configuration (IMCR473)	32	RW	0000_0000h
11A8h	SIUL2 Input Multiplexed Signal Configuration (IMCR474)	32	RW	0000_0000h
11ACh	SIUL2 Input Multiplexed Signal Configuration (IMCR475)	32	RW	0000_0000h
11B0h	SIUL2 Input Multiplexed Signal Configuration (IMCR476)	32	RW	0000_0000h
11B4h	SIUL2 Input Multiplexed Signal Configuration (IMCR477)	32	RW	0000_0000h
11B8h	SIUL2 Input Multiplexed Signal Configuration (IMCR478)	32	RW	0000_0000h
11BCh	SIUL2 Input Multiplexed Signal Configuration (IMCR479)	32	RW	0000_0000h
11C0h	SIUL2 Input Multiplexed Signal Configuration (IMCR480)	32	RW	0000_0000h
11C4h	SIUL2 Input Multiplexed Signal Configuration (IMCR481)	32	RW	0000_0000h
11C8h	SIUL2 Input Multiplexed Signal Configuration (IMCR482)	32	RW	0000_0000h
11CCh	SIUL2 Input Multiplexed Signal Configuration (IMCR483)	32	RW	0000_0000h
11D0h	SIUL2 Input Multiplexed Signal Configuration (IMCR484)	32	RW	0000_0000h
11D4h	SIUL2 Input Multiplexed Signal Configuration (IMCR485)	32	RW	0000_0000h
11D8h	SIUL2 Input Multiplexed Signal Configuration (IMCR486)	32	RW	0000_0000h
11DCh	SIUL2 Input Multiplexed Signal Configuration (IMCR487)	32	RW	0000_0000h
11E0h	SIUL2 Input Multiplexed Signal Configuration (IMCR488)	32	RW	0000_0000h
11E4h	SIUL2 Input Multiplexed Signal Configuration (IMCR489)	32	RW	0000_0000h
11E8h	SIUL2 Input Multiplexed Signal Configuration (IMCR490)	32	RW	0000_0000h
11ECh	SIUL2 Input Multiplexed Signal Configuration (IMCR491)	32	RW	0000_0000h
11F0h	SIUL2 Input Multiplexed Signal Configuration (IMCR492)	32	RW	0000_0000h
11F4h	SIUL2 Input Multiplexed Signal Configuration (IMCR493)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
11F8h	SIUL2 Input Multiplexed Signal Configuration (IMCR494)	32	RW	0000_0000h
11FCh	SIUL2 Input Multiplexed Signal Configuration (IMCR495)	32	RW	0000_0000h
1200h	SIUL2 Input Multiplexed Signal Configuration (IMCR496)	32	RW	0000_0000h
1204h	SIUL2 Input Multiplexed Signal Configuration (IMCR497)	32	RW	0000_0000h
1208h	SIUL2 Input Multiplexed Signal Configuration (IMCR498)	32	RW	0000_0000h
120Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR499)	32	RW	0000_0000h
1210h	SIUL2 Input Multiplexed Signal Configuration (IMCR500)	32	RW	0000_0000h
1214h	SIUL2 Input Multiplexed Signal Configuration (IMCR501)	32	RW	0000_0000h
1218h	SIUL2 Input Multiplexed Signal Configuration (IMCR502)	32	RW	0000_0000h
121Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR503)	32	RW	0000_0000h
1220h	SIUL2 Input Multiplexed Signal Configuration (IMCR504)	32	RW	0000_0000h
1224h	SIUL2 Input Multiplexed Signal Configuration (IMCR505)	32	RW	0000_0000h
1228h	SIUL2 Input Multiplexed Signal Configuration (IMCR506)	32	RW	0000_0000h
122Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR507)	32	RW	0000_0000h
1230h	SIUL2 Input Multiplexed Signal Configuration (IMCR508)	32	RW	0000_0000h
1234h	SIUL2 Input Multiplexed Signal Configuration (IMCR509)	32	RW	0000_0000h
1238h	SIUL2 Input Multiplexed Signal Configuration (IMCR510)	32	RW	0000_0000h
123Ch	SIUL2 Input Multiplexed Signal Configuration (IMCR511)	32	RW	0000_0000h
1300h	SIUL2 GPIO Pad Data Output (GPDO3)	8	RW	00h
1301h	SIUL2 GPIO Pad Data Output (GPDO2)	8	RW	00h
1302h	SIUL2 GPIO Pad Data Output (GPDO1)	8	RW	00h
1303h	SIUL2 GPIO Pad Data Output (GPDO0)	8	RW	00h
1304h	SIUL2 GPIO Pad Data Output (GPDO7)	8	RW	00h
1305h	SIUL2 GPIO Pad Data Output (GPDO6)	8	RW	00h
1306h	SIUL2 GPIO Pad Data Output (GPDO5)	8	RW	00h
1307h	SIUL2 GPIO Pad Data Output (GPDO4)	8	RW	00h
1309h	SIUL2 GPIO Pad Data Output (GPDO10)	8	RW	00h
130Ah	SIUL2 GPIO Pad Data Output (GPDO9)	8	RW	00h
130Bh	SIUL2 GPIO Pad Data Output (GPDO8)	8	RW	00h
130Ch	SIUL2 GPIO Pad Data Output (GPDO15)	8	RW	00h
130Dh	SIUL2 GPIO Pad Data Output (GPDO14)	8	RW	00h

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Offset	Register	Width (In bits)	Access	Reset value
1310h	SIUL2 GPIO Pad Data Output (GPDO19)	8	RW	00h
1311h	SIUL2 GPIO Pad Data Output (GPDO18)	8	RW	00h
1312h	SIUL2 GPIO Pad Data Output (GPDO17)	8	RW	00h
1313h	SIUL2 GPIO Pad Data Output (GPDO16)	8	RW	00h
1314h	SIUL2 GPIO Pad Data Output (GPDO23)	8	RW	00h
1315h	SIUL2 GPIO Pad Data Output (GPDO22)	8	RW	00h
1316h	SIUL2 GPIO Pad Data Output (GPDO21)	8	RW	00h
1317h	SIUL2 GPIO Pad Data Output (GPDO20)	8	RW	00h
1319h	SIUL2 GPIO Pad Data Output (GPDO26)	8	RW	00h
131Ah	SIUL2 GPIO Pad Data Output (GPDO25)	8	RW	00h
131Bh	SIUL2 GPIO Pad Data Output (GPDO24)	8	RW	00h
131Ch	SIUL2 GPIO Pad Data Output (GPDO31)	8	RW	00h
131Dh	SIUL2 GPIO Pad Data Output (GPDO30)	8	RW	00h
131Eh	SIUL2 GPIO Pad Data Output (GPDO29)	8	RW	00h
131Fh	SIUL2 GPIO Pad Data Output (GPDO28)	8	RW	00h
1320h	SIUL2 GPIO Pad Data Output (GPDO35)	8	RW	00h
1321h	SIUL2 GPIO Pad Data Output (GPDO34)	8	RW	00h
1322h	SIUL2 GPIO Pad Data Output (GPDO33)	8	RW	00h
1323h	SIUL2 GPIO Pad Data Output (GPDO32)	8	RW	00h
1326h	SIUL2 GPIO Pad Data Output (GPDO37)	8	RW	00h
1327h	SIUL2 GPIO Pad Data Output (GPDO36)	8	RW	00h
1328h	SIUL2 GPIO Pad Data Output (GPDO43)	8	RW	00h
1329h	SIUL2 GPIO Pad Data Output (GPDO42)	8	RW	00h
132Ah	SIUL2 GPIO Pad Data Output (GPDO41)	8	RW	00h
132Bh	SIUL2 GPIO Pad Data Output (GPDO40)	8	RW	00h
132Ch	SIUL2 GPIO Pad Data Output (GPDO47)	8	RW	00h
132Dh	SIUL2 GPIO Pad Data Output (GPDO46)	8	RW	00h
132Eh	SIUL2 GPIO Pad Data Output (GPDO45)	8	RW	00h
132Fh	SIUL2 GPIO Pad Data Output (GPDO44)	8	RW	00h
1330h	SIUL2 GPIO Pad Data Output (GPDO51)	8	RW	00h
1331h	SIUL2 GPIO Pad Data Output (GPDO50)	8	RW	00h

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Offset	Register	Width (In bits)	Access	Reset value
1332h	SIUL2 GPIO Pad Data Output (GPDO49)	8	RW	00h
1333h	SIUL2 GPIO Pad Data Output (GPDO48)	8	RW	00h
1334h	SIUL2 GPIO Pad Data Output (GPDO55)	8	RW	00h
1335h	SIUL2 GPIO Pad Data Output (GPDO54)	8	RW	00h
1336h	SIUL2 GPIO Pad Data Output (GPDO53)	8	RW	00h
1337h	SIUL2 GPIO Pad Data Output (GPDO52)	8	RW	00h
1338h	SIUL2 GPIO Pad Data Output (GPDO59)	8	RW	00h
1339h	SIUL2 GPIO Pad Data Output (GPDO58)	8	RW	00h
133Ah	SIUL2 GPIO Pad Data Output (GPDO57)	8	RW	00h
133Bh	SIUL2 GPIO Pad Data Output (GPDO56)	8	RW	00h
133Eh	SIUL2 GPIO Pad Data Output (GPDO61)	8	RW	00h
133Fh	SIUL2 GPIO Pad Data Output (GPDO60)	8	RW	00h
1340h	SIUL2 GPIO Pad Data Output (GPDO67)	8	RW	00h
1341h	SIUL2 GPIO Pad Data Output (GPDO66)	8	RW	00h
1342h	SIUL2 GPIO Pad Data Output (GPDO65)	8	RW	00h
1343h	SIUL2 GPIO Pad Data Output (GPDO64)	8	RW	00h
1344h	SIUL2 GPIO Pad Data Output (GPDO71)	8	RW	00h
1345h	SIUL2 GPIO Pad Data Output (GPDO70)	8	RW	00h
1346h	SIUL2 GPIO Pad Data Output (GPDO69)	8	RW	00h
1347h	SIUL2 GPIO Pad Data Output (GPDO68)	8	RW	00h
1348h	SIUL2 GPIO Pad Data Output (GPDO75)	8	RW	00h
1349h	SIUL2 GPIO Pad Data Output (GPDO74)	8	RW	00h
134Ah	SIUL2 GPIO Pad Data Output (GPDO73)	8	RW	00h
134Bh	SIUL2 GPIO Pad Data Output (GPDO72)	8	RW	00h
134Ch	SIUL2 GPIO Pad Data Output (GPDO79)	8	RW	00h
134Dh	SIUL2 GPIO Pad Data Output (GPDO78)	8	RW	00h
134Eh	SIUL2 GPIO Pad Data Output (GPDO77)	8	RW	00h
134Fh	SIUL2 GPIO Pad Data Output (GPDO76)	8	RW	00h
1350h	SIUL2 GPIO Pad Data Output (GPDO83)	8	RW	00h
1351h	SIUL2 GPIO Pad Data Output (GPDO82)	8	RW	00h
1352h	SIUL2 GPIO Pad Data Output (GPDO81)	8	RW	00h

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Offset	Register	Width (In bits)	Access	Reset value
1353h	SIUL2 GPIO Pad Data Output (GPDO80)	8	RW	00h
1354h	SIUL2 GPIO Pad Data Output (GPDO87)	8	RW	00h
1356h	SIUL2 GPIO Pad Data Output (GPDO85)	8	RW	00h
1357h	SIUL2 GPIO Pad Data Output (GPDO84)	8	RW	00h
1358h	SIUL2 GPIO Pad Data Output (GPDO91)	8	RW	00h
1359h	SIUL2 GPIO Pad Data Output (GPDO90)	8	RW	00h
135Ah	SIUL2 GPIO Pad Data Output (GPDO89)	8	RW	00h
135Bh	SIUL2 GPIO Pad Data Output (GPDO88)	8	RW	00h
135Ch	SIUL2 GPIO Pad Data Output (GPDO95)	8	RW	00h
135Dh	SIUL2 GPIO Pad Data Output (GPDO94)	8	RW	00h
135Eh	SIUL2 GPIO Pad Data Output (GPDO93)	8	RW	00h
135Fh	SIUL2 GPIO Pad Data Output (GPDO92)	8	RW	00h
1360h	SIUL2 GPIO Pad Data Output (GPDO99)	8	RW	00h
1361h	SIUL2 GPIO Pad Data Output (GPDO98)	8	RW	00h
1362h	SIUL2 GPIO Pad Data Output (GPDO97)	8	RW	00h
1363h	SIUL2 GPIO Pad Data Output (GPDO96)	8	RW	00h
1364h	SIUL2 GPIO Pad Data Output (GPDO103)	8	RW	00h
1365h	SIUL2 GPIO Pad Data Output (GPDO102)	8	RW	00h
1366h	SIUL2 GPIO Pad Data Output (GPDO101)	8	RW	00h
1367h	SIUL2 GPIO Pad Data Output (GPDO100)	8	RW	00h
1368h	SIUL2 GPIO Pad Data Output (GPDO107)	8	RW	00h
1369h	SIUL2 GPIO Pad Data Output (GPDO106)	8	RW	00h
136Ah	SIUL2 GPIO Pad Data Output (GPDO105)	8	RW	00h
136Bh	SIUL2 GPIO Pad Data Output (GPDO104)	8	RW	00h
136Ch	SIUL2 GPIO Pad Data Output (GPDO111)	8	RW	00h
136Dh	SIUL2 GPIO Pad Data Output (GPDO110)	8	RW	00h
136Eh	SIUL2 GPIO Pad Data Output (GPDO109)	8	RW	00h
136Fh	SIUL2 GPIO Pad Data Output (GPDO108)	8	RW	00h
1370h	SIUL2 GPIO Pad Data Output (GPDO115)	8	RW	00h
1371h	SIUL2 GPIO Pad Data Output (GPDO114)	8	RW	00h
1372h	SIUL2 GPIO Pad Data Output (GPDO113)	8	RW	00h

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Offset	Register	Width (In bits)	Access	Reset value
1373h	SIUL2 GPIO Pad Data Output (GPDO112)	8	RW	00h
1374h	SIUL2 GPIO Pad Data Output (GPDO119)	8	RW	00h
1375h	SIUL2 GPIO Pad Data Output (GPDO118)	8	RW	00h
1376h	SIUL2 GPIO Pad Data Output (GPDO117)	8	RW	00h
1377h	SIUL2 GPIO Pad Data Output (GPDO116)	8	RW	00h
1378h	SIUL2 GPIO Pad Data Output (GPDO123)	8	RW	00h
1379h	SIUL2 GPIO Pad Data Output (GPDO122)	8	RW	00h
137Ah	SIUL2 GPIO Pad Data Output (GPDO121)	8	RW	00h
137Bh	SIUL2 GPIO Pad Data Output (GPDO120)	8	RW	00h
137Ch	SIUL2 GPIO Pad Data Output (GPDO127)	8	RW	00h
137Dh	SIUL2 GPIO Pad Data Output (GPDO126)	8	RW	00h
137Eh	SIUL2 GPIO Pad Data Output (GPDO125)	8	RW	00h
137Fh	SIUL2 GPIO Pad Data Output (GPDO124)	8	RW	00h
1381h	SIUL2 GPIO Pad Data Output (GPDO130)	8	RW	00h
1382h	SIUL2 GPIO Pad Data Output (GPDO129)	8	RW	00h
1383h	SIUL2 GPIO Pad Data Output (GPDO128)	8	RW	00h
1384h	SIUL2 GPIO Pad Data Output (GPDO135)	8	RW	00h
1385h	SIUL2 GPIO Pad Data Output (GPDO134)	8	RW	00h
1386h	SIUL2 GPIO Pad Data Output (GPDO133)	8	RW	00h
1387h	SIUL2 GPIO Pad Data Output (GPDO132)	8	RW	00h
1388h	SIUL2 GPIO Pad Data Output (GPDO139)	8	RW	00h
1389h	SIUL2 GPIO Pad Data Output (GPDO138)	8	RW	00h
138Ah	SIUL2 GPIO Pad Data Output (GPDO137)	8	RW	00h
138Bh	SIUL2 GPIO Pad Data Output (GPDO136)	8	RW	00h
138Ch	SIUL2 GPIO Pad Data Output (GPDO143)	8	RW	00h
138Dh	SIUL2 GPIO Pad Data Output (GPDO142)	8	RW	00h
138Fh	SIUL2 GPIO Pad Data Output (GPDO140)	8	RW	00h
1390h	SIUL2 GPIO Pad Data Output (GPDO147)	8	RW	00h
1391h	SIUL2 GPIO Pad Data Output (GPDO146)	8	RW	00h
1392h	SIUL2 GPIO Pad Data Output (GPDO145)	8	RW	00h
1393h	SIUL2 GPIO Pad Data Output (GPDO144)	8	RW	00h

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Offset	Register	Width (In bits)	Access	Reset value
1394h	SIUL2 GPIO Pad Data Output (GPDO151)	8	RW	00h
1396h	SIUL2 GPIO Pad Data Output (GPDO149)	8	RW	00h
1397h	SIUL2 GPIO Pad Data Output (GPDO148)	8	RW	00h
1398h	SIUL2 GPIO Pad Data Output (GPDO155)	8	RW	00h
1399h	SIUL2 GPIO Pad Data Output (GPDO154)	8	RW	00h
139Ch	SIUL2 GPIO Pad Data Output (GPDO159)	8	RW	00h
139Dh	SIUL2 GPIO Pad Data Output (GPDO158)	8	RW	00h
139Eh	SIUL2 GPIO Pad Data Output (GPDO157)	8	RW	00h
139Fh	SIUL2 GPIO Pad Data Output (GPDO156)	8	RW	00h
13A0h	SIUL2 GPIO Pad Data Output (GPDO163)	8	RW	00h
13A1h	SIUL2 GPIO Pad Data Output (GPDO162)	8	RW	00h
13A2h	SIUL2 GPIO Pad Data Output (GPDO161)	8	RW	00h
13A3h	SIUL2 GPIO Pad Data Output (GPDO160)	8	RW	00h
13A4h	SIUL2 GPIO Pad Data Output (GPDO167)	8	RW	00h
13A5h	SIUL2 GPIO Pad Data Output (GPDO166)	8	RW	00h
13A6h	SIUL2 GPIO Pad Data Output (GPDO165)	8	RW	00h
13A7h	SIUL2 GPIO Pad Data Output (GPDO164)	8	RW	00h
13A8h	SIUL2 GPIO Pad Data Output (GPDO171)	8	RW	00h
13A9h	SIUL2 GPIO Pad Data Output (GPDO170)	8	RW	00h
13AAh	SIUL2 GPIO Pad Data Output (GPDO169)	8	RW	00h
13ABh	SIUL2 GPIO Pad Data Output (GPDO168)	8	RW	00h
13ACh	SIUL2 GPIO Pad Data Output (GPDO175)	8	RW	00h
13ADh	SIUL2 GPIO Pad Data Output (GPDO174)	8	RW	00h
13AEh	SIUL2 GPIO Pad Data Output (GPDO173)	8	RW	00h
13AFh	SIUL2 GPIO Pad Data Output (GPDO172)	8	RW	00h
13B0h	SIUL2 GPIO Pad Data Output (GPDO179)	8	RW	00h
13B1h	SIUL2 GPIO Pad Data Output (GPDO178)	8	RW	00h
13B2h	SIUL2 GPIO Pad Data Output (GPDO177)	8	RW	00h
13B3h	SIUL2 GPIO Pad Data Output (GPDO176)	8	RW	00h
13B4h	SIUL2 GPIO Pad Data Output (GPDO183)	8	RW	00h
13B6h	SIUL2 GPIO Pad Data Output (GPDO181)	8	RW	00h

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Offset	Register	Width (In bits)	Access	Reset value
13B7h	SIUL2 GPIO Pad Data Output (GPDO180)	8	RW	00h
13B8h	SIUL2 GPIO Pad Data Output (GPDO187)	8	RW	00h
13B9h	SIUL2 GPIO Pad Data Output (GPDO186)	8	RW	00h
13BAh	SIUL2 GPIO Pad Data Output (GPDO185)	8	RW	00h
13BBh	SIUL2 GPIO Pad Data Output (GPDO184)	8	RW	00h
13BCh	SIUL2 GPIO Pad Data Output (GPDO191)	8	RW	00h
13BDh	SIUL2 GPIO Pad Data Output (GPDO190)	8	RW	00h
13BEh	SIUL2 GPIO Pad Data Output (GPDO189)	8	RW	00h
13BFh	SIUL2 GPIO Pad Data Output (GPDO188)	8	RW	00h
13C0h	SIUL2 GPIO Pad Data Output (GPDO195)	8	RW	00h
13C1h	SIUL2 GPIO Pad Data Output (GPDO194)	8	RW	00h
13C2h	SIUL2 GPIO Pad Data Output (GPDO193)	8	RW	00h
13C3h	SIUL2 GPIO Pad Data Output (GPDO192)	8	RW	00h
13C4h	SIUL2 GPIO Pad Data Output (GPDO199)	8	RW	00h
13C5h	SIUL2 GPIO Pad Data Output (GPDO198)	8	RW	00h
13C6h	SIUL2 GPIO Pad Data Output (GPDO197)	8	RW	00h
13C7h	SIUL2 GPIO Pad Data Output (GPDO196)	8	RW	00h
13C8h	SIUL2 GPIO Pad Data Output (GPDO203)	8	RW	00h
13C9h	SIUL2 GPIO Pad Data Output (GPDO202)	8	RW	00h
13CAh	SIUL2 GPIO Pad Data Output (GPDO201)	8	RW	00h
13CBh	SIUL2 GPIO Pad Data Output (GPDO200)	8	RW	00h
13CCh	SIUL2 GPIO Pad Data Output (GPDO207)	8	RW	00h
13CDh	SIUL2 GPIO Pad Data Output (GPDO206)	8	RW	00h
13CEh	SIUL2 GPIO Pad Data Output (GPDO205)	8	RW	00h
13CFh	SIUL2 GPIO Pad Data Output (GPDO204)	8	RW	00h
13D0h	SIUL2 GPIO Pad Data Output (GPDO211)	8	RW	00h
13D1h	SIUL2 GPIO Pad Data Output (GPDO210)	8	RW	00h
13D2h	SIUL2 GPIO Pad Data Output (GPDO209)	8	RW	00h
13D3h	SIUL2 GPIO Pad Data Output (GPDO208)	8	RW	00h
13D4h	SIUL2 GPIO Pad Data Output (GPDO215)	8	RW	00h
13D5h	SIUL2 GPIO Pad Data Output (GPDO214)	8	RW	00h

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Offset	Register	Width (In bits)	Access	Reset value
13D6h	SIUL2 GPIO Pad Data Output (GPDO213)	8	RW	00h
13D7h	SIUL2 GPIO Pad Data Output (GPDO212)	8	RW	00h
13D8h	SIUL2 GPIO Pad Data Output (GPDO219)	8	RW	00h
13D9h	SIUL2 GPIO Pad Data Output (GPDO218)	8	RW	00h
13DAh	SIUL2 GPIO Pad Data Output (GPDO217)	8	RW	00h
13DBh	SIUL2 GPIO Pad Data Output (GPDO216)	8	RW	00h
13E4h	SIUL2 GPIO Pad Data Output (GPDO231)	8	RW	00h
13E8h	SIUL2 GPIO Pad Data Output (GPDO235)	8	RW	00h
13E9h	SIUL2 GPIO Pad Data Output (GPDO234)	8	RW	00h
13EAh	SIUL2 GPIO Pad Data Output (GPDO233)	8	RW	00h
13EBh	SIUL2 GPIO Pad Data Output (GPDO232)	8	RW	00h
13EFh	SIUL2 GPIO Pad Data Output (GPDO236)	8	RW	00h
1500h	SIUL2 GPIO Pad Data Input (GPDI3)	8	R	00h
1501h	SIUL2 GPIO Pad Data Input (GPDI2)	8	R	00h
1502h	SIUL2 GPIO Pad Data Input (GPDI1)	8	R	00h
1503h	SIUL2 GPIO Pad Data Input (GPDI0)	8	R	00h
1504h	SIUL2 GPIO Pad Data Input (GPDI7)	8	R	00h
1505h	SIUL2 GPIO Pad Data Input (GPDI6)	8	R	00h
1506h	SIUL2 GPIO Pad Data Input (GPDI5)	8	R	00h
1507h	SIUL2 GPIO Pad Data Input (GPDI4)	8	R	00h
1509h	SIUL2 GPIO Pad Data Input (GPDI10)	8	R	00h
150Ah	SIUL2 GPIO Pad Data Input (GPDI9)	8	R	00h
150Bh	SIUL2 GPIO Pad Data Input (GPDI8)	8	R	00h
150Ch	SIUL2 GPIO Pad Data Input (GPDI15)	8	R	00h
150Dh	SIUL2 GPIO Pad Data Input (GPDI14)	8	R	00h
1510h	SIUL2 GPIO Pad Data Input (GPDI19)	8	R	00h
1511h	SIUL2 GPIO Pad Data Input (GPDI18)	8	R	00h
1512h	SIUL2 GPIO Pad Data Input (GPDI17)	8	R	00h
1513h	SIUL2 GPIO Pad Data Input (GPDI16)	8	R	00h
1514h	SIUL2 GPIO Pad Data Input (GPDI23)	8	R	00h
1515h	SIUL2 GPIO Pad Data Input (GPDI22)	8	R	00h

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Offset	Register	Width (In bits)	Access	Reset value
1516h	SIUL2 GPIO Pad Data Input (GPDI21)	8	R	00h
1517h	SIUL2 GPIO Pad Data Input (GPDI20)	8	R	00h
1519h	SIUL2 GPIO Pad Data Input (GPDI26)	8	R	00h
151Ah	SIUL2 GPIO Pad Data Input (GPDI25)	8	R	00h
151Bh	SIUL2 GPIO Pad Data Input (GPDI24)	8	R	00h
151Ch	SIUL2 GPIO Pad Data Input (GPDI31)	8	R	00h
151Dh	SIUL2 GPIO Pad Data Input (GPDI30)	8	R	00h
151Eh	SIUL2 GPIO Pad Data Input (GPDI29)	8	R	00h
151Fh	SIUL2 GPIO Pad Data Input (GPDI28)	8	R	00h
1520h	SIUL2 GPIO Pad Data Input (GPDI35)	8	R	00h
1521h	SIUL2 GPIO Pad Data Input (GPDI34)	8	R	00h
1522h	SIUL2 GPIO Pad Data Input (GPDI33)	8	R	00h
1523h	SIUL2 GPIO Pad Data Input (GPDI32)	8	R	00h
1526h	SIUL2 GPIO Pad Data Input (GPDI37)	8	R	00h
1527h	SIUL2 GPIO Pad Data Input (GPDI36)	8	R	00h
1528h	SIUL2 GPIO Pad Data Input (GPDI43)	8	R	00h
1529h	SIUL2 GPIO Pad Data Input (GPDI42)	8	R	00h
152Ah	SIUL2 GPIO Pad Data Input (GPDI41)	8	R	00h
152Bh	SIUL2 GPIO Pad Data Input (GPDI40)	8	R	00h
152Ch	SIUL2 GPIO Pad Data Input (GPDI47)	8	R	00h
152Dh	SIUL2 GPIO Pad Data Input (GPDI46)	8	R	00h
152Eh	SIUL2 GPIO Pad Data Input (GPDI45)	8	R	00h
152Fh	SIUL2 GPIO Pad Data Input (GPDI44)	8	R	00h
1530h	SIUL2 GPIO Pad Data Input (GPDI51)	8	R	00h
1531h	SIUL2 GPIO Pad Data Input (GPDI50)	8	R	00h
1532h	SIUL2 GPIO Pad Data Input (GPDI49)	8	R	00h
1533h	SIUL2 GPIO Pad Data Input (GPDI48)	8	R	00h
1534h	SIUL2 GPIO Pad Data Input (GPDI55)	8	R	00h
1535h	SIUL2 GPIO Pad Data Input (GPDI54)	8	R	00h
1536h	SIUL2 GPIO Pad Data Input (GPDI53)	8	R	00h
1537h	SIUL2 GPIO Pad Data Input (GPDI52)	8	R	00h

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Offset	Register	Width (In bits)	Access	Reset value
1538h	SIUL2 GPIO Pad Data Input (GPDI59)	8	R	00h
1539h	SIUL2 GPIO Pad Data Input (GPDI58)	8	R	00h
153Ah	SIUL2 GPIO Pad Data Input (GPDI57)	8	R	00h
153Bh	SIUL2 GPIO Pad Data Input (GPDI56)	8	R	00h
153Eh	SIUL2 GPIO Pad Data Input (GPDI61)	8	R	00h
153Fh	SIUL2 GPIO Pad Data Input (GPDI60)	8	R	00h
1540h	SIUL2 GPIO Pad Data Input (GPDI67)	8	R	00h
1541h	SIUL2 GPIO Pad Data Input (GPDI66)	8	R	00h
1542h	SIUL2 GPIO Pad Data Input (GPDI65)	8	R	00h
1543h	SIUL2 GPIO Pad Data Input (GPDI64)	8	R	00h
1544h	SIUL2 GPIO Pad Data Input (GPDI71)	8	R	00h
1545h	SIUL2 GPIO Pad Data Input (GPDI70)	8	R	00h
1546h	SIUL2 GPIO Pad Data Input (GPDI69)	8	R	00h
1547h	SIUL2 GPIO Pad Data Input (GPDI68)	8	R	00h
1548h	SIUL2 GPIO Pad Data Input (GPDI75)	8	R	00h
1549h	SIUL2 GPIO Pad Data Input (GPDI74)	8	R	00h
154Ah	SIUL2 GPIO Pad Data Input (GPDI73)	8	R	00h
154Bh	SIUL2 GPIO Pad Data Input (GPDI72)	8	R	00h
154Ch	SIUL2 GPIO Pad Data Input (GPDI79)	8	R	00h
154Dh	SIUL2 GPIO Pad Data Input (GPDI78)	8	R	00h
154Eh	SIUL2 GPIO Pad Data Input (GPDI77)	8	R	00h
154Fh	SIUL2 GPIO Pad Data Input (GPDI76)	8	R	00h
1550h	SIUL2 GPIO Pad Data Input (GPDI83)	8	R	00h
1551h	SIUL2 GPIO Pad Data Input (GPDI82)	8	R	00h
1552h	SIUL2 GPIO Pad Data Input (GPDI81)	8	R	00h
1553h	SIUL2 GPIO Pad Data Input (GPDI80)	8	R	00h
1554h	SIUL2 GPIO Pad Data Input (GPDI87)	8	R	00h
1556h	SIUL2 GPIO Pad Data Input (GPDI85)	8	R	00h
1557h	SIUL2 GPIO Pad Data Input (GPDI84)	8	R	00h
1558h	SIUL2 GPIO Pad Data Input (GPDI91)	8	R	00h
1559h	SIUL2 GPIO Pad Data Input (GPDI90)	8	R	00h

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Offset	Register	Width (In bits)	Access	Reset value
155Ah	SIUL2 GPIO Pad Data Input (GPDI89)	8	R	00h
155Bh	SIUL2 GPIO Pad Data Input (GPDI88)	8	R	00h
155Ch	SIUL2 GPIO Pad Data Input (GPDI95)	8	R	00h
155Dh	SIUL2 GPIO Pad Data Input (GPDI94)	8	R	00h
155Eh	SIUL2 GPIO Pad Data Input (GPDI93)	8	R	00h
155Fh	SIUL2 GPIO Pad Data Input (GPDI92)	8	R	00h
1560h	SIUL2 GPIO Pad Data Input (GPDI99)	8	R	00h
1561h	SIUL2 GPIO Pad Data Input (GPDI98)	8	R	00h
1562h	SIUL2 GPIO Pad Data Input (GPDI97)	8	R	00h
1563h	SIUL2 GPIO Pad Data Input (GPDI96)	8	R	00h
1564h	SIUL2 GPIO Pad Data Input (GPDI103)	8	R	00h
1565h	SIUL2 GPIO Pad Data Input (GPDI102)	8	R	00h
1566h	SIUL2 GPIO Pad Data Input (GPDI101)	8	R	00h
1567h	SIUL2 GPIO Pad Data Input (GPDI100)	8	R	00h
1568h	SIUL2 GPIO Pad Data Input (GPDI107)	8	R	00h
1569h	SIUL2 GPIO Pad Data Input (GPDI106)	8	R	00h
156Ah	SIUL2 GPIO Pad Data Input (GPDI105)	8	R	00h
156Bh	SIUL2 GPIO Pad Data Input (GPDI104)	8	R	00h
156Ch	SIUL2 GPIO Pad Data Input (GPDI111)	8	R	00h
156Dh	SIUL2 GPIO Pad Data Input (GPDI110)	8	R	00h
156Eh	SIUL2 GPIO Pad Data Input (GPDI109)	8	R	00h
156Fh	SIUL2 GPIO Pad Data Input (GPDI108)	8	R	00h
1570h	SIUL2 GPIO Pad Data Input (GPDI115)	8	R	00h
1571h	SIUL2 GPIO Pad Data Input (GPDI114)	8	R	00h
1572h	SIUL2 GPIO Pad Data Input (GPDI113)	8	R	00h
1573h	SIUL2 GPIO Pad Data Input (GPDI112)	8	R	00h
1574h	SIUL2 GPIO Pad Data Input (GPDI119)	8	R	00h
1575h	SIUL2 GPIO Pad Data Input (GPDI118)	8	R	00h
1576h	SIUL2 GPIO Pad Data Input (GPDI117)	8	R	00h
1577h	SIUL2 GPIO Pad Data Input (GPDI116)	8	R	00h
1578h	SIUL2 GPIO Pad Data Input (GPDI123)	8	R	00h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
1579h	SIUL2 GPIO Pad Data Input (GPDI122)	8	R	00h
157Ah	SIUL2 GPIO Pad Data Input (GPDI121)	8	R	00h
157Bh	SIUL2 GPIO Pad Data Input (GPDI120)	8	R	00h
157Ch	SIUL2 GPIO Pad Data Input (GPDI127)	8	R	00h
157Dh	SIUL2 GPIO Pad Data Input (GPDI126)	8	R	00h
157Eh	SIUL2 GPIO Pad Data Input (GPDI125)	8	R	00h
157Fh	SIUL2 GPIO Pad Data Input (GPDI124)	8	R	00h
1581h	SIUL2 GPIO Pad Data Input (GPDI130)	8	R	00h
1582h	SIUL2 GPIO Pad Data Input (GPDI129)	8	R	00h
1583h	SIUL2 GPIO Pad Data Input (GPDI128)	8	R	00h
1584h	SIUL2 GPIO Pad Data Input (GPDI135)	8	R	00h
1585h	SIUL2 GPIO Pad Data Input (GPDI134)	8	R	00h
1586h	SIUL2 GPIO Pad Data Input (GPDI133)	8	R	00h
1587h	SIUL2 GPIO Pad Data Input (GPDI132)	8	R	00h
1588h	SIUL2 GPIO Pad Data Input (GPDI139)	8	R	00h
1589h	SIUL2 GPIO Pad Data Input (GPDI138)	8	R	00h
158Ah	SIUL2 GPIO Pad Data Input (GPDI137)	8	R	00h
158Bh	SIUL2 GPIO Pad Data Input (GPDI136)	8	R	00h
158Ch	SIUL2 GPIO Pad Data Input (GPDI143)	8	R	00h
158Dh	SIUL2 GPIO Pad Data Input (GPDI142)	8	R	00h
158Fh	SIUL2 GPIO Pad Data Input (GPDI140)	8	R	00h
1590h	SIUL2 GPIO Pad Data Input (GPDI147)	8	R	00h
1591h	SIUL2 GPIO Pad Data Input (GPDI146)	8	R	00h
1592h	SIUL2 GPIO Pad Data Input (GPDI145)	8	R	00h
1593h	SIUL2 GPIO Pad Data Input (GPDI144)	8	R	00h
1594h	SIUL2 GPIO Pad Data Input (GPDI151)	8	R	00h
1596h	SIUL2 GPIO Pad Data Input (GPDI149)	8	R	00h
1597h	SIUL2 GPIO Pad Data Input (GPDI148)	8	R	00h
1598h	SIUL2 GPIO Pad Data Input (GPDI155)	8	R	00h
1599h	SIUL2 GPIO Pad Data Input (GPDI154)	8	R	00h
159Ch	SIUL2 GPIO Pad Data Input (GPDI159)	8	R	00h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
159Dh	SIUL2 GPIO Pad Data Input (GPDI158)	8	R	00h
159Eh	SIUL2 GPIO Pad Data Input (GPDI157)	8	R	00h
159Fh	SIUL2 GPIO Pad Data Input (GPDI156)	8	R	00h
15A0h	SIUL2 GPIO Pad Data Input (GPDI163)	8	R	00h
15A1h	SIUL2 GPIO Pad Data Input (GPDI162)	8	R	00h
15A2h	SIUL2 GPIO Pad Data Input (GPDI161)	8	R	00h
15A3h	SIUL2 GPIO Pad Data Input (GPDI160)	8	R	00h
15A4h	SIUL2 GPIO Pad Data Input (GPDI167)	8	R	00h
15A5h	SIUL2 GPIO Pad Data Input (GPDI166)	8	R	00h
15A6h	SIUL2 GPIO Pad Data Input (GPDI165)	8	R	00h
15A7h	SIUL2 GPIO Pad Data Input (GPDI164)	8	R	00h
15A8h	SIUL2 GPIO Pad Data Input (GPDI171)	8	R	00h
15A9h	SIUL2 GPIO Pad Data Input (GPDI170)	8	R	00h
15AAh	SIUL2 GPIO Pad Data Input (GPDI169)	8	R	00h
15ABh	SIUL2 GPIO Pad Data Input (GPDI168)	8	R	00h
15ACh	SIUL2 GPIO Pad Data Input (GPDI175)	8	R	00h
15ADh	SIUL2 GPIO Pad Data Input (GPDI174)	8	R	00h
15AEh	SIUL2 GPIO Pad Data Input (GPDI173)	8	R	00h
15AFh	SIUL2 GPIO Pad Data Input (GPDI172)	8	R	00h
15B0h	SIUL2 GPIO Pad Data Input (GPDI179)	8	R	00h
15B1h	SIUL2 GPIO Pad Data Input (GPDI178)	8	R	00h
15B2h	SIUL2 GPIO Pad Data Input (GPDI177)	8	R	00h
15B3h	SIUL2 GPIO Pad Data Input (GPDI176)	8	R	00h
15B4h	SIUL2 GPIO Pad Data Input (GPDI183)	8	R	00h
15B6h	SIUL2 GPIO Pad Data Input (GPDI181)	8	R	00h
15B7h	SIUL2 GPIO Pad Data Input (GPDI180)	8	R	00h
15B8h	SIUL2 GPIO Pad Data Input (GPDI187)	8	R	00h
15B9h	SIUL2 GPIO Pad Data Input (GPDI186)	8	R	00h
15BAh	SIUL2 GPIO Pad Data Input (GPDI185)	8	R	00h
15BBh	SIUL2 GPIO Pad Data Input (GPDI184)	8	R	00h
15BCh	SIUL2 GPIO Pad Data Input (GPDI191)	8	R	00h

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Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
15BDh	SIUL2 GPIO Pad Data Input (GPDI190)	8	R	00h
15BEh	SIUL2 GPIO Pad Data Input (GPDI189)	8	R	00h
15BFh	SIUL2 GPIO Pad Data Input (GPDI188)	8	R	00h
15C0h	SIUL2 GPIO Pad Data Input (GPDI195)	8	R	00h
15C1h	SIUL2 GPIO Pad Data Input (GPDI194)	8	R	00h
15C2h	SIUL2 GPIO Pad Data Input (GPDI193)	8	R	00h
15C3h	SIUL2 GPIO Pad Data Input (GPDI192)	8	R	00h
15C4h	SIUL2 GPIO Pad Data Input (GPDI199)	8	R	00h
15C5h	SIUL2 GPIO Pad Data Input (GPDI198)	8	R	00h
15C6h	SIUL2 GPIO Pad Data Input (GPDI197)	8	R	00h
15C7h	SIUL2 GPIO Pad Data Input (GPDI196)	8	R	00h
15C8h	SIUL2 GPIO Pad Data Input (GPDI203)	8	R	00h
15C9h	SIUL2 GPIO Pad Data Input (GPDI202)	8	R	00h
15CAh	SIUL2 GPIO Pad Data Input (GPDI201)	8	R	00h
15CBh	SIUL2 GPIO Pad Data Input (GPDI200)	8	R	00h
15CCh	SIUL2 GPIO Pad Data Input (GPDI207)	8	R	00h
15CDh	SIUL2 GPIO Pad Data Input (GPDI206)	8	R	00h
15CEh	SIUL2 GPIO Pad Data Input (GPDI205)	8	R	00h
15CFh	SIUL2 GPIO Pad Data Input (GPDI204)	8	R	00h
15D0h	SIUL2 GPIO Pad Data Input (GPDI211)	8	R	00h
15D1h	SIUL2 GPIO Pad Data Input (GPDI210)	8	R	00h
15D2h	SIUL2 GPIO Pad Data Input (GPDI209)	8	R	00h
15D3h	SIUL2 GPIO Pad Data Input (GPDI208)	8	R	00h
15D4h	SIUL2 GPIO Pad Data Input (GPDI215)	8	R	00h
15D5h	SIUL2 GPIO Pad Data Input (GPDI214)	8	R	00h
15D6h	SIUL2 GPIO Pad Data Input (GPDI213)	8	R	00h
15D7h	SIUL2 GPIO Pad Data Input (GPDI212)	8	R	00h
15D8h	SIUL2 GPIO Pad Data Input (GPDI219)	8	R	00h
15D9h	SIUL2 GPIO Pad Data Input (GPDI218)	8	R	00h
15DAh	SIUL2 GPIO Pad Data Input (GPDI217)	8	R	00h
15DBh	SIUL2 GPIO Pad Data Input (GPDI216)	8	R	00h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
15E4h	SIUL2 GPIO Pad Data Input (GPDI231)	8	R	00h
15E8h	SIUL2 GPIO Pad Data Input (GPDI235)	8	R	00h
15E9h	SIUL2 GPIO Pad Data Input (GPDI234)	8	R	00h
15EAh	SIUL2 GPIO Pad Data Input (GPDI233)	8	R	00h
15EBh	SIUL2 GPIO Pad Data Input (GPDI232)	8	R	00h
15EFh	SIUL2 GPIO Pad Data Input (GPDI236)	8	R	00h
1700h	SIUL2 Parallel GPIO Pad Data Out (PGPDO1)	16	RW	0000h
1702h	SIUL2 Parallel GPIO Pad Data Out (PGPDO0)	16	RW	0000h
1704h	SIUL2 Parallel GPIO Pad Data Out (PGPDO3)	16	RW	0000h
1706h	SIUL2 Parallel GPIO Pad Data Out (PGPDO2)	16	RW	0000h
1708h	SIUL2 Parallel GPIO Pad Data Out (PGPDO5)	16	RW	0000h
170Ah - 170Eh	SIUL2 Parallel GPIO Pad Data Out (PGPDO4 - PGPDO7) [1]	16	RW	0000h
1710h	SIUL2 Parallel GPIO Pad Data Out (PGPDO9)	16	RW	0000h
1712h	SIUL2 Parallel GPIO Pad Data Out (PGPDO8)	16	RW	0000h
1714h	SIUL2 Parallel GPIO Pad Data Out (PGPDO11)	16	RW	0000h
1716h	SIUL2 Parallel GPIO Pad Data Out (PGPDO10)	16	RW	0000h
1718h	SIUL2 Parallel GPIO Pad Data Out (PGPDO13)	16	RW	0000h
171Ah	SIUL2 Parallel GPIO Pad Data Out (PGPDO12)	16	RW	0000h
171Eh	SIUL2 Parallel GPIO Pad Data Out (PGPDO14)	16	RW	0000h
1740h	SIUL2 Parallel GPIO Pad Data In (PGPDI1)	16	R	0000h
1742h	SIUL2 Parallel GPIO Pad Data In (PGPDI0)	16	R	0000h
1744h	SIUL2 Parallel GPIO Pad Data In (PGPDI3)	16	R	0000h
1746h	SIUL2 Parallel GPIO Pad Data In (PGPDI2)	16	R	0000h
1748h	SIUL2 Parallel GPIO Pad Data In (PGPDI5)	16	R	0000h
174Ah - 174Eh	SIUL2 Parallel GPIO Pad Data In (PGPDI4 - PGPDI7) [1]	16	R	0000h
1750h	SIUL2 Parallel GPIO Pad Data In (PGPDI9)	16	R	0000h
1752h	SIUL2 Parallel GPIO Pad Data In (PGPDI8)	16	R	0000h
1754h	SIUL2 Parallel GPIO Pad Data In (PGPDI11)	16	R	0000h
1756h	SIUL2 Parallel GPIO Pad Data In (PGPDI10)	16	R	0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
1758h	SIUL2 Parallel GPIO Pad Data In (PGPDI13)	16	R	0000h
175Ah	SIUL2 Parallel GPIO Pad Data In (PGPDI12)	16	R	0000h
175Eh	SIUL2 Parallel GPIO Pad Data In (PGPDI14)	16	R	0000h
1780h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO0)	32	W	0000_0000h
1784h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO1)	32	W	0000_0000h
1788h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO2)	32	W	0000_0000h
178Ch	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO3)	32	W	0000_0000h
1790h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO4)	32	W	0000_0000h
1794h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO5)	32	W	0000_0000h
1798h - 179Ch	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO6 - MPGPDO7)	32	W	0000_0000h
17A0h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO8)	32	W	0000_0000h
17A4h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO9)	32	W	0000_0000h
17A8h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO10)	32	W	0000_0000h
17ACh	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO11)	32	W	0000_0000h
17B0h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO12)	32	W	0000_0000h
17B4h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO13)	32	W	0000_0000h
17B8h	SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO14)	32	W	0000_0000h

1. In this array, the index and offset values of the registers do not increment in direct alignment. For details, see the register description.

10.6.2 SIUL2 MCU ID Register #1 (MIDR1)

Offset

Register	Offset
MIDR1	4h

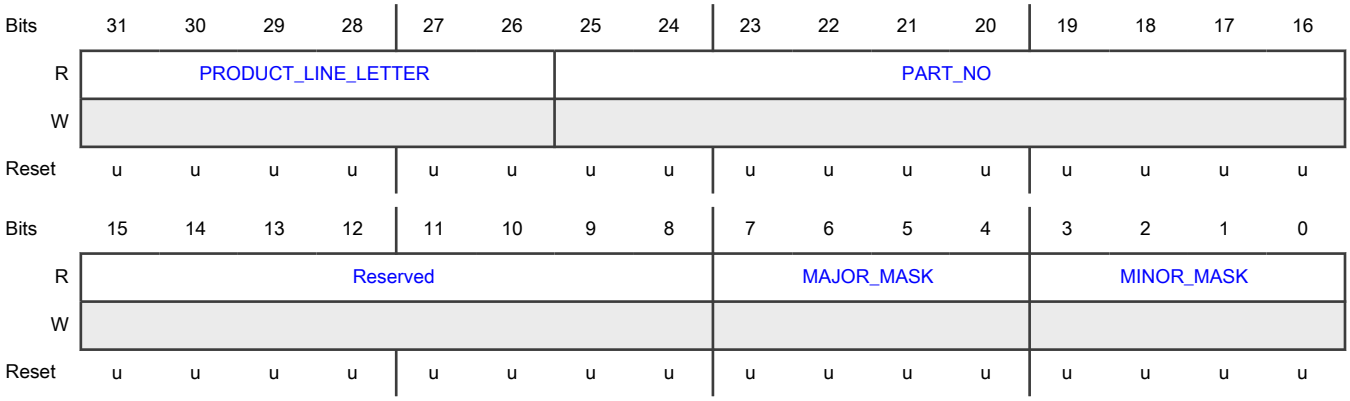
Function

This register holds identification information about the device.

NOTE

This register supports only 32-bit accesses. Byte and half-word accesses are not supported.

Diagram



Fields

Field	Function
31-26 PRODUCT_LINE_LETTER	Product Line Letter Identified the ASCII character in MCU Part Number. This field specifies the part number suffix, and needs to be combined with MIDR1[PART_NO] to provide the full chip number. 0x0B K This value is set at the factory and cannot be changed. All other values are reserved.
25-16 PART_NO	MCU Part Number S32K364 - 0x16C S32K366 - 0x16E S32K374 - 0x176 S32K376 - 0x178 S32K394 - 0x18A S32K396 - 0x18C
15-8 —	Reserved
7-4 MAJOR_MASK	Major Mask Revision
3-0 MINOR_MASK	Minor Mask Revision

10.6.3 SIUL2 MCU ID Register #2 (MIDR2)

Offset

Register	Offset
MIDR2	8h

Function

NOTE

This register supports only 32-bit accesses. Byte and half-word accesses are not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TECHNOLOGY				TEMPERATURE				PACKAGE				FREQUENCY			
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	FLASH_CODE		FLASH_DATA		FLASH_SIZE_DATA				FLASH_SIZE_CODE							
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-29 TECHNOLOGY	Technology Identifies the silicon technology. 001b - C40EFS3
28-26 TEMPERATURE	Temperature Identifies the ambient temperature range. 010b - V = 105C 100b - M = 125C
25-20 PACKAGE	Package This field can by read by software to determine the package type that is used for the particular device. 00_0100b - 289-MAPBGA 11_0100b - 176-LQFP_EP
19-16	Frequency

Table continues on the next page...

Table continued from the previous page...

Field	Function
FREQUENCY	Identifies maximum core frequency. Qualified by Product Line Letter to provide wider range of frequencies. 0100b - 160 MHz 0101b - 240 MHz 0110b - 320 MHz
15-14 FLASH_CODE	Flash Code Identifies the location of Code Flash, if any, within the package. 10b - Monolithic
13-12 FLASH_DATA	Flash Data Identifies the location of Data Flash, if any, within the package. 10b - Monolithic
11-8 FLASH_SIZE_DATA	Flash Size Data Identifies the Flash (EE) memory size. 0001b - 128KB
7-0 FLASH_SIZE_CODE	Flash Size Code Identifies the Flash (code) memory size. 0001_0000b - 4.00MB 0001_1000b - 6.00MB

10.6.4 SIUL2 DMA/Interrupt Status Flag 0 (DISR0)

Offset

Register	Offset
DISR0	10h

Function

Contains flag bits that record an event on the external IRQ pins. When an event as defined in IREER0 and IFEER0 occurs, the corresponding flag bit is set. The IRQ flag bit is set regardless of the state of the corresponding DIRER0[EIRE*n*] field. The IRQ flag bit remains set until you write 0 to it or the servicing of a DMA request writes a 0 to the field. The IRQ flag bits are cleared by writing a 1 to the bits. A write of 0 has no effect.

This register supports 8-, 16-, and 32-bit accesses.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EIF31	EIF30	EIF29	EIF28	EIF27	EIF26	EIF25	EIF24	EIF23	EIF22	EIF21	EIF20	EIF19	EIF18	EIF17	EIF16
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	EIF15	EIF14	EIF13	EIF12	EIF11	EIF10	EIF9	EIF8	EIF7	EIF6	EIF5	EIF4	EIF3	EIF2	EIF1	EIF0
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EIF31	External Interrupt Status Flag 31 If enabled (DIRERR31 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER31 and IFEER31 has occurred.
30 EIF30	External Interrupt Status Flag 30 If enabled (DIRERR30 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER30 and IFEER30 has occurred.
29 EIF29	External Interrupt Status Flag 29 If enabled (DIRERR29 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER29 and IFEER29 has occurred.
28 EIF28	External Interrupt Status Flag 28 If enabled (DIRERR28 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER28 and IFEER28 has occurred.
27 EIF27	External Interrupt Status Flag 27 If enabled (DIRERR27 = 1) causes an interrupt.

Table continues on the next page...

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Field	Function
	This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER27 and IFEER27 has occurred.
26 EIF26	External Interrupt Status Flag 26 If enabled (DIRERR26 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER26 and IFEER26 has occurred.
25 EIF25	External Interrupt Status Flag 25 If enabled (DIRERR25 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER25 and IFEER25 has occurred.
24 EIF24	External Interrupt Status Flag 24 If enabled (DIRERR24 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER24 and IFEER24 has occurred.
23 EIF23	External Interrupt Status Flag 23 If enabled (DIRERR23 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER23 and IFEER23 has occurred.
22 EIF22	External Interrupt Status Flag 22 If enabled (DIRERR22 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER22 and IFEER22 has occurred.
21 EIF21	External Interrupt Status Flag 21 If enabled (DIRERR21 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER21 and IFEER21 has occurred.
20 EIF20	External Interrupt Status Flag 20 If enabled (DIRERR20 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER20 and IFEER20 has occurred.
19 EIF19	External Interrupt Status Flag 19 If enabled (DIRERR19 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER19 and IFEER19 has occurred.
18 EIF18	External Interrupt Status Flag 18 If enabled (DIRERR18 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER18 and IFEER18 has occurred.
17 EIF17	External Interrupt Status Flag 17 If enabled (DIRERR17 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER17 and IFEER17 has occurred.
16 EIF16	External Interrupt Status Flag 16 If enabled (DIRERR16 = 1) causes an interrupt. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER16 and IFEER16 has occurred.
15 EIF15	External Interrupt Status Flag 15 If enabled (DIRERR15 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad.

Table continues on the next page...

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Field	Function
	1b - An interrupt event as defined by IREER15 and IFEER15 has occurred.
14 EIF14	External Interrupt Status Flag 14 If enabled (DIRERR14 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER14 and IFEER14 has occurred.
13 EIF13	External Interrupt Status Flag 13 If enabled (DIRERR13 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER13 and IFEER13 has occurred.
12 EIF12	External Interrupt Status Flag 12 If enabled (DIRERR12 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER12 and IFEER12 has occurred.
11 EIF11	External Interrupt Status Flag 11 If enabled (DIRERR11 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER11 and IFEER11 has occurred.
10 EIF10	External Interrupt Status Flag 10 If enabled (DIRERR10 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER10 and IFEER10 has occurred.
9 EIF9	External Interrupt Status Flag 9 If enabled (DIRERR9 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER9 and IFEER9 has occurred.

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Field	Function
8 EIF8	External Interrupt Status Flag 8 If enabled (DIRERR8 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER8 and IFEER8 has occurred.
7 EIF7	External Interrupt Status Flag 7 If enabled (DIRERR7 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER7 and IFEER7 has occurred.
6 EIF6	External Interrupt Status Flag 6 If enabled (DIRERR6 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER6 and IFEER6 has occurred.
5 EIF5	External Interrupt Status Flag 5 If enabled (DIRERR5 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER5 and IFEER5 has occurred.
4 EIF4	External Interrupt Status Flag 4 If enabled (DIRERR4 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER4 and IFEER4 has occurred.
3 EIF3	External Interrupt Status Flag 3 If enabled (DIRERR3 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER3 and IFEER3 has occurred.
2	External Interrupt Status Flag 2 If enabled (DIRERR2 = 1) causes an interrupt or DMA request.

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Field	Function
EIF2	This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER2 and IFEER2 has occurred.
1 EIF1	External Interrupt Status Flag 1 If enabled (DIRERR1 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER1 and IFEER1 has occurred.
0 EIF0	External Interrupt Status Flag 0 If enabled (DIRERR0 = 1) causes an interrupt or DMA request. This flag can be cleared only by writing 1. Writing 0 has no effect. 0b - No interrupt event has occurred on the pad. 1b - An interrupt event as defined by IREER0 and IFEER0 has occurred.

10.6.5 SIUL2 DMA/Interrupt Request Enable 0 (DIRER0)

Offset

Register	Offset
DIRER0	18h

Function

Enables the assertion of DMA or interrupt request to the interrupt controller if the corresponding DISR0[EIF*n*] bit is set. The type of request is determined by the corresponding DIRSR0[DIRSR*n*] bit.

This register supports 8-, 16-, and 32-bit accesses.

NOTE

Once DIRSR0 selects a DMA request, you cannot enable or disable it.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	EIRE31	EIRE30	EIRE29	EIRE28	EIRE27	EIRE26	EIRE25	EIRE24	EIRE23	EIRE22	EIRE21	EIRE20	EIRE19	EIRE18	EIRE17	EIRE16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	EIRE15	EIRE14	EIRE13	EIRE12	EIRE11	EIRE10	EIRE9	EIRE8	EIRE7	EIRE6	EIRE5	EIRE4	EIRE3	EIRE2	EIRE1	EIRE0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EIRE31	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
30 EIRE30	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
29 EIRE29	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
28 EIRE28	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
27 EIRE27	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
26 EIRE26	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin.

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Field	Function
	0b - Disabled 1b - Enabled
25 EIRE25	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
24 EIRE24	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
23 EIRE23	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
22 EIRE22	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
21 EIRE21	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
20 EIRE20	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
19 EIRE19	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
18	External Interrupt Request Enable

Table continues on the next page...

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Field	Function
EIRE18	Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
17 EIRE17	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
16 EIRE16	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
15 EIRE15	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
14 EIRE14	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
13 EIRE13	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
12 EIRE12	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
11 EIRE11	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled

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Field	Function
10 EIRE10	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
9 EIRE9	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
8 EIRE8	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
7 EIRE7	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
6 EIRE6	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
5 EIRE5	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
4 EIRE4	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
3 EIRE3	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled

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Field	Function
	1b - Enabled
2 EIRE2	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
1 EIRE1	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled
0 EIRE0	External Interrupt Request Enable Enables or disables interrupt requests from the corresponding pin. 0b - Disabled 1b - Enabled

10.6.6 SIUL2 DMA/Interrupt Request Select 0 (DIRSR0)

Offset

Register	Offset
DIRSR0	20h

Function

Selects between the DMA or interrupt request. The DIRSR0[DIRSR*n*] bit determines whether DMA or an interrupt request asserts the corresponding DISR0[EIF*n*] bit.

This register supports 8-, 16-, and 32-bit accesses.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	DIRSR 31	DIRSR 30	DIRSR 29	DIRSR 28	DIRSR 27	DIRSR 26	DIRSR 25	DIRSR 24	DIRSR 23	DIRSR 22	DIRSR 21	DIRSR 20	DIRSR 19	DIRSR 18	DIRSR 17	DIRSR 16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DIRSR 15	DIRSR 14	DIRSR 13	DIRSR 12	DIRSR 11	DIRSR 10	DIRSR 9	DIRSR 8	DIRSR 7	DIRSR 6	DIRSR 5	DIRSR 4	DIRSR 3	DIRSR 2	DIRSR 1	DIRSR 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DIRSR31	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
30 DIRSR30	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
29 DIRSR29	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
28 DIRSR28	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
27 DIRSR27	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
26 DIRSR26	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
25 DIRSR25	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin.

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Field	Function
	0b - Interrupt request 1b - Reserved
24 DIRSR24	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
23 DIRSR23	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
22 DIRSR22	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
21 DIRSR21	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
20 DIRSR20	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
19 DIRSR19	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
18	DMA/Interrupt Request Select Register

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Field	Function
DIRSR18	Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
17 DIRSR17	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
16 DIRSR16	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - Reserved
15 DIRSR15	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
14 DIRSR14	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
13 DIRSR13	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
12 DIRSR12	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request

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Field	Function
11 DIRSR11	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
10 DIRSR10	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
9 DIRSR9	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
8 DIRSR8	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
7 DIRSR7	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
6 DIRSR6	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
5 DIRSR5	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin.

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Field	Function
	0b - Interrupt request 1b - DMA request
4 DIRSR4	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
3 DIRSR3	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
2 DIRSR2	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
1 DIRSR1	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request
0 DIRSR0	DMA/Interrupt Request Select Register Selects between DMA request or external interrupt request when an edge-triggered event occurs on the corresponding pin. 0b - Interrupt request 1b - DMA request

10.6.7 SIUL2 Interrupt Rising-Edge Event Enable 0 (IREER0)

Offset

Register	Offset
IREER0	28h

Function

Enables the rising-edge triggered events on the corresponding interrupt pads.

This register supports 8-, 16-, and 32-bit accesses.

NOTE

If both the IREE and IFEE bits are cleared for the same interrupt source, the interrupt status flag for the corresponding external interrupt will never be set.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	IREE31	IREE30	IREE29	IREE28	IREE27	IREE26	IREE25	IREE24	IREE23	IREE22	IREE21	IREE20	IREE19	IREE18	IREE17	IREE16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	IREE15	IREE14	IREE13	IREE12	IREE11	IREE10	IREE9	IREE8	IREE7	IREE6	IREE5	IREE4	IREE3	IREE2	IREE1	IREE0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 IREE31	Enables rising-edge events to set DISR0[EIF31]. 0b - Disabled 1b - Enabled
30 IREE30	Enables rising-edge events to set DISR0[EIF30]. 0b - Disabled 1b - Enabled
29 IREE29	Enables rising-edge events to set DISR0[EIF29]. 0b - Disabled 1b - Enabled
28 IREE28	Enables rising-edge events to set DISR0[EIF28]. 0b - Disabled 1b - Enabled
27 IREE27	Enables rising-edge events to set DISR0[EIF27]. 0b - Disabled 1b - Enabled
26	Enables rising-edge events to set DISR0[EIF26].

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Field	Function
IREE26	0b - Disabled 1b - Enabled
25 IREE25	Enables rising-edge events to set DISR0[EIF25]. 0b - Disabled 1b - Enabled
24 IREE24	Enables rising-edge events to set DISR0[EIF24]. 0b - Disabled 1b - Enabled
23 IREE23	Enables rising-edge events to set DISR0[EIF23]. 0b - Disabled 1b - Enabled
22 IREE22	Enables rising-edge events to set DISR0[EIF22]. 0b - Disabled 1b - Enabled
21 IREE21	Enables rising-edge events to set DISR0[EIF21]. 0b - Disabled 1b - Enabled
20 IREE20	Enables rising-edge events to set DISR0[EIF20]. 0b - Disabled 1b - Enabled
19 IREE19	Enables rising-edge events to set DISR0[EIF19]. 0b - Disabled 1b - Enabled
18 IREE18	Enables rising-edge events to set DISR0[EIF18]. 0b - Disabled 1b - Enabled
17 IREE17	Enables rising-edge events to set DISR0[EIF17]. 0b - Disabled 1b - Enabled
16 IREE16	Enables rising-edge events to set DISR0[EIF16]. 0b - Disabled 1b - Enabled

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Field	Function
15 IREE15	Enables rising-edge events to set DISR0[EIF15]. 0b - Disabled 1b - Enabled
14 IREE14	Enables rising-edge events to set DISR0[EIF14]. 0b - Disabled 1b - Enabled
13 IREE13	Enables rising-edge events to set DISR0[EIF13]. 0b - Disabled 1b - Enabled
12 IREE12	Enables rising-edge events to set DISR0[EIF12]. 0b - Disabled 1b - Enabled
11 IREE11	Enables rising-edge events to set DISR0[EIF11]. 0b - Disabled 1b - Enabled
10 IREE10	Enables rising-edge events to set DISR0[EIF10]. 0b - Disabled 1b - Enabled
9 IREE9	Enables rising-edge events to set DISR0[EIF9]. 0b - Disabled 1b - Enabled
8 IREE8	Enables rising-edge events to set DISR0[EIF8]. 0b - Disabled 1b - Enabled
7 IREE7	Enables rising-edge events to set DISR0[EIF7]. 0b - Disabled 1b - Enabled
6 IREE6	Enables rising-edge events to set DISR0[EIF6]. 0b - Disabled 1b - Enabled
5 IREE5	Enables rising-edge events to set DISR0[EIF5].

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Field	Function
	0b - Disabled 1b - Enabled
4 IREE4	Enables rising-edge events to set DISR0[EIF4]. 0b - Disabled 1b - Enabled
3 IREE3	Enables rising-edge events to set DISR0[EIF3]. 0b - Disabled 1b - Enabled
2 IREE2	Enables rising-edge events to set DISR0[EIF2]. 0b - Disabled 1b - Enabled
1 IREE1	Enables rising-edge events to set DISR0[EIF1]. 0b - Disabled 1b - Enabled
0 IREE0	Enables rising-edge events to set DISR0[EIF0]. 0b - Disabled 1b - Enabled

10.6.8 SIUL2 Interrupt Falling-Edge Event Enable 0 (IFEER0)

Offset

Register	Offset
IFEER0	30h

Function

Enables falling-edge triggered events on the corresponding interrupt pads.

This register supports 8-, 16-, and 32-bit accesses.

NOTE

If both the IREE and IFEE bits are cleared for the same interrupt source, the interrupt status flag for the corresponding external interrupt will never be set.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	IFEE31	IFEE30	IFEE29	IFEE28	IFEE27	IFEE26	IFEE25	IFEE24	IFEE23	IFEE22	IFEE21	IFEE20	IFEE19	IFEE18	IFEE17	IFEE16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	IFEE15	IFEE14	IFEE13	IFEE12	IFEE11	IFEE10	IFEE9	IFEE8	IFEE7	IFEE6	IFEE5	IFEE4	IFEE3	IFEE2	IFEE1	IFEE0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 IFEE31	Enables falling-edge events to set DISR0[EIF31]. 0b - Disabled 1b - Enabled
30 IFEE30	Enables falling-edge events to set DISR0[EIF30]. 0b - Disabled 1b - Enabled
29 IFEE29	Enables falling-edge events to set DISR0[EIF29]. 0b - Disabled 1b - Enabled
28 IFEE28	Enables falling-edge events to set DISR0[EIF28]. 0b - Disabled 1b - Enabled
27 IFEE27	Enables falling-edge events to set DISR0[EIF27]. 0b - Disabled 1b - Enabled
26 IFEE26	Enables falling-edge events to set DISR0[EIF26]. 0b - Disabled 1b - Enabled
25 IFEE25	Enables falling-edge events to set DISR0[EIF25]. 0b - Disabled 1b - Enabled
24	Enables falling-edge events to set DISR0[EIF24].

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Field	Function
IFEE24	0b - Disabled 1b - Enabled
23 IFEE23	Enables falling-edge events to set DISR0[EIF23]. 0b - Disabled 1b - Enabled
22 IFEE22	Enables falling-edge events to set DISR0[EIF22]. 0b - Disabled 1b - Enabled
21 IFEE21	Enables falling-edge events to set DISR0[EIF21]. 0b - Disabled 1b - Enabled
20 IFEE20	Enables falling-edge events to set DISR0[EIF20]. 0b - Disabled 1b - Enabled
19 IFEE19	Enables falling-edge events to set DISR0[EIF19]. 0b - Disabled 1b - Enabled
18 IFEE18	Enables falling-edge events to set DISR0[EIF18]. 0b - Disabled 1b - Enabled
17 IFEE17	Enables falling-edge events to set DISR0[EIF17]. 0b - Disabled 1b - Enabled
16 IFEE16	Enables falling-edge events to set DISR0[EIF16]. 0b - Disabled 1b - Enabled
15 IFEE15	Enables falling-edge events to set DISR0[EIF15]. 0b - Disabled 1b - Enabled
14 IFEE14	Enables falling-edge events to set DISR0[EIF14]. 0b - Disabled 1b - Enabled

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Field	Function
13 IFEE13	Enables falling-edge events to set DISR0[EIF13]. 0b - Disabled 1b - Enabled
12 IFEE12	Enables falling-edge events to set DISR0[EIF12]. 0b - Disabled 1b - Enabled
11 IFEE11	Enables falling-edge events to set DISR0[EIF11]. 0b - Disabled 1b - Enabled
10 IFEE10	Enables falling-edge events to set DISR0[EIF10]. 0b - Disabled 1b - Enabled
9 IFEE9	Enables falling-edge events to set DISR0[EIF9]. 0b - Disabled 1b - Enabled
8 IFEE8	Enables falling-edge events to set DISR0[EIF8]. 0b - Disabled 1b - Enabled
7 IFEE7	Enables falling-edge events to set DISR0[EIF7]. 0b - Disabled 1b - Enabled
6 IFEE6	Enables falling-edge events to set DISR0[EIF6]. 0b - Disabled 1b - Enabled
5 IFEE5	Enables falling-edge events to set DISR0[EIF5]. 0b - Disabled 1b - Enabled
4 IFEE4	Enables falling-edge events to set DISR0[EIF4]. 0b - Disabled 1b - Enabled
3 IFEE3	Enables falling-edge events to set DISR0[EIF3].

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
2 IFEE2	Enables falling-edge events to set DISR0[EIF2]. 0b - Disabled 1b - Enabled
1 IFEE1	Enables falling-edge events to set DISR0[EIF1]. 0b - Disabled 1b - Enabled
0 IFEE0	Enables falling-edge events to set DISR0[EIF0]. 0b - Disabled 1b - Enabled

10.6.9 SIUL2 Interrupt Filter Enable 0 (IFER0)

Offset

Register	Offset
IFER0	38h

Function

Enables a digital filter counter on the corresponding interrupt pads to filter out glitches on the inputs.

This register supports 8-, 16-, and 32-bit accesses.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	IFE31	IFE30	IFE29	IFE28	IFE27	IFE26	IFE25	IFE24	IFE23	IFE22	IFE21	IFE20	IFE19	IFE18	IFE17	IFE16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	IFE15	IFE14	IFE13	IFE12	IFE11	IFE10	IFE9	IFE8	IFE7	IFE6	IFE5	IFE4	IFE3	IFE2	IFE1	IFE0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 IFE31	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
30 IFE30	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
29 IFE29	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
28 IFE28	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
27 IFE27	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
26 IFE26	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
25 IFE25	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
24 IFE24	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
23 IFE23	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
22 IFE22	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
21 IFE21	Enables digital glitch filter on the interrupt pad input.

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Field	Function
	0b - Disabled 1b - Enabled
20 IFE20	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
19 IFE19	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
18 IFE18	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
17 IFE17	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
16 IFE16	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
15 IFE15	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
14 IFE14	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
13 IFE13	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
12 IFE12	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
11 IFE11	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
10 IFE10	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
9 IFE9	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
8 IFE8	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
7 IFE7	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
6 IFE6	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
5 IFE5	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
4 IFE4	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
3 IFE3	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
2 IFE2	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
1 IFE1	Enables digital glitch filter on the interrupt pad input. 0b - Disabled 1b - Enabled
0	Enables digital glitch filter on the interrupt pad input.

Table continues on the next page...

Table continued from the previous page...

Field	Function
IFE0	0b - Disabled 1b - Enabled

10.6.10 SIUL2 Interrupt Filter Maximum Counter (IFMCR0 - IFMCR31)

Offset

For a = 0 to 31:

Register	Offset
IFMCRa	40h + (a × 4h)

Function

Configure the filter counter associated with each digital glitch filter.

NOTE

These registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												MAXCNT			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved
3-0 MAXCNT	Maximum Interrupt Filter Counter setting MAXCNT can be 0d to 15d.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	• A value of 0d, 1d, or 2d sets the filter as an all pass filter. • A value of 3d to 15d sets the filter period to TCK × MAXCNT + *n* × TCK, where: — *n* is 1, 2, 3, or 4. — TCK is the prescaled filter clock period, which is the IRC clock prescaled to the IFCP value specified in IFCPR. n accounts for the uncertainty factor in filter period calculation.

10.6.11 SIUL2 Interrupt Filter Clock Prescaler (IFCPR)

Offset

Register	Offset
IFCPR	C0h

Function

Configures the clock prescaler which selects the clock for all digital filters. A prescaler is applied to the input clock to SIUL2, which is the peripheral clock counter in the SIUL2.

NOTE

This register supports only 32-bit accesses. Byte and half-word accesses are not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												IFCP			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
3-0 IFCP	Interrupt Filter Clock Prescaler setting Prescaled Filter Clock period is T_{IRC} × (IFCP + 1), where: • T_{IRC} is the internal oscillator period. • IFCP is 0 to 15.

10.6.12 MUX0_TIMER_EN1 (MUX0_TIMER_EN1)

Offset

Register	Offset
MUX0_TIMER_EN1	100h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...	EMIO SFL...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved								EMIOS FL...	EMIOS FL...	EMIOS FL...	EMIOS FL...	EMIOS FL...	EMIOS FL...	EMIOS FL...	EMIOS FL...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31 EMIOSFLG15_EN	EMIOS0 Output Flag 15 Monitor Enable
30 EMIOSFLG14_EN	EMIOS0 Output Flag 14 Monitor Enable
29 EMIOSFLG13_EN	EMIOS0 Output Flag 13 Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
28 EMIOSFLG12_EN	EMIOS0 Output Flag 12 Monitor Enable
27 EMIOSFLG11_EN	EMIOS0 Output Flag 11 Monitor Enable
26 EMIOSFLG10_EN	EMIOS0 Output Flag 10 Monitor Enable
25 EMIOSFLG9_EN	EMIOS0 Output Flag 9 Monitor Enable
24 EMIOSFLG8_EN	EMIOS0 Output Flag 8 Monitor Enable
23 EMIOSFLG7_EN	EMIOS0 Output Flag 7 Monitor Enable
22 EMIOSFLG6_EN	EMIOS0 Output Flag 6 Monitor Enable
21 EMIOSFLG5_EN	EMIOS0 Output Flag 5 Monitor Enable
20 EMIOSFLG4_EN	EMIOS0 Output Flag 4 Monitor Enable
19 EMIOSFLG3_EN	EMIOS0 Output Flag 3 Monitor Enable
18 EMIOSFLG2_EN	EMIOS0 Output Flag 2 Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
17 EMIOSFLG1_EN	EMIOS0 Output Flag 1 Monitor Enable
16 EMIOSFLG0_EN	EMIOS0 Output Flag 0 Monitor Enable
15-8 —	Reserved
7 EMIOSFLG23_EN	EMIOS0 Output Flag 23 Monitor Enable
6 EMIOSFLG22_EN	EMIOS0 Output Flag 22 Monitor Enable
5 EMIOSFLG21_EN	EMIOS0 Output Flag 21 Monitor Enable
4 EMIOSFLG20_EN	EMIOS0 Output Flag 20 Monitor Enable
3 EMIOSFLG19_EN	EMIOS0 Output Flag 19 Monitor Enable
2 EMIOSFLG18_EN	EMIOS0 Output Flag 18 Monitor Enable
1 EMIOSFLG17_EN	EMIOS0 Output Flag 17 Monitor Enable
0 EMIOSFLG16_EN	EMIOS0 Output Flag 16 Monitor Enable

10.6.13 MUX0_BCTU1_EN (MUX0_BCTU1_EN)

Offset

Register	Offset
MUX0_BCTU1_EN	104h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved			BCTU 0AD...	BCTU 0AD...	BCTU 0AD...	BCTU 0LI...	BCTU 0FI...	BCTU 0FI...	BCTU 0FI...	BCTU 0AD...	BCTU 0AD...	BCTU 0AD...	BCTU 0FI...	BCTU 0FI...	BCTU 0FI...
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1LI...	BCTU 1FI...	BCTU 1FI...	BCTU 1FI...	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1FI...	BCTU 1FI...	BCTU 1FI...
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-29 —	Reserved
28 BCTU0ADC2INT_EN	BCTU ADC2DR Interrupt Request Monitor Enable
27 BCTU0ADC1INT_EN	BCTU ADC1DR Interrupt Request Monitor Enable
26 BCTU0ADC0INT_EN	BCTU ADC0DR Interrupt Request Monitor Enable
25 BCTU0LISTINT_EN	BCTU Conversion List Interrupt Request Enable
24 BCTU0FIFO2INT_EN	BCTU FIFO2 Interrupt Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
23 BCTU0FIFO1INT_EN	BCTU FIFO1 Interrupt Request Monitor Enable
22 BCTU0FIFO0INT_EN	BCTU FIFO0 Interrupt Request Monitor Enable
21 BCTU0ADC2DMA_EN	BCTU ADC2DR DMA Request Monitor Enable
20 BCTU0ADC1DMA_EN	BCTU ADC1DR DMA Request Monitor Enable
19 BCTU0ADC0DMA_EN	BCTU ADC0DR DMA Request Monitor Enable
18 BCTU0FIFO2DMA_EN	BCTU FIFO2 DMA Request Monitor Enable
17 BCTU0FIFO1DMA_EN	BCTU FIFO1 DMA Request Monitor Enable
16 BCTU0FIFO0DMA_EN	BCTU FIFO0 DMA Request Monitor Enable
15 —	Reserved
14 BCTU1ADC3INT_EN	BCTU ADC3DR Interrupt Request Monitor Enable
13 BCTU1ADC2INT_EN	BCTU ADC2DR Interrupt Request Monitor Enable
12	BCTU ADC1DR Interrupt Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
BCTU1ADC1INT_EN	
11 BCTU1ADC0INT_EN	BCTU ADC0DR Interrupt Request Monitor Enable
10 BCTU1LISTINT_EN	BCTU Conversion List Interrupt Request Enable
9 BCTU1FIFO2INT_EN	BCTU FIFO2 Interrupt Request Monitor Enable
8 BCTU1FIFO1INT_EN	BCTU FIFO1 Interrupt Request Monitor Enable
7 BCTU1FIFO0INT_EN	BCTU FIFO0 Interrupt Request Monitor Enable
6 BCTU1ADC3DMA_EN	BCTU ADC3DR DMA Request Monitor Enable
5 BCTU1ADC2DMA_EN	BCTU ADC2DR DMA Request Monitor Enable
4 BCTU1ADC1DMA_EN	BCTU ADC1DR DMA Request Monitor Enable
3 BCTU1ADC0DMA_EN	BCTU ADC0DR DMA Request Monitor Enable
2 BCTU1FIFO2DMA_EN	BCTU FIFO2 DMA Request Monitor Enable
1	BCTU FIFO1 DMA Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
BCTU1FIFO1DMA_EN	
0 BCTU1FIFO0DMA_EN	BCTU FIFO0 DMA Request Monitor Enable

10.6.14 MUX1_TIMER_EN0 (MUX1_TIMER_EN0)

Offset

Register	Offset
MUX1_TIMER_EN0	108h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	lpi2c_1...	lpi2c_1...	lpi2c_t...	lpi2c_t...	LPUART3...	LPUART2...	LPUART1...	LPUART0...	Reserved	ADC6EOC...	ADC5EOC...	ADC4EOC...	ADC3EOC...	ADC2EOC...	ADC1EOC...	ADC0EOC...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PWM03OU...	PWM02OU...	PWM01OU...	PWM00OU...	PWM03OU...	PWM02OU...	PWM01OU...	PWM00OU...	PWM03TR...	PWM02TR...	PWM01TR...	PWM00TR...	PWM03TR...	PWM02TR...	PWM01TR...	PWM00TR...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31 lpi2c_1_trg_slave	LPI2C 1 Slave trigger output
30 lpi2c_1_trg_master	LPI2C 1 Master trigger output
29 lpi2c_trg_slave	LPI2C 0 Slave trigger output

Table continues on the next page...

Table continued from the previous page...

Field	Function
28 lpi2c_trg_master	LPI2C 0 Master trigger output
27 LPUART3TRG_EN	LPUART3 Output Trigger Monitor Enable
26 LPUART2TRG_EN	LPUART2 Output Trigger Monitor Enable
25 LPUART1TRG_EN	LPUART1 Output Trigger Monitor Enable
24 LPUART0TRG_EN	LPUART0 Output Trigger Monitor Enable
23 —	Reserved
22 ADC6EOC_EN	ADC6 End of Conversion Trigger Monitor
21 ADC5EOC_EN	ADC5 End of Conversion Trigger Monitor
20 ADC4EOC_EN	ADC4 End of Conversion Trigger Monitor
19 ADC3EOC_EN	ADC3 End of Conversion Trigger Monitor
18 ADC2EOC_EN	ADC2 End of Conversion Trigger Monitor
17 ADC1EOC_EN	ADC1 End of Conversion Trigger Monitor
16 ADC0EOC_EN	ADC0 End of Conversion Trigger Monitor

Table continues on the next page...

Table continued from the previous page...

Field	Function
15 PWM03OUTB_EN	PWM03 Output B Monitor Enable
14 PWM02OUTB_EN	PWM02 Output B Monitor Enable
13 PWM01OUTB_EN	PWM01 Output B Monitor Enable
12 PWM00OUTB_EN	PWM00 Output B Monitor Enable
11 PWM03OUTA_EN	PWM03 Output A Monitor Enabl2
10 PWM02OUTA_EN	PWM02 Output A Monitor Enable
9 PWM01OUTA_EN	PWM01 Output A Monitor Enable
8 PWM00OUTA_EN	PWM00 Output A Monitor Enable
7 PWM03TRG1_EN	PWM03 Output Trigger 1 Monitor Enable
6 PWM02TRG1_EN	PWM02 Output Trigger 1 Monitor Enable
5 PWM01TRG1_EN	PWM01 Output Trigger 1 Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
4 PWM00TRG1_EN	PWM00 Output Trigger 1 Monitor Enable
3 PWM03TRG0_EN	PWM03 Output Trigger 0 Monitor Enable
2 PWM02TRG0_EN	PWM02 Output Trigger 0 Monitor Enable
1 PWM01TRG0_EN	PWM01 Output Trigger 0 Monitor Enable
0 PWM00TRG0_EN	PWM00 Output Trigger 0 Monitor Enable

10.6.15 MUX1_BCTU0_EN (MUX1_BCTU0_EN)

Offset

Register	Offset
MUX1_BCTU0_EN	10Ch

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															PWM0MST...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved			BCTU0AD...	BCTU0AD...	BCTU0AD...	BCTU0LI...	BCTU0FI...	BCTU0FI...	BCTU0FI...	BCTU0AD...	BCTU0AD...	BCTU0AD...	BCTU0FI...	BCTU0FI...	BCTU0FI...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-17 —	Reserved
16 PWM0MSTRELOAD_EN	PWM0 Master Reload Monitor Enable
15-13 —	Reserved
12 BCTU0ADC2INT_EN	BCTU ADC2DR Interrupt Request Monitor Enable
11 BCTU0ADC1INT_EN	BCTU ADC1DR Interrupt Request Monitor Enable
10 BCTU0ADC0INT_EN	BCTU ADC0DR Interrupt Request Monitor Enable
9 BCTU0LISTINT_EN	BCTU Conversion List Interrupt Request Enable
8 BCTU0FIFO2INT_EN	BCTU FIFO2 Interrupt Request Monitor Enable
7 BCTU0FIFO1INT_EN	BCTU FIFO1 Interrupt Request Monitor Enable
6 BCTU0FIFO0INT_EN	BCTU FIFO0 Interrupt Request Monitor Enable
5 BCTU0ADC2DMA_EN	BCTU ADC2DR DMA Request Monitor Enable
4	BCTU ADC1DR DMA Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
BCTU0ADC1DMA_EN	
3 BCTU0ADC0DMA_EN	BCTU ADC0DR DMA Request Monitor Enable
2 BCTU0FIFO2DMA_EN	BCTU FIFO2 DMA Request Monitor Enable
1 BCTU0FIFO1DMA_EN	BCTU FIFO1 DMA Request Monitor Enable
0 BCTU0FIFO0DMA_EN	BCTU FIFO0 DMA Request Monitor Enable

10.6.16 MUX1_MISC_EN (MUX1_MISC_EN)

Offset

Register	Offset
MUX1_MISC_EN	110h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved	BCTU1AD...	BCTU1AD...	BCTU1AD...	BCTU1AD...	BCTU1LI...	BCTU1FI...	BCTU1FI...	BCTU1FI...	BCTU1AD...	BCTU1AD...	BCTU1AD...	BCTU1AD...	BCTU1FI...	BCTU1FI...	BCTU1FI...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	lpi2c_1...	lpi2c_1...	lpi2c_t..	lpi2c_t..	LPUART3...	LPUART2...	LPUART1...	LPUART0...	Reserved	ADC6EOC...	ADC5EOC...	ADC4EOC...	ADC3EOC...	ADC2EOC...	ADC1EOC...	ADC0EOC...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31 —	Reserved
30 BCTU1ADC3INT_EN	BCTU ADC3DR Interrupt Request Monitor Enable
29 BCTU1ADC2INT_EN	BCTU ADC2DR Interrupt Request Monitor Enable
28 BCTU1ADC1INT_EN	BCTU ADC1DR Interrupt Request Monitor Enable
27 BCTU1ADC0INT_EN	BCTU ADC0DR Interrupt Request Monitor Enable
26 BCTU1LISTINT_EN	BCTU Conversion List Interrupt Request Enable
25 BCTU1FIFO2INT_EN	BCTU FIFO2 Interrupt Request Monitor Enable
24 BCTU1FIFO1INT_EN	BCTU FIFO1 Interrupt Request Monitor Enable
23 BCTU1FIFO0INT_EN	BCTU FIFO0 Interrupt Request Monitor Enable
22 BCTU1ADC3DMA_EN	BCTU ADC3DR DMA Request Monitor Enable
21 BCTU1ADC2DMA_EN	BCTU ADC2DR DMA Request Monitor Enable
20	BCTU ADC1DR DMA Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
BCTU1ADC1DMA_EN	
19 BCTU1ADC0DMA_EN	BCTU ADC0DR DMA Request Monitor Enable
18 BCTU1FIFO2DMA_EN	BCTU FIFO2 DMA Request Monitor Enable
17 BCTU1FIFO1DMA_EN	BCTU FIFO1 DMA Request Monitor Enable
16 BCTU1FIFO0DMA_EN	BCTU FIFO0 DMA Request Monitor Enable
15 lpi2c_1_trg_slave	LPI2C 1 Slave trigger output
14 lpi2c_1_trg_master	LPI2C 1 Master trigger output
13 lpi2c_trg_slave	LPI2C 0 Slave trigger output
12 lpi2c_trg_master	LPI2C 0 Master trigger output
11 LPUART3TRG_EN	LPUART3 Output Trigger Monitor Enablee
10 LPUART2TRG_EN	LPUART2 Output Trigger Monitor Enable
9	LPUART1 Output Trigger Monitor Enable

Table continues on the next page...

Table continued from the previous page...

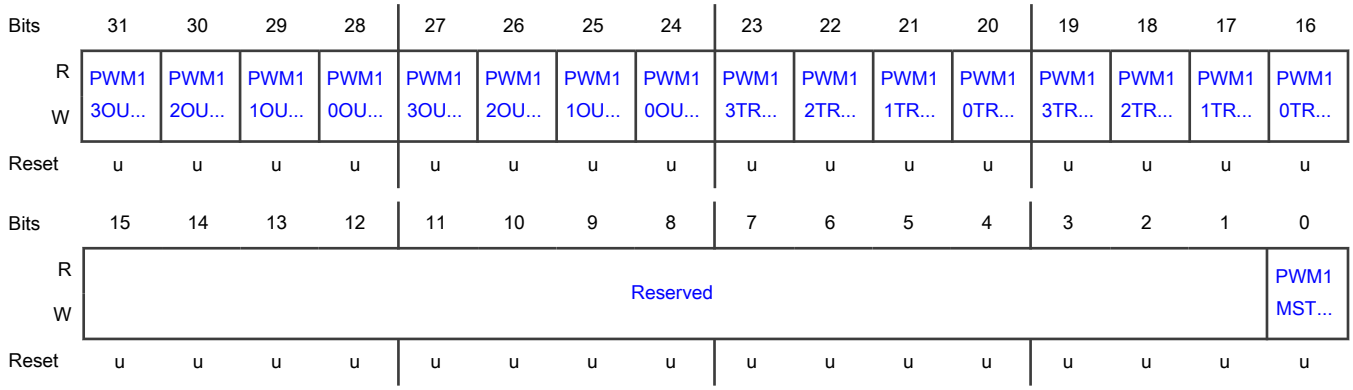
Field	Function
LPUART1TRG_EN	
8 LPUART0TRG_EN	LPUART0 Output Trigger Monitor Enable
7 —	Reserved
6 ADC6EOC_EN	ADC6 End of Conversion Trigger Monitor
5 ADC5EOC_EN	ADC5 End of Conversion Trigger Monitor
4 ADC4EOC_EN	ADC4 End of Conversion Trigger Monitor
3 ADC3EOC_EN	ADC3 End of Conversion Trigger Monitor
2 ADC2EOC_EN	ADC2 End of Conversion Trigger Monitor
1 ADC1EOC_EN	ADC1 End of Conversion Trigger Monitor
0 ADC0EOC_EN	ADC0 End of Conversion Trigger Monitor

10.6.17 MUX2_TIMER_EN1 (MUX2_TIMER_EN1)

Offset

Register	Offset
MUX2_TIMER_EN1	114h

Diagram



Fields

Field	Function
31 PWM13OUTB_EN	PWM13 Output B Monitor Enable
30 PWM12OUTB_EN	PWM12 Output B Monitor Enable
29 PWM11OUTB_EN	PWM11 Output B Monitor Enable
28 PWM10OUTB_EN	PWM10 Output B Monitor Enable
27 PWM13OUTA_EN	PWM13 Output A Monitor Enable
26 PWM12OUTA_EN	PWM12 Output A Monitor Enable
25 PWM11OUTA_EN	PWM11 Output A Monitor Enable
24 PWM10OUTA_EN	PWM10 Output A Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
23 PWM13TRG1_EN	PWM13 Output Trigger 1 Monitor Enable
22 PWM12TRG1_EN	PWM12 Output Trigger 1 Monitor Enable
21 PWM11TRG1_EN	PWM11 Output Trigger 1 Monitor Enable
20 PWM10TRG1_EN	PWM10 Output Trigger 1 Monitor Enable
19 PWM13TRG0_EN	PWM13 Output Trigger 0 Monitor Enable
18 PWM12TRG0_EN	PWM12 Output Trigger 0 Monitor Enable
17 PWM11TRG0_EN	PWM11 Output Trigger 0 Monitor Enable
16 PWM10TRG0_EN	PWM10 Output Trigger 0 Monitor Enable
15-1 —	Reserved
0 PWM1MSTRELOAD_EN	BCTU FIFO0 DMA Request Monitor Enable

10.6.18 MUX2_BCTU1_EN (MUX2_BCTU1_EN)

Offset

Register	Offset
MUX2_BCTU1_EN	118h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved			BCTU 0AD...	BCTU 0AD...	BCTU 0AD...	BCTU 0LI...	BCTU 0FI...	BCTU 0FI...	BCTU 0FI...	BCTU 0AD...	BCTU 0AD...	BCTU 0AD...	BCTU 0FI...	BCTU 0FI...	BCTU 0FI...
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1LI...	BCTU 1FI...	BCTU 1FI...	BCTU 1FI...	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1AD...	BCTU 1FI...	BCTU 1FI...	BCTU 1FI...
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-29 —	Reserved
28 BCTU0ADC2INT_EN	BCTU ADC2DR Interrupt Request Monitor Enable
27 BCTU0ADC1INT_EN	BCTU ADC1DR Interrupt Request Monitor Enable
26 BCTU0ADC0INT_EN	CTU ADC0DR Interrupt Request Monitor Enable
25 BCTU0LISTINT_EN	BCTU Conversion List Interrupt Request Enable
24 BCTU0FIFO2INT_EN	BCTU FIFO2 Interrupt Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
23 BCTU0FIFO1INT_EN	BCTU FIFO1 Interrupt Request Monitor Enable
22 BCTU0FIFO0INT_EN	BCTU FIFO0 Interrupt Request Monitor Enable
21 BCTU0ADC2DMA_EN	BCTU ADC2DR DMA Request Monitor Enable
20 BCTU0ADC1DMA_EN	BCTU ADC1DR DMA Request Monitor Enable
19 BCTU0ADC0DMA_EN	BCTU ADC0DR DMA Request Monitor Enable
18 BCTU0FIFO2DMA_EN	BCTU FIFO2 DMA Request Monitor Enable
17 BCTU0FIFO1DMA_EN	BCTU FIFO1 DMA Request Monitor Enable
16 BCTU0FIFO0DMA_EN	BCTU FIFO0 DMA Request Monitor Enable
15 —	Reserved
14 BCTU1ADC3INT_EN	BCTU ADC3DR Interrupt Request Monitor Enable
13 BCTU1ADC2INT_EN	BCTU ADC2DR Interrupt Request Monitor Enable
12	BCTU ADC1DR Interrupt Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
BCTU1ADC1INT_EN	
11 BCTU1ADC0INT_EN	BCTU ADC0DR Interrupt Request Monitor Enable
10 BCTU1LISTINT_EN	BCTU Conversion List Interrupt Request Enable
9 BCTU1FIFO2INT_EN	BCTU FIFO2 Interrupt Request Monitor Enable
8 BCTU1FIFO1INT_EN	BCTU FIFO1 Interrupt Request Monitor Enable
7 BCTU1FIFO0INT_EN	BCTU FIFO0 Interrupt Request Monitor Enable
6 BCTU1ADC3DMA_EN	BCTU ADC3DR DMA Request Monitor Enable
5 BCTU1ADC2DMA_EN	BCTU ADC2DR DMA Request Monitor Enable
4 BCTU1ADC1DMA_EN	BCTU ADC1DR DMA Request Monitor Enable
3 BCTU1ADC0DMA_EN	BCTU ADC0DR DMA Request Monitor Enable
2 BCTU1FIFO2DMA_EN	BCTU FIFO2 DMA Request Monitor Enable
1	BCTU FIFO1 DMA Request Monitor Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
BCTU1FIFO1DMA_EN	
0 BCTU1FIFO0DMA_EN	BCTU FIFO0 DMA Request Monitor Enable

10.6.19 MUX2_MISC_EN (MUX2_MISC_EN)

Offset

Register	Offset
MUX2_MISC_EN	11Ch

Function

NOTE

Bits 16 to 31 are marked reserved because they are not applicable.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	lpi2c_1...	lpi2c_1...	lpi2c_t...	lpi2c_t...	LPUART3...	LPUART2...	LPUART1...	LPUART0...	Reserved	ADC6EOC...	ADC5EOC...	ADC4EOC...	ADC3EOC...	ADC2EOC...	ADC1EOC...	ADC0EOC...
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-16 —	Reserved
15 lpi2c_1_trg_slave	LPI2C 1 Slave trigger output

Table continues on the next page...

Table continued from the previous page...

Field	Function
14 lpi2c_1_trg_master	LPI2C 1 Master trigger output
13 lpi2c_trg_slave	LPI2C 0 Slave trigger output
12 lpi2c_trg_master	LPI2C 0 Master trigger outputt
11 LPUART3TRG_EN	LPUART3 Output Trigger Monitor Enable
10 LPUART2TRG_EN	LPUART2 Output Trigger Monitor Enable
9 LPUART1TRG_EN	LPUART1 Output Trigger Monitor Enable
8 LPUART0TRG_EN	LPUART0 Output Trigger Monitor Enable
7 —	Reserved
6 ADC6EOC_EN	ADC6 End of Conversion Trigger Monitor
5 ADC5EOC_EN	ADC5 End of Conversion Trigger Monitor
4 ADC4EOC_EN	ADC4 End of Conversion Trigger Monitor
3 ADC3EOC_EN	ADC3 End of Conversion Trigger Monitor
2	ADC2 End of Conversion Trigger Monitor

Table continues on the next page...

Table continued from the previous page...

Field	Function
ADC2EOC_EN	
1 ADC1EOC_EN	ADC1 End of Conversion Trigger Monitor
0 ADC0EOC_EN	ADC0 End of Conversion Trigger Monitor

10.6.20 SIUL2 MCU ID Register #3 (MIDR3)

Offset

Register	Offset
MIDR3	200h

Function

NOTE

This register supports only 32-bit accesses. Byte and half-word accesses are not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PROD_FAM_LET						PROD_FAM_NO									
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PART_NO_SUF						0				SYS_RAM_SIZE					
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-26 PROD_FAM_LET	Product Family Letter Identifies the product family letter. 01_0011b - S

Table continues on the next page...

Table continued from the previous page...

Field	Function
25-16 PROD_FAM_NO	Product Family Number Identifies the product family number. 00_0010_0000b - 32
15-10 PART_NO_SUF	Part Number Suffix Describes the part number suffix. 00_0000b - None
9-6 —	Reserved
5-0 SYS_RAM_SIZE	System RAM Size Total RAM size in SoC, including TCMs. 00_1000b - 800kB 00_1001b - 704kB

10.6.21 SIUL2 MCU ID Register #4 (MIDR4)

Offset

Register	Offset
MIDR4	204h

Function

NOTE

This register supports only 32-bit accesses. Byte and half-word accesses are not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CORE_PLAT_FET_1		0						Reserved				CORE_PLAT_FET_2			
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-16 —	Reserved
15-14 CORE_PLAT_FET_1	Core Platform Options Feature Core platform options feature. **NOTE** The 5 bit field is a concatenation of bits 15-14 (CORE_PLAT_FET_1) and 2-0 (CORE_PLAT_FET_2). 00101b — 1x M7 LS core + 2x M7 split-lock cores + DSP 00111b — 1x M7 LS core + 1x M7 core + DSP + dual eTPU 01000b — 1x M7 LS core + 2x M7 split-lock cores + DSP + dual eTPU
13-7 —	Reserved
6-3 —	Reserved
2-0 CORE_PLAT_FET_2	Core Platform Options Feature Core platform options feature. For field values, see the description of CORE_PLAT_FET_1

10.6.22 SIUL2 Multiplexed Signal Configuration Register (MSCR0 - MSCR236)

Offset

Register	Offset
MSCR0	240h
MSCR1	244h
MSCR2	248h
MSCR3	24Ch
MSCR4	250h
MSCR5	254h
MSCR6	258h
MSCR7	25Ch

Table continues on the next page...

Table continued from the previous page...

Register	Offset
MSCR8	260h
MSCR9	264h
MSCR10	268h
MSCR14	278h
MSCR15	27Ch
MSCR16	280h
MSCR17	284h
MSCR18	288h
MSCR19	28Ch
MSCR20	290h
MSCR21	294h
MSCR22	298h
MSCR23	29Ch
MSCR24	2A0h
MSCR25	2A4h
MSCR26	2A8h
MSCR28	2B0h
MSCR29	2B4h
MSCR30	2B8h
MSCR31	2BCh
MSCR32	2C0h
MSCR33	2C4h
MSCR34	2C8h
MSCR35	2CCh
MSCR36	2D0h
MSCR37	2D4h
MSCR40	2E0h
MSCR41	2E4h
MSCR42	2E8h
MSCR43	2ECh
MSCR44	2F0h
MSCR45	2F4h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
MSCR46	2F8h
MSCR47	2FCh
MSCR48	300h
MSCR49	304h
MSCR50	308h
MSCR51	30Ch
MSCR52	310h
MSCR53	314h
MSCR54	318h
MSCR55	31Ch
MSCR56	320h
MSCR57	324h
MSCR58	328h
MSCR59	32Ch
MSCR60	330h
MSCR61	334h
MSCR64	340h
MSCR65	344h
MSCR66	348h
MSCR67	34Ch
MSCR68	350h
MSCR69	354h
MSCR70	358h
MSCR71	35Ch
MSCR72	360h
MSCR73	364h
MSCR74	368h
MSCR75	36Ch
MSCR76	370h
MSCR77	374h
MSCR78	378h
MSCR79	37Ch

Table continues on the next page...

Table continued from the previous page...

Register	Offset
MSCR80	380h
MSCR81	384h
MSCR82	388h
MSCR83	38Ch
MSCR84	390h
MSCR85	394h
MSCR87	39Ch
MSCR88	3A0h
MSCR89	3A4h
MSCR90	3A8h
MSCR91	3ACh
MSCR92	3B0h
MSCR93	3B4h
MSCR94	3B8h
MSCR95	3BCh
MSCR96	3C0h
MSCR97	3C4h
MSCR98	3C8h
MSCR99	3CCh
MSCR100	3D0h
MSCR101	3D4h
MSCR102	3D8h
MSCR103	3DCh
MSCR104	3E0h
MSCR105	3E4h
MSCR106	3E8h
MSCR107	3ECh
MSCR108	3F0h
MSCR109	3F4h
MSCR110	3F8h
MSCR111	3FCh
MSCR112	400h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
MSCR113	404h
MSCR114	408h
MSCR115	40Ch
MSCR116	410h
MSCR117	414h
MSCR118	418h
MSCR119	41Ch
MSCR120	420h
MSCR121	424h
MSCR122	428h
MSCR123	42Ch
MSCR124	430h
MSCR125	434h
MSCR126	438h
MSCR127	43Ch
MSCR128	440h
MSCR129	444h
MSCR130	448h
MSCR132	450h
MSCR133	454h
MSCR134	458h
MSCR135	45Ch
MSCR136	460h
MSCR137	464h
MSCR138	468h
MSCR139	46Ch
MSCR140	470h
MSCR142	478h
MSCR143	47Ch
MSCR144	480h
MSCR145	484h
MSCR146	488h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
MSCR147	48Ch
MSCR148	490h
MSCR149	494h
MSCR151	49Ch
MSCR154	4A8h
MSCR155	4ACh
MSCR156	4B0h
MSCR157	4B4h
MSCR158	4B8h
MSCR159	4BCh
MSCR160	4C0h
MSCR161	4C4h
MSCR162	4C8h
MSCR163	4CCh
MSCR164	4D0h
MSCR165	4D4h
MSCR166	4D8h
MSCR167	4DCh
MSCR168	4E0h
MSCR169	4E4h
MSCR170	4E8h
MSCR171	4ECh
MSCR172	4F0h
MSCR173	4F4h
MSCR174	4F8h
MSCR175	4FCh
MSCR176	500h
MSCR177	504h
MSCR178	508h
MSCR179	50Ch
MSCR180	510h
MSCR181	514h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
MSCR183	51Ch
MSCR184	520h
MSCR185	524h
MSCR186	528h
MSCR187	52Ch
MSCR188	530h
MSCR189	534h
MSCR190	538h
MSCR191	53Ch
MSCR192	540h
MSCR193	544h
MSCR194	548h
MSCR195	54Ch
MSCR196	550h
MSCR197	554h
MSCR198	558h
MSCR199	55Ch
MSCR200	560h
MSCR201	564h
MSCR202	568h
MSCR203	56Ch
MSCR204	570h
MSCR205	574h
MSCR206	578h
MSCR207	57Ch
MSCR208	580h
MSCR209	584h
MSCR210	588h
MSCR211	58Ch
MSCR212	590h
MSCR213	594h
MSCR214	598h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
MSCR215	59Ch
MSCR216	5A0h
MSCR217	5A4h
MSCR218	5A8h
MSCR219	5ACh
MSCR231	5DCh
MSCR232	5E0h
MSCR233	5E4h
MSCR234	5E8h
MSCR235	5ECh
MSCR236	5F0h

Function

Select the source signal connected to the register's associated destination, which is a chip output pin or a chip pin that can be configured as an output.

MSCR*n* also specifies the electrical properties of the associated pin.

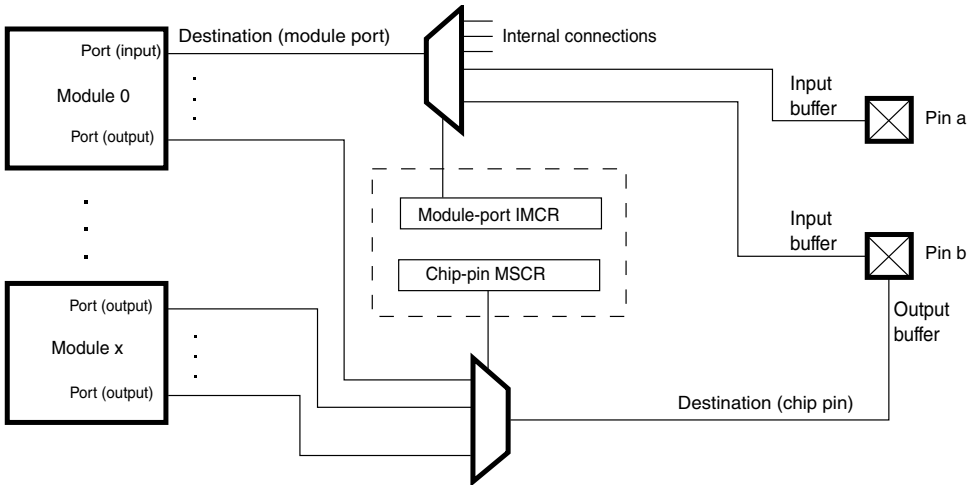


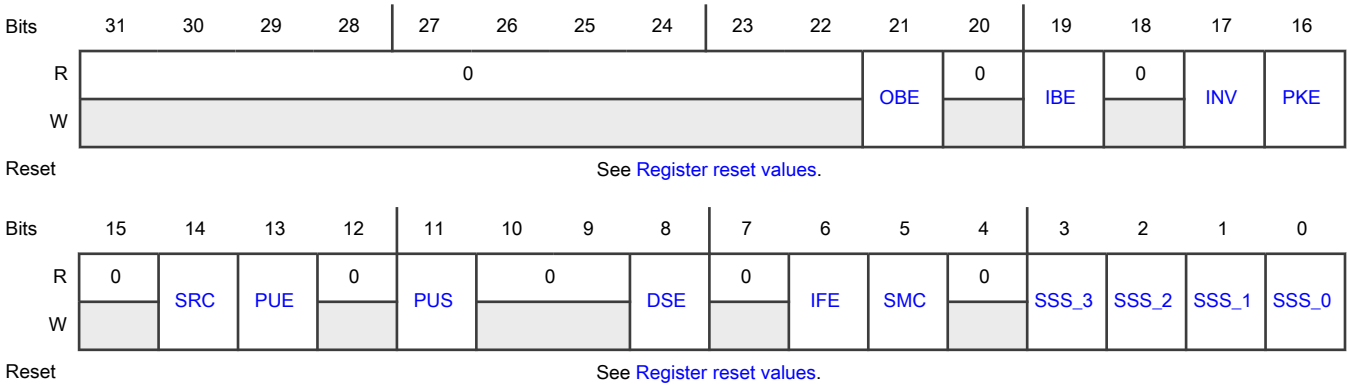
Figure 22. MSCR and IMCR port and pin connection

For chip-pin MSCR assignments and pin types, see the IOMUX file attached to this document.

NOTE

- MSCR*n* registers support only 32-bit accesses. Byte and half-word write accesses are not supported.
- MSCR*n* registers must be configured only during application initialization and must not be modified during application runtime.
- Accessing a reserved MSCR*n* register generates a transfer error.
- These registers are a part of SIUL memory map but physical implementation of these register is a part of IOMUX RTL.
- SIUL2 interprets accesses to MSCR*n* at module level.

Diagram



Register reset values

Register	Reset value
MSCR0–MSCR3	0000_0000h
MSCR4	0008_2827h
MSCR5–MSCR9	0000_0000h
MSCR10	0000_0127h
MSCR11–MSCR13	Register not supported
MSCR14–MSCR21	0000_0000h
MSCR22	0000_0009h
MSCR23–MSCR34	0000_0000h
MSCR27	Register not supported
MSCR35	0000_4000h
MSCR36–MSCR51	0000_0000h
MSCR38–MSCR39	Register not supported
MSCR52	0000_4000h
MSCR53–MSCR56	0000_0000h
MSCR57	0000_4000h

Table continues on the next page...

Table continued from the previous page...

Register	Reset value
MSCR58–MSCR59	0000_0000h
MSCR60–MSCR67	0000_4000h
MSCR62–MSCR63	Register not supported
MSCR68	0008_2000h
MSCR69	0008_2800h
MSCR70–MSCR75	0000_0000h
MSCR76	0000_4000h
MSCR77–MSCR79	0000_0000h
MSCR80–MSCR83	0000_4000h
MSCR84–MSCR100	0000_0000h
MSCR86	Register not supported
MSCR101–MSCR108	0000_4000h
MSCR109–MSCR135	0000_0000h
MSCR131	Register not supported
MSCR136	0000_4000h
MSCR137–MSCR236	0000_0000h
MSCR141	Register not supported
MSCR150	Register not supported
MSCR152–MSCR153	Register not supported
MSCR182	Register not supported
MSCR220–MSCR230	Register not supported

Fields

Field	Function
31-22 —	Reserved
21 OBE	GPIO Output Buffer Enable Applies only to digital pins. Otherwise this bit is reserved. 0b - Output driver disabled 1b - Output driver enabled
20	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
19 IBE	Input Buffer Enable Used only when the associated destination is a chip pin. Enables the associated pin's input buffer. 0b - Disabled 1b - Enabled
18 —	Reserved
17 INV	Invert Inverts the signal selected by SSS before transmitting it to the associated destination (chip pin or module port). 0b - Don't invert 1b - Invert
16 PKE	Pad keeping enable Pad keeping enable 0b - Disabled 1b - Enabled
15 —	Reserved
14 SRC	Slew Rate Control 0b - Fastest setting 1b - Slowest setting
13 PUE	Pull Enable Enables the pull function. Used only when the associated destination is a chip pin. 0b - Disabled 1b - Enabled
12 —	Reserved
11 PUS	Pull Select Determines whether the pull function is a pullup or pulldown when the pull function is enabled by the PUE field. Used only when the associated destination is a chip pin. 0b - Pull down

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Pull up
10-9 —	Reserved
8 DSE	DSE Drive strength enable 0b - Disabled 1b - Enabled
7 —	Reserved
6 IFE	IFE Input filter enable **NOTE** This field is supported for RESET pad only (PTA5). 0b - Disabled 1b - Enabled
5 SMC	Safe Mode Control Used only when the associated destination is a chip pin. Pin's output buffer configuration when FCCU is in Fault state. 0b - Disabled (high Z) 1b - Retain
4 —	Reserved
3 SSS_3	Source Signal Select_3 Selects a function for the pad. Refer to “SSS” column of the ‘IO Signal Table' tab of the IOMUX spreadsheet attachment.
2 SSS_2	Source Signal Select_2 Selects a function for the pad. Refer to “SSS” column of the ‘IO Signal Table' tab of the IOMUX spreadsheet attachment.
1 SSS_1	Source Signal Select_1 Selects a function for the pad. Refer to “SSS” column of the ‘IO Signal Table' tab of the IOMUX spreadsheet attachment.
0	Source Signal Select_0

Table continues on the next page...

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Field	Function
SSS_0	Selects a function for the pad. Refer to “SSS” column of the ‘IO Signal Table' tab of the IOMUX spreadsheet attachment.

10.6.23 SIUL2 Input Multiplexed Signal Configuration (IMCR0 - IMCR511)

Offset

Register	Offset
IMCR0	A40h
IMCR1	A44h
IMCR2	A48h
IMCR3	A4Ch
IMCR4	A50h
IMCR5	A54h
IMCR16	A80h
IMCR17	A84h
IMCR18	A88h
IMCR19	A8Ch
IMCR20	A90h
IMCR21	A94h
IMCR22	A98h
IMCR23	A9Ch
IMCR24	AA0h
IMCR25	AA4h
IMCR26	AA8h
IMCR27	AACh
IMCR28	AB0h
IMCR29	AB4h
IMCR30	AB8h
IMCR31	ABCh
IMCR32	AC0h
IMCR33	AC4h
IMCR34	AC8h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
IMCR35	ACCh
IMCR36	AD0h
IMCR37	AD4h
IMCR38	AD8h
IMCR39	ADCh
IMCR40	AE0h
IMCR41	AE4h
IMCR42	AE8h
IMCR43	AECh
IMCR44	AF0h
IMCR45	AF4h
IMCR46	AF8h
IMCR47	AFCh
IMCR48	B00h
IMCR49	B04h
IMCR50	B08h
IMCR51	B0Ch
IMCR52	B10h
IMCR53	B14h
IMCR54	B18h
IMCR55	B1Ch
IMCR56	B20h
IMCR57	B24h
IMCR58	B28h
IMCR59	B2Ch
IMCR60	B30h
IMCR61	B34h
IMCR62	B38h
IMCR63	B3Ch
IMCR64	B40h
IMCR65	B44h
IMCR66	B48h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
IMCR67	B4Ch
IMCR68	B50h
IMCR69	B54h
IMCR70	B58h
IMCR71	B5Ch
IMCR144	C80h
IMCR145	C84h
IMCR146	C88h
IMCR147	C8Ch
IMCR148	C90h
IMCR149	C94h
IMCR152	CA0h
IMCR153	CA4h
IMCR154	CA8h
IMCR155	CACh
IMCR156	CB0h
IMCR157	CB4h
IMCR158	CB8h
IMCR159	CBCh
IMCR160	CC0h
IMCR161	CC4h
IMCR162	CC8h
IMCR163	CCCh
IMCR164	CD0h
IMCR165	CD4h
IMCR166	CD8h
IMCR167	CDCh
IMCR168	CE0h
IMCR169	CE4h
IMCR170	CE8h
IMCR171	CECh
IMCR172	CF0h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
IMCR173	CF4h
IMCR174	CF8h
IMCR175	CFCh
IMCR176	D00h
IMCR177	D04h
IMCR178	D08h
IMCR179	D0Ch
IMCR180	D10h
IMCR181	D14h
IMCR182	D18h
IMCR183	D1Ch
IMCR184	D20h
IMCR185	D24h
IMCR186	D28h
IMCR187	D2Ch
IMCR188	D30h
IMCR189	D34h
IMCR190	D38h
IMCR211	D8Ch
IMCR212	D90h
IMCR213	D94h
IMCR214	D98h
IMCR215	D9Ch
IMCR216	DA0h
IMCR217	DA4h
IMCR218	DA8h
IMCR219	DACh
IMCR220	DB0h
IMCR221	DB4h
IMCR222	DB8h
IMCR223	DBCh
IMCR224	DC0h

Table continues on the next page...

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Register	Offset
IMCR225	DC4h
IMCR226	DC8h
IMCR227	DCCh
IMCR228	DD0h
IMCR229	DD4h
IMCR230	DD8h
IMCR231	DDCh
IMCR232	DE0h
IMCR233	DE4h
IMCR234	DE8h
IMCR235	DECh
IMCR236	DF0h
IMCR237	DF4h
IMCR238	DF8h
IMCR239	DFCh
IMCR240	E00h
IMCR241	E04h
IMCR242	E08h
IMCR243	E0Ch
IMCR244	E10h
IMCR245	E14h
IMCR246	E18h
IMCR247	E1Ch
IMCR248	E20h
IMCR249	E24h
IMCR250	E28h
IMCR251	E2Ch
IMCR252	E30h
IMCR253	E34h
IMCR254	E38h
IMCR255	E3Ch
IMCR256	E40h

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Register	Offset
IMCR257	E44h
IMCR258	E48h
IMCR259	E4Ch
IMCR260	E50h
IMCR261	E54h
IMCR262	E58h
IMCR263	E5Ch
IMCR264	E60h
IMCR265	E64h
IMCR266	E68h
IMCR267	E6Ch
IMCR268	E70h
IMCR289	EC4h
IMCR290	EC8h
IMCR291	ECCh
IMCR292	ED0h
IMCR293	ED4h
IMCR294	ED8h
IMCR295	EDCh
IMCR296	EE0h
IMCR297	EE4h
IMCR298	EE8h
IMCR299	EECh
IMCR300	EF0h
IMCR301	EF4h
IMCR302	EF8h
IMCR303	EFCh
IMCR304	F00h
IMCR305	F04h
IMCR306	F08h
IMCR307	F0Ch
IMCR308	F10h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
IMCR309	F14h
IMCR343	F9Ch
IMCR344	FA0h
IMCR345	FA4h
IMCR346	FA8h
IMCR347	FACh
IMCR348	FB0h
IMCR349	FB4h
IMCR350	FB8h
IMCR351	FBCh
IMCR352	FC0h
IMCR353	FC4h
IMCR360	FE0h
IMCR361	FE4h
IMCR362	FE8h
IMCR363	FECh
IMCR364	FF0h
IMCR365	FF4h
IMCR366	FF8h
IMCR371	100Ch
IMCR372	1010h
IMCR373	1014h
IMCR374	1018h
IMCR375	101Ch
IMCR376	1020h
IMCR377	1024h
IMCR378	1028h
IMCR379	102Ch
IMCR380	1030h
IMCR381	1034h
IMCR382	1038h
IMCR383	103Ch

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Register	Offset
IMCR384	1040h
IMCR385	1044h
IMCR386	1048h
IMCR387	104Ch
IMCR388	1050h
IMCR389	1054h
IMCR390	1058h
IMCR391	105Ch
IMCR392	1060h
IMCR393	1064h
IMCR394	1068h
IMCR395	106Ch
IMCR396	1070h
IMCR397	1074h
IMCR398	1078h
IMCR399	107Ch
IMCR400	1080h
IMCR401	1084h
IMCR402	1088h
IMCR403	108Ch
IMCR404	1090h
IMCR405	1094h
IMCR406	1098h
IMCR407	109Ch
IMCR408	10A0h
IMCR409	10A4h
IMCR410	10A8h
IMCR411	10ACh
IMCR413	10B4h
IMCR414	10B8h
IMCR415	10BCh
IMCR416	10C0h

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Register	Offset
IMCR417	10C4h
IMCR418	10C8h
IMCR419	10CCh
IMCR420	10D0h
IMCR421	10D4h
IMCR422	10D8h
IMCR423	10DCh
IMCR424	10E0h
IMCR425	10E4h
IMCR426	10E8h
IMCR427	10ECh
IMCR428	10F0h
IMCR429	10F4h
IMCR430	10F8h
IMCR431	10FCh
IMCR432	1100h
IMCR433	1104h
IMCR434	1108h
IMCR435	110Ch
IMCR436	1110h
IMCR437	1114h
IMCR438	1118h
IMCR439	111Ch
IMCR440	1120h
IMCR441	1124h
IMCR442	1128h
IMCR443	112Ch
IMCR444	1130h
IMCR445	1134h
IMCR446	1138h
IMCR447	113Ch
IMCR448	1140h

Table continues on the next page...

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Register	Offset
IMCR449	1144h
IMCR450	1148h
IMCR451	114Ch
IMCR452	1150h
IMCR453	1154h
IMCR454	1158h
IMCR455	115Ch
IMCR456	1160h
IMCR457	1164h
IMCR458	1168h
IMCR459	116Ch
IMCR460	1170h
IMCR461	1174h
IMCR462	1178h
IMCR463	117Ch
IMCR464	1180h
IMCR465	1184h
IMCR466	1188h
IMCR467	118Ch
IMCR468	1190h
IMCR469	1194h
IMCR470	1198h
IMCR471	119Ch
IMCR472	11A0h
IMCR473	11A4h
IMCR474	11A8h
IMCR475	11ACh
IMCR476	11B0h
IMCR477	11B4h
IMCR478	11B8h
IMCR479	11BCh
IMCR480	11C0h

Table continues on the next page...

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Register	Offset
IMCR481	11C4h
IMCR482	11C8h
IMCR483	11CCh
IMCR484	11D0h
IMCR485	11D4h
IMCR486	11D8h
IMCR487	11DCh
IMCR488	11E0h
IMCR489	11E4h
IMCR490	11E8h
IMCR491	11ECh
IMCR492	11F0h
IMCR493	11F4h
IMCR494	11F8h
IMCR495	11FCh
IMCR496	1200h
IMCR497	1204h
IMCR498	1208h
IMCR499	120Ch
IMCR500	1210h
IMCR501	1214h
IMCR502	1218h
IMCR503	121Ch
IMCR504	1220h
IMCR505	1224h
IMCR506	1228h
IMCR507	122Ch
IMCR508	1230h
IMCR509	1234h
IMCR510	1238h
IMCR511	123Ch

Function

Select the source signal connected to the register's associated destination, which is an internal module port that is an input port or can be configured as an input.

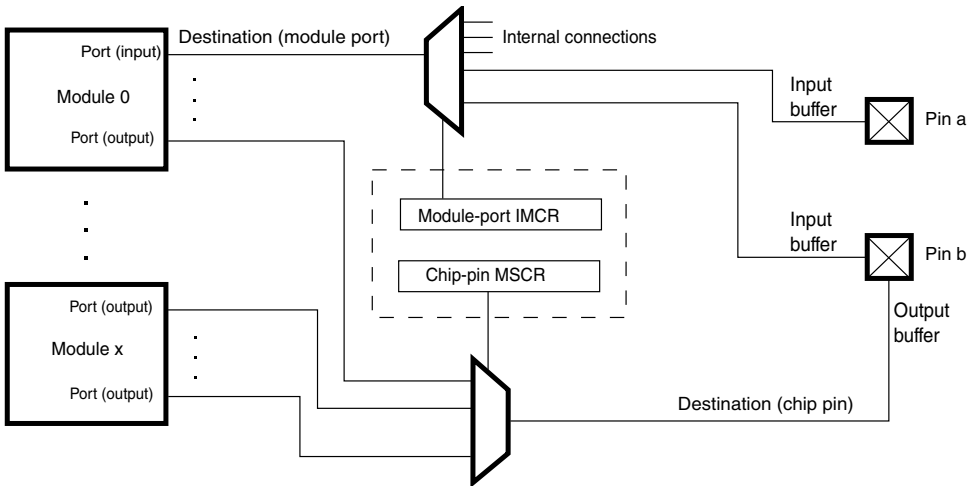


Figure 23. MSCR and IMCR port and pin connection

For IMCR assignments and field values, see the IOMUX file attached to this document.

NOTE

- IMCR*n* registers support only 32-bit accesses. Byte and half-word write accesses are not supported.
- IMCR*n* registers must be configured only during application initialization and must not be modified during application runtime.
- Accessing a reserved IMCR*n* register generates a transfer error.
- These registers are a part of SIUL memory map but physical implementation of these register is a part of IOMUX RTL.
- SIUL2 interprets accesses to MSCR*n* at module level.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SSS			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved
3-0 SSS	Source Signal Select Selects which source signal is connected to the associated destination (chip pin).

10.6.24 SIUL2 GPIO Pad Data Output (GPDO0 - GPDO236)

Offset

For n = 0 to 10; n = 14 to 26; n = 28 to 37; n = 40 to 61; n = 64 to 85; n = 87 to 130; n = 132 to 140; n = 142 to 149; n = 151; n = 154 to 181; n = 183 to 219; n = 231 to 236:

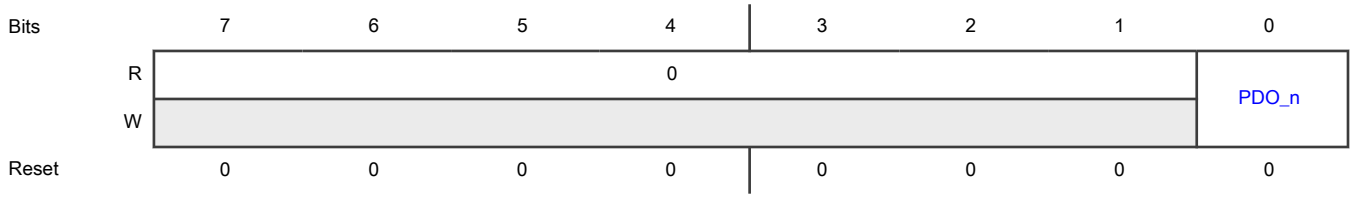
Register	Offset
GPDOn	1300h + (n + 3 - 2 × (n mod 4))

Function

Writes 0 or 1 to a single GPIO pad with a byte access.

These registers support 8-, 16-, and 32-bit accesses.

Diagram



Fields

Field	Function
7-1 —	Reserved
0 PDO_n	Pad Data Out Stores the data to be driven out on the external GPIO pad controlled by this register when the pad is configured as an output. PDO_*n* represents PDO[*n*], where *n* is the instance of the register. 0b - Pad Data Out Low. Logic low value 1b - Pad Data Out High. Logic high value

10.6.25 SIUL2 GPIO Pad Data Input (GPDI0 - GPDI236)

Offset

For n = 0 to 10; n = 14 to 26; n = 28 to 37; n = 40 to 61; n = 64 to 85; n = 87 to 130; n = 132 to 140; n = 142 to 149; n = 151; n = 154 to 181; n = 183 to 219; n = 231 to 236:

Register	Offset
GPDIn	1500h + (n + 3 - 2 × (n mod 4))

Function

Each GPDI*n* register reads the GPIO pad data with a byte access.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	7	6	5	4	3	2	1	0
R	0							PDI_n
W								
Reset	0	0	0	0	0	0	0	0

Fields

Field	Function
7-1 —	Reserved
0 PDI_n	Pad Data In Stores the value of the external GPIO pad associated with this register. PDI_*n* represents PDI[*n*], where *n* is the instance of the register. 0b - Pad Data In Low. Logic low 1b - Pad Data In High. Logic high

10.6.26 SIUL2 Parallel GPIO Pad Data Out (PGPDO1)

Offset

Register	Offset
PGPDO1	1700h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	0	PPDO 3	PPDO 2	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 —	Reserved Always write zero to this field.
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0	Parallel Pad Data Out 0

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPDO0	0b - Logic low 1b - Logic high

10.6.27 SIUL2 Parallel GPIO Pad Data Out (PGPDO0)

Offset

Register	Offset
PGPDO0	1702h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	0	0	0	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15	Parallel Pad Data Out 15

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPDO15	0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
4 —	Reserved Always write zero to this field.
3 —	Reserved Always write zero to this field.
2 —	Reserved Always write zero to this field.
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.28 SIUL2 Parallel GPIO Pad Data Out (PGPDO3)

Offset

Register	Offset
PGPDO3	1704h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	PPDO 2	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 —	Reserved Always write zero to this field.
0 —	Reserved Always write zero to this field.

10.6.29 SIUL2 Parallel GPIO Pad Data Out (PGPDO2)

Offset

Register	Offset
PGPDO2	1706h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	0	0	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	PPDO 2	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Logic high
9 —	Reserved Always write zero to this field.
8 —	Reserved Always write zero to this field.
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.30 SIUL2 Parallel GPIO Pad Data Out (PGPDO5)

Offset

Register	Offset
PGPDO5	1708h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	0	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	PPDO 2	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 —	Reserved Always write zero to this field.
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.31 SIUL2 Parallel GPIO Pad Data Out (PGPDO4 - PGPDO7)

Offset

Register	Offset
PGPDO4	170Ah
PGPDO7	170Ch
PGPDO6	170Eh

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	PPDO 2	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.32 SIUL2 Parallel GPIO Pad Data Out (PGPDO9)

Offset

Register	Offset
PGPDO9	1710h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	0	PPDO 8	0	0	PPDO 5	PPDO 4	PPDO 3	PPDO 2	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10	Parallel Pad Data Out 10

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPDO10	0b - Logic low 1b - Logic high
9 —	Reserved Always write zero to this field.
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 —	Reserved Always write zero to this field.
6 —	Reserved Always write zero to this field.
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.33 SIUL2 Parallel GPIO Pad Data Out (PGPDO8)

Offset

Register	Offset
PGPDO8	1712h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	0	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	0	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 —	Reserved Always write zero to this field.
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 —	Reserved Always write zero to this field.
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.34 SIUL2 Parallel GPIO Pad Data Out (PGPDO11)

Offset

Register	Offset
PGPDO11	1714h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	0	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	PPDO 2	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 —	Reserved Always write zero to this field.
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.35 SIUL2 Parallel GPIO Pad Data Out (PGPDO10)

Offset

Register	Offset
PGPDO10	1716h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	PPDO 2	PPDO 1	PPDO 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.36 SIUL2 Parallel GPIO Pad Data Out (PGPDO13)

Offset

Register	Offset
PGPDO13	1718h

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 —	Reserved Always write zero to this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 —	Reserved Always write zero to this field.
1 —	Reserved Always write zero to this field.
0 —	Reserved Always write zero to this field.

10.6.37 SIUL2 Parallel GPIO Pad Data Out (PGPDO12)

Offset

Register	Offset
PGPDO12	171Ah

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDO 15	PPDO 14	PPDO 13	PPDO 12	PPDO 11	PPDO 10	PPDO 9	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	PPDO 2	PPDO 1	PPDO 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDO15	Parallel Pad Data Out 15 0b - Logic low 1b - Logic high
14 PPDO14	Parallel Pad Data Out 14 0b - Logic low 1b - Logic high
13 PPDO13	Parallel Pad Data Out 13 0b - Logic low 1b - Logic high
12 PPDO12	Parallel Pad Data Out 12 0b - Logic low 1b - Logic high
11 PPDO11	Parallel Pad Data Out 11 0b - Logic low 1b - Logic high
10 PPDO10	Parallel Pad Data Out 10 0b - Logic low 1b - Logic high
9 PPDO9	Parallel Pad Data Out 9 0b - Logic low 1b - Logic high
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 PPDO2	Parallel Pad Data Out 2 0b - Logic low 1b - Logic high
1 PPDO1	Parallel Pad Data Out 1 0b - Logic low 1b - Logic high
0 PPDO0	Parallel Pad Data Out 0 0b - Logic low 1b - Logic high

10.6.38 SIUL2 Parallel GPIO Pad Data Out (PGPDO14)

Offset

Register	Offset
PGPDO14	171Eh

Function

Each PGPDO*n* register sets or clears the respective pads of the chip.

PGPDO*n* registers can set the values of all output pins assigned to a chip port with a single 16-bit register write, while the GPDO*n* registers set the value on a specific pin with byte writes.

Each bit writes or reads the data register that stores the value to be driven on the pad in output mode. Access to this register location is coherent with access to the bit-wise GPDO*n*.

For a given PGPDO*x*[PPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

PGPDO*x*[PPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDO0[PPDO15] = GPDO0[PDO_0]
- PGPDO2[PPDO15] = GPDO32[PDO_32]
- PGPDO31[PPDO0] = GPDO511[PDO_511]

PGPDO*n* registers access the same physical resource as the PDO and MPGPDO address locations.

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	PPDO 8	PPDO 7	PPDO 6	PPDO 5	PPDO 4	PPDO 3	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 —	Reserved Always write zero to this field.
14 —	Reserved Always write zero to this field.
13 —	Reserved Always write zero to this field.
12 —	Reserved Always write zero to this field.
11 —	Reserved Always write zero to this field.
10 —	Reserved Always write zero to this field.
9 —	Reserved Always write zero to this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
8 PPDO8	Parallel Pad Data Out 8 0b - Logic low 1b - Logic high
7 PPDO7	Parallel Pad Data Out 7 0b - Logic low 1b - Logic high
6 PPDO6	Parallel Pad Data Out 6 0b - Logic low 1b - Logic high
5 PPDO5	Parallel Pad Data Out 5 0b - Logic low 1b - Logic high
4 PPDO4	Parallel Pad Data Out 4 0b - Logic low 1b - Logic high
3 PPDO3	Parallel Pad Data Out 3 0b - Logic low 1b - Logic high
2 —	Reserved Always write zero to this field.
1 —	Reserved Always write zero to this field.
0 —	Reserved Always write zero to this field.

10.6.39 SIUL2 Parallel GPIO Pad Data In (PGPDI1)

Offset

Register	Offset
PGPDI1	1740h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	Reserved	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 —	Reserved
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Logic high

10.6.40 SIUL2 Parallel GPIO Pad Data In (PGPDI0)

Offset

Register	Offset
PGPDI0	1742h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	Reserved	Reserved	Reserved	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 —	Reserved
2 —	Reserved
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.41 SIUL2 Parallel GPIO Pad Data In (PGPDI3)

Offset

Register	Offset
PGPDI3	1744h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	PPDI2	Reserved	Reserved
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 —	Reserved
0 —	Reserved

10.6.42 SIUL2 Parallel GPIO Pad Data In (PGPDI2)

Offset

Register	Offset
PGPDI2	1746h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	Reserved	Reserved	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
9 —	Reserved
8 —	Reserved
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.43 SIUL2 Parallel GPIO Pad Data In (PGPDI5)

Offset

Register	Offset
PGPDI5	1748h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	Reserved	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13	Parallel Pad Data In 13

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPDI13	0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 —	Reserved
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.44 SIUL2 Parallel GPIO Pad Data In (PGPDI4 - PGPDI7)

Offset

Register	Offset
PGPDI4	174Ah
PGPDI7	174Ch
PGPDI6	174Eh

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.45 SIUL2 Parallel GPIO Pad Data In (PGPDI9)

Offset

Register	Offset
PGPDI9	1750h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	Reserved	PPDI8	Reserved	Reserved	PPDI5	PPDI4	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 —	Reserved
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 —	Reserved
6 —	Reserved
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.46 SIUL2 Parallel GPIO Pad Data In (PGPDI8)

Offset

Register	Offset
PGPDI8	1752h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	Reserved	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	Reserved	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13	Parallel Pad Data In 13

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPDI13	0b - Logic low 1b - Logic high
12 —	Reserved
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 —	Reserved
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.47 SIUL2 Parallel GPIO Pad Data In (PGPDI11)

Offset

Register	Offset
PGPDI11	1754h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	Reserved	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 —	Reserved
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.48 SIUL2 Parallel GPIO Pad Data In (PGPDI10)

Offset

Register	Offset
PGPDI10	1756h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high

Table continues on the next page...

Table continued from the previous page...

Field	Function
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.49 SIUL2 Parallel GPIO Pad Data In (PGPDI13)

Offset

Register	Offset
PGPDI13	1758h

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	Reserved	Reserved	Reserved	Reserved
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13	Parallel Pad Data In 13

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPDI13	0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 —	Reserved
1 —	Reserved
0 —	Reserved

10.6.50 SIUL2 Parallel GPIO Pad Data In (PGPDI12)

Offset

Register	Offset
PGPDI12	175Ah

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PPDI15	PPDI14	PPDI13	PPDI12	PPDI11	PPDI10	PPDI9	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	PPDI2	PPDI1	PPDI0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 PPDI15	Parallel Pad Data In 15 0b - Logic low 1b - Logic high
14 PPDI14	Parallel Pad Data In 14 0b - Logic low 1b - Logic high
13 PPDI13	Parallel Pad Data In 13 0b - Logic low 1b - Logic high
12 PPDI12	Parallel Pad Data In 12 0b - Logic low 1b - Logic high
11 PPDI11	Parallel Pad Data In 11 0b - Logic low 1b - Logic high
10 PPDI10	Parallel Pad Data In 10 0b - Logic low 1b - Logic high
9 PPDI9	Parallel Pad Data In 9 0b - Logic low 1b - Logic high
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 PPDI2	Parallel Pad Data In 2 0b - Logic low 1b - Logic high
1 PPDI1	Parallel Pad Data In 1 0b - Logic low 1b - Logic high
0 PPDI0	Parallel Pad Data In 0 0b - Logic low 1b - Logic high

10.6.51 SIUL2 Parallel GPIO Pad Data In (PGPDI14)

Offset

Register	Offset
PGPDI14	175Eh

Function

Hold the synchronized input value from the pads.

PGPDI*n* registers can read the values of all input pins assigned to a chip port with a single 16-bit register read, while the GPDI*n* registers read the value on a specific pin with a byte read.

Each bit reads the current pad value. Access to this register location is coherent with access to the bit-wise GPDI*n*.

For a given PGPDI*x*[PPDI*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDI*n*[PDI_*n*] bit:

PGPDI*x*[PPDI*y*] = GPDI(*x* × 16) + (15 - *y*)[PDI_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- PGPDI0[PPDI15] = GPDI0[PDI_0]
- PGPDI2[PPDI15] = GPDI32[PDI_32]
- PGPDI31[PPDI0] = GPDI511[PDI_511]

These registers support 8-, 16-, and 32-bit accesses.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	PPDI8	PPDI7	PPDI6	PPDI5	PPDI4	PPDI3	Reserved	Reserved	Reserved
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 —	Reserved
14 —	Reserved
13 —	Reserved
12 —	Reserved
11 —	Reserved
10 —	Reserved
9 —	Reserved

Table continues on the next page...

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Field	Function
8 PPDI8	Parallel Pad Data In 8 0b - Logic low 1b - Logic high
7 PPDI7	Parallel Pad Data In 7 0b - Logic low 1b - Logic high
6 PPDI6	Parallel Pad Data In 6 0b - Logic low 1b - Logic high
5 PPDI5	Parallel Pad Data In 5 0b - Logic low 1b - Logic high
4 PPDI4	Parallel Pad Data In 4 0b - Logic low 1b - Logic high
3 PPDI3	Parallel Pad Data In 3 0b - Logic low 1b - Logic high
2 —	Reserved
1 —	Reserved
0 —	Reserved

10.6.52 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO0)

Offset

Register	Offset
MPGPDO0	1780h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	Reserved	Reserved	Reserved	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	Reserved	Reserved	Reserved	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29	Mask Field 13

Table continues on the next page...

Table continued from the previous page...

Field	Function
MASK13	Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written

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Field	Function
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 —	Reserved Always write zero to this field.
19 —	Reserved Always write zero to this field.
18 —	Reserved Always write zero to this field.
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.

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Field	Function
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 —	Reserved Always write zero to this field.
3 —	Reserved Always write zero to this field.
2 —	Reserved Always write zero to this field.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.53 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO1)

Offset

Register	Offset
MPGPDO1	1784h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	Reserved	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	Reserved	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written

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Field	Function
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored

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Field	Function
	1b - MPPDO5 is written
20 —	Reserved Always write zero to this field.
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10	Masked Parallel Pad Data Out 10

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Field	Function
MPPDO10	Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 —	Reserved Always write zero to this field.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.54 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO2)

Offset

Register	Offset
MPGPDO2	1788h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	Reserved	Reserved	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	Reserved	Reserved	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29	Mask Field 13

Table continues on the next page...

Table continued from the previous page...

Field	Function
MASK13	Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 —	Reserved Always write zero to this field.
24 —	Reserved Always write zero to this field.
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written

Table continues on the next page...

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Field	Function
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.

Table continues on the next page...

Table continued from the previous page...

Field	Function
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 —	Reserved Always write zero to this field.
8 —	Reserved Always write zero to this field.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.55 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO3)

Offset

Register	Offset
MPGPDO3	178Ch

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29	Mask Field 13

Table continues on the next page...

Table continued from the previous page...

Field	Function
MASK13	Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written

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Field	Function
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 —	Reserved Always write zero to this field.
16 —	Reserved Always write zero to this field.
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.

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Field	Function
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 —	Reserved Always write zero to this field.
0 —	Reserved Always write zero to this field.

10.6.56 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO4)

Offset

Register	Offset
MPGPDO4	1790h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29	Mask Field 13

Table continues on the next page...

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Field	Function
MASK13	Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written

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Field	Function
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12	Masked Parallel Pad Data Out 12

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Field	Function
MPPDO12	Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.57 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO5)

Offset

Register	Offset
MPGPDO5	1794h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	Reserved	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	Reserved	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31	Mask Field 15

Table continues on the next page...

Table continued from the previous page...

Field	Function
MASK15	Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 —	Reserved Always write zero to this field.
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance.

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Field	Function
	0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15	Masked Parallel Pad Data Out 15

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Field	Function
MPPDO15	Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 —	Reserved Always write zero to this field.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.

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Field	Function
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.58 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO6 - MPGPDO7)

Offset

Register	Offset
MPGPDO6	1798h
MPGPDO7	179Ch

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26	Mask Field 10

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Field	Function
MASK10	Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written

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Field	Function
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.

Table continues on the next page...

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Field	Function
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.59 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO8)

Offset

Register	Offset
MPGPDO8	17A0h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	Reserved	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	Reserved	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	Reserved	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	Reserved	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 —	Reserved Always write zero to this field.
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written

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Field	Function
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored

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Field	Function
	1b - MPPDO3 is written
18 —	Reserved Always write zero to this field.
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 —	Reserved Always write zero to this field.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.

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Field	Function
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 —	Reserved Always write zero to this field.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.60 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO9)

Offset

Register	Offset
MPGPDO9	17A4h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	Reserved	MASK 8	Reserved	Reserved	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	Reserved	MPPDO8	Reserved	Reserved	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance.

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Field	Function
	0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 —	Reserved Always write zero to this field.
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 —	Reserved Always write zero to this field.
22 —	Reserved Always write zero to this field.
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance.

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Field	Function
	0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 —	Reserved Always write zero to this field.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 —	Reserved Always write zero to this field.
6	Reserved Always write zero to this field.

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Field	Function
—	
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.61 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO10)

Offset

Register	Offset
MPGPDO10	17A8h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]

- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance.

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Field	Function
	0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19	Mask Field 3

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Field	Function
MASK3	Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8	Masked Parallel Pad Data Out 8

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Field	Function
MPPDO8	Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.62 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO11)

Offset

Register	Offset
MPGPDO11	17ACh

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	Reserved	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	Reserved	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance.

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Field	Function
	0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 —	Reserved Always write zero to this field.
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance.

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Field	Function
	0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.

Table continues on the next page...

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Field	Function
9 —	Reserved Always write zero to this field.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.63 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO12)

Offset

Register	Offset
MPGPDO12	17B0h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	MASK 3	MASK 2	MASK 1	MASK 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	MPPDO2	MPPDO1	MPPDO0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance. 0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written

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Field	Function
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored

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Field	Function
	1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18 MASK2	Mask Field 2 Masks MPPDO2 in the same MPGPDO*n* register instance. 0b - MPPDO2 is ignored 1b - MPPDO2 is written
17 MASK1	Mask Field 1 Masks MPPDO1 in the same MPGPDO*n* register instance. 0b - MPPDO1 is ignored 1b - MPPDO1 is written
16 MASK0	Mask Field 0 Masks MPPDO0 in the same MPGPDO*n* register instance. 0b - MPPDO0 is ignored 1b - MPPDO0 is written
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11	Masked Parallel Pad Data Out 11

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Field	Function
MPPDO11	Writes the data register that stores the value to be driven on the pad in output mode.
10 MPPDO10	Masked Parallel Pad Data Out 10 Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 MPPDO2	Masked Parallel Pad Data Out 2 Writes the data register that stores the value to be driven on the pad in output mode.
1 MPPDO1	Masked Parallel Pad Data Out 1 Writes the data register that stores the value to be driven on the pad in output mode.
0 MPPDO0	Masked Parallel Pad Data Out 0 Writes the data register that stores the value to be driven on the pad in output mode.

10.6.64 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO13)

Offset

Register	Offset
MPGPDO13	17B4h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MASK 15	MASK 14	MASK 13	MASK 12	MASK 11	MASK 10	MASK 9	MASK 8	MASK 7	MASK 6	MASK 5	MASK 4	Reserved	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	MPPDO15	MPPDO14	MPPDO13	MPPDO12	MPPDO11	MPPDO10	MPPDO9	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	Reserved	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MASK15	Mask Field 15 Masks MPPDO15 in the same MPGPDO*n* register instance. 0b - MPPDO15 is ignored 1b - MPPDO15 is written
30 MASK14	Mask Field 14 Masks MPPDO14 in the same MPGPDO*n* register instance.

Table continues on the next page...

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Field	Function
	0b - MPPDO14 is ignored 1b - MPPDO14 is written
29 MASK13	Mask Field 13 Masks MPPDO13 in the same MPGPDO*n* register instance. 0b - MPPDO13 is ignored 1b - MPPDO13 is written
28 MASK12	Mask Field 12 Masks MPPDO12 in the same MPGPDO*n* register instance. 0b - MPPDO12 is ignored 1b - MPPDO12 is written
27 MASK11	Mask Field 11 Masks MPPDO11 in the same MPGPDO*n* register instance. 0b - MPPDO11 is ignored 1b - MPPDO11 is written
26 MASK10	Mask Field 10 Masks MPPDO10 in the same MPGPDO*n* register instance. 0b - MPPDO10 is ignored 1b - MPPDO10 is written
25 MASK9	Mask Field 9 Masks MPPDO9 in the same MPGPDO*n* register instance. 0b - MPPDO9 is ignored 1b - MPPDO9 is written
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22	Mask Field 6

Table continues on the next page...

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Field	Function
MASK6	Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 —	Reserved Always write zero to this field.
18 —	Reserved Always write zero to this field.
17 —	Reserved Always write zero to this field.
16 —	Reserved Always write zero to this field.
15 MPPDO15	Masked Parallel Pad Data Out 15 Writes the data register that stores the value to be driven on the pad in output mode.
14 MPPDO14	Masked Parallel Pad Data Out 14 Writes the data register that stores the value to be driven on the pad in output mode.
13 MPPDO13	Masked Parallel Pad Data Out 13 Writes the data register that stores the value to be driven on the pad in output mode.
12 MPPDO12	Masked Parallel Pad Data Out 12 Writes the data register that stores the value to be driven on the pad in output mode.
11 MPPDO11	Masked Parallel Pad Data Out 11 Writes the data register that stores the value to be driven on the pad in output mode.
10	Masked Parallel Pad Data Out 10

Table continues on the next page...

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Field	Function
MPPDO10	Writes the data register that stores the value to be driven on the pad in output mode.
9 MPPDO9	Masked Parallel Pad Data Out 9 Writes the data register that stores the value to be driven on the pad in output mode.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.
3 —	Reserved Always write zero to this field.
2 —	Reserved Always write zero to this field.
1 —	Reserved Always write zero to this field.
0 —	Reserved Always write zero to this field.

10.6.65 SIUL2 Masked Parallel GPIO Pad Data Out (MPGPDO14)

Offset

Register	Offset
MPGPDO14	17B8h

Function

Each MPGPDO*n* register selectively modifies the pad values associated with PGPDO*n*.

NOTE

MPGPDO*n* registers must only be accessed with 32-bit writes. 8-bit or 16-bit writes will not modify any bits in the register and cause a transfer error. Read access will return 0.

NOTE

MPGPDO*n* registers support only 32-bit accesses. Byte and half-word accesses are not supported.

Accesses to each MPGPDO*n* register location is coherent with access to the bit-wise GPDO*n*.

For a given MPGPDO*x*[MPPDO*y*] where *x* is the register instance index and *y* is the field index, the following equation shows the equivalent GPDO*n*[PDO_*n*] bit:

MPGPDO*x*[MPPDO*y*] = GPDO(*x* × 16) + (15 - *y*)[PDO_(*x* × 16) + (15 - *y*)]

Some examples of the mapping:

- MPGPDO0[MPPDO15] = GPDO0[PDO_0]
- MPGPDO2[MPPDO15] = GPDO32[PDO_32]
- MPGPDO31[MPPDO0] = GPDO511[PDO_511]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	MASK8	MASK7	MASK6	MASK5	MASK4	MASK3	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	MPPDO8	MPPDO7	MPPDO6	MPPDO5	MPPDO4	MPPDO3	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved Always write zero to this field.
30 —	Reserved Always write zero to this field.
29 —	Reserved Always write zero to this field.
28 —	Reserved Always write zero to this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
27 —	Reserved Always write zero to this field.
26 —	Reserved Always write zero to this field.
25 —	Reserved Always write zero to this field.
24 MASK8	Mask Field 8 Masks MPPDO8 in the same MPGPDO*n* register instance. 0b - MPPDO8 is ignored 1b - MPPDO8 is written
23 MASK7	Mask Field 7 Masks MPPDO7 in the same MPGPDO*n* register instance. 0b - MPPDO7 is ignored 1b - MPPDO7 is written
22 MASK6	Mask Field 6 Masks MPPDO6 in the same MPGPDO*n* register instance. 0b - MPPDO6 is ignored 1b - MPPDO6 is written
21 MASK5	Mask Field 5 Masks MPPDO5 in the same MPGPDO*n* register instance. 0b - MPPDO5 is ignored 1b - MPPDO5 is written
20 MASK4	Mask Field 4 Masks MPPDO4 in the same MPGPDO*n* register instance. 0b - MPPDO4 is ignored 1b - MPPDO4 is written
19 MASK3	Mask Field 3 Masks MPPDO3 in the same MPGPDO*n* register instance. 0b - MPPDO3 is ignored 1b - MPPDO3 is written
18	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	Always write zero to this field.
17 —	Reserved Always write zero to this field.
16 —	Reserved Always write zero to this field.
15 —	Reserved Always write zero to this field.
14 —	Reserved Always write zero to this field.
13 —	Reserved Always write zero to this field.
12 —	Reserved Always write zero to this field.
11 —	Reserved Always write zero to this field.
10 —	Reserved Always write zero to this field.
9 —	Reserved Always write zero to this field.
8 MPPDO8	Masked Parallel Pad Data Out 8 Writes the data register that stores the value to be driven on the pad in output mode.
7 MPPDO7	Masked Parallel Pad Data Out 7 Writes the data register that stores the value to be driven on the pad in output mode.
6 MPPDO6	Masked Parallel Pad Data Out 6 Writes the data register that stores the value to be driven on the pad in output mode.
5 MPPDO5	Masked Parallel Pad Data Out 5 Writes the data register that stores the value to be driven on the pad in output mode.
4 MPPDO4	Masked Parallel Pad Data Out 4 Writes the data register that stores the value to be driven on the pad in output mode.

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Field	Function
3 MPPDO3	Masked Parallel Pad Data Out 3 Writes the data register that stores the value to be driven on the pad in output mode.
2 —	Reserved Always write zero to this field.
1 —	Reserved Always write zero to this field.
0 —	Reserved Always write zero to this field.

Chapter 11
Crossbar Switch Lite (AXBS_Lite)

11.1 Chip-specific AXBS_Lite information

11.1.1 AXBS instances and connectivity matrix

This chip has 7 instances of AXBS.

- AXBS_0 (Main XBAR)
- AXBS_1 (PERIPH XBAR)
- AXBS_2 (EDMA XBAR)
- AXBS_3 (TCM XBAR)
- AXBS_4 (HSE XBAR)
- AXBS_5 (EDMA1 XBAR)
- AXBS_6 (ZIPWIRE XBAR)

Table 38. AXBS connectivity matrix

<table>
<tr><th>Instance</th><th>Master and slave assignments</th></tr>
<tr><td>AXBS_0 (Main)</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th></th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>Cortex-M7_0 AHBM</td><td></td><td>S0</td><td>Flash memory port 0</td></tr>
<tr><td>M1</td><td>DMA</td><td></td><td>S1</td><td>Flash memory port 1</td></tr>
<tr><td>M2</td><td>HSE_B</td><td></td><td>S2</td><td>PRAM_0</td></tr>
<tr><td>M3</td><td>EMAC</td><td></td><td>S3</td><td>Cortex-M7 TCMs</td></tr>
<tr><td>M4</td><td>Cortex-M7_1 AHBM</td><td></td><td>S4</td><td>Flash memory port 2</td></tr>
<tr><td>M5</td><td>Cortex-M7_2 AHBM</td><td></td><td>S5</td><td>QuadSPI</td></tr>
<tr><td>M6</td><td>DMA1</td><td></td><td>S6</td><td>PRAM_1</td></tr>
<tr><td>M7</td><td>Zipwire</td><td></td><td>S7</td><td>Flash memory port 3</td></tr>
</table>
</td></tr>
<tr><td>AXBS_1 (Peripheral)</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th></th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>Cortex-M7_0 AHBP</td><td></td><td>S0</td><td>AIPS_0</td></tr>
<tr><td>M1</td><td>DMA</td><td></td><td>S1</td><td>AIPS_1</td></tr>
<tr><td></td><td></td><td></td><td>S2</td><td>AIPS_2</td></tr>
<tr><td>M2</td><td>HSE_ACP_MC_TAG_00_MSCMB</td><td></td><td>S3</td><td>AIPS_3</td></tr>
<tr><td>M3</td><td>Cortex-M7_1 AHBP</td><td></td><td></td><td></td></tr>
<tr><td>M4</td><td>Cortex-M7_2 AHBP</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
</table>

Instance	Master and slave assignments
	M5 -- M6 DMA1 M7 Zipwire
AXBS_2 (eDMA)	**Master port** / **Master module** / **Slave port** / **Slave module**: M0 / eDMA / S0 / System XBAR; S1 / Peripheral XBAR
AXBS_3 (Cortex-M7 TCM)	**Master port** / **Master module** / **Slave port** / **Slave module**: M0 / System XBAR / S0 / Cortex-M7_0 TCM; S1 / Cortex-M7_1 TCM; S2 / Cortex-M7_2 TCM
AXBS_4 (HSE_B)	**Master port** / **Master module** / **Slave port** / **Slave module**: M0 / HSE_B / S0 / System XBAR; S1 / Peripheral XBAR
AXBS_5 (DMA1)	**Master port** / **Master module** / **Slave port** / **Slave module**: M0 / eDMA_1 / S0 / System XBAR; S1 / Peripheral XBAR
AXBS_6 (Zipwire)	**Master port** / **Master module** / **Slave port** / **Slave module**: M0 / Zipwire / S0 / System XBAR; S1 / Peripheral XBAR

11.2 Overview

This section provides information on the layout, configuration, and programming of the crossbar switch.

The crossbar switch connects bus masters and bus slaves using a crossbar switch structure. This structure allows all bus masters to access different bus slaves simultaneously, while providing arbitration among the bus masters when they access the same slave. A variety of bus arbitration methods and attributes may be programmed on a slave-by-slave basis.

11.2.1 Features

- Symmetric crossbar bus switch implementation
  - Allows concurrent access from different masters to different slaves
  - Slave arbitration attributes configured on a slave-by-slave basis
- Single-clock 64-bit transfer
- Support for burst transfers of 64 bits of data
- Support for low-power park mode
- Master high-priority elevation
- 64-bit AHB crossbar bus switch compatible with ARM's AMBA Specification v2.0

11.3 Functional description

Information about general operation and arbitration are provided in this section.

11.3.1 General operation

When a master accesses the crossbar switch, the access is immediately taken. If the targeted slave port of the access is available, then the access is immediately presented on the slave port. Single-clock or zero-wait-state accesses are possible through the crossbar. If the targeted slave port of the access is busy or parked on a different master port, the requesting master sees wait states inserted until the targeted slave port can service the master's request. The latency in servicing the request depends on each master's priority level and the responding slave's access time.

Because the crossbar switch appears to be just another slave to the master device, the master device does not know whether it owns the slave port it is targeting. The master waits while it does not have control of the slave port it is targeting.

After the master acquires control of the slave port, it controls the port until it relinquishes the port by running an IDLE cycle or by targeting a different slave port for its next access.

The master can also lose control of the slave port if another higher-priority master makes a request to the slave port. However, if the master is running a fixed-length burst transfer, it retains control of the slave port until that transfer completes.

The crossbar terminates all master IDLE transfers, as opposed to allowing the termination to come from one of the slave buses. Additionally, when no master is requesting access to a slave port, the crossbar drives IDLE transfers onto the slave bus, even though a default master may be granted access to the slave port.

When a slave bus is being idled by the crossbar, it can park the slave port on the master port indicated by CRS*n*[PARK]. This is done to save the initial clock of arbitration delay that otherwise would be seen if the same master had to arbitrate to gain control of the slave port. The slave port can also be put into low-power park mode to save power, by using CRS*n*[PCTL].

11.3.2 Register coherency

The operation of the crossbar is affected as soon as a register is written. The values of the registers do not track with slave-port-related master accesses, but instead track only with slave accesses.

11.3.3 Arbitration

The crossbar switch supports the following arbitration algorithms:

- Fixed priority
- Round-robin

The arbitration scheme is independently programmable for each slave port.

11.3.3.1 Fixed-priority operation

When operating in fixed-priority mode, each master is assigned a unique priority level in the priority registers (PRS*n*). If two masters request access to the same slave port, the master with the highest priority in the selected priority register gains control over the slave port.

NOTE

In this arbitration mode, a higher-priority master can monopolize a slave port, preventing access from any lower-priority master to the port.

When a master makes a request to a slave port, the slave port checks whether the new requesting master's priority level is higher than that of the master that currently has control over the slave port, unless the slave port is in a parked state. The slave port performs an arbitration check at every clock edge to ensure that the master, if any, has control of the slave port.

The following table describes possible scenarios based on the requesting master port.

Table 39. Methods of how the crossbar switch grants control of a slave port to a master

When	Then the crossbar switch grants control to the requesting master
Both of the following are true: • The current master is not running a transfer. • The new requesting master's priority level is higher than that of the current master.	At the next clock edge
Both of the following are true: • The current master is running a fixed-length burst transfer or a locked transfer. • The requesting master's priority level is higher than that of the current master.	At the end of the burst transfer or locked transfer
The requesting master's priority level is lower than the current master.	At the conclusion of one of the following cycles: • An IDLE cycle • A non-IDLE cycle to a location other than the current slave port

11.3.3.2 Round-robin priority operation

When operating in round-robin mode, each master is assigned a relative priority based on the master port number. This relative priority is compared to the master port number (ID) of the last master to perform a transfer on the slave bus. The highest priority requests the master owns the slave bus at the next transfer boundary, accounting for locked and fixed-length burst transfers. Priority is based on how far ahead the ID of the requesting master is of the ID of the last master.

After a master is granted access to a slave port, a master may perform as many transfers as desired to that port until another master requests the same slave port. The next master in line is granted access to the slave port at the next transfer boundary, or possibly on the next clock cycle, if the current master has no pending access request.

As an example of arbitration in round-robin mode, assume that the crossbar is implemented with master ports 0, 1, 4, and 5. If the last master of the slave port was master 1, and masters 0, 4, and 5 make simultaneous requests, they are serviced in this order: 4,5, and then 0.

Parking may continue to be used in a round-robin mode, but does not affect the round-robin pointer unless the parked master performs a transfer. Handoff occurs to the next master in line after one cycle of arbitration. If the slave port is put into low-power park mode, the round-robin pointer is reset to point at master port 0, giving it the highest priority.

11.3.3.3 Clocking

This module has no clocking considerations.

11.3.3.4 Interrupts

This module has no interrupts.

11.3.3.5 Priority assignment

Each master port must be assigned a unique 3-bit priority level. If an attempt is made to program multiple master ports with the same priority level within the priority registers (PRS*n*), the crossbar switch responds with a bus error and the registers are not updated.

11.4 External signals

This module has no external signals.

11.5 Initialization/application information

No initialization is required for the crossbar switch.

Hardware reset ensures that all the register bits used by the crossbar switch are properly initialized to a valid state. However, the following settings and priorities may be programmed to achieve the maximum system performance:

- During the configuration of the crossbar switch, all other masters must be IDLE.
- To prevent reconfiguration of the crossbar switch, write 1 to CRS*n*[RO].

11.6 Memory map and register definition

Each slave port of the crossbar switch contains configuration registers. Read- and write transfers require two bus clock cycles. The registers can be read from and written to only in supervisor mode. Additionally, these registers can be read from or written to only by 32-bit accesses.

A bus error response is returned if an unimplemented location is accessed within the crossbar switch.

The CRS*n* and PRS*n* registers can be programmed as read-only to prevent changes to their configuration. After being read-only protected, future writes to them terminate with a data storage error.

NOTE

This section shows the registers for all eight master and slave ports. If a master or slave is not used on this particular chip, then unexpected results occur when writing to its registers. See the chip configuration details for the exact master and slave assignments for your chip.

All references to the crossbar switch registers are based on the physical port connections.

11.6.1 AXBS register descriptions

11.6.1.1 AXBS memory map

AXBS_LITE base address: 4020_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Priority Slave Registers (PRS0)	32	RW	7654_3210h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
10h	Control Register (CRS0)	32	RW	0002_0110h
100h	Priority Slave Registers (PRS1)	32	RW	7654_3210h
110h	Control Register (CRS1)	32	RW	0002_0110h
200h	Priority Slave Registers (PRS2)	32	RW	7654_3210h
210h	Control Register (CRS2)	32	RW	0002_0110h
300h	Priority Slave Registers (PRS3)	32	RW	7654_3210h
310h	Control Register (CRS3)	32	RW	0002_0110h
400h	Priority Slave Registers (PRS4)	32	RW	7654_3210h
410h	Control Register (CRS4)	32	RW	0002_0110h
500h	Priority Slave Registers (PRS5)	32	RW	7654_3210h
510h	Control Register (CRS5)	32	RW	0002_0110h
600h	Priority Slave Registers (PRS6)	32	RW	7654_3210h
610h	Control Register (CRS6)	32	RW	0002_0110h
700h	Priority Slave Registers (PRS7)	32	RW	7654_3210h
710h	Control Register (CRS7)	32	RW	0002_0110h

11.6.1.2 Priority Slave Registers (PRS0 - PRS7)

Offset

Register	Offset
PRS0	0h
PRS1	100h
PRS2	200h
PRS3	300h
PRS4	400h
PRS5	500h
PRS6	600h
PRS7	700h

Function

The priority slave registers(PRS*n*) set the priority of each master port on a per slave port basis and reside in each slave port. The priority register can be accessed only with 32-bit access. After the CRS*n*[RO] bit is set, the PRS*n* register can only be read; attempts to write to it have no effect on PRS*n* and result in a bus-error response to the master initiating the write.

Two available masters must not be programmed with the same priority level. Attempts to program two or more masters with the same priority level result in a bus-error response and the PRS*n* is not updated.

NOTE

Valid values for the M*n* priority fields depend on which masters are available on the chip. This information can be found in the chip-specific information for the crossbar.

- If the chip contains fewer than three masters, only one bit is valid.
- If the chip contains fewer than five masters, only two bits are valid.
- If five or more masters are present, all three bits of the priority field are used.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	M7			0	M6			0	M5			0	M4		
W																
Reset	0	1	1	1	0	1	1	0	0	1	0	1	0	1	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	M3			0	M2			0	M1			0	M0		
W																
Reset	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0

Fields

Field	Function
31 —	Reserved
30-28 M7	Master 7 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port. 001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port. 110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8 or lowest priority when accessing the slave port.
27 —	Reserved

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Field	Function
26-24 M6	Master 6 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port. 001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port. 110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8the or lowest priority when accessing the slave port.
23 —	Reserved
22-20 M5	Master 5 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port. 001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port. 110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8 or lowest priority when accessing the slave port.
19 —	Reserved
18-16 M4	Master 4 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port. 001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port.

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Field	Function
	110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8 or lowest priority when accessing the slave port.
15 —	Reserved
14-12 M3	Master 3 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port. 001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port. 110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8the or lowest priority when accessing the slave port.
11 —	Reserved
10-8 M2	Master 2 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port. 001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port. 110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8the or lowest priority when accessing the slave port.
7 —	Reserved
6-4 M1	Master 1 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port.

Table continues on the next page...

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Field	Function
	001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port. 110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8 or lowest priority when accessing the slave port.
3 —	Reserved
2-0 M0	Master 0 Priority This field sets the arbitration priority for this port on the associated slave port. 000b - This master has level 1 or highest priority when accessing the slave port. 001b - This master has level 2 priority when accessing the slave port. 010b - This master has level 3 priority when accessing the slave port. 011b - This master has level 4 priority when accessing the slave port. 100b - This master has level 5 priority when accessing the slave port. 101b - This master has level 6 priority when accessing the slave port. 110b - This master has level 7 priority when accessing the slave port. 111b - This master has level 8 or the lowest priority when accessing the slave port.

11.6.1.3 Control Register (CRS0 - CRS7)

Offset

Register	Offset
CRS0	10h
CRS1	110h
CRS2	210h
CRS3	310h
CRS4	410h
CRS5	510h
CRS6	610h
CRS7	710h

Function

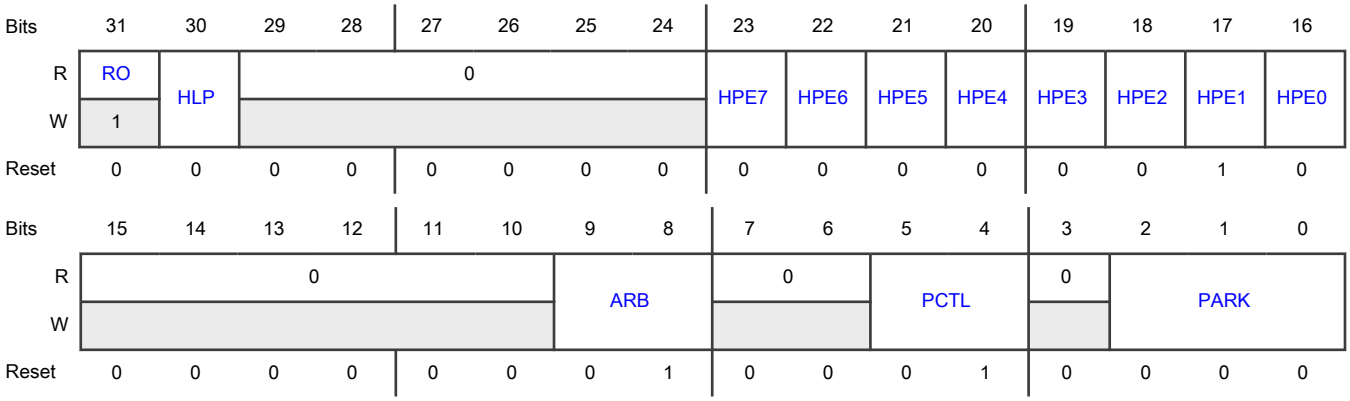
These registers control several features of each slave port and must be accessed using 32-bit accesses. After CRS*n*[RO] is set, the PRS*n* can only be read; attempts to write to it have no effect and results in an error response.

NOTE

See the chip-specific crossbar information for the reset value of this register.

Not all HPE *n* fields may be active. See the chip-specific crossbar information for which masters support master high-priority elevation. Setting a field corresponding to a master that does not support master, high-priority elevation has no effect.

Diagram



Fields

Field	Function
31 RO	Read Only Forces the PRS*n* and CRS*n* registers to be read-only. After being set, only a hardware reset clears this field. 0b - The CRS*n* and PRS*n* registers are writeable 1b - The CRS*n* and PRS*n* registers are read-only and cannot be written (attempted writes have no effect on the registers and result in a bus error response).
30 HLP	Halt Low Priority This field sets the initial arbitration priority for low power-mode requests . Setting this bit will not affect the ,request for low power-mode from attaining the highest priority after it has control of the slave ports. 0b - The low-power mode request has the highest priority for arbitration on this slave port. 1b - The low-power mode request has the lowest initial priority for arbitration on this slave port.
29-24 —	Reserved
23 HPE7	High Priority Elevation 7 This field enables master high-priority elevation for master 7,on this slave port. If enabled, the master is able to elevate its priority to the highest.

Table continues on the next page...

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Field	Function
	0b - Master high-priority elevation for master 7. is disabled on this slave port. 1b - Master high-priority elevation for master 7. is enabled on this slave port.
22 HPE6	High Priority Elevation 6 This field enables master high-priority elevation for master 6, on this slave port. If enabled, the master is able to elevate its priority to the highest. 0b - Master high-priority elevation for master 6. is disabled on this slave port. 1b - Master high-priority elevation for master 6. is enabled on this slave port.
21 HPE5	High Priority Elevation 5 This field enables master high-priority elevation for master 5,on this slave port. If enabled, the master is able to elevate its priority to the highest. 0b - Master high-priority elevation for master 5. is disabled on this slave port. 1b - Master high-priority elevation for master 5. is enabled on this slave port.
20 HPE4	High Priority Elevation 4 This field enables master high-priority elevation for master 4,on this slave port. If enabled, the master can elevate its priority to the highest. 0b - Master high-priority elevation for master 4. is disabled on this slave port. 1b - Master high-priority elevation for master 4. is enabled on this slave port.
19 HPE3	High Priority Elevation 3 This field enables master high-priority elevation for master 3,on this slave port. If enabled, the master can elevate its priority to the highest. 0b - Master high-priority elevation for master 3. is disabled on this slave port. 1b - Master high-priority elevation for master 3. is enabled on this slave port.
18 HPE2	High Priority Elevation 2 This field enables master high-priority elevation for master 2, on this slave port. If enabled, the master can elevate its priority to the highest. 0b - Master high-priority elevation for master 2. is disabled on this slave port. 1b - Master high-priority elevation for master 2. is enabled on this slave port.
17 HPE1	High Priority Elevation 1 This field enables master high-priority elevation for master 1 on this slave port. If enabled, the master can elevate its priority to the highest. 0b - Master high-priority elevation for master 1. is disabled on this slave port. 1b - Master high-priority elevation for master 1. is enabled on this slave port.
16	High Priority Elevation 0

Table continues on the next page...

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Field	Function
HPE0	This field enables master high-priority elevation for master 0,on this slave port. If enabled, the master can elevate its priority to the highest. 0b - Master high-priority elevation for master 0. is disabled on this slave port. 1b - Master high-priority elevation for master 0. is enabled on this slave port.
15-10 —	Reserved
9-8 ARB	Arbitration Mode This field selects the arbitration policy for the slave port. 00b - Fixed priority 01b - Round-robin (rotating) priority 10b - Reserved 11b - Reserved
7-6 —	Reserved
5-4 PCTL	Parking Control This field determines the slave port's parking control. The low-power park feature results in an overall power savings if the slave port is not saturated; however, this forces an extra latency clock when any master tries to access the slave port when not in use because it is not parked on any master. 00b - When no master makes a request, the arbiter parks the slave port on the master port defined by the PARK bit field. 01b - When no master makes a request, the arbiter parks the slave port on the last master to be in control of the slave port. 10b - Low-power park. When no master makes a request, the slave port is not parked on a master and the arbiter drives all outputs to a constant safe state. 11b - Reserved
3 —	Reserved
2-0 PARK	Park This field determines which master port the current slave port parks on when no masters are actively making requests and the PCTL bits are cleared. **NOTE** Select only master ports that are present on the chip. Otherwise, undefined behavior might occur.

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Field	Function
	000b - Park on master port M0 001b - Park on master port M1 010b - Park on master port M2 011b - Park on master port M3 100b - Park on master port M4 101b - Park on master port M5 110b - Park on master port M6 111b - Park on master port M7

11.7 Glossary

AMBA Advanced Microcontroller Bus Architecture

IDLE A type of transfer that a master uses when it does not want to perform a data transfer

ID Master port number

Chapter 12
Peripheral Bridge (AIPS_Lite)

12.1 Chip-specific AIPS_Lite information

12.1.1 AIPS_Lite instances

The following table summarizes AIPS_Lite instances on S32K396 product series to support simultaneous data transfers to different peripherals. There are 4 AIPS_Lite instances:

- AIPS_0
- AIPS_1
- AIPS_2
- AIPS_3

12.2 Overview

AIPS_Lite converts the crossbar switch interface to an interface that can access most of the slave peripherals on this chip.

This peripheral bridge occupies 64 MB of the address space, which is divided into peripheral slots of 16 KB each. All the peripherals may not be used. See the memory map chapter for details on slot assignments. The bridge includes separate clock enable inputs for each of the slots to accommodate slower peripherals.

12.2.1 Features

Following are the key features of the peripheral bridge:

- Supports peripheral slots with 8-, 16-, and 32-bit datapath width
- Supports a pair of 32-bit transactions for selected 64-bit memory accesses

12.2.2 General operation

The slave devices connected to the peripheral bridge are modules that contain a programming model of control and status registers. The system masters read and write these registers through the peripheral bridge.

The register maps of the peripherals are located on 16 KB boundaries. Each peripheral is allocated one or more 16-KB block(s) of the memory map.

12.3 Functional description

The peripheral bridge functions as a bus protocol translator between the crossbar switch and the slave peripheral bus. Support is provided for generating a pair of 32-bit slave accesses when performing certain 64-bit peripheral accesses.

The peripheral bridge manages all transactions for the attached slave devices and generates select signals for modules on the peripheral bus by decoding accesses within the attached address space.

12.3.1 Access support

All combinations of access size and peripheral data port width are supported. An access that is larger than the target peripheral's data width is decomposed to multiple, smaller accesses. Bus decomposition is terminated by a transfer error caused by an access to an empty register area.

12.3.2 Clocking

This module has no clocking considerations.

12.3.3 Interrupts

This module has no interrupts.

12.4 External signals

This module has no external signals.

12.5 Memory map and register definition

The AIPS module(s) on this chip do(es) not contain any user-programmable registers.

Chapter 13
Direct Memory Access Multiplexer (DMAMUX)

13.1 Chip-specific DMAMUX information

13.1.1 DMAMUX instances

This chip has four instances of DMAMUX. See the DMAMUX map file attached to this document to find information related to the slot number for each DMA trigger source.

All the DMA requests are routed to DMA controller through DMAMUX.

DMAMUX_0 and DMAMUX_1 channels are mapped to eDMA_TCD 0–15 and 16–31, respectively.

DMAMUX_2 and DMAMUX_3 are mapped to eDMA1_TCD 0-15 and 16-31 respectively.

13.1.2 Periodic DMA triggering

PIT generates periodic trigger events to DMAMUX as shown in this table.

Table 40. PIT channel assignment for periodic DMA triggering through DMAMUX

	DMA_CH_MUX_0	DMA_CH_MUX_1	DMA_CH_MUX_2	DMA_CH_MUX_3
Trigger 0	PIT0_CH0	PIT0_CH0	PIT1_CH0	PIT1_CH0
Trigger 1	PIT0_CH1	PIT0_CH1	PIT1_CH1	PIT1_CH1
Trigger 2	PIT0_CH2	PIT0_CH2	PIT1_CH2	PIT1_CH2
Trigger 3	PIT0_CH3	PIT0_CH3	PIT1_CH3	PIT1_CH3

13.2 Introduction

13.2.1 Overview

DMAMUX routes a DMA source, called slot, to any of the 16 DMA channels. See the chip-specific information for details.

13.2.2 Block diagram

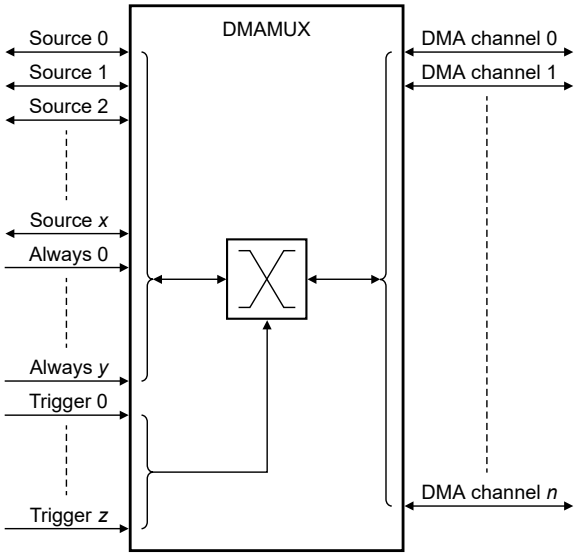


Figure 24. Block diagram

13.2.3 Features

- Ability to route up to 61 peripheral slots and up to 2 always-on slots to 16 channels
- Supports 16 independently selectable DMA channel routers (the first 4 channels provide an additional trigger functionality)
- Allows assignment of each channel router to one of the possible peripheral DMA slots or always-on slots

13.2.4 Modes of operation

The following table describes the functional operating modes of DMAMUX.

Table 41. Modes of operation

Mode	Description
Disabled	In this mode, the DMA channel is disabled. Because disabling and enabling of DMA channels is done primarily via the DMA configuration registers, this mode is used mainly as the reset state for a DMA channel in the DMA channel MUX. You can also use this mode to temporarily suspend a DMA channel while system reconfiguration takes place, for example, by changing the period of a DMA trigger.
Normal	In this mode, a DMA source is routed directly to the specified DMA channel. The operation of DMAMUX in this mode is completely transparent to the system.
Periodic trigger	In this mode, a DMA source can only request a DMA transfer, such as, when a transmit buffer becomes empty or a receive buffer becomes full, periodically. You configure the period using an external periodic interrupt timer (PIT). This mode is available only for channels 0–3. See the chip-specific section for more details.

13.3 Functional description

The primary purpose of DMAMUX is to provide flexibility in the system's use of the available DMA channels. Configuration of DMAMUX is intended to be a static procedure performed during the execution of the system boot code. However, if you follow the procedure outlined in Enabling and configuring sources, you can change the configuration of DMAMUX during the normal operation of the system. All DMA channels must be inactive before and during a configuration change.

Functionally, DMAMUX channels can be divided into two classes:

- Channels that implement the normal routing functionality plus the periodic triggering capability
- Channels that implement only the normal routing functionality

13.3.1 DMA channels with periodic triggering capability

Besides the normal routing functionality, the first four channels of DMAMUX provide a special periodic triggering capability that you can use to provide an automatic mechanism to transmit bytes, frames, or packets at fixed intervals without the need for processor intervention (see Figure 25).

An external periodic interrupt timer (PIT) generates the trigger; for example, by configuring the external periodic timer, you configure the periodic triggering interval.

NOTE

Because of the dynamic nature of the system (owing to DMA channel priorities, bus arbitration, interrupt service routine lengths, and so on), the number of clock cycles between a trigger and the actual DMA transfer cannot be guaranteed.

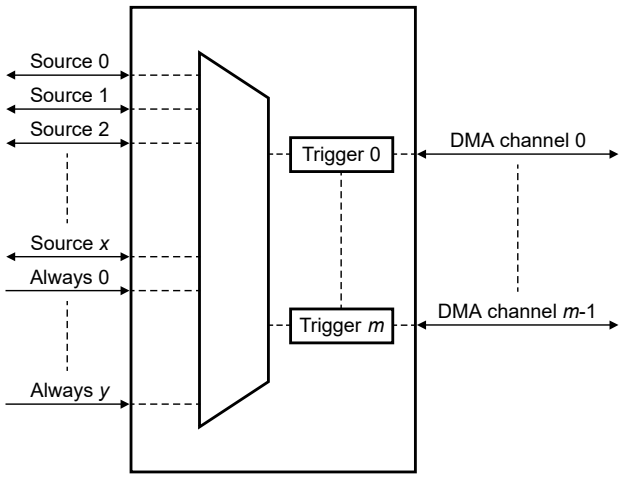


Figure 25. DMAMUX triggered channels

The DMA channel triggering capability allows the system to schedule regular DMA transfers, usually on the transmit side of certain peripherals, without the intervention of the processor. This trigger works by gating the request from the peripheral to DMA until a trigger event is observed (see Figure 26).

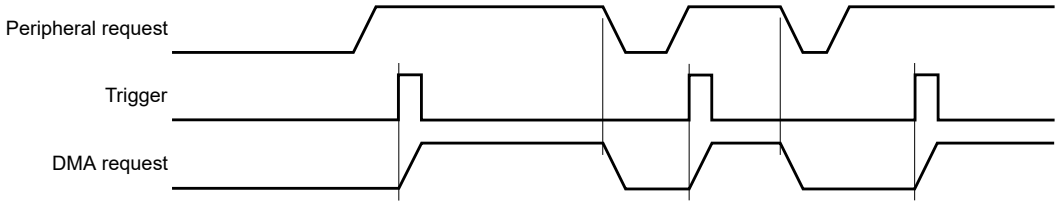


Figure 26. DMAMUX channel triggering: normal operation

After the DMA request is serviced, the peripheral negates its request, effectively resetting the gating mechanism until the peripheral reasserts its request and the next trigger event is seen. This means that if a trigger is seen, but the peripheral is not requesting a transfer, then that trigger is ignored (see Figure 27).

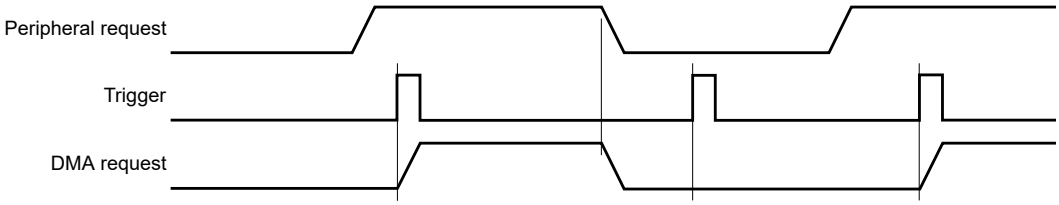


Figure 27. DMAMUX channel triggering: ignored trigger

You can use this triggering capability with any peripheral that supports DMA transfers, and is most useful in the following situations:

- Periodic polling of external devices on a particular bus: as an example, the transmit side of an SPI is assigned to a DMA channel with a trigger, as described in the aforementioned text. After periodic polling is set up, SPI requests DMA transfers, presumably from memory, as long as its transmit buffer is empty. By using a trigger on this channel, the SPI transfers can be automatically performed every 5 µs (as an example). On the receive side of SPI, you can configure SPI and DMA to transfer the received data into memory, effectively implementing a method to periodically read data from external devices and transferring the results into memory without processor intervention.
- Using the GPIO ports to drive or sample waveforms: by configuring DMA to transfer data to one or more GPIO ports, it is possible to create complex waveforms using tabular data stored in on-chip memory. Conversely, using DMA to periodically transfer data from one or more GPIO ports, it is possible to sample complex waveforms and store the results in a tabular form in on-chip memory.

13.3.2 DMA channels with no triggering capability

The other channels of DMAMUX provide the normal routing functionality as described in Modes of operation.

13.3.3 Always-enabled DMA sources

In addition to the peripherals that you can use as DMA sources, 2 additional DMA sources are always enabled. Unlike the peripheral DMA sources, where the peripheral controls the flow of data during DMA transfers, the sources that are always enabled provide no such "throttling" of data transfers. These sources are most useful in the following cases:

- Performing DMA transfers to and from GPIO: moving data to and from one or more GPIO pins, either unthrottled (that is, as fast as possible), or periodically (using the DMA triggering capability)
- Performing DMA transfers from memory to memory: moving data from memory to memory, typically as fast as possible, sometimes with software activation
- Performing DMA transfers from memory to the external bus, or vice-versa: similar to memory-to-memory transfers, this is typically done as quickly as possible
- Any DMA transfer that software must explicitly start or activate

In cases where software must initiate the start of a DMA transfer, an always-enabled DMA source can be used to provide maximum flexibility. When activating a DMA channel via software, subsequent executions of the minor loop require that a new start event be sent. This can either be a new software activation or a transfer request from the DMA channel MUX. The options for doing this are as follows.

- Transfer all data in a single minor loop: by configuring DMA to transfer all of the data in a single minor loop (that is, major loop counter = 1), no reactivation of the channel is necessary. The disadvantage of this option is reduced granularity in determining the load that the DMA transfer imposes on the system. For this option, the DMA channel must be disabled in the DMA channel MUX.
- Use explicit software reactivation: using this option, DMA is configured to transfer the data using both minor and major loops, but the processor is required to reactivate the channel by writing to the DMA registers after every minor loop. For this option, the DMA channel must be disabled in the DMA channel MUX.
- Use an always-enabled DMA source: using this option, DMA is configured to transfer the data using both minor and major loops, and the DMA channel MUX does the channel reactivation. For this option, you must enable the DMA channel and point it to an "always-enabled" source. Channel reactivation can be continuous (DMA triggering is disabled) or can use the DMA triggering capability. In this manner, it is possible to execute periodic transfers of data packets from one source to another, without processor intervention.

13.4 Initialization and application information

This section provides instructions for initializing the DMA channel MUX.

13.4.1 Reset

The reset state of each field is shown in Memory map and register definition. In summary, after reset, all channels are disabled and you must enable them explicitly before use.

13.4.2 Enabling and configuring sources

13.4.2.1 Enable a source with periodic triggering

Perform the following procedure to enable a source with periodic triggering:

1. Determine the DMA channel with which the source is associated. Only the first 4 DMA channels have periodic triggering capability.
2. Write 0 to CHCFG*n*[ENBL] and CHCFG*n*[TRIG] of the DMA channel.
3. Ensure that the DMA channel is properly configured in DMA. You can enable the DMA channel at this point.
4. Configure the corresponding timer.
5. Select the source to be routed to the DMA channel. Write to the corresponding CHCFG register, ensuring that CHCFG*n*[ENBL] and CHCFG*n*[TRIG] are 1.

The following is an example. See the chip-specific information for the number of DMA channels on this chip that have triggering capability.

Example: To configure source 5 transmit for use with DMA channel 1, with periodic triggering capability:

1. Write 0h to CHCFG1.
2. Configure channel 1 in DMA, including enabling the channel.
3. Configure a timer for the desired trigger interval.
4. Write C5h to CHCFG1.

The following code example illustrates steps 1 and 4 above:

```
In File registers.h:
#define DMAMUX_BASE_ADDR     0x40021000/* Example only ! */
/* Following example assumes char is 8-bits */
volatile unsigned char *CHCFG0 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0003);
volatile unsigned char *CHCFG1 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0002);
volatile unsigned char *CHCFG2 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0001);
volatile unsigned char *CHCFG3 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0000);
volatile unsigned char *CHCFG4 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0007);
volatile unsigned char *CHCFG5 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0006);
volatile unsigned char *CHCFG6 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0005);
volatile unsigned char *CHCFG7 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0004);
volatile unsigned char *CHCFG8 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000B);
volatile unsigned char *CHCFG9 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000A);
volatile unsigned char *CHCFG10= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0009);
volatile unsigned char *CHCFG11= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0008);
volatile unsigned char *CHCFG12= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000F);
volatile unsigned char *CHCFG13= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000E);
volatile unsigned char *CHCFG14= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000D);
volatile unsigned char *CHCFG15= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000C);

In File main.c:
#include "registers.h"
:
:
*CHCFG1 = 0x00;                              /* Clear all the fields of CHCFG1 register */
*CHCFG1 = 0xC5;                              /* ENBL = 1  DMA Channel is enabled */
                                             /* TRIG = 1  Triggering is enabled */
                                             /* SOURCE = 5  DMA Source 5 is selected */
```

Code Listing 1. Configuring source 5 with DMA channel 1 (with periodic triggering)

13.4.2.2 Enable a source without periodic triggering

Perform the following procedure to enable a source without periodic triggering:

1. Determine the DMA channel with which the source is associated. Only the first 4 DMA channels have periodic triggering capability.
2. Write 0 to CHCFG*n*[ENBL] and CHCFG*n*[TRIG] of the DMA channel.
3. Ensure that the DMA channel is properly configured in DMA. You can enable the DMA channel at this point.
4. Select the source to be routed to the DMA channel. Write to the corresponding CHCFG register, ensuring that CHCFG*n*[ENBL] is 1 while CHCFG*n*[TRIG] is 0.

The following is an example. See the chip configuration details for the number of DMA channels on this chip that have triggering capability.

Example: To configure source 5 transmit for use with DMA channel 1, with no periodic triggering capability:

1. Write 0h to CHCFG1.
2. Configure channel 1 in DMA, including enabling the channel.
3. Write 85h to CHCFG1.

The following code example illustrates steps 1 and 3 above:

```
In File registers.h:
#define DMAMUX_BASE_ADDR     0x40021000/* Example only ! */
/* Following example assumes char is 8-bits */
volatile unsigned char *CHCFG0 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0003);
volatile unsigned char *CHCFG1 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0002);
volatile unsigned char *CHCFG2 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0001);
volatile unsigned char *CHCFG3 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0000);
volatile unsigned char *CHCFG4 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0007);
volatile unsigned char *CHCFG5 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0006);
volatile unsigned char *CHCFG6 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0005);
volatile unsigned char *CHCFG7 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0004);
volatile unsigned char *CHCFG8 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000B);
volatile unsigned char *CHCFG9 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000A);
volatile unsigned char *CHCFG10= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0009);
volatile unsigned char *CHCFG11= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0008);
volatile unsigned char *CHCFG12= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000F);
volatile unsigned char *CHCFG13= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000E);
volatile unsigned char *CHCFG14= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000D);
volatile unsigned char *CHCFG15= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000C);

In File main.c:
#include "registers.h"
:
:
*CHCFG1 = 0x00;                              /* Clear all the fields of CHCFG1 register */
*CHCFG1 = 0x85;                              /* ENBL = 1  DMA Channel is enabled */
                                             /* TRIG = 0  Triggering is disabled */
                                             /* SOURCE = 5  DMA Source 5 is selected */
```

Code Listing 2. Configuring source 5 with DMA channel 1 (without periodic triggering)

13.4.2.3 Disable a source

You can disable a particular DMA source by not writing the corresponding source value into any of the CHCFG registers. Additionally, some module-specific configurations may be necessary. See the "Enhanced Direct Memory Access (eDMA)" chapter for details.

To switch the source of a DMA channel:

1. Disable the DMA channel in the DMA and reconfigure the channel for the new source.
2. Write 0 to CHCFG*n*[ENBL] and CHCFG*n*[TRIG] of the DMA channel.
3. Select the source to be routed to the DMA channel. Write to the corresponding CHCFG register, ensuring that CHCFG*n*[ENBL] and CHCFG*n*[TRIG] are 1.

Example: To switch DMA channel 8 from source 5 transmit to source 7 transmit:

1. In the DMA configuration registers, disable DMA channel 8 and reconfigure it to handle the transfers to peripheral slot 7. This example assumes channel 8 does not have the triggering capability.
2. Write 0h to CHCFG8.
3. Write 87h to CHCFG8. (In this example, writing 1 to CHCFG[TRIG] has no effect because of the assumption that channel 8 does not support the periodic triggering functionality.)

The following code example illustrates steps 2 and 3 above:

```
In File registers.h:
#define DMAMUX_BASE_ADDR     0x40021000/* Example only ! */
/* Following example assumes char is 8-bits */
volatile unsigned char *CHCFG0 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0003);
volatile unsigned char *CHCFG1 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0002);
volatile unsigned char *CHCFG2 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0001);
volatile unsigned char *CHCFG3 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0000);
volatile unsigned char *CHCFG4 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0007);
volatile unsigned char *CHCFG5 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0006);
volatile unsigned char *CHCFG6 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0005);
volatile unsigned char *CHCFG7 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0004);
volatile unsigned char *CHCFG8 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000B);
volatile unsigned char *CHCFG9 = (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000A);
volatile unsigned char *CHCFG10= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0009);
volatile unsigned char *CHCFG11= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x0008);
volatile unsigned char *CHCFG12= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000F);
volatile unsigned char *CHCFG13= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000E);
volatile unsigned char *CHCFG14= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000D);
volatile unsigned char *CHCFG15= (volatile unsigned char *) (DMAMUX_BASE_ADDR+0x000C);

In File main.c:
#include "registers.h"
:
:
*CHCFG8 = 0x00;                              /* Clear all the fields of CHCFG1 register */
*CHCFG8 = 0x87;                              /* ENBL = 1  DMA Channel is enabled */
                                             /* TRIG = 0  Triggering is disabled */
                                             /* SOURCE = 7  DMA Source 7 is selected */
```

Code Listing 3. Switching DMA channel 8 from source 5 transmit to source 7 transmit

13.5 Memory map and register definition

This section provides a detailed description of all memory-mapped registers in DMAMUX.

13.5.1 DMAMUX register descriptions

13.5.1.1 DMAMUX memory map

DMAMUX_0 base address: 4028_0000h

DMAMUX_1 base address: 4028_4000h

DMAMUX_2 base address: 406A_0000h

DMAMUX_3 base address: 406A_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Channel Configuration (CHCFG3)	8	RW	00h
1h	Channel Configuration (CHCFG2)	8	RW	00h
2h	Channel Configuration (CHCFG1)	8	RW	00h
3h	Channel Configuration (CHCFG0)	8	RW	00h
4h	Channel Configuration (CHCFG7)	8	RW	00h
5h	Channel Configuration (CHCFG6)	8	RW	00h
6h	Channel Configuration (CHCFG5)	8	RW	00h
7h	Channel Configuration (CHCFG4)	8	RW	00h
8h	Channel Configuration (CHCFG11)	8	RW	00h
9h	Channel Configuration (CHCFG10)	8	RW	00h
Ah	Channel Configuration (CHCFG9)	8	RW	00h
Bh	Channel Configuration (CHCFG8)	8	RW	00h
Ch	Channel Configuration (CHCFG15)	8	RW	00h
Dh	Channel Configuration (CHCFG14)	8	RW	00h
Eh	Channel Configuration (CHCFG13)	8	RW	00h
Fh	Channel Configuration (CHCFG12)	8	RW	00h

13.5.1.2 Channel Configuration (CHCFG0 - CHCFG15)

Offset

For n = 0 to 15:

Register	Offset
CHCFGn	0h + (n + 3 - 2 × (n mod 4))

Function

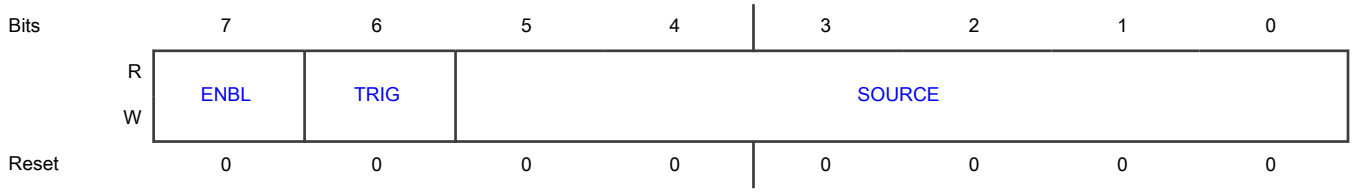
Provides you with the configuration to enable or disable, and to associate each of the DMA channels with one of the DMA slots (peripheral slots or always-on slots) in the system.

NOTE

Writing to multiple CHCFG registers with the same source value results in unpredictable behavior. This is true, even if a channel is disabled (CHCFG*n*[ENBL] == 0).

Before changing the trigger or source settings, you must disable a DMA channel using CHCFG*n*[ENBL].

Diagram



Fields

Field	Function
7 ENBL	DMA Channel Enable Enables the DMA channel. The condition when the DMA channel is disabled (ENBL = 0) is called Disabled mode. This mode is primarily used during the configuration of DMAMUX. DMA has separate channel enables or disables, which you must use to disable or reconfigure a DMA channel. 0b - Disable 1b - Enable
6 TRIG	DMA Channel Trigger Enable Enables the periodic triggering capability for the triggered DMA channel. If triggering is disabled and ENBL = 1, the DMA channel routes the specified source to the DMA channel (Normal mode). If triggering is enabled and ENBL = 1, then DMAMUX is in Periodic Trigger mode. 0b - Disable 1b - Enable
5-0 SOURCE	DMA Channel Source (Slot) Specifies which DMA source, if any, is routed to a particular DMA channel. See the chip-specific DMAMUX information for details about peripherals and their slot numbers.

13.6 Glossary

Slot	DMA source that either reflects a peripheral source or an always-enabled source
Periodic trigger	Trigger that an external source generates at periodic intervals for DMA transfer

Chapter 14
Enhanced Direct Memory Access (eDMA3)

14.1 Chip-specific eDMA3 information

14.1.1 DMA channels

The chip has 2 DMA with 32 number of DMA channels each; eDMA_0 and eDMA_1. eDMA_1 is in the lockstep configuration for self-check.

14.1.2 eDMA ID replication

The eDMA replicates the IDs for the access based on the configurations of XRDC and eDMA itself. The below figure describes the details of the hmaster and DID corresponding to the eDMA.

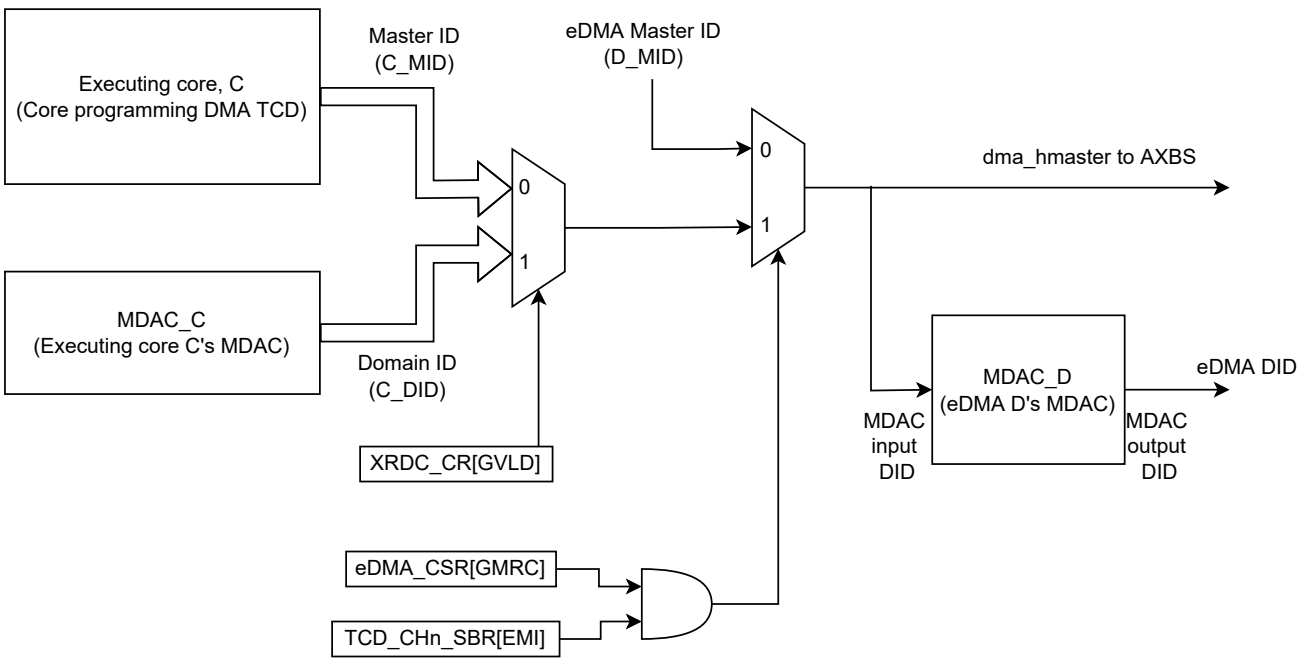


Figure 28. Details of the hmaster and DID corresponding to the eDMA

14.2 Overview

The enhanced direct memory access (eDMA) controller is capable of performing complex data transfers with minimal intervention from a host processor. The hardware microarchitecture includes:

- A DMA engine that performs:
  - Source address and destination address calculations
  - Data-movement operations
- Local memory containing transfer control descriptors for each of the 32 channels

14.2.1 Block diagram

Figure 29 illustrates the components of the eDMA system, including the eDMA module (engine).

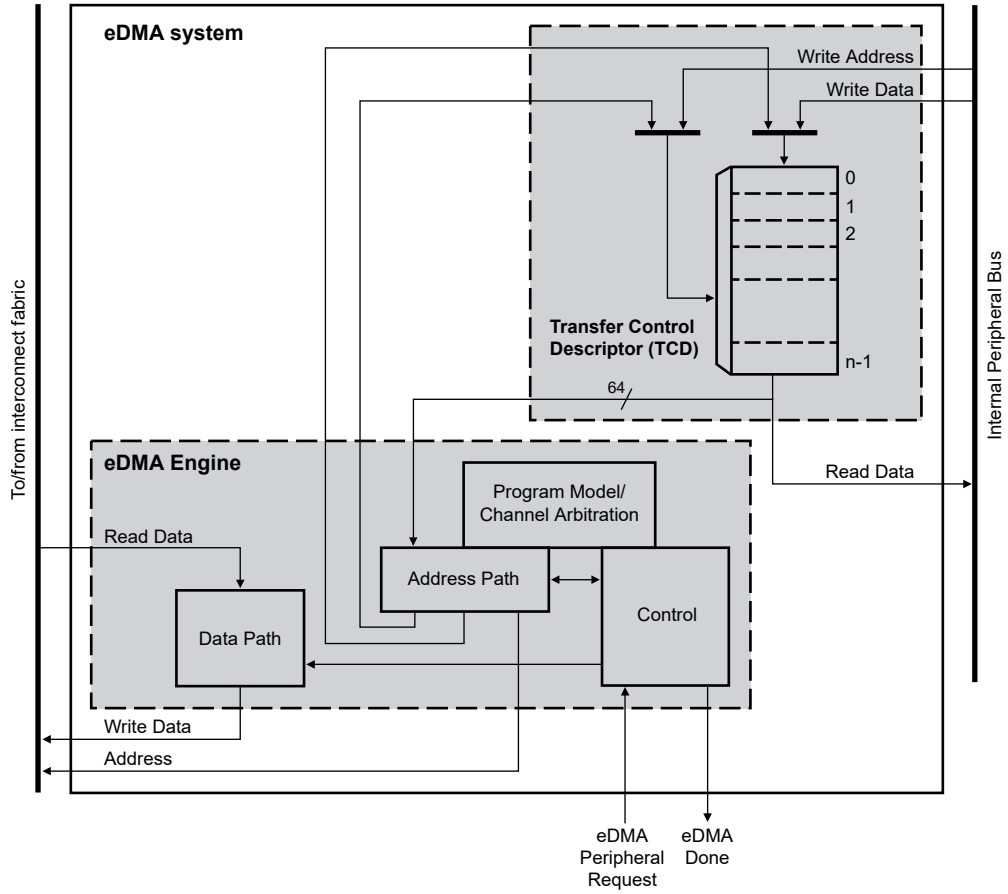


Figure 29. Block diagram

14.2.2 Block parts

The eDMA module is partitioned into two major modules: the eDMA engine and the transfer control descriptor local memory.

The eDMA engine is further partitioned into four submodules:

Table 42. eDMA engine submodules

Submodule	Function
Address path	This block: • Implements a primary channel and secondary (preempt) channel • Manages all master bus-address calculations All the channels provide the same functionality. This structure allows data transfers associated with one channel to be preempted after the completion of a read/write sequence if a higher priority channel activation is asserted while the primary channel is active. After a channel is activated, it runs until the minor loop is completed, unless preempted by a higher priority channel. This provides a mechanism (enabled by CH*n*_PRI[ECP]) where a large data transfer can be preempted to minimize the time another channel is blocked from execution.

Table continues on the next page...

Table 42. eDMA engine submodules (continued)

Submodule	Function
	When any channel is selected to execute, the contents of its TCD are read from local memory and loaded into the address path channel x registers for a normal start and into channel y registers for a preemption start. After the minor loop completes execution, the address path hardware writes the new values for the TCD*n*_{SADDR, DADDR, CITER} back to local memory. If the major iteration count is exhausted, additional processing is performed, including the final address pointer updates, reloading the TCD*n*_CITER field, and a possible fetch of a new TCD*n* from memory as part of a scatter/gather operation. See Dynamic scatter/gather for more details.
Data path	This block implements the bus master read/write data path. It includes a data buffer and the necessary multiplex logic to support any required data alignment. The internal read data bus is the primary input, and the internal write data bus is the primary output. The address and data path modules directly support the 2-stage pipelined internal bus. The address path module represents the first stage of the bus pipeline (address phase), and the data path module implements the second stage of the pipeline (data phase).
Program model/channel arbitration	This block implements the first section of the eDMA programming model as well as the channel arbitration logic. The programming model registers are connected to the internal peripheral bus. The eDMA peripheral request inputs and interrupt request outputs are also connected to this block (via control logic).
Control	This block provides all the control functions for the eDMA engine. For data transfers where the source and destination sizes are equal, the eDMA engine performs a series of source read/destination write operations until the number of bytes specified in the minor loop byte count has been moved from the source to the destination. For descriptors where the sizes are not equal, multiple accesses of the smaller size data are required for each reference of the larger size. As an example, if the source size references 16-bit data and the destination is 32-bit data, the eDMA performs two reads, then one 32-bit write.

The transfer control descriptor local memory is further partitioned into:

Table 43. Transfer control descriptor memory

Submodule	Description
Memory controller	This logic implements the required dual-ported controller, and manages accesses from the eDMA engine as well as references from the internal peripheral bus. In simultaneous accesses, the eDMA engine is given priority and the peripheral transaction is stalled.
Memory array	TCD storage for each channel's transfer profile.

14.2.3 Features

The eDMA is a highly programmable data-transfer engine optimized to minimize any required intervention from the host processor. It is intended for use in applications where the data size to be transferred is statically known and not defined within the transferred data itself. The eDMA module features:

- All data movement via dual-address transfers: read from source, write to destination
  - Programmable source and destination addresses and transfer size
  - Support for complex address calculations
- Implementation that performs complex data transfers with minimal intervention from a host processor
  - Internal data buffer, used as temporary storage for all transfers

  - Connections to the crossbar switch for bus mastering the data movement
- TCD organized to support two-deep, nested transfer operations
  - 32-byte TCD stored in local memory for each channel
  - An inner data transfer loop defined by a minor byte transfer count
  - An outer data transfer loop defined by a major iteration count
- Channel activation via one of three methods:
  - Explicit software initiation
  - Initiation via a channel-to-channel linking mechanism for continuous transfers
  - Peripheral-paced hardware requests, one per channel
- Fixed-priority and round-robin channel arbitration
- Channel completion reported via programmable interrupt requests
  - One interrupt per channel, which can be asserted at completion of major iteration count
  - Programmable error terminations per channel that are logically summed together to form one error interrupt to the interrupt controller
- Programmable support for scatter/gather DMA processing
- Support for complex data structures

In the discussion of this module, *n* is used to reference the channel number.

14.3 Functional description

The operation of eDMA is described in the following subsections.

14.3.1 Modes of operation

The eDMA operates in the following modes:

Table 44. Modes of operation

Mode	Description
Normal	In Normal mode, eDMA transfers data between a source and a destination. The source and destination can be a memory block or an I/O block capable of operation with eDMA. A service request initiates a transfer of a specific number of bytes (NBYTES) as specified in the TCD. The minor loop is the sequence of read-write operations that transfers these NBYTES per service request. Each service request executes one iteration of the major loop, which transfers NBYTES of data.
Debug	eDMA operation is configurable in Debug mode via the control register: • If CSR[EDBG] is cleared to 0, eDMA continues to operate. • If CSR[EDBG] is set to 1, eDMA stops transferring data. If Debug mode is entered when a channel is active, eDMA continues operation until the channel retires.

14.3.2 eDMA basic data flow

The basic flow of a data transfer can be partitioned into three segments.

As shown in the following diagram, the first segment involves the channel activation:

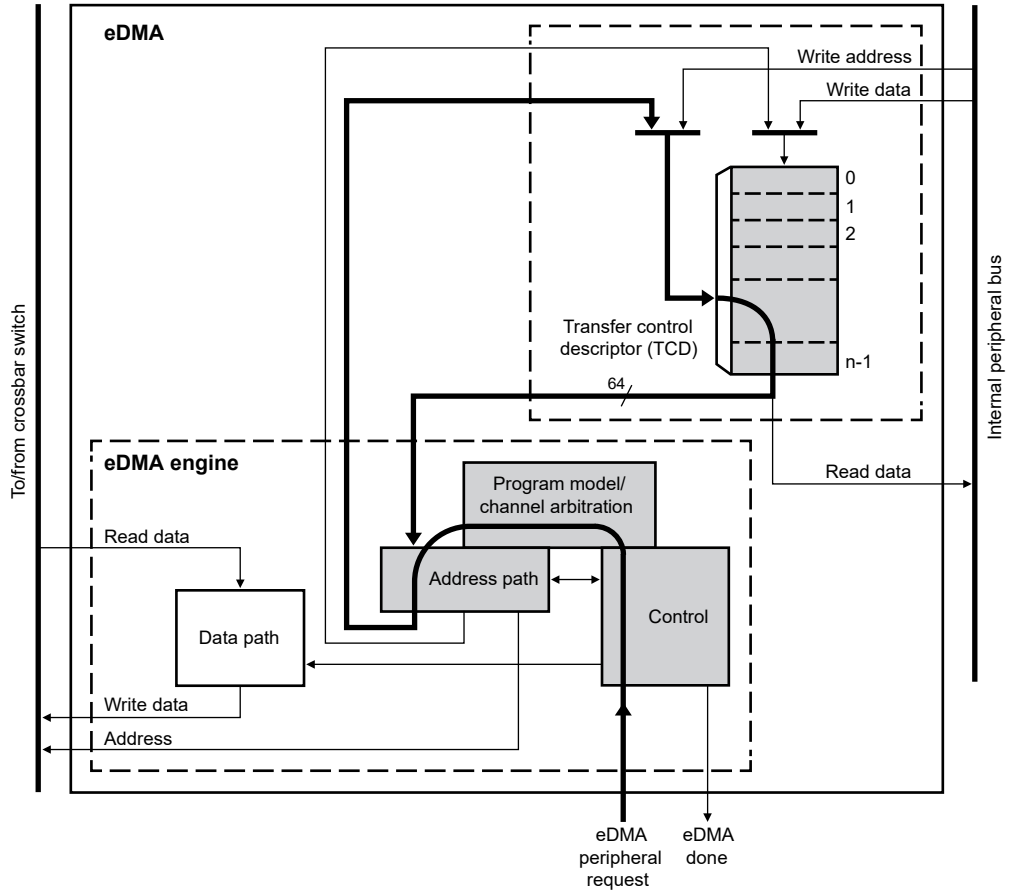


Figure 30. eDMA operation, part 1

This example uses the assertion of the eDMA peripheral request signal to request service for channel *n*. Channel activation via software and the TCD*n*_CSR[START] field follows the same basic flow as peripheral requests. The eDMA request input signal is registered internally and then routed through the eDMA engine: first through the control module, then into the program model and channel arbitration.

In the next cycle, the channel arbitration begins using fixed-priority plus the optional round-robin algorithm. After arbitration is complete, the activated channel number is sent through the address path and converted into the required address to access the local memory for TCD*n*. Next, the TCD memory is accessed and the required descriptor is read from the local memory and then loaded into the eDMA engine address path's primary or secondary channel execution registers. The TCD memory is 64 bits wide to minimize the time needed to fetch the activated channel descriptor and load it into the address path registers.

The following diagram illustrates the second part of the basic data flow:

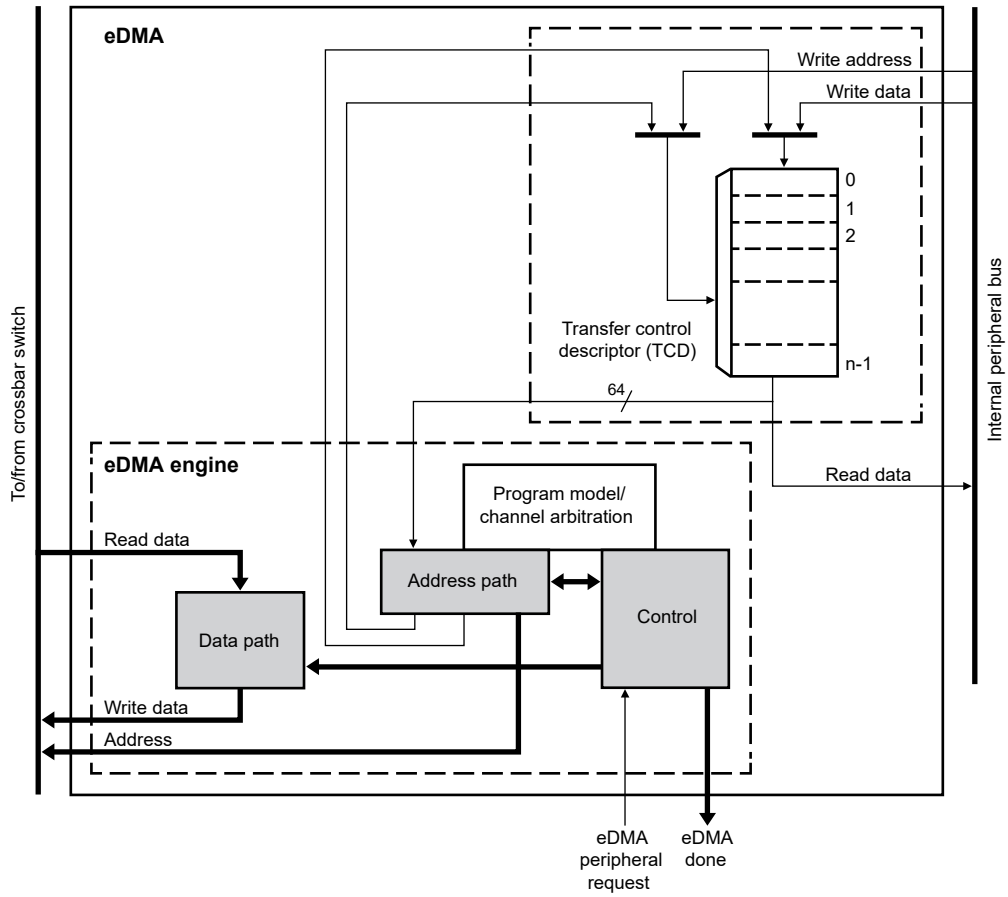


Figure 31. eDMA operation, part 2

The modules associated with the data transfer (address path, data path, and control) go through the required sequence of source reads and destination writes to perform the actual data movement. The source reads are initiated, and the fetched data is temporarily stored in the data path block until it is gated onto the internal bus during the destination write. This source read/destination write processing continues until the byte count, NBYTES, has been transferred.

After NBYTES of data has been moved, the final phase of the basic data flow is performed. In this segment, the address path logic performs the required updates to certain fields in the appropriate TCD (for example, SADDR, DADDR, CITER). If the major iteration count is exhausted, additional operations are performed. These include the final address adjustments and reloading of the BITER field into the CITER field. Assertion of an optional interrupt request also occurs at this time, as does a possible fetch of a new TCD from memory using the scatter/gather address pointer included in the descriptor (if scatter/gather is enabled). The updates to the TCD memory and the assertion of an interrupt request are shown in the following diagram.

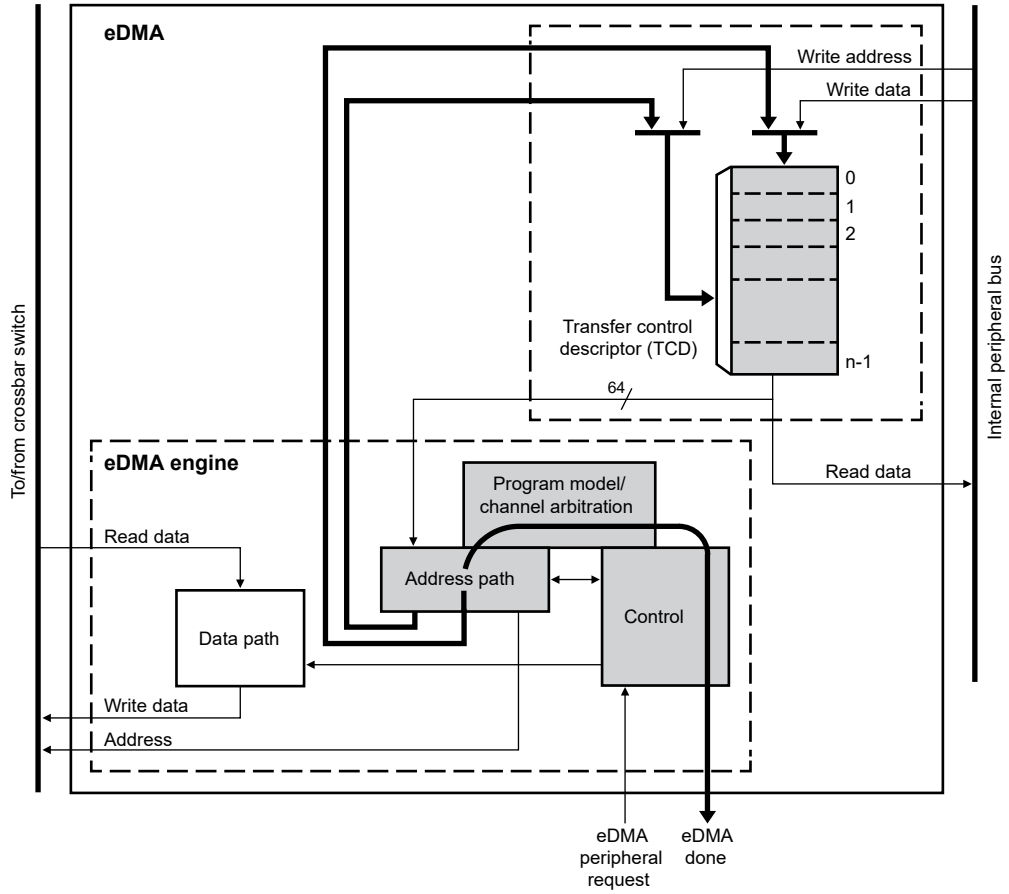


Figure 32. eDMA operation, part 3

14.3.3 Fault reporting and handling

Channel errors are reported in the Error Status register (CHn_ES) and can be caused by any of the following:

- A configuration error, which is an illegal setting in the transfer control descriptor
- An active channel canceled via a "cancel transfer with error" hardware or software request
- A TCD memory error
- An error termination to a bus master read or write cycle

A configuration error is reported when an inconsistent state is represented by one of these factors:

- Starting source or destination address
- Source or destination offsets
- Minor loop byte count
- Transfer size

Each of these possible causes is detailed below:

- The addresses and offsets must be aligned on zero-modulo-transfer-sized boundaries.
- The minor loop byte count must be a multiple of the source and destination transfer sizes.
- All source reads and destination writes must be configured to the natural boundary of the programmed transfer size.

NOTE

To aid in debugging, set the Halt After Error field in the DMA's Control Status register, CSR[HAE]. Upon any error condition, the DMA is halted after the error is recorded. The DMA remains halted and does not process any channel service requests. After the error is fixed, the DMA may be enabled again by clearing the Halt field, CSR[HALT].

- If a scatter/gather operation is enabled upon channel completion, a configuration error is reported if the scatter/gather address (TCDn_DLAST_SGA) is not aligned on a 32-byte boundary.
- If minor loop channel linking is enabled upon channel completion, a configuration error is reported when the link is attempted if the TCDn_CITER[ELINK] field does not equal the TCDn_BITER[ELINK] field.

If enabled, all configuration error conditions, except the scatter/gather and minor-loop link errors, are reported as the channel activates and asserts an error interrupt request. A scatter/gather configuration error is reported when the scatter/gather operation begins at major loop completion if properly enabled. A minor loop channel link configuration error is reported when the link operation is serviced at minor loop completion.

If a system bus read or write is terminated with an error, the data transfer is stopped and the appropriate bus error flag set. In this case, the state of the channel's transfer control descriptor is updated by the eDMA engine with the current source address, destination address, and current iteration count at the point of the fault. When a system bus error occurs, the channel terminates after the next transfer. Due to pipeline effect, the next transfer is already in progress when the bus error is received by the eDMA. If a bus error occurs on the last read prior to beginning the write sequence, the write executes using the data captured during the bus error. If a bus error occurs on the last write prior to switching to the next read sequence, the read sequence executes before the channel terminates due to the destination bus error.

The occurrence of any error causes the eDMA engine to stop normal processing of the active channel immediately (it goes to its error processing states and the transaction to the system bus still has pipeline effect), and the appropriate channel field in the eDMA error register is set to 1. At the same time, the details of the error condition are loaded into the Error Status register (CHn_ES). The major loop complete indicators, setting the transfer control descriptor DONE flag, and the possible assertion of an interrupt request are not affected when an error is detected.

After the error status has been updated, the eDMA engine continues operating by servicing the next appropriate channel. A channel that experiences an error condition is not automatically disabled. If a channel is terminated by an error and then issues another service request before the error is fixed, that channel executes and terminates with the same error condition.

The error status fields are read-only. These error indicators are sticky and cannot be cleared. They show the last recorded error until the DMA is reset. CHn_ES[ERR] is used to determine if a new error condition exists. This field is the logical OR of each channel's error interrupt field (ERR).

After the software has resolved all errors and cleared all of the error interrupt fields, the ES[VLD] is cleared to 0 but the cause of the last error is still indicated.

14.3.4 Channel preemption

The eDMA uses a priority vector value to determine the highest priority channel requesting service.

The priority vector is a combination of:

1. the channel's group priority, CHn_GRPRI
2. the channel's priority level, CHn_PRI[APL]
3. the channel number

Priority vector = ((CHn_GRPRI << 8) + (CHn_PRI[APL] << 5) + CHn_*)

A channel requesting service with the highest priority vector value will receive the next execution slot.

An execution slot is available:

1. immediately if the eDMA is idle
2. when an active channel retires
3. when valid preemption conditions exist

NOTE

Preemption is strictly priority based. Preemption is not bound by a specific group number as defined by CHn_GRPRI.

Channel preemption is enabled on a per-channel basis by setting the CHn_PRI[ECP] field. Channel preemption allows the executing channel's data transfers to temporarily suspend in favor of starting a higher-priority channel. After the preempting channel has completed all of its minor loop data transfers, the preempted channel is restored and resumes execution.

After the restored channel completes one read/write sequence, it is again eligible for preemption. If any higher priority channel is requesting service, the restored channel is suspended, and the higher-priority channel is serviced. Nested preemption, that is, attempting to preempt a preempting channel, is not supported. After a preempting channel begins execution, it cannot be preempted.

A channel's ability to preempt another channel can be disabled by setting CHn_PRI[DPA] to 1. When a channel's preempt ability is disabled, that channel cannot suspend a lower-priority channel's data transfer, regardless of the lower-priority channel's ECP setting. This allows for a pool of low-priority, large-data-moving channels to be defined.

You can configure these low-priority channels to not preempt each other, thus preventing a low-priority channel from consuming the preempt slot normally available to a true high-priority channel. When you enable round-robin channel arbitration mode (CSR[ERCA] is set to 1), any channel with a priority level equal to 0 (CHn_PRI[APL] = 0) has preemption disabled and cannot preempt another channel.

14.3.5 Clocking

This module has no clocking considerations.

14.3.6 Interrupts

Software can enable the interrupt for each channel for the following events:

1. The major loop is half complete (INTHALF)
2. The major loop is complete (INTMAJOR)
3. A configuration error occurs (EEI)

14.4 External signals

This module has no external signals.

14.5 Initialization

The following sections discuss initialization of the eDMA and programming considerations.

14.5.1 eDMA initialization

To initialize the eDMA:

1. Write to the CSR if a configuration other than the default is wanted.
2. Write the channel priority levels to the CHn_PRI registers and group priority levels to the CHn_GRPRI registers if a configuration other than the default is wanted.
3. Enable error interrupts in the CHn_CSR[EEI] registers if they are wanted.
4. Write the 32-byte TCD for each channel that may request service.
5. Enable any hardware service requests via the CHn_CSR[ERQ] registers.
6. Request channel service via either:
   - Software: setting TCDn_CSR[START]
   - Hardware: slave device asserting its eDMA peripheral request signal

After any channel requests service, a channel is selected for execution based on the arbitration and priority levels written into the programmer's model. The eDMA engine reads the entire TCD, including the TCD control and status fields, as shown in Table 45, for the selected channel into its internal address path module.

As the TCD is read, the first transfer is initiated on the internal bus, unless a configuration error is detected. Transfers from the source, defined by TCDn_SADDR, to the destination, defined by TCD_DADDR, continue until the number of bytes specified by TCDn_NBYTES are transferred.

When the transfer is complete, the eDMA engine's local TCDn_SADDR, TCDn_DADDR, and TCDn_CITER are written back to the main TCD memory and any minor loop channel linking is performed, if enabled. If the major loop is exhausted, then eDMA executes further post-processing, such as interrupts, major loop channel linking, and scatter/gather operations, if enabled.

Table 45. TCD control and status (TCDn_CSR) fields

TCDn_CSR field name	Description
START	Control field to start the channel explicitly when using a software-initiated DMA service (automatically cleared by hardware)
ESDA	Control field to enable storing of the destination address to system memory after the major loop completes
DREQ	Control field to disable hardware-initiated DMA service requests after major loop completion
BWC	Control field for throttling the bandwidth control of a channel
ESG	Control field to enable the scatter-gather feature
INTHALF	Control field to enable interrupt when major loop is half-complete
INTMAJOR	Control field to enable interrupt when major loop completes

Table 46. Channel control and status (CHn_CSR) fields

CHn_CSR field name	Description
ACTIVE	Status field indicating the channel is currently in execution
DONE	Status field indicating major loop completion (cleared by software when a channel begins execution)
EEI	Control field to enable error interrupts
EARQ	Control field to enable external, asynchronous wakeup event in conjunction with the ERQ field
ERQ	Control field to enable hardware service requests

The following figure shows how each DMA request initiates one minor-loop transfer, or iteration, without CPU intervention. DMA arbitration can occur after each minor loop, and one level of minor loop DMA preemption is allowed. The number of minor loops in a major loop is specified by the beginning iteration count (BITER).

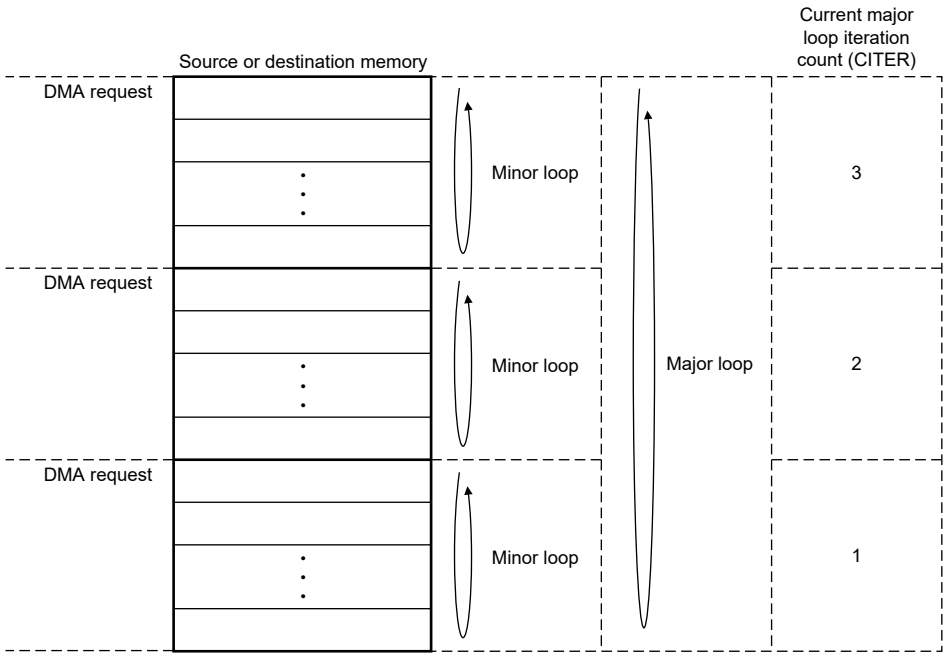


Figure 33. Example of multiple loop iterations

The following figure lists the memory array terms and how the TCD settings are related.

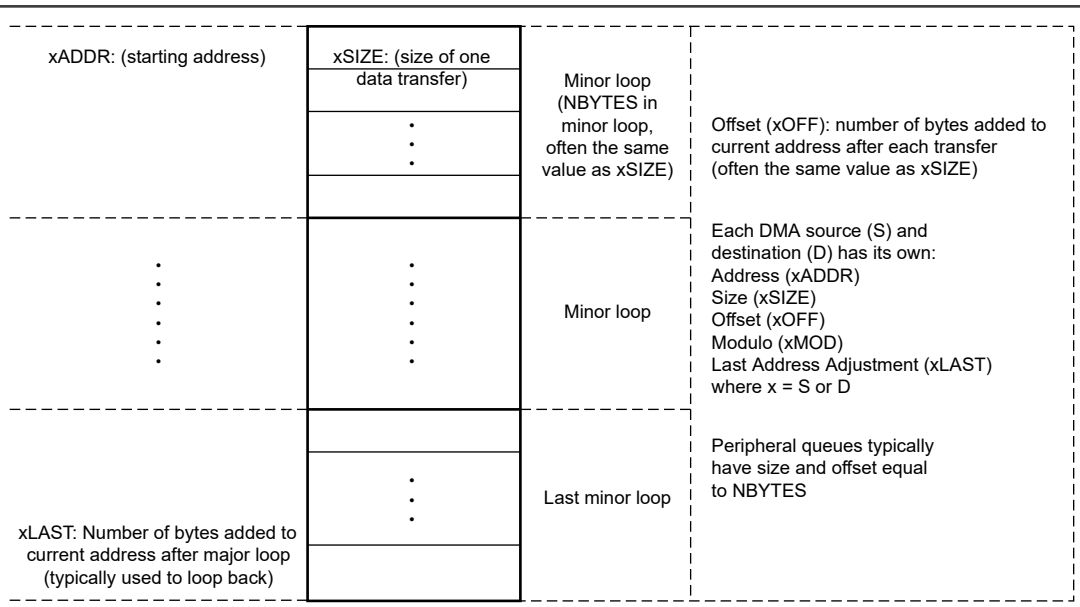


Figure 34. Memory array terms

14.5.2 eDMA arbitration

The eDMA uses a layered arbitration scheme composed of multiple priority levels. The eDMA uses a fixed-priority arbitration scheme with optional round-robin arbitration under specific conditions. The priorities are evaluated in the following order:

Table 47. eDMA arbitration priorities

Priority	Scheme	Description
1 (Highest)	Arbitration group priority	Each channel is assigned an arbitration group via the CHn_GRPRI registers. Priority is given to the highest value (31 being the highest possible value) down to the lowest value (zero, the default).
2	Channel priority	Each channel is assigned a channel priority level via the CHn_PRI registers. The channel priority is a relative priority level within an arbitration group. Priority is given to the highest value (seven being the highest possible value) down to the lowest value (zero, the default). Channel priorities within each arbitration group need not be unique. If multiple channels have the same channel priority level, the channel number will be used to determine priority as defined in row three.
3	Channel number	When two or more channels have the same arbitration group priority and channel priority, the channel number (CHn_NUM) is used to determine the highest priority. Priority is giver to the highest channel number. Lowest priority is channel 0. The channel numbers are static and cannot be changed in the programmer's model.
4 (Lowest)	Round-robin	When round-robin is enabled, any channel configured for round-robin operation has lowest priority within an arbitration group. Round-robin is enabled by setting the CSR[ERCA] field to 1. After being enabled, channels with a channel priority of zero (CHn_PRI=0) will use round-robin arbitration. Round-robin arbitration will rotate the channel selection among the channels requesting service with CHn_PRI=0 within the arbitration group. Any non-zero channel within the arbitration group will continue to use fixed-priority arbitration, and if requesting service will be selected over any round-robin channels.

For fixed arbitration, the overall priority can be considered a number composed of three concatenated priority levels: CHn_GRPRI:CHn_PRI:CH_NUM. The largest number has the highest priority and the lowest number has the lowest priority.

For round-robin arbitration, the priority number is CHn_GRPRI:0:X. The module rotates through the CHn_PRI=0 channels requesting service without regard to priority among these channels. Any channel within the arbitration group for which CHn_PRI is greater than 0 will be serviced before the round-robin channels.

14.5.3 Programming errors

The eDMA performs various tests on the transfer control descriptor to verify consistency in the descriptor data.

The channel number causing the error is recorded in the Error Status register (CHn_ES). If the error source is not removed before the next activation of the problematic channel, the error is detected and recorded again. Setting the halt after error field, CSR[HAE], will halt the DMA and prevent recurrence of the error.

14.5.4 Arbitration mode considerations

This section discusses arbitration considerations for eDMA.

14.5.4.1 Fixed group arbitration, fixed channel arbitration

In this mode, eDMA selects for execution the channel service request from the highest-priority channel in the highest-priority group. If eDMA is programmed so that the channels within a high-priority group have a high number of requests or large data transfers, that group may consume all the bandwidth of the eDMA controller. That is, no lower-priority groups are serviced if there is always at least one DMA request pending on a channel in the highest-priority group when the controller arbitrates the next DMA request. The advantage of this scenario is that latency can be small for channels that need to be serviced quickly.

14.5.4.2 Fixed group arbitration, round-robin channel arbitration

The highest-priority group with a request is serviced. Lower-priority groups are serviced if no pending requests exist in the higher-priority groups.

Within each group, channels are serviced starting with the highest non-zero channel priority. For all channels with a channel priority programmed to 0, selection begins with the highest channel number requesting service and then rotates through to the lowest channel number requesting service. The round-robin channel arbitration can provide a fairness mechanism to lower-priority channels.

This scenario could cause the same bandwidth consumption problem as indicated in Fixed group arbitration, fixed channel arbitration, but all the channels in the highest-priority group will be serviced. Service latency is short on the highest-priority group, but could potentially be very much longer as the group priority decreases.

14.5.5 Performing DMA transfers

This section presents examples on how to perform DMA transfers with the eDMA.

14.5.5.1 Single request

To perform a simple transfer of n bytes of data with one activation, set the major loop to one (TCD*n*_CITER = TCD*n*_BITER = 1). The data transfer begins after the channel service request is acknowledged and the channel is selected to execute. After the transfer is complete, the CH*n*_CSR[DONE] field is set to 1 and an interrupt is generated if properly enabled.

For example, the following TCD entry is configured to transfer 16 bytes of data. The eDMA is programmed for one iteration of the major loop transferring 16 bytes per iteration. The source memory has a byte-wide memory port located at 0x1000. The destination memory has a 32-bit port located at 0x2000. The address offsets are programmed in increments to match the transfer size: one byte for the source, and four bytes for the destination. The final source and destination addresses are adjusted to return to their beginning values.

```
TCDn_CITER = TCDn_BITER = 1
TCDn_NBYTES = 16
TCDn_SADDR = 0x1000
TCDn_SOFF = 1
TCDn_ATTR[SSIZE] = 0
TCDn_SLAST = -16
TCDn_DADDR = 0x2000
TCDn_DOFF = 4
TCDn_ATTR[DSIZE] = 2
```

```
TCDn_DLAST_SGA= -16
TCDn_CSR[INTMAJ] = 1
TCDn_CSR[START] = 1 (should be written last after all other fields have been initialized)
All other TCDn fields = 0
```

This generates the following event sequence:

1. User write to the TCD*n*_CSR[START] field requests channel service.
2. The channel is selected by arbitration for servicing.
3. eDMA engine writes:
   - CH*n*_CSR[DONE] = 0
   - TCD*n*_CSR[START] = 0
   - CH*n*_CSR[ACTIVE] = 1
4. eDMA engine reads: channel TCD data from local memory to internal register file.
5. The source-to-destination transfers are executed as follows:
   a. Read byte from location 0x1000, read byte from location 0x1001, read byte from 0x1002, read byte from 0x1003.
   b. Write 32 bits to location 0x2000 → first iteration of the minor loop.
   c. Read byte from location 0x1004, read byte from location 0x1005, read byte from 0x1006, read byte from 0x1007.
   d. Write 32 bits to location 0x2004 → second iteration of the minor loop.
   e. Read byte from location 0x1008, read byte from location 0x1009, read byte from 0x100A, read byte from 0x100B.
   f. Write 32 bits to location 0x2008 → third iteration of the minor loop.
   g. Read byte from location 0x100C, read byte from location 0x100D, read byte from 0x100E, read byte from 0x100F.
   h. Write 32 bits to location 0x200C → last iteration of the minor loop → major loop complete.
6. The eDMA engine writes: TCD*n*_SADDR = 0x1000, TCD*n*_DADDR = 0x2000, TCD*n*_CITER = 1 (TCD*n*_BITER).
7. The eDMA engine writes: CH*n*_CSR[ACTIVE] = 0, CH*n*_CSR[DONE] = 1, CH*n*_INT[INT] = 1.
8. The channel retires and the eDMA goes idle or services the next channel.

14.5.5.2 Multiple requests

The following example transfers 32 bytes via two hardware requests, but is otherwise the same as the previous example. The only fields that change are the major loop iteration count and the final address offsets. The eDMA is programmed for two iterations of the major loop, transferring 16 bytes per iteration. After the channel's hardware requests are enabled via the CHn_CSR[ERQ] register field, the slave device initiates channel service requests.

```
TCDn_CITER = TCDn_BITER = 2
TCDn_SLAST = -32
TCDn_DLAST_SGA = -32
```

This would generate the following sequence of events:

1. First hardware (eDMA peripheral) requests channel service.
2. The channel is selected by arbitration for servicing.
3. eDMA engine writes: CH*n*_CSR[DONE] = 0, TCD*n*_CSR[START] = 0, CH*n*_CSR[ACTIVE] = 1.
4. eDMA engine reads: channel TCD*n* data from local memory to internal register file.
5. The source-to-destination transfers are executed as follows:

a. Read byte from location 0x1000, read byte from location 0x1001, read byte from 0x1002, read byte from 0x1003.
b. Write 32 bits to location 0x2000 → first iteration of the minor loop.
c. Read byte from location 0x1004, read byte from location 0x1005, read byte from 0x1006, read byte from 0x1007.
d. Write 32 bits to location 0x2004 → second iteration of the minor loop.
e. Read byte from location 0x1008, read byte from location 0x1009, read byte from 0x100A, read byte from 0x100B.
f. Write 32 bits to location 0x2008 → third iteration of the minor loop.
g. Read byte from location 0x100C, read byte from location 0x100D, read byte from 0x100E, read byte from 0x100F.
h. Write 32 bits to location 0x200C → last iteration of the minor loop.

6. eDMA engine writes: TCD*n*_SADDR = 0x1010, TCD*n*_DADDR = 0x2010, TCD*n*_CITER = 1.
7. eDMA engine writes: CH*n*_CSR[ACTIVE] = 0.
8. The channel retires, which concludes one iteration of the major loop. The eDMA goes idle or services the next channel.
9. Second hardware (eDMA peripheral) requests channel service.
10. The channel is selected by arbitration for servicing.
11. eDMA engine writes: CH*n*_CSR[DONE] = 0, TCD*n*_CSR[START] = 0, CH*n*_CSR[ACTIVE] = 1.
12. eDMA engine reads: Channel TCD data from local memory to internal register file.
13. The source-to-destination transfers are executed as follows:
    a. Read byte from location 0x1010, read byte from location 0x1011, read byte from 0x1012, read byte from 0x1013.
    b. Write 32 bits to location 0x2010 → first iteration of the minor loop.
    c. Read byte from location 0x1014, read byte from location 0x1015, read byte from 0x1016, read byte from 0x1017.
    d. Write 32 bits to location 0x2014 → second iteration of the minor loop.
    e. Read byte from location 0x1018, read byte from location 0x1019, read byte from 0x101A, read byte from 0x101B.
    f. Write 32 bits to location 0x2018 → third iteration of the minor loop.
    g. Read byte from location 0x101C, read byte from location 0x101D, read byte from 0x101E, read byte from 0x101F.
    h. Write 32 bits to location 0x201C → last iteration of the minor loop → major loop complete.
14. eDMA engine writes: TCD*n*_SADDR = 0x1000, TCD*n*_DADDR = 0x2000, TCD*n*_CITER = 2 (TCD*n*_BITER).
15. eDMA engine writes: CH*n*_CSR[ACTIVE] = 0, CH*n*_CSR[DONE] = 1, CH*n*_INT[INT] = 1.
16. The channel retires, which concludes with the major loop complete. The eDMA goes idle or services the next channel.

14.5.5.3 Using the modulo feature

The modulo feature of the eDMA allows implementation of a circular data queue in which the size of the queue is a power of 2. xMOD is a 5-bit field for the source and destination in the TCD, and it specifies which lower address bits increment from their original value after the address+offset calculation. All upper address bits remain the same as in the original value. A setting of 0 for this field disables the modulo feature. Modulo addressing applies to cases where the minor loop offset is enabled; that is, the upper address bits remain the same after the minor loop offset is added to the source or destination address.

The following table shows how the transfer addresses are specified based on the setting of the MOD field. Here a circular buffer is created where the address wraps to the original value but the 28 upper address bits (0x1234567*x*) retain their original value. In this example, the source address is set to 0x12345670, the offset is set to four bytes, and the MOD field is set to four, which allows for a 2^4 byte (16 byte) queue size.

Table 48. Modulo example

Transfer number	Address
1	0x12345670
2	0x12345674
3	0x12345678
4	0x1234567C
5	0x12345670
6	0x12345674

14.5.6 Monitoring transfer descriptor status

This section discusses how to monitor eDMA status.

14.5.6.1 Testing for minor loop completion

There are two methods to test for minor loop completion when using software-initiated service requests.

1. The first method is to read the TCDn_CITER field and test for a change.
2. The second method, extracted from the sequence shown below, is to test the TCDn_CSR[START] field and the CHn_CSR[ACTIVE] field. The minor-loop-complete condition is indicated by both fields reading 0 after TCDn_CSR[START] is set to 1. Polling the CHn_CSR[ACTIVE] field only may be inconclusive because the active status may be missed if the channel execution is short in duration.

The CHn_CSR and TCDn_CSR status fields execute the following sequence for a software-activated channel:

Stage	TCDn_CSR field	CHn_CSR fields		State
	START	ACTIVE	DONE	
1	1	0	0	Initiate channel service request via software.
2	0	1	0	Channel is executing.
3a	0	0	0	Channel has completed the minor loop and is idle.
3b	0	0	1	Channel has completed the major loop and is idle.

The best method to test for minor-loop completion when using hardware-initiated (that is, peripheral-initiated) service requests is to read the TCDn_CITER field and test for a change. The hardware request and acknowledge handshake signals are not visible in the programmer's model.

The TCD status fields execute the following sequence for a hardware-activated channel:

Stage	TCDn_CSR field	CHn_CSR fields		State
	START	ACTIVE	DONE	
1	0	0	0	Initiate channel service request via hardware (peripheral request asserted).
2	0	1	0	Channel is executing.
3a	0	0	0	Channel has completed the minor loop and is idle.
3b	0	0	1	Channel has completed the major loop and is idle.

For both activation types, the major-loop-complete status is explicitly indicated via the CHn_CSR[DONE] field.

The TCDn_CSR[START] field is cleared to 0 automatically when the channel begins execution, regardless of how the channel activates.

14.5.6.2 Reading the transfer descriptors of active channels

The eDMA reads back the true TCDn_SADDR, TCDn_DADDR, and TCDn_NBYTES values if they are read when a channel executes. The true values of SADDR, DADDR, and NBYTES are the values the eDMA engine currently uses in its internal register file, and not the values in the TCD local memory for that channel. The addresses, SADDR and DADDR, and NBYTES (which decrements to zero as the transfer progresses), can give an indication of the progress of the transfer. All other values are read back from the TCD local memory.

14.5.6.3 Checking channel preemption status

A preemptive situation is one in which a preempt-enabled channel is executing and a higher-priority request becomes active. When round-robin channel arbitration mode is enabled, all channels with their channel priority set to 0 lose their preempt ability. Channel priorities of 0 are treated as equal, that is, they are constantly rotating, when round-robin arbitration mode is enabled.

The CHn_CSR[ACTIVE] field for the preempted channel remains asserted throughout the preemption. The preempted channel is temporarily suspended when the preempting channel executes one major loop iteration. If two CHn_CSR[ACTIVE] fields are set simultaneously in the global TCD map, a higher-priority channel is actively preempting a lower-priority channel.

14.5.7 Channel linking

Channel linking (or chaining) is a mechanism in which one channel sets the TCDn_CSR[START] field of another channel (or itself), thus initiating a service request for that channel. When properly enabled, the eDMA engine automatically performs this operation at the major or minor loop completion.

The minor loop channel linking occurs at the completion of the minor loop (or one iteration of the major loop). The TCDn_CITER[ELINK] field determines whether a minor loop link is requested. When enabled, the channel link is made after each iteration of the major loop except for the last. When the major loop is exhausted, only the major loop channel link fields are used to determine if a channel link should be made. For example, using an initial field setting of:

```
TCDn_CITER[ELINK] = 1
TCDn_CITER[LINKCH] = 0xC
TCDn_CITER[CITER] value = 0x4
TCDn_CSR[MAJORELINK] = 1
TCDn_CSR[MAJORLINKCH] = 0x7
```

executes as:

1. Minor loop done → set TCD12_CSR[START] field

2. Minor loop done → set TCD12_CSR[START] field
3. Minor loop done → set TCD12_CSR[START] field
4. Minor loop done, major loop done→ set TCD7_CSR[START] field

When minor loop linking is enabled (TCDn_CITER[ELINK] = 1), the TCDn_CITER[CITER] field uses a nine-bit vector to form the current iteration count. When minor loop linking is disabled (TCDn_CITER[ELINK] = 0), the TCDn_CITER[CITER] field uses a 15-bit vector to form the current iteration count. The bits associated with the TCDn_CITER[LINKCH] field are concatenated onto the CITER value to increase the range of the CITER.

NOTE

The TCDn_CITER[ELINK] field and the TCDn_BITER[ELINK] field must be equal — if they are not, a configuration error is reported. The CITER and BITER vector widths must be equal to calculate the major loop halfway done interrupt point.

The following table summarizes how a DMA channel can link to another DMA channel, that is, use another channel's TCD, at the end of a loop.

Table 49. Channel linking parameters

Wanted link behavior	TCD control field name	Description
Link at end of minor loop	TCDn_CITER[ELINK]	Enable channel-to-channel linking on minor loop completion (current iteration)
	TCDn_CITER[LINKCH]	Link channel number when linking at end of minor loop (current iteration)
Link at end of major loop	TCDn_CSR[MAJORELINK]	Enable channel-to-channel linking on major loop completion
	TCDn_CSR[MAJORLINKCH]	Link channel number when linking at end of major loop

14.5.8 Dynamic programming

This section provides recommended methods to change the programming model during channel execution.

14.5.8.1 Dynamically changing the channel priority

To change group or channel priority levels:

1. Halt the DMA by writing 1 to the CSR[HALT] field.
2. Change the group or channel priorities as wanted.
3. Enable normal DMA operations by writing 0 to the CSR[HALT] field.

14.5.8.2 Dynamic channel linking

Dynamic channel linking is the process of setting the TCDn_CSR[MAJORELINK] field during channel execution (see the diagram in TCD structure). This field is read from the TCD local memory at the end of channel execution, thus allowing you to enable the feature during channel execution.

Because you are allowed to change the configuration during execution, you need a coherency model. Consider the scenario where you attempt to execute a dynamic channel link by enabling the TCDn_CSR[MAJORELINK] field at the same time the eDMA engine is retiring the channel. TCDn_CSR[MAJORELINK] would be set in the programmer's model, but it would be unclear whether the actual link was made before the channel retired.

We recommend that you use the following coherency model when executing a dynamic channel link request.

1. Write 1 to the TCDn_CSR[MAJORELINK] field.

2. Read back the TCDn_CSR[MAJORELINK] field.
3. Test the TCDn_CSR[MAJORELINK] request status:
   - If TCDn_CSR[MAJORELINK] = 1, the dynamic link attempt was successful.
   - If TCDn_CSR[MAJORELINK] = 0, the attempted dynamic link did not succeed (the channel was already retiring).

For this request, the TCD local memory controller forces the TCDn_CSR[MAJORELINK] field to 0 on any writes to a channel's TCDn_CSR[7:0] after that channel's CHn_CSR[DONE] field is set to 1, indicating the major loop is complete.

NOTE

You must clear the CHn_CSR[DONE] field to 0 before writing to the TCDn_CSR[MAJORELINK] field. The CHn_CSR[DONE] field is cleared to 0 automatically by the eDMA engine after a channel begins execution.

14.5.8.3 Dynamic scatter/gather

Scatter/gather is the process of automatically loading a new TCD into a channel. It allows a DMA channel to use multiple TCDs; this enables a DMA channel to scatter the DMA data to multiple destinations or gather it from multiple sources. When scatter/gather is enabled and the channel has finished its major loop, a new TCD is fetched from system memory and loaded into that channel's descriptor location in the eDMA programmer's model, thus replacing the current descriptor.

Because you are allowed to change the configuration during execution, you need a coherency model. Consider the scenario where you attempt to execute a dynamic scatter/gather operation by enabling the TCDn_CSR[ESG] field at the same time the eDMA engine is retiring the channel. The TCDn_CSR[ESG] field would be set in the programmer's model, but it would be unclear whether the actual scatter/gather request was honored before the channel retired.

Two methods are recommended for executing a dynamic scatter/gather request. Whenever the TCDn_CSR is written, the TCD local memory controller forces the TCDn_CSR[ESG] field to 0 on any writes to a channel's TCDn_CSR[7:0] after that channel's CHn_CSR[DONE] field has been set to 1, indicating the major loop is complete. If attempting to set the ESG, ensure the DONE field is cleared to 0.

NOTE

You must clear the CHn_CSR[DONE] field to 0 before writing the TCDn_CSR[MAJORELINK] or TCDn_CSR[ESG] fields. The CHn_CSR[DONE] field is cleared to 0 automatically by the eDMA engine after a channel begins execution and is set to 1 upon major loop completion.

14.5.8.3.1 Method 1 (channel not using major loop channel linking)

For a channel not using major loop channel linking, the coherency model described here may be used for a dynamic scatter/gather request.

When the TCDn_CSR[MAJORELINK] field is 0, the TCDn_CSR[MAJORLINKCH] field is not used by the eDMA. In this case, the TCDn_CSR[MAJORLINKCH] bits may be used for other purposes. This method uses the TCDn_CSR[MAJORLINKCH] field as a TCDn_CSR identification (ID).

When the descriptors are built, write a unique TCDn_CSR ID in the TCDn_CSR[MAJORLINKCH] field for each TCDn_CSR associated with a channel using dynamic scatter/gather.

1. Write a 1 to the TCDn_CSR[DREQ] field. Should a dynamic scatter/gather attempt fail, setting the TCDn_CSR[DREQ] field to 1 will prevent future hardware activation of this channel. This stops the channel from executing with a destination address (daddr) that was calculated using a scatter/gather address (written in the next step) instead of a DLAST final offset value.
2. Write the TCDn_DLAST_SGA field with the scatter/gather address.
3. Write a 1 to the TCDn_CSR[ESG] field.
4. Read back the 16-bit TCDn_CSR control/status field.
5. Test the TCDn_CSR[ESG] request status and TCDn_CSR[MAJORLINKCH] value:
   - If ESG = 1, the dynamic scatter/gather attempt was successful.

- If ESG = 0 and the MAJORLINKCH (ID) did not change, the dynamic scatter/gather attempt was not successful (the channel was already retiring).
- If ESG = 0 and the MAJORLINKCH (ID) changed, the dynamic scatter/gather attempt was successful (the new TCDn_CSR's ESG value cleared the ESG field to 0).

14.5.8.3.2 Method 2 (channel using major loop channel linking)

For a channel using major loop channel linking, the coherency model described here may be used for a dynamic scatter/gather request. This method uses the TCDn_DLAST_SGA field as a TCD identification (ID).

1. Write a 1 to the TCDn_CSR[DREQ] field. Should a dynamic scatter/gather attempt fail, setting the DREQ field to 1 will prevent a future hardware activation of this channel. This stops the channel from executing with a destination address (DADDR) that was calculated using a scatter/gather address (written in the next step) instead of a DLAST final offset value.
2. Write the TCDn_DLAST_SGA field with the scatter/gather address.
3. Write a 1 to the TCDn_CSR[ESG] field.
4. Read back the TCDn_CSR[ESG] field.
5. Test the TCDn_CSR[ESG] request status:
   - If ESG = 1, the dynamic scatter/gather attempt was successful.
   - If ESG = 0, read the 32-bit TCDn_DLAST_SGA field.
   - If ESG = 0 and the TCDn_DLAST_SGA did not change, the dynamic scatter/gather attempt was not successful (the channel was already retiring).
   - If ESG = 0 and the TCDn_DLAST_SGA changed, the dynamic scatter/gather attempt was successful (the new TCDn_CSR's ESG value cleared the ESG field to 0).

14.5.9 Suspend/resume a DMA channel with active hardware service requests

The DMA allows you to move data from memory or peripheral registers to another location in memory or to peripheral registers without CPU interaction. After the DMA and peripherals are configured and active, it is rare but supported to suspend a peripheral's service request dynamically. In this scenario, there are certain restrictions to disabling a DMA hardware service request. For coherency, you must follow a specific procedure. This section provides guidance on how to coherently suspend and resume a Direct Memory Access (DMA) channel when the DMA is triggered by a slave module such as the Serial Peripheral Interface (DSPI), Sigma Delta Analog to Digital Convertor (SDADC), or other module.

14.5.9.1 Suspend an active DMA channel

To suspend an active DMA channel:

1. Stop the DMA service request at the peripheral first. Confirm it has been disabled by reading back the appropriate register in the peripheral.
2. Check the DMA's Hardware Request Status (HRS) to ensure there is no service request to the DMA channel being suspended. Then disable the hardware service request by clearing the ERQ field to 0 on the appropriate DMA channel.

For example, assume the DSPI is set as a master for transmitting data via a DMA service request when the TXFIFO has an empty slot. The DMA will transfer the next command and data to the TXFIFO upon the request. If you need to suspend the DMA/DSPI transfer loop, perform the following steps:

1. Disable the DMA service request at the source by writing 0 to DSPI_RSER[TFFF_RE]. Confirm that DSPI_RSER[TFFF_RE] is 0.
2. Ensure there is no DMA service request from the DSPI by verifying that HRS[HRS] is 0 for the appropriate channel. If no service request is present, disable the DMA channel by clearing the channel's ERQ field to 0. If a service request is present, wait until the request has been processed and the HRS field reads 0.

14.5.9.2 Resume a DMA channel

To resume a DMA channel:

1. Enable the DMA service request on the appropriate channel by setting its ERQ field to 1.
2. Enable the DMA service request at the peripheral.

14.6 Memory map/register definition

The eDMA programming model is partitioned into three parts:

1. The first part defines a number of registers providing overall control functions and is known as the management page.
2. The second part corresponds to the channel (CH) control, status, and configuration.
3. The third part corresponds to the local TCD memory.

TCD memory

Each channel requires a 32-byte transfer control descriptor for defining the data movement operation. Each TCDn definition is presented as 11 registers of 16 or 32 bits.

TCD initialization

The TCD memory is in an unknown state after reset. Only the TCD START bit is initialized to 0. Prior to activating a channel, you must initialize its TCD with the appropriate transfer profile.

TCD structure

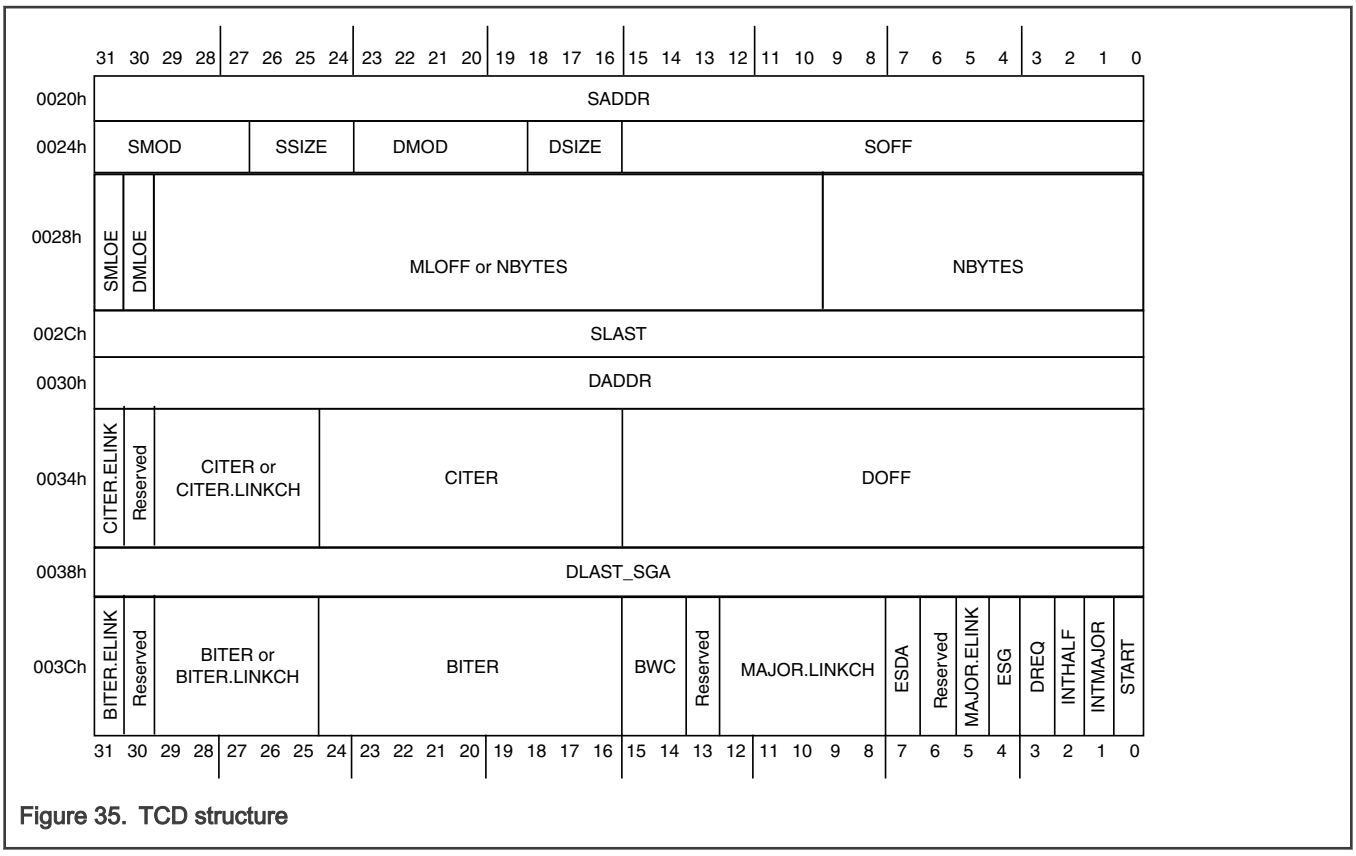


Figure 35. TCD structure

Accesses to reserved memory and fields

- Reading reserved fields in a register returns the value of zero.
- Writes to reserved fields in a register are ignored.
- Reading or writing a reserved memory location generates a bus error.

14.6.1 eDMA register descriptions

14.6.1.1 eDMA memory map

eDMA_0 base address: 4020_C000h

eDMA_1 base address: 4001_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Management Page Control (CSR)	32	RW	0030_0000h
4h	Management Page Error Status (ES)	32	R	0000_0000h
8h	Management Page Interrupt Request Status (INT)	32	R	0000_0000h
Ch	Management Page Hardware Request Status (HRS)	32	R	0000_0000h
100h - 17Ch	Channel Arbitration Group (CH0_GRPRI - CH31_GRPRI)	32	RW	0000_0000h

14.6.1.2 Management Page Control (CSR)

Offset

Register	Offset
CSR	0h

Function

The Management Page Control register defines the basic operating configuration of the DMA.

Arbitration uses a two-tier priority system; group and channel priority. The eDMA assigns each channel to a priority group. Group arbitration is fixed-priority and cannot be changed. Channel arbitration uses fixed priority and may be configured to use a selective round-robin scheme for specified channels within each priority group. For fixed-priority arbitration, eDMA selects for execution the highest priority channel requesting service in the highest priority arbitration group.

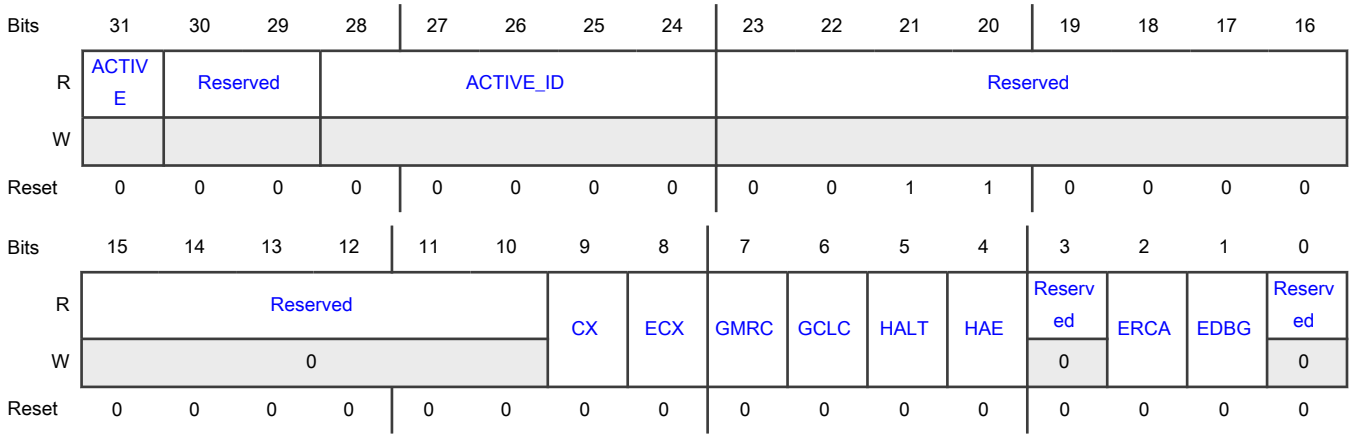
The channel priority registers assign the relative priorities within each arbitration group; see CHn_PRI. All channels with a non-zero CHn_PRI value use fixed-priority arbitration.

When you enable round-robin arbitration, all channels with channel priority set to zero do not have a priority and, of those channels requesting service, are cycled through (from high to low channel number) without regard to priority relative to each other within the same priority group. Any channel with a non-zero CHn_PRI value automatically has a higher priority over the round-robin channels. A channel's priority group is assigned in Channel Arbitration Group (CH0_GRPRI - CH31_GRPRI).

NOTE

For correct operation, changes to the CSR[ERCA, GCLC, GMRC] fields must be performed when the DMA channels are inactive; that is, when the CSR[ACTIVE] field is 0.

Diagram



Fields

Field	Function
31 ACTIVE	DMA Active Status 0b - eDMA is idle 1b - eDMA is executing a channel
30-29 —	Reserved
28-24 ACTIVE_ID	Active Channel ID This field identifies the channel number that is executing when the ACTIVE bit is 1.
23-16 —	Reserved
15-10 —	Reserved
9 CX	Cancel Transfer When set to 1, this field cancels the remaining data transfer, stops the executing channel, and forces the minor loop to finish. The cancel takes effect after the last write of the current read/write sequence. CX clears itself to 0 after the cancel has been honored. This cancel retires the channel normally as if the minor loop had been completed. 0b - Normal operation 1b - Cancel the remaining data transfer
8 ECX	Cancel Transfer With Error Cancellation of the remaining data transfer is similar to that of the CX field. Execution of the channel is stopped and the minor loop is forced to finish. The cancellation takes effect after the last write of the current read/write sequence. The ECX field clears itself to 0 after the cancel is honored. In addition to

Table continues on the next page...

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Field	Function
	cancelling the transfer, ECX treats the cancel as an error condition, thus updating Management Page Error Status (ES) and generating an optional error interrupt. 0b - Normal operation 1b - Cancel the remaining data transfer
7 GMRC	Global Master ID Replication Control **NOTE** If master ID replication is disabled, the privileged protection level (Supervisor mode) for DMA transfers is used. See chip-specific eDMA information for details on ID replication. 0b - Master ID replication disabled for all channels 1b - Master ID replication available and controlled by each channel's CHn_SBR[EMI] setting
6 GCLC	Global Channel Linking Control 0b - Channel linking disabled for all channels 1b - Channel linking available and controlled by each channel's link settings
5 HALT	Halt DMA Operations This field stalls the start of any new channels. Executing channels are allowed to complete. Channel execution resumes when this field is cleared to 0. 0b - Normal operation 1b - Stall the start of any new channels
4 HAE	Halt After Error When this field is set to 1, any error causes the HALT field to be set to 1. Then all service requests are ignored until the HALT field is cleared to 0. 0b - Normal operation 1b - Any error causes the HALT field to be set to 1
3 —	Reserved
2 ERCA	Enable Round Robin Channel Arbitration 0b - Round-robin channel arbitration disabled. Fixed priority arbitration used for channel selection within each group 1b - Round-robin channel arbitration enabled. Round-robin arbitration used for channel selection within each group
1 EDBG	Enable Debug When in debug mode, the DMA stalls the start of a new channel. Executing channels are allowed to complete. DMA resumes channel execution when the system exits debug mode or clears the EDBG field to 0.

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Field	Function
	0b - Debug mode disabled. When in debug mode, the DMA continues to operate 1b - Debug mode is enabled. When in debug mode, the DMA stalls the start of a new channel
0 —	Reserved

14.6.1.3 Management Page Error Status (ES)

Offset

Register	Offset
ES	4h

Function

The ES provides information concerning the last recorded channel error. Channel errors can be caused by:

- An illegal setting in the transfer control descriptor
- An error termination to a bus master read or write cycle
- An uncorrectable error that occurred when the device was accessing the TCD SRAM
- A "cancel transfer with error" request was made via the corresponding cancel transfer field or input signal

Upon any error condition, the software must initialize the TCD of the channel that contains the error, as it is in an incomplete state after an error. See Fault reporting and handling for more details.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	VLD	Reserved			ERRCHN				0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0						UCE	ECX	SAE	SOE	DAE	DOE	NCE	SGE	SBE	DBE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31	Valid

Table continues on the next page...

Table continued from the previous page...

Field	Function
VLD	Logical OR of all ERR status fields. 0b - No ERR fields are set to 1 1b - At least one ERR field is set to 1, indicating a valid error exists that software has not cleared
30-29 —	Reserved
28-24 ERRCHN	Error Channel Number or Canceled Channel Number The channel number of the last recorded error or last recorded error-canceled transfer.
23-10 —	Reserved
9 UCE	Uncorrectable TCD Error During Channel Execution UCE is set to 1 only when an uncorrectable ECC error occurs on an access generated by the DMA. If a CPU access to the TCD causes an uncorrectable ECC error, then that access receives a bus error response. **NOTE** When the eDMA sees a RAM error on an IPS access (when you are accessing a TCD), it reports the error as a bus abort. When the DMA engine receives a RAM error (the execution engine is accessing a TCD) it is recorded in the Error Status register, ES[UCE], along with the channel number. 0b - No uncorrectable ECC error 1b - Last recorded error was an uncorrectable TCD RAM error
8 ECX	Transfer Canceled The ECX operation is a management page function. When employed, the targeted channel's CHn_ES register reports an unspecified error; that is, only the ERR field is set to 1. The management page has full view of the error condition. 0b - No canceled transfers 1b - Last recorded entry was a canceled transfer by the error cancel transfer input
7 SAE	Source Address Error When this field is 1, it indicates that TCDn_SADDR is inconsistent with TCDn_ATTR[SSIZE]. 0b - No source address configuration error 1b - Last recorded error was a configuration error detected in the TCDn_SADDR field
6 SOE	Source Offset Error When this field is 1, it indicates that TCDn_SOFF is inconsistent with TCDn_ATTR[SSIZE]. 0b - No source offset configuration error 1b - Last recorded error was a configuration error detected in the TCDn_SOFF field

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Field	Function
5 DAE	Destination Address Error When this field is 1, it indicates that TCDn_DADDR is inconsistent with TCDn_ATTR[DSIZE]. 0b - No destination address configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DADDR field
4 DOE	Destination Offset Error When this field is 1, it indicates that TCDn_DOFF is inconsistent with TCDn_ATTR[DSIZE]. 0b - No destination offset configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DOFF field
3 NCE	NBYTES/CITER Configuration Error This error indicates that one of the following has occurred: • TCDn_NBYTES is not a multiple of TCDn_ATTR[SSIZE] and TCDn_ATTR[DSIZE] • TCDn_CITER[CITER] is equal to zero • TCDn_CITER[ELINK] is not equal to TCDn_BITER[ELINK] 0b - No NBYTES/CITER configuration error 1b - The last recorded error was NBYTES equal to zero or a CITER not equal to BITER error. Last recorded error was a configuration error detected in the TCDn_NBYTES or TCDn_CITER fields
2 SGE	Scatter/Gather Configuration Error When this field is 1, it indicates that TCDn_DLAST_SGA is not on a 32-byte boundary. This field is checked at the beginning of a scatter/gather operation after major loop completion if TCDn_CSR[ESG] is enabled. 0b - No scatter/gather configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DLAST_SGA field
1 SBE	Source Bus Error 0b - No source bus error 1b - Last recorded error was a bus error on a source read
0 DBE	Destination Bus Error 0b - No destination bus error 1b - Last recorded error was a bus error on a destination write

14.6.1.4 Management Page Interrupt Request Status (INT)

Offset

Register	Offset
INT	8h

Function

This register shows the current state of the interrupt service requests for all eDMA channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	INT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	INT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 INT	Interrupt Request Status The INT register presents the interrupt request status for each eDMA channel. Depending on the appropriate field setting in the transfer control descriptors, the eDMA engine generates an interrupt on data transfer completion or an error condition. The eDMA routes channel interrupt requests to the interrupt controller. During the interrupt service routine associated with any given channel, it is the software's responsibility to clear the appropriate field in the channel's interrupt request register, CHn_INT, thus negating the interrupt request. 0b - Interrupt request for corresponding channel not present 1b - Interrupt request for corresponding channel present

14.6.1.5 Management Page Hardware Request Status (HRS)

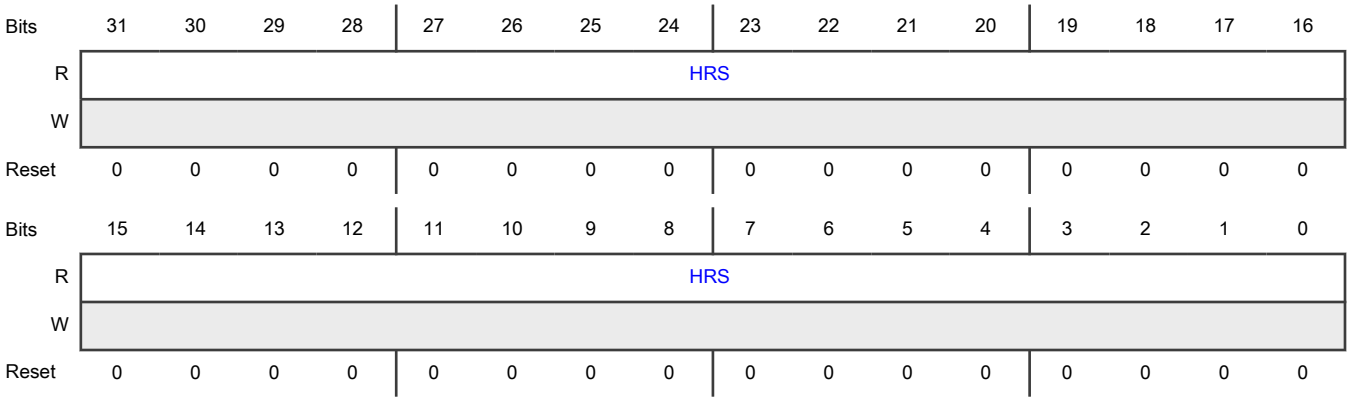
Offset

Register	Offset
HRS	Ch

Function

The hardware request status register (HRS) shows the current state of the hardware service request signaling as seen by eDMA's arbitration logic.

Diagram



Fields

Field	Function
31-0 HRS	Hardware Request Status The HRS bit for its respective channel remains asserted for the period when a hardware request is present on the channel. 0b - Hardware service request for corresponding channel is not present 1b - Hardware service request for corresponding channel is present

14.6.1.6 Channel Arbitration Group (CH0_GRPRI - CH31_GRPRI)

Offset

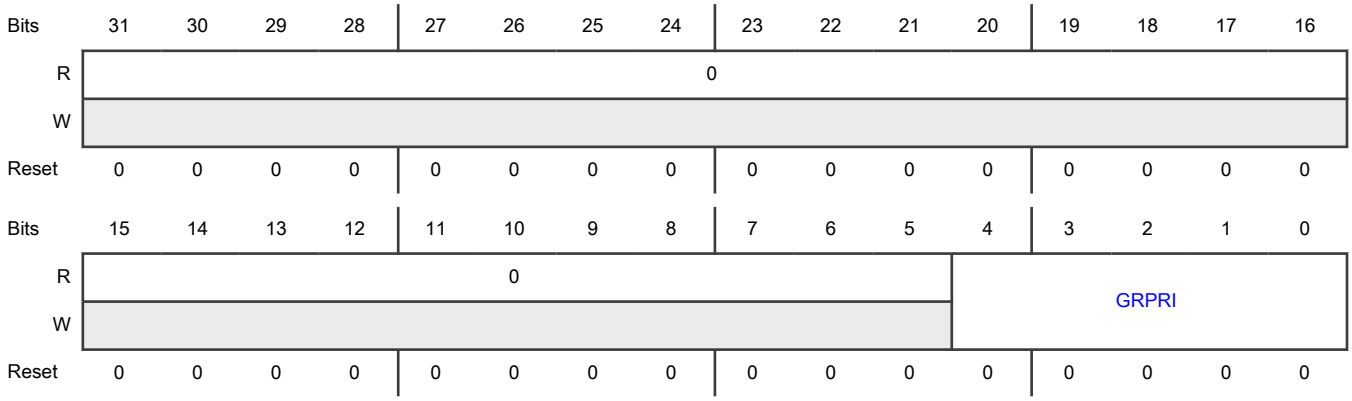
For n = 0 to 31:

Register	Offset
CHn_GRPRI	100h + (n × 4h)

Function

The contents of this register define the arbitration group associated with each channel. Using a fixed-priority group arbitration scheme, eDMA evaluates the arbitration group priorities by numeric value from highest group number to lowest; for example, 0 is the lowest priority, 1 is the next higher priority, then 2, 3, and so on. The range of the group priority values is limited to the values of 0 through 31. Within each arbitration group, the channel priority assignment CH*n*_PRI determines the highest-priority channel.

Diagram



Fields

Field	Function
31-5 —	Reserved
4-0 GRPRI	Arbitration Group For Channel n Fixed-priority arbitration group number.

14.6.2 TCD_0 register descriptions

14.6.2.1 TCD_0 memory map

TCD_0 base address: 4021_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Channel Control and Status (CH0_CSR)	32	RW	0000_0000h
4h	Channel Error Status (CH0_ES)	32	RW	0000_0000h
8h	Channel Interrupt Status (CH0_INT)	32	RW	0000_0000h
Ch	Channel System Bus (CH0_SBR)	32	RW	0000_8002h
10h	Channel Priority (CH0_PRI)	32	RW	0000_0000h
20h	TCD Source Address (TCD0_SADDR)	32	RW	0000_0000h
24h	TCD Signed Source Address Offset (TCD0_SOFF)	16	RW	0000h
26h	TCD Transfer Attributes (TCD0_ATTR)	16	RW	0000h
28h	TCD Transfer Size Without Minor Loop Offsets (TCD0_NBYTES_MLOFFNO)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
28h	TCD Transfer Size with Minor Loop Offsets (TCD0_NBYTES_MLOFFYES)	32	RW	0000_0000h
2Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD0_SLAST_SDA)	32	RW	0000_0000h
30h	TCD Destination Address (TCD0_DADDR)	32	RW	0000_0000h
34h	TCD Signed Destination Address Offset (TCD0_DOFF)	16	RW	0000h
36h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_CITER_ELINKNO)	16	RW	0000h
36h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_CITER_ELINKYES)	16	RW	0000h
38h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD0_DLAST_SGA)	32	RW	0000_0000h
3Ch	TCD Control and Status (TCD0_CSR)	16	RW	0000h
3Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_BITER_ELINKNO)	16	RW	0000h
3Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_BITER_ELINKYES)	16	RW	0000h
4000h	Channel Control and Status (CH1_CSR)	32	RW	0000_0000h
4004h	Channel Error Status (CH1_ES)	32	RW	0000_0000h
4008h	Channel Interrupt Status (CH1_INT)	32	RW	0000_0000h
400Ch	Channel System Bus (CH1_SBR)	32	RW	0000_8002h
4010h	Channel Priority (CH1_PRI)	32	RW	0000_0000h
4020h	TCD Source Address (TCD1_SADDR)	32	RW	0000_0000h
4024h	TCD Signed Source Address Offset (TCD1_SOFF)	16	RW	0000h
4026h	TCD Transfer Attributes (TCD1_ATTR)	16	RW	0000h
4028h	TCD Transfer Size Without Minor Loop Offsets (TCD1_NBYTES_MLOFFNO)	32	RW	0000_0000h
4028h	TCD Transfer Size with Minor Loop Offsets (TCD1_NBYTES_MLOFFYES)	32	RW	0000_0000h
402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD1_SLAST_SDA)	32	RW	0000_0000h
4030h	TCD Destination Address (TCD1_DADDR)	32	RW	0000_0000h
4034h	TCD Signed Destination Address Offset (TCD1_DOFF)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD1_CITER_ELINKNO)	16	RW	0000h
4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD1_CITER_ELINKYES)	16	RW	0000h
4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD1_DLAST_SGA)	32	RW	0000_0000h
403Ch	TCD Control and Status (TCD1_CSR)	16	RW	0000h
403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD1_BITER_ELINKNO)	16	RW	0000h
403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD1_BITER_ELINKYES)	16	RW	0000h
8000h	Channel Control and Status (CH2_CSR)	32	RW	0000_0000h
8004h	Channel Error Status (CH2_ES)	32	RW	0000_0000h
8008h	Channel Interrupt Status (CH2_INT)	32	RW	0000_0000h
800Ch	Channel System Bus (CH2_SBR)	32	RW	0000_8002h
8010h	Channel Priority (CH2_PRI)	32	RW	0000_0000h
8020h	TCD Source Address (TCD2_SADDR)	32	RW	0000_0000h
8024h	TCD Signed Source Address Offset (TCD2_SOFF)	16	RW	0000h
8026h	TCD Transfer Attributes (TCD2_ATTR)	16	RW	0000h
8028h	TCD Transfer Size Without Minor Loop Offsets (TCD2_NBYTES_MLOFFNO)	32	RW	0000_0000h
8028h	TCD Transfer Size with Minor Loop Offsets (TCD2_NBYTES_MLOFFYES)	32	RW	0000_0000h
802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD2_SLAST_SDA)	32	RW	0000_0000h
8030h	TCD Destination Address (TCD2_DADDR)	32	RW	0000_0000h
8034h	TCD Signed Destination Address Offset (TCD2_DOFF)	16	RW	0000h
8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD2_CITER_ELINKNO)	16	RW	0000h
8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD2_CITER_ELINKYES)	16	RW	0000h
8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD2_DLAST_SGA)	32	RW	0000_0000h
803Ch	TCD Control and Status (TCD2_CSR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD2_BITER_ELINKNO)	16	RW	0000h
803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD2_BITER_ELINKYES)	16	RW	0000h
C000h	Channel Control and Status (CH3_CSR)	32	RW	0000_0000h
C004h	Channel Error Status (CH3_ES)	32	RW	0000_0000h
C008h	Channel Interrupt Status (CH3_INT)	32	RW	0000_0000h
C00Ch	Channel System Bus (CH3_SBR)	32	RW	0000_8002h
C010h	Channel Priority (CH3_PRI)	32	RW	0000_0000h
C020h	TCD Source Address (TCD3_SADDR)	32	RW	0000_0000h
C024h	TCD Signed Source Address Offset (TCD3_SOFF)	16	RW	0000h
C026h	TCD Transfer Attributes (TCD3_ATTR)	16	RW	0000h
C028h	TCD Transfer Size Without Minor Loop Offsets (TCD3_NBYTES_MLOFFNO)	32	RW	0000_0000h
C028h	TCD Transfer Size with Minor Loop Offsets (TCD3_NBYTES_MLOFFYES)	32	RW	0000_0000h
C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD3_SLAST_SDA)	32	RW	0000_0000h
C030h	TCD Destination Address (TCD3_DADDR)	32	RW	0000_0000h
C034h	TCD Signed Destination Address Offset (TCD3_DOFF)	16	RW	0000h
C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD3_CITER_ELINKNO)	16	RW	0000h
C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD3_CITER_ELINKYES)	16	RW	0000h
C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD3_DLAST_SGA)	32	RW	0000_0000h
C03Ch	TCD Control and Status (TCD3_CSR)	16	RW	0000h
C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD3_BITER_ELINKNO)	16	RW	0000h
C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD3_BITER_ELINKYES)	16	RW	0000h
1_0000h	Channel Control and Status (CH4_CSR)	32	RW	0000_0000h
1_0004h	Channel Error Status (CH4_ES)	32	RW	0000_0000h
1_0008h	Channel Interrupt Status (CH4_INT)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1_000Ch	Channel System Bus (CH4_SBR)	32	RW	0000_8002h
1_0010h	Channel Priority (CH4_PRI)	32	RW	0000_0000h
1_0020h	TCD Source Address (TCD4_SADDR)	32	RW	0000_0000h
1_0024h	TCD Signed Source Address Offset (TCD4_SOFF)	16	RW	0000h
1_0026h	TCD Transfer Attributes (TCD4_ATTR)	16	RW	0000h
1_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD4_NBYTES_MLOFFNO)	32	RW	0000_0000h
1_0028h	TCD Transfer Size with Minor Loop Offsets (TCD4_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD4_SLAST_SDA)	32	RW	0000_0000h
1_0030h	TCD Destination Address (TCD4_DADDR)	32	RW	0000_0000h
1_0034h	TCD Signed Destination Address Offset (TCD4_DOFF)	16	RW	0000h
1_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD4_CITER_ELINKNO)	16	RW	0000h
1_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD4_CITER_ELINKYES)	16	RW	0000h
1_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD4_DLAST_SGA)	32	RW	0000_0000h
1_003Ch	TCD Control and Status (TCD4_CSR)	16	RW	0000h
1_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD4_BITER_ELINKNO)	16	RW	0000h
1_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD4_BITER_ELINKYES)	16	RW	0000h
1_4000h	Channel Control and Status (CH5_CSR)	32	RW	0000_0000h
1_4004h	Channel Error Status (CH5_ES)	32	RW	0000_0000h
1_4008h	Channel Interrupt Status (CH5_INT)	32	RW	0000_0000h
1_400Ch	Channel System Bus (CH5_SBR)	32	RW	0000_8002h
1_4010h	Channel Priority (CH5_PRI)	32	RW	0000_0000h
1_4020h	TCD Source Address (TCD5_SADDR)	32	RW	0000_0000h
1_4024h	TCD Signed Source Address Offset (TCD5_SOFF)	16	RW	0000h
1_4026h	TCD Transfer Attributes (TCD5_ATTR)	16	RW	0000h
1_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD5_NBYTES_MLOFFNO)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1_4028h	TCD Transfer Size with Minor Loop Offsets (TCD5_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD5_SLAST_SDA)	32	RW	0000_0000h
1_4030h	TCD Destination Address (TCD5_DADDR)	32	RW	0000_0000h
1_4034h	TCD Signed Destination Address Offset (TCD5_DOFF)	16	RW	0000h
1_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD5_CITER_ELINKNO)	16	RW	0000h
1_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD5_CITER_ELINKYES)	16	RW	0000h
1_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD5_DLAST_SGA)	32	RW	0000_0000h
1_403Ch	TCD Control and Status (TCD5_CSR)	16	RW	0000h
1_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD5_BITER_ELINKNO)	16	RW	0000h
1_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD5_BITER_ELINKYES)	16	RW	0000h
1_8000h	Channel Control and Status (CH6_CSR)	32	RW	0000_0000h
1_8004h	Channel Error Status (CH6_ES)	32	RW	0000_0000h
1_8008h	Channel Interrupt Status (CH6_INT)	32	RW	0000_0000h
1_800Ch	Channel System Bus (CH6_SBR)	32	RW	0000_8002h
1_8010h	Channel Priority (CH6_PRI)	32	RW	0000_0000h
1_8020h	TCD Source Address (TCD6_SADDR)	32	RW	0000_0000h
1_8024h	TCD Signed Source Address Offset (TCD6_SOFF)	16	RW	0000h
1_8026h	TCD Transfer Attributes (TCD6_ATTR)	16	RW	0000h
1_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD6_NBYTES_MLOFFNO)	32	RW	0000_0000h
1_8028h	TCD Transfer Size with Minor Loop Offsets (TCD6_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD6_SLAST_SDA)	32	RW	0000_0000h
1_8030h	TCD Destination Address (TCD6_DADDR)	32	RW	0000_0000h
1_8034h	TCD Signed Destination Address Offset (TCD6_DOFF)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
1_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD6_CITER_ELINKNO)	16	RW	0000h
1_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD6_CITER_ELINKYES)	16	RW	0000h
1_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD6_DLAST_SGA)	32	RW	0000_0000h
1_803Ch	TCD Control and Status (TCD6_CSR)	16	RW	0000h
1_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD6_BITER_ELINKNO)	16	RW	0000h
1_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD6_BITER_ELINKYES)	16	RW	0000h
1_C000h	Channel Control and Status (CH7_CSR)	32	RW	0000_0000h
1_C004h	Channel Error Status (CH7_ES)	32	RW	0000_0000h
1_C008h	Channel Interrupt Status (CH7_INT)	32	RW	0000_0000h
1_C00Ch	Channel System Bus (CH7_SBR)	32	RW	0000_8002h
1_C010h	Channel Priority (CH7_PRI)	32	RW	0000_0000h
1_C020h	TCD Source Address (TCD7_SADDR)	32	RW	0000_0000h
1_C024h	TCD Signed Source Address Offset (TCD7_SOFF)	16	RW	0000h
1_C026h	TCD Transfer Attributes (TCD7_ATTR)	16	RW	0000h
1_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD7_NBYTES_MLOFFNO)	32	RW	0000_0000h
1_C028h	TCD Transfer Size with Minor Loop Offsets (TCD7_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD7_SLAST_SDA)	32	RW	0000_0000h
1_C030h	TCD Destination Address (TCD7_DADDR)	32	RW	0000_0000h
1_C034h	TCD Signed Destination Address Offset (TCD7_DOFF)	16	RW	0000h
1_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD7_CITER_ELINKNO)	16	RW	0000h
1_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD7_CITER_ELINKYES)	16	RW	0000h
1_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD7_DLAST_SGA)	32	RW	0000_0000h
1_C03Ch	TCD Control and Status (TCD7_CSR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
1_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD7_BITER_ELINKNO)	16	RW	0000h
1_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD7_BITER_ELINKYES)	16	RW	0000h
2_0000h	Channel Control and Status (CH8_CSR)	32	RW	0000_0000h
2_0004h	Channel Error Status (CH8_ES)	32	RW	0000_0000h
2_0008h	Channel Interrupt Status (CH8_INT)	32	RW	0000_0000h
2_000Ch	Channel System Bus (CH8_SBR)	32	RW	0000_8002h
2_0010h	Channel Priority (CH8_PRI)	32	RW	0000_0000h
2_0020h	TCD Source Address (TCD8_SADDR)	32	RW	0000_0000h
2_0024h	TCD Signed Source Address Offset (TCD8_SOFF)	16	RW	0000h
2_0026h	TCD Transfer Attributes (TCD8_ATTR)	16	RW	0000h
2_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD8_NBYTES_MLOFFNO)	32	RW	0000_0000h
2_0028h	TCD Transfer Size with Minor Loop Offsets (TCD8_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD8_SLAST_SDA)	32	RW	0000_0000h
2_0030h	TCD Destination Address (TCD8_DADDR)	32	RW	0000_0000h
2_0034h	TCD Signed Destination Address Offset (TCD8_DOFF)	16	RW	0000h
2_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD8_CITER_ELINKNO)	16	RW	0000h
2_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD8_CITER_ELINKYES)	16	RW	0000h
2_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD8_DLAST_SGA)	32	RW	0000_0000h
2_003Ch	TCD Control and Status (TCD8_CSR)	16	RW	0000h
2_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD8_BITER_ELINKNO)	16	RW	0000h
2_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD8_BITER_ELINKYES)	16	RW	0000h
2_4000h	Channel Control and Status (CH9_CSR)	32	RW	0000_0000h
2_4004h	Channel Error Status (CH9_ES)	32	RW	0000_0000h
2_4008h	Channel Interrupt Status (CH9_INT)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
2_400Ch	Channel System Bus (CH9_SBR)	32	RW	0000_8002h
2_4010h	Channel Priority (CH9_PRI)	32	RW	0000_0000h
2_4020h	TCD Source Address (TCD9_SADDR)	32	RW	0000_0000h
2_4024h	TCD Signed Source Address Offset (TCD9_SOFF)	16	RW	0000h
2_4026h	TCD Transfer Attributes (TCD9_ATTR)	16	RW	0000h
2_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD9_NBYTES_MLOFFNO)	32	RW	0000_0000h
2_4028h	TCD Transfer Size with Minor Loop Offsets (TCD9_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD9_SLAST_SDA)	32	RW	0000_0000h
2_4030h	TCD Destination Address (TCD9_DADDR)	32	RW	0000_0000h
2_4034h	TCD Signed Destination Address Offset (TCD9_DOFF)	16	RW	0000h
2_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD9_CITER_ELINKNO)	16	RW	0000h
2_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD9_CITER_ELINKYES)	16	RW	0000h
2_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD9_DLAST_SGA)	32	RW	0000_0000h
2_403Ch	TCD Control and Status (TCD9_CSR)	16	RW	0000h
2_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD9_BITER_ELINKNO)	16	RW	0000h
2_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD9_BITER_ELINKYES)	16	RW	0000h
2_8000h	Channel Control and Status (CH10_CSR)	32	RW	0000_0000h
2_8004h	Channel Error Status (CH10_ES)	32	RW	0000_0000h
2_8008h	Channel Interrupt Status (CH10_INT)	32	RW	0000_0000h
2_800Ch	Channel System Bus (CH10_SBR)	32	RW	0000_8002h
2_8010h	Channel Priority (CH10_PRI)	32	RW	0000_0000h
2_8020h	TCD Source Address (TCD10_SADDR)	32	RW	0000_0000h
2_8024h	TCD Signed Source Address Offset (TCD10_SOFF)	16	RW	0000h
2_8026h	TCD Transfer Attributes (TCD10_ATTR)	16	RW	0000h
2_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD10_NBYTES_MLOFFNO)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
2_8028h	TCD Transfer Size with Minor Loop Offsets (TCD10_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD10_SLAST_SDA)	32	RW	0000_0000h
2_8030h	TCD Destination Address (TCD10_DADDR)	32	RW	0000_0000h
2_8034h	TCD Signed Destination Address Offset (TCD10_DOFF)	16	RW	0000h
2_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD10_CITER_ELINKNO)	16	RW	0000h
2_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD10_CITER_ELINKYES)	16	RW	0000h
2_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD10_DLAST_SGA)	32	RW	0000_0000h
2_803Ch	TCD Control and Status (TCD10_CSR)	16	RW	0000h
2_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD10_BITER_ELINKNO)	16	RW	0000h
2_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD10_BITER_ELINKYES)	16	RW	0000h
2_C000h	Channel Control and Status (CH11_CSR)	32	RW	0000_0000h
2_C004h	Channel Error Status (CH11_ES)	32	RW	0000_0000h
2_C008h	Channel Interrupt Status (CH11_INT)	32	RW	0000_0000h
2_C00Ch	Channel System Bus (CH11_SBR)	32	RW	0000_8002h
2_C010h	Channel Priority (CH11_PRI)	32	RW	0000_0000h
2_C020h	TCD Source Address (TCD11_SADDR)	32	RW	0000_0000h
2_C024h	TCD Signed Source Address Offset (TCD11_SOFF)	16	RW	0000h
2_C026h	TCD Transfer Attributes (TCD11_ATTR)	16	RW	0000h
2_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD11_NBYTES_MLOFFNO)	32	RW	0000_0000h
2_C028h	TCD Transfer Size with Minor Loop Offsets (TCD11_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD11_SLAST_SDA)	32	RW	0000_0000h
2_C030h	TCD Destination Address (TCD11_DADDR)	32	RW	0000_0000h
2_C034h	TCD Signed Destination Address Offset (TCD11_DOFF)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
2_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD11_CITER_ELINKNO)	16	RW	0000h
2_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD11_CITER_ELINKYES)	16	RW	0000h
2_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD11_DLAST_SGA)	32	RW	0000_0000h
2_C03Ch	TCD Control and Status (TCD11_CSR)	16	RW	0000h
2_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD11_BITER_ELINKNO)	16	RW	0000h
2_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD11_BITER_ELINKYES)	16	RW	0000h
20_0000h	Channel Control and Status (CH12_CSR)	32	RW	0000_0000h
20_0004h	Channel Error Status (CH12_ES)	32	RW	0000_0000h
20_0008h	Channel Interrupt Status (CH12_INT)	32	RW	0000_0000h
20_000Ch	Channel System Bus (CH12_SBR)	32	RW	0000_8002h
20_0010h	Channel Priority (CH12_PRI)	32	RW	0000_0000h
20_0020h	TCD Source Address (TCD12_SADDR)	32	RW	0000_0000h
20_0024h	TCD Signed Source Address Offset (TCD12_SOFF)	16	RW	0000h
20_0026h	TCD Transfer Attributes (TCD12_ATTR)	16	RW	0000h
20_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD12_NBYTES_MLOFFNO)	32	RW	0000_0000h
20_0028h	TCD Transfer Size with Minor Loop Offsets (TCD12_NBYTES_MLOFFYES)	32	RW	0000_0000h
20_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD12_SLAST_SDA)	32	RW	0000_0000h
20_0030h	TCD Destination Address (TCD12_DADDR)	32	RW	0000_0000h
20_0034h	TCD Signed Destination Address Offset (TCD12_DOFF)	16	RW	0000h
20_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD12_CITER_ELINKNO)	16	RW	0000h
20_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD12_CITER_ELINKYES)	16	RW	0000h
20_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD12_DLAST_SGA)	32	RW	0000_0000h
20_003Ch	TCD Control and Status (TCD12_CSR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
20_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD12_BITER_ELINKNO)	16	RW	0000h
20_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD12_BITER_ELINKYES)	16	RW	0000h
20_4000h	Channel Control and Status (CH13_CSR)	32	RW	0000_0000h
20_4004h	Channel Error Status (CH13_ES)	32	RW	0000_0000h
20_4008h	Channel Interrupt Status (CH13_INT)	32	RW	0000_0000h
20_400Ch	Channel System Bus (CH13_SBR)	32	RW	0000_8002h
20_4010h	Channel Priority (CH13_PRI)	32	RW	0000_0000h
20_4020h	TCD Source Address (TCD13_SADDR)	32	RW	0000_0000h
20_4024h	TCD Signed Source Address Offset (TCD13_SOFF)	16	RW	0000h
20_4026h	TCD Transfer Attributes (TCD13_ATTR)	16	RW	0000h
20_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD13_NBYTES_MLOFFNO)	32	RW	0000_0000h
20_4028h	TCD Transfer Size with Minor Loop Offsets (TCD13_NBYTES_MLOFFYES)	32	RW	0000_0000h
20_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD13_SLAST_SDA)	32	RW	0000_0000h
20_4030h	TCD Destination Address (TCD13_DADDR)	32	RW	0000_0000h
20_4034h	TCD Signed Destination Address Offset (TCD13_DOFF)	16	RW	0000h
20_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD13_CITER_ELINKNO)	16	RW	0000h
20_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD13_CITER_ELINKYES)	16	RW	0000h
20_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD13_DLAST_SGA)	32	RW	0000_0000h
20_403Ch	TCD Control and Status (TCD13_CSR)	16	RW	0000h
20_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD13_BITER_ELINKNO)	16	RW	0000h
20_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD13_BITER_ELINKYES)	16	RW	0000h
20_8000h	Channel Control and Status (CH14_CSR)	32	RW	0000_0000h
20_8004h	Channel Error Status (CH14_ES)	32	RW	0000_0000h
20_8008h	Channel Interrupt Status (CH14_INT)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
20_800Ch	Channel System Bus (CH14_SBR)	32	RW	0000_8002h
20_8010h	Channel Priority (CH14_PRI)	32	RW	0000_0000h
20_8020h	TCD Source Address (TCD14_SADDR)	32	RW	0000_0000h
20_8024h	TCD Signed Source Address Offset (TCD14_SOFF)	16	RW	0000h
20_8026h	TCD Transfer Attributes (TCD14_ATTR)	16	RW	0000h
20_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD14_NBYTES_MLOFFNO)	32	RW	0000_0000h
20_8028h	TCD Transfer Size with Minor Loop Offsets (TCD14_NBYTES_MLOFFYES)	32	RW	0000_0000h
20_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD14_SLAST_SDA)	32	RW	0000_0000h
20_8030h	TCD Destination Address (TCD14_DADDR)	32	RW	0000_0000h
20_8034h	TCD Signed Destination Address Offset (TCD14_DOFF)	16	RW	0000h
20_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD14_CITER_ELINKNO)	16	RW	0000h
20_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD14_CITER_ELINKYES)	16	RW	0000h
20_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD14_DLAST_SGA)	32	RW	0000_0000h
20_803Ch	TCD Control and Status (TCD14_CSR)	16	RW	0000h
20_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD14_BITER_ELINKNO)	16	RW	0000h
20_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD14_BITER_ELINKYES)	16	RW	0000h
20_C000h	Channel Control and Status (CH15_CSR)	32	RW	0000_0000h
20_C004h	Channel Error Status (CH15_ES)	32	RW	0000_0000h
20_C008h	Channel Interrupt Status (CH15_INT)	32	RW	0000_0000h
20_C00Ch	Channel System Bus (CH15_SBR)	32	RW	0000_8002h
20_C010h	Channel Priority (CH15_PRI)	32	RW	0000_0000h
20_C020h	TCD Source Address (TCD15_SADDR)	32	RW	0000_0000h
20_C024h	TCD Signed Source Address Offset (TCD15_SOFF)	16	RW	0000h
20_C026h	TCD Transfer Attributes (TCD15_ATTR)	16	RW	0000h
20_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD15_NBYTES_MLOFFNO)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
20_C028h	TCD Transfer Size with Minor Loop Offsets (TCD15_NBYTES_MLOFFYES)	32	RW	0000_0000h
20_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD15_SLAST_SDA)	32	RW	0000_0000h
20_C030h	TCD Destination Address (TCD15_DADDR)	32	RW	0000_0000h
20_C034h	TCD Signed Destination Address Offset (TCD15_DOFF)	16	RW	0000h
20_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD15_CITER_ELINKNO)	16	RW	0000h
20_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD15_CITER_ELINKYES)	16	RW	0000h
20_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD15_DLAST_SGA)	32	RW	0000_0000h
20_C03Ch	TCD Control and Status (TCD15_CSR)	16	RW	0000h
20_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD15_BITER_ELINKNO)	16	RW	0000h
20_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD15_BITER_ELINKYES)	16	RW	0000h
21_0000h	Channel Control and Status (CH16_CSR)	32	RW	0000_0000h
21_0004h	Channel Error Status (CH16_ES)	32	RW	0000_0000h
21_0008h	Channel Interrupt Status (CH16_INT)	32	RW	0000_0000h
21_000Ch	Channel System Bus (CH16_SBR)	32	RW	0000_8002h
21_0010h	Channel Priority (CH16_PRI)	32	RW	0000_0000h
21_0020h	TCD Source Address (TCD16_SADDR)	32	RW	0000_0000h
21_0024h	TCD Signed Source Address Offset (TCD16_SOFF)	16	RW	0000h
21_0026h	TCD Transfer Attributes (TCD16_ATTR)	16	RW	0000h
21_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD16_NBYTES_MLOFFNO)	32	RW	0000_0000h
21_0028h	TCD Transfer Size with Minor Loop Offsets (TCD16_NBYTES_MLOFFYES)	32	RW	0000_0000h
21_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD16_SLAST_SDA)	32	RW	0000_0000h
21_0030h	TCD Destination Address (TCD16_DADDR)	32	RW	0000_0000h
21_0034h	TCD Signed Destination Address Offset (TCD16_DOFF)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
21_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD16_CITER_ELINKNO)	16	RW	0000h
21_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD16_CITER_ELINKYES)	16	RW	0000h
21_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD16_DLAST_SGA)	32	RW	0000_0000h
21_003Ch	TCD Control and Status (TCD16_CSR)	16	RW	0000h
21_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD16_BITER_ELINKNO)	16	RW	0000h
21_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD16_BITER_ELINKYES)	16	RW	0000h
21_4000h	Channel Control and Status (CH17_CSR)	32	RW	0000_0000h
21_4004h	Channel Error Status (CH17_ES)	32	RW	0000_0000h
21_4008h	Channel Interrupt Status (CH17_INT)	32	RW	0000_0000h
21_400Ch	Channel System Bus (CH17_SBR)	32	RW	0000_8002h
21_4010h	Channel Priority (CH17_PRI)	32	RW	0000_0000h
21_4020h	TCD Source Address (TCD17_SADDR)	32	RW	0000_0000h
21_4024h	TCD Signed Source Address Offset (TCD17_SOFF)	16	RW	0000h
21_4026h	TCD Transfer Attributes (TCD17_ATTR)	16	RW	0000h
21_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD17_NBYTES_MLOFFNO)	32	RW	0000_0000h
21_4028h	TCD Transfer Size with Minor Loop Offsets (TCD17_NBYTES_MLOFFYES)	32	RW	0000_0000h
21_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD17_SLAST_SDA)	32	RW	0000_0000h
21_4030h	TCD Destination Address (TCD17_DADDR)	32	RW	0000_0000h
21_4034h	TCD Signed Destination Address Offset (TCD17_DOFF)	16	RW	0000h
21_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD17_CITER_ELINKNO)	16	RW	0000h
21_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD17_CITER_ELINKYES)	16	RW	0000h
21_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD17_DLAST_SGA)	32	RW	0000_0000h
21_403Ch	TCD Control and Status (TCD17_CSR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
21_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD17_BITER_ELINKNO)	16	RW	0000h
21_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD17_BITER_ELINKYES)	16	RW	0000h
21_8000h	Channel Control and Status (CH18_CSR)	32	RW	0000_0000h
21_8004h	Channel Error Status (CH18_ES)	32	RW	0000_0000h
21_8008h	Channel Interrupt Status (CH18_INT)	32	RW	0000_0000h
21_800Ch	Channel System Bus (CH18_SBR)	32	RW	0000_8002h
21_8010h	Channel Priority (CH18_PRI)	32	RW	0000_0000h
21_8020h	TCD Source Address (TCD18_SADDR)	32	RW	0000_0000h
21_8024h	TCD Signed Source Address Offset (TCD18_SOFF)	16	RW	0000h
21_8026h	TCD Transfer Attributes (TCD18_ATTR)	16	RW	0000h
21_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD18_NBYTES_MLOFFNO)	32	RW	0000_0000h
21_8028h	TCD Transfer Size with Minor Loop Offsets (TCD18_NBYTES_MLOFFYES)	32	RW	0000_0000h
21_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD18_SLAST_SDA)	32	RW	0000_0000h
21_8030h	TCD Destination Address (TCD18_DADDR)	32	RW	0000_0000h
21_8034h	TCD Signed Destination Address Offset (TCD18_DOFF)	16	RW	0000h
21_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD18_CITER_ELINKNO)	16	RW	0000h
21_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD18_CITER_ELINKYES)	16	RW	0000h
21_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD18_DLAST_SGA)	32	RW	0000_0000h
21_803Ch	TCD Control and Status (TCD18_CSR)	16	RW	0000h
21_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD18_BITER_ELINKNO)	16	RW	0000h
21_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD18_BITER_ELINKYES)	16	RW	0000h
21_C000h	Channel Control and Status (CH19_CSR)	32	RW	0000_0000h
21_C004h	Channel Error Status (CH19_ES)	32	RW	0000_0000h
21_C008h	Channel Interrupt Status (CH19_INT)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
21_C00Ch	Channel System Bus (CH19_SBR)	32	RW	0000_8002h
21_C010h	Channel Priority (CH19_PRI)	32	RW	0000_0000h
21_C020h	TCD Source Address (TCD19_SADDR)	32	RW	0000_0000h
21_C024h	TCD Signed Source Address Offset (TCD19_SOFF)	16	RW	0000h
21_C026h	TCD Transfer Attributes (TCD19_ATTR)	16	RW	0000h
21_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD19_NBYTES_MLOFFNO)	32	RW	0000_0000h
21_C028h	TCD Transfer Size with Minor Loop Offsets (TCD19_NBYTES_MLOFFYES)	32	RW	0000_0000h
21_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD19_SLAST_SDA)	32	RW	0000_0000h
21_C030h	TCD Destination Address (TCD19_DADDR)	32	RW	0000_0000h
21_C034h	TCD Signed Destination Address Offset (TCD19_DOFF)	16	RW	0000h
21_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD19_CITER_ELINKNO)	16	RW	0000h
21_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD19_CITER_ELINKYES)	16	RW	0000h
21_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD19_DLAST_SGA)	32	RW	0000_0000h
21_C03Ch	TCD Control and Status (TCD19_CSR)	16	RW	0000h
21_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD19_BITER_ELINKNO)	16	RW	0000h
21_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD19_BITER_ELINKYES)	16	RW	0000h
22_0000h	Channel Control and Status (CH20_CSR)	32	RW	0000_0000h
22_0004h	Channel Error Status (CH20_ES)	32	RW	0000_0000h
22_0008h	Channel Interrupt Status (CH20_INT)	32	RW	0000_0000h
22_000Ch	Channel System Bus (CH20_SBR)	32	RW	0000_8002h
22_0010h	Channel Priority (CH20_PRI)	32	RW	0000_0000h
22_0020h	TCD Source Address (TCD20_SADDR)	32	RW	0000_0000h
22_0024h	TCD Signed Source Address Offset (TCD20_SOFF)	16	RW	0000h
22_0026h	TCD Transfer Attributes (TCD20_ATTR)	16	RW	0000h
22_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD20_NBYTES_MLOFFNO)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
22_0028h	TCD Transfer Size with Minor Loop Offsets (TCD20_NBYTES_MLOFFYES)	32	RW	0000_0000h
22_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD20_SLAST_SDA)	32	RW	0000_0000h
22_0030h	TCD Destination Address (TCD20_DADDR)	32	RW	0000_0000h
22_0034h	TCD Signed Destination Address Offset (TCD20_DOFF)	16	RW	0000h
22_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD20_CITER_ELINKNO)	16	RW	0000h
22_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD20_CITER_ELINKYES)	16	RW	0000h
22_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD20_DLAST_SGA)	32	RW	0000_0000h
22_003Ch	TCD Control and Status (TCD20_CSR)	16	RW	0000h
22_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD20_BITER_ELINKNO)	16	RW	0000h
22_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD20_BITER_ELINKYES)	16	RW	0000h
22_4000h	Channel Control and Status (CH21_CSR)	32	RW	0000_0000h
22_4004h	Channel Error Status (CH21_ES)	32	RW	0000_0000h
22_4008h	Channel Interrupt Status (CH21_INT)	32	RW	0000_0000h
22_400Ch	Channel System Bus (CH21_SBR)	32	RW	0000_8002h
22_4010h	Channel Priority (CH21_PRI)	32	RW	0000_0000h
22_4020h	TCD Source Address (TCD21_SADDR)	32	RW	0000_0000h
22_4024h	TCD Signed Source Address Offset (TCD21_SOFF)	16	RW	0000h
22_4026h	TCD Transfer Attributes (TCD21_ATTR)	16	RW	0000h
22_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD21_NBYTES_MLOFFNO)	32	RW	0000_0000h
22_4028h	TCD Transfer Size with Minor Loop Offsets (TCD21_NBYTES_MLOFFYES)	32	RW	0000_0000h
22_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD21_SLAST_SDA)	32	RW	0000_0000h
22_4030h	TCD Destination Address (TCD21_DADDR)	32	RW	0000_0000h
22_4034h	TCD Signed Destination Address Offset (TCD21_DOFF)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
22_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD21_CITER_ELINKNO)	16	RW	0000h
22_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD21_CITER_ELINKYES)	16	RW	0000h
22_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD21_DLAST_SGA)	32	RW	0000_0000h
22_403Ch	TCD Control and Status (TCD21_CSR)	16	RW	0000h
22_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD21_BITER_ELINKNO)	16	RW	0000h
22_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD21_BITER_ELINKYES)	16	RW	0000h
22_8000h	Channel Control and Status (CH22_CSR)	32	RW	0000_0000h
22_8004h	Channel Error Status (CH22_ES)	32	RW	0000_0000h
22_8008h	Channel Interrupt Status (CH22_INT)	32	RW	0000_0000h
22_800Ch	Channel System Bus (CH22_SBR)	32	RW	0000_8002h
22_8010h	Channel Priority (CH22_PRI)	32	RW	0000_0000h
22_8020h	TCD Source Address (TCD22_SADDR)	32	RW	0000_0000h
22_8024h	TCD Signed Source Address Offset (TCD22_SOFF)	16	RW	0000h
22_8026h	TCD Transfer Attributes (TCD22_ATTR)	16	RW	0000h
22_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD22_NBYTES_MLOFFNO)	32	RW	0000_0000h
22_8028h	TCD Transfer Size with Minor Loop Offsets (TCD22_NBYTES_MLOFFYES)	32	RW	0000_0000h
22_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD22_SLAST_SDA)	32	RW	0000_0000h
22_8030h	TCD Destination Address (TCD22_DADDR)	32	RW	0000_0000h
22_8034h	TCD Signed Destination Address Offset (TCD22_DOFF)	16	RW	0000h
22_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD22_CITER_ELINKNO)	16	RW	0000h
22_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD22_CITER_ELINKYES)	16	RW	0000h
22_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD22_DLAST_SGA)	32	RW	0000_0000h
22_803Ch	TCD Control and Status (TCD22_CSR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
22_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD22_BITER_ELINKNO)	16	RW	0000h
22_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD22_BITER_ELINKYES)	16	RW	0000h
22_C000h	Channel Control and Status (CH23_CSR)	32	RW	0000_0000h
22_C004h	Channel Error Status (CH23_ES)	32	RW	0000_0000h
22_C008h	Channel Interrupt Status (CH23_INT)	32	RW	0000_0000h
22_C00Ch	Channel System Bus (CH23_SBR)	32	RW	0000_8002h
22_C010h	Channel Priority (CH23_PRI)	32	RW	0000_0000h
22_C020h	TCD Source Address (TCD23_SADDR)	32	RW	0000_0000h
22_C024h	TCD Signed Source Address Offset (TCD23_SOFF)	16	RW	0000h
22_C026h	TCD Transfer Attributes (TCD23_ATTR)	16	RW	0000h
22_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD23_NBYTES_MLOFFNO)	32	RW	0000_0000h
22_C028h	TCD Transfer Size with Minor Loop Offsets (TCD23_NBYTES_MLOFFYES)	32	RW	0000_0000h
22_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD23_SLAST_SDA)	32	RW	0000_0000h
22_C030h	TCD Destination Address (TCD23_DADDR)	32	RW	0000_0000h
22_C034h	TCD Signed Destination Address Offset (TCD23_DOFF)	16	RW	0000h
22_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD23_CITER_ELINKNO)	16	RW	0000h
22_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD23_CITER_ELINKYES)	16	RW	0000h
22_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD23_DLAST_SGA)	32	RW	0000_0000h
22_C03Ch	TCD Control and Status (TCD23_CSR)	16	RW	0000h
22_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD23_BITER_ELINKNO)	16	RW	0000h
22_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD23_BITER_ELINKYES)	16	RW	0000h
23_0000h	Channel Control and Status (CH24_CSR)	32	RW	0000_0000h
23_0004h	Channel Error Status (CH24_ES)	32	RW	0000_0000h
23_0008h	Channel Interrupt Status (CH24_INT)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
23_000Ch	Channel System Bus (CH24_SBR)	32	RW	0000_8002h
23_0010h	Channel Priority (CH24_PRI)	32	RW	0000_0000h
23_0020h	TCD Source Address (TCD24_SADDR)	32	RW	0000_0000h
23_0024h	TCD Signed Source Address Offset (TCD24_SOFF)	16	RW	0000h
23_0026h	TCD Transfer Attributes (TCD24_ATTR)	16	RW	0000h
23_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD24_NBYTES_MLOFFNO)	32	RW	0000_0000h
23_0028h	TCD Transfer Size with Minor Loop Offsets (TCD24_NBYTES_MLOFFYES)	32	RW	0000_0000h
23_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD24_SLAST_SDA)	32	RW	0000_0000h
23_0030h	TCD Destination Address (TCD24_DADDR)	32	RW	0000_0000h
23_0034h	TCD Signed Destination Address Offset (TCD24_DOFF)	16	RW	0000h
23_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD24_CITER_ELINKNO)	16	RW	0000h
23_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD24_CITER_ELINKYES)	16	RW	0000h
23_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD24_DLAST_SGA)	32	RW	0000_0000h
23_003Ch	TCD Control and Status (TCD24_CSR)	16	RW	0000h
23_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD24_BITER_ELINKNO)	16	RW	0000h
23_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD24_BITER_ELINKYES)	16	RW	0000h
23_4000h	Channel Control and Status (CH25_CSR)	32	RW	0000_0000h
23_4004h	Channel Error Status (CH25_ES)	32	RW	0000_0000h
23_4008h	Channel Interrupt Status (CH25_INT)	32	RW	0000_0000h
23_400Ch	Channel System Bus (CH25_SBR)	32	RW	0000_8002h
23_4010h	Channel Priority (CH25_PRI)	32	RW	0000_0000h
23_4020h	TCD Source Address (TCD25_SADDR)	32	RW	0000_0000h
23_4024h	TCD Signed Source Address Offset (TCD25_SOFF)	16	RW	0000h
23_4026h	TCD Transfer Attributes (TCD25_ATTR)	16	RW	0000h
23_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD25_NBYTES_MLOFFNO)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
23_4028h	TCD Transfer Size with Minor Loop Offsets (TCD25_NBYTES_MLOFFYES)	32	RW	0000_0000h
23_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD25_SLAST_SDA)	32	RW	0000_0000h
23_4030h	TCD Destination Address (TCD25_DADDR)	32	RW	0000_0000h
23_4034h	TCD Signed Destination Address Offset (TCD25_DOFF)	16	RW	0000h
23_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD25_CITER_ELINKNO)	16	RW	0000h
23_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD25_CITER_ELINKYES)	16	RW	0000h
23_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD25_DLAST_SGA)	32	RW	0000_0000h
23_403Ch	TCD Control and Status (TCD25_CSR)	16	RW	0000h
23_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD25_BITER_ELINKNO)	16	RW	0000h
23_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD25_BITER_ELINKYES)	16	RW	0000h
23_8000h	Channel Control and Status (CH26_CSR)	32	RW	0000_0000h
23_8004h	Channel Error Status (CH26_ES)	32	RW	0000_0000h
23_8008h	Channel Interrupt Status (CH26_INT)	32	RW	0000_0000h
23_800Ch	Channel System Bus (CH26_SBR)	32	RW	0000_8002h
23_8010h	Channel Priority (CH26_PRI)	32	RW	0000_0000h
23_8020h	TCD Source Address (TCD26_SADDR)	32	RW	0000_0000h
23_8024h	TCD Signed Source Address Offset (TCD26_SOFF)	16	RW	0000h
23_8026h	TCD Transfer Attributes (TCD26_ATTR)	16	RW	0000h
23_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD26_NBYTES_MLOFFNO)	32	RW	0000_0000h
23_8028h	TCD Transfer Size with Minor Loop Offsets (TCD26_NBYTES_MLOFFYES)	32	RW	0000_0000h
23_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD26_SLAST_SDA)	32	RW	0000_0000h
23_8030h	TCD Destination Address (TCD26_DADDR)	32	RW	0000_0000h
23_8034h	TCD Signed Destination Address Offset (TCD26_DOFF)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
23_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD26_CITER_ELINKNO)	16	RW	0000h
23_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD26_CITER_ELINKYES)	16	RW	0000h
23_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD26_DLAST_SGA)	32	RW	0000_0000h
23_803Ch	TCD Control and Status (TCD26_CSR)	16	RW	0000h
23_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD26_BITER_ELINKNO)	16	RW	0000h
23_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD26_BITER_ELINKYES)	16	RW	0000h
23_C000h	Channel Control and Status (CH27_CSR)	32	RW	0000_0000h
23_C004h	Channel Error Status (CH27_ES)	32	RW	0000_0000h
23_C008h	Channel Interrupt Status (CH27_INT)	32	RW	0000_0000h
23_C00Ch	Channel System Bus (CH27_SBR)	32	RW	0000_8002h
23_C010h	Channel Priority (CH27_PRI)	32	RW	0000_0000h
23_C020h	TCD Source Address (TCD27_SADDR)	32	RW	0000_0000h
23_C024h	TCD Signed Source Address Offset (TCD27_SOFF)	16	RW	0000h
23_C026h	TCD Transfer Attributes (TCD27_ATTR)	16	RW	0000h
23_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD27_NBYTES_MLOFFNO)	32	RW	0000_0000h
23_C028h	TCD Transfer Size with Minor Loop Offsets (TCD27_NBYTES_MLOFFYES)	32	RW	0000_0000h
23_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD27_SLAST_SDA)	32	RW	0000_0000h
23_C030h	TCD Destination Address (TCD27_DADDR)	32	RW	0000_0000h
23_C034h	TCD Signed Destination Address Offset (TCD27_DOFF)	16	RW	0000h
23_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD27_CITER_ELINKNO)	16	RW	0000h
23_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD27_CITER_ELINKYES)	16	RW	0000h
23_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD27_DLAST_SGA)	32	RW	0000_0000h
23_C03Ch	TCD Control and Status (TCD27_CSR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
23_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD27_BITER_ELINKNO)	16	RW	0000h
23_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD27_BITER_ELINKYES)	16	RW	0000h
24_0000h	Channel Control and Status (CH28_CSR)	32	RW	0000_0000h
24_0004h	Channel Error Status (CH28_ES)	32	RW	0000_0000h
24_0008h	Channel Interrupt Status (CH28_INT)	32	RW	0000_0000h
24_000Ch	Channel System Bus (CH28_SBR)	32	RW	0000_8002h
24_0010h	Channel Priority (CH28_PRI)	32	RW	0000_0000h
24_0020h	TCD Source Address (TCD28_SADDR)	32	RW	0000_0000h
24_0024h	TCD Signed Source Address Offset (TCD28_SOFF)	16	RW	0000h
24_0026h	TCD Transfer Attributes (TCD28_ATTR)	16	RW	0000h
24_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD28_NBYTES_MLOFFNO)	32	RW	0000_0000h
24_0028h	TCD Transfer Size with Minor Loop Offsets (TCD28_NBYTES_MLOFFYES)	32	RW	0000_0000h
24_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD28_SLAST_SDA)	32	RW	0000_0000h
24_0030h	TCD Destination Address (TCD28_DADDR)	32	RW	0000_0000h
24_0034h	TCD Signed Destination Address Offset (TCD28_DOFF)	16	RW	0000h
24_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD28_CITER_ELINKNO)	16	RW	0000h
24_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD28_CITER_ELINKYES)	16	RW	0000h
24_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD28_DLAST_SGA)	32	RW	0000_0000h
24_003Ch	TCD Control and Status (TCD28_CSR)	16	RW	0000h
24_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD28_BITER_ELINKNO)	16	RW	0000h
24_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD28_BITER_ELINKYES)	16	RW	0000h
24_4000h	Channel Control and Status (CH29_CSR)	32	RW	0000_0000h
24_4004h	Channel Error Status (CH29_ES)	32	RW	0000_0000h
24_4008h	Channel Interrupt Status (CH29_INT)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
24_400Ch	Channel System Bus (CH29_SBR)	32	RW	0000_8002h
24_4010h	Channel Priority (CH29_PRI)	32	RW	0000_0000h
24_4020h	TCD Source Address (TCD29_SADDR)	32	RW	0000_0000h
24_4024h	TCD Signed Source Address Offset (TCD29_SOFF)	16	RW	0000h
24_4026h	TCD Transfer Attributes (TCD29_ATTR)	16	RW	0000h
24_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD29_NBYTES_MLOFFNO)	32	RW	0000_0000h
24_4028h	TCD Transfer Size with Minor Loop Offsets (TCD29_NBYTES_MLOFFYES)	32	RW	0000_0000h
24_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD29_SLAST_SDA)	32	RW	0000_0000h
24_4030h	TCD Destination Address (TCD29_DADDR)	32	RW	0000_0000h
24_4034h	TCD Signed Destination Address Offset (TCD29_DOFF)	16	RW	0000h
24_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD29_CITER_ELINKNO)	16	RW	0000h
24_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD29_CITER_ELINKYES)	16	RW	0000h
24_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD29_DLAST_SGA)	32	RW	0000_0000h
24_403Ch	TCD Control and Status (TCD29_CSR)	16	RW	0000h
24_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD29_BITER_ELINKNO)	16	RW	0000h
24_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD29_BITER_ELINKYES)	16	RW	0000h
24_8000h	Channel Control and Status (CH30_CSR)	32	RW	0000_0000h
24_8004h	Channel Error Status (CH30_ES)	32	RW	0000_0000h
24_8008h	Channel Interrupt Status (CH30_INT)	32	RW	0000_0000h
24_800Ch	Channel System Bus (CH30_SBR)	32	RW	0000_8002h
24_8010h	Channel Priority (CH30_PRI)	32	RW	0000_0000h
24_8020h	TCD Source Address (TCD30_SADDR)	32	RW	0000_0000h
24_8024h	TCD Signed Source Address Offset (TCD30_SOFF)	16	RW	0000h
24_8026h	TCD Transfer Attributes (TCD30_ATTR)	16	RW	0000h
24_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD30_NBYTES_MLOFFNO)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
24_8028h	TCD Transfer Size with Minor Loop Offsets (TCD30_NBYTES_MLOFFYES)	32	RW	0000_0000h
24_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD30_SLAST_SDA)	32	RW	0000_0000h
24_8030h	TCD Destination Address (TCD30_DADDR)	32	RW	0000_0000h
24_8034h	TCD Signed Destination Address Offset (TCD30_DOFF)	16	RW	0000h
24_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD30_CITER_ELINKNO)	16	RW	0000h
24_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD30_CITER_ELINKYES)	16	RW	0000h
24_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD30_DLAST_SGA)	32	RW	0000_0000h
24_803Ch	TCD Control and Status (TCD30_CSR)	16	RW	0000h
24_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD30_BITER_ELINKNO)	16	RW	0000h
24_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD30_BITER_ELINKYES)	16	RW	0000h
24_C000h	Channel Control and Status (CH31_CSR)	32	RW	0000_0000h
24_C004h	Channel Error Status (CH31_ES)	32	RW	0000_0000h
24_C008h	Channel Interrupt Status (CH31_INT)	32	RW	0000_0000h
24_C00Ch	Channel System Bus (CH31_SBR)	32	RW	0000_8002h
24_C010h	Channel Priority (CH31_PRI)	32	RW	0000_0000h
24_C020h	TCD Source Address (TCD31_SADDR)	32	RW	0000_0000h
24_C024h	TCD Signed Source Address Offset (TCD31_SOFF)	16	RW	0000h
24_C026h	TCD Transfer Attributes (TCD31_ATTR)	16	RW	0000h
24_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD31_NBYTES_MLOFFNO)	32	RW	0000_0000h
24_C028h	TCD Transfer Size with Minor Loop Offsets (TCD31_NBYTES_MLOFFYES)	32	RW	0000_0000h
24_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD31_SLAST_SDA)	32	RW	0000_0000h
24_C030h	TCD Destination Address (TCD31_DADDR)	32	RW	0000_0000h
24_C034h	TCD Signed Destination Address Offset (TCD31_DOFF)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
24_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD31_CITER_ELINKNO)	16	RW	0000h
24_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD31_CITER_ELINKYES)	16	RW	0000h
24_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD31_DLAST_SGA)	32	RW	0000_0000h
24_C03Ch	TCD Control and Status (TCD31_CSR)	16	RW	0000h
24_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD31_BITER_ELINKNO)	16	RW	0000h
24_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD31_BITER_ELINKYES)	16	RW	0000h

14.6.2.2 Channel Control and Status (CH0_CSR - CH31_CSR)

Offset

Register	Offset
CH0_CSR	0h
CH1_CSR	4000h
CH2_CSR	8000h
CH3_CSR	C000h
CH4_CSR	1_0000h
CH5_CSR	1_4000h
CH6_CSR	1_8000h
CH7_CSR	1_C000h
CH8_CSR	2_0000h
CH9_CSR	2_4000h
CH10_CSR	2_8000h
CH11_CSR	2_C000h
CH12_CSR	20_0000h
CH13_CSR	20_4000h
CH14_CSR	20_8000h
CH15_CSR	20_C000h

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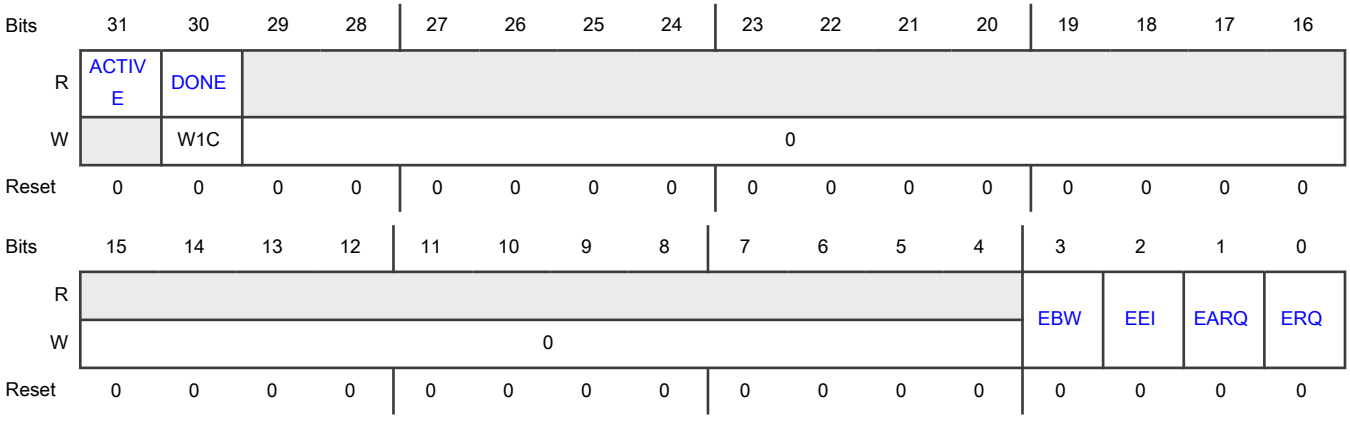
Register	Offset
CH16_CSR	21_0000h
CH17_CSR	21_4000h
CH18_CSR	21_8000h
CH19_CSR	21_C000h
CH20_CSR	22_0000h
CH21_CSR	22_4000h
CH22_CSR	22_8000h
CH23_CSR	22_C000h
CH24_CSR	23_0000h
CH25_CSR	23_4000h
CH26_CSR	23_8000h
CH27_CSR	23_C000h
CH28_CSR	24_0000h
CH29_CSR	24_4000h
CH30_CSR	24_8000h
CH31_CSR	24_C000h

Function

This register contains several fields related to hardware and interrupt requests, configuration, and status for the given channel.

Diagram



Fields

Field	Function
31 ACTIVE	Channel Active The ACTIVE field indicates the channel was selected by arbitration and is executing the prescribed transfers. The eDMA sets it to 1 when channel service begins, and clears it to 0 as the minor loop completes or when any error condition is detected. Except for dynamic scatter/gather or dynamic channel linking, you must not modify the transfer control descriptor when a channel is active.
30 DONE	Channel Done The DONE field indicates the eDMA has completed the major loop. The eDMA engine sets this field as the CITER count reaches zero. If enabled, the eDMA generates an interrupt request corresponding to this completed channel. The software clears it, or the hardware clears it when the channel is activated. **NOTE** This field must be cleared to 0 before writing the MAJORELINK or ESG fields.
29-4 —	Reserved
3 EBW	Enable Buffered Writes When buffered writes are enabled, all writes except for the last write sequence of the minor loop are signaled by the eDMA as bufferable. 0b - Buffered writes on system bus disabled. Buffered writes on system bus disabled 1b - Buffered writes on system bus enabled. Bufferable write signal asserted on all system bus writes except during last write sequence
2 EEI	Enable Error Interrupt The EEI field enables the error interrupt signal for the channel. The DMA error indicator and the error interrupt enable flag must be asserted before an error interrupt request for a given channel is asserted to the interrupt controller. 0b - Error signal for corresponding channel does not generate error interrupt 1b - Assertion of error signal for corresponding channel generates error interrupt request
1 EARQ	Enable Asynchronous DMA Request In Stop Mode For Channel The enable asynchronous DMA request field (EARQ) does not affect DMA operations. When set to 1, this field allows the hardware service request enable field (ERQ) to propagate out of the DMA to the power controller. When cleared to 0, this field masks the hardware service request enable field to the power controller. 0b - Disable asynchronous DMA request for the channel 1b - Enable asynchronous DMA request for the channel
0 ERQ	Enable DMA Request Disable a channel's hardware service request at the source before clearing the channel's ERQ field. The DMA hardware request input signal and the enable request field (ERQ) must be asserted before a channel's hardware service request is accepted. The state of the eDMA enable request field does not

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Field	Function
	affect a channel service request made explicitly through software or channel linking. The state of the ERQ field does not affect the channel's START field. 0b - DMA hardware request signal for corresponding channel disabled 1b - DMA hardware request signal for corresponding channel enabled

14.6.2.3 Channel Error Status (CH0_ES - CH31_ES)

Offset

Register	Offset
CH0_ES	4h
CH1_ES	4004h
CH2_ES	8004h
CH3_ES	C004h
CH4_ES	1_0004h
CH5_ES	1_4004h
CH6_ES	1_8004h
CH7_ES	1_C004h
CH8_ES	2_0004h
CH9_ES	2_4004h
CH10_ES	2_8004h
CH11_ES	2_C004h
CH12_ES	20_0004h
CH13_ES	20_4004h
CH14_ES	20_8004h
CH15_ES	20_C004h
CH16_ES	21_0004h
CH17_ES	21_4004h
CH18_ES	21_8004h
CH19_ES	21_C004h
CH20_ES	22_0004h
CH21_ES	22_4004h
CH22_ES	22_8004h

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Register	Offset
CH23_ES	22_C004h
CH24_ES	23_0004h
CH25_ES	23_4004h
CH26_ES	23_8004h
CH27_ES	23_C004h
CH28_ES	24_0004h
CH29_ES	24_4004h
CH30_ES	24_8004h
CH31_ES	24_C004h

Function

The ES provides information concerning the last recorded channel error. Channel errors can be caused by:

- An illegal setting in the transfer control descriptor
- An error termination to a bus master read or write cycle

The ERR field signals the presence of an error for the channel. The eDMA engine signals the occurrence of an error condition by setting the appropriate field in this register. The outputs of this register are enabled by the contents of the CHn_CSR[EEI] field, then logically summed across all channels to form an error interrupt request, which may be routed to the interrupt controller. In addition, this enabled error status is logically OR'd onto the channel done interrupt, CHn_INT[INT], thus forming a done or error interrupt on a per channel basis.

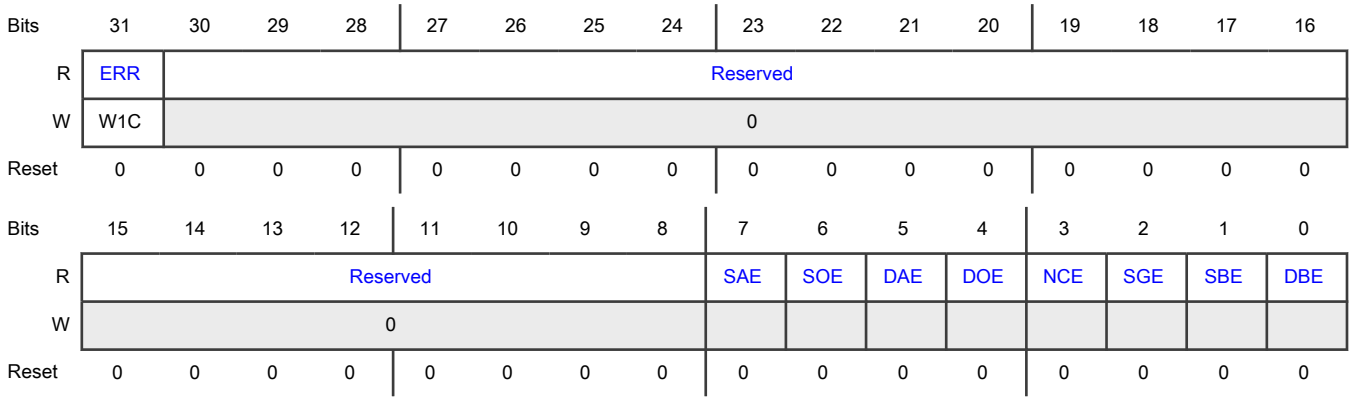
During the execution of the interrupt service routine associated with any DMA errors, it is software's responsibility to clear the appropriate bit, negating the error-interrupt request. The normal DMA channel completion indicators (setting the transfer control descriptor DONE flag and the possible assertion of an interrupt request) are not affected when eDMA detects an error. The contents of this ERR register field can also be polled because a non-zero value indicates the presence of a channel error, regardless of the state of the EEI mask.

The state of any given channel's error indicators is affected by writes to this register. Writing a 1 to the ERR field clears the channel's error status, and writing a 0 has no effect.

An unspecified error, where only the ERR field is set to 1, indicates that either a transfer was cancelled with an error or else an uncorrectable TCD error occurred. The Management Page Error Status register has full view of the error condition.

See Fault reporting and handling for more details.

Diagram



Fields

Field	Function
31 ERR	Error In Channel 0b - An error in this channel has not occurred 1b - An error in this channel has occurred
30-8 —	Reserved
7 SAE	Source Address Error TCDn_SADDR is inconsistent with TCDn_ATTR[SSIZE]. 0b - No source address configuration error 1b - Last recorded error was a configuration error detected in the TCDn_SADDR field
6 SOE	Source Offset Error TCDn_SOFF is inconsistent with TCDn_ATTR[SSIZE]. 0b - No source offset configuration error 1b - Last recorded error was a configuration error detected in the TCDn_SOFF field
5 DAE	Destination Address Error TCDn_DADDR is inconsistent with TCDn_ATTR[DSIZE]. 0b - No destination address configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DADDR field
4 DOE	Destination Offset Error TCDn_DOFF is inconsistent with TCDn_ATTR[DSIZE]. 0b - No destination offset configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DOFF field

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Field	Function
3 NCE	NBYTES/CITER Configuration Error This error indicates that one of the following has occurred: • TCDn_NBYTES is not a multiple of TCDn_ATTR[SSIZE] and TCDn_ATTR[DSIZE] • TCDn_CITER[CITER] is equal to zero • TCDn_CITER[ELINK] is not equal to TCDn_BITER[ELINK] 0b - No NBYTES/CITER configuration error 1b - Last recorded error was a configuration error detected in the TCDn_NBYTES or TCDn_CITER fields
2 SGE	Scatter/Gather Configuration Error When this field is 1, it indicates that TCDn_DLAST_SGA is not on a 32-byte boundary. This field is checked at the beginning of a scatter/gather operation after major loop completion if TCDn_CSR[ESG]is enabled. 0b - No scatter/gather configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DLAST_SGA field
1 SBE	Source Bus Error 0b - No source bus error 1b - Last recorded error was bus error on source read
0 DBE	Destination Bus Error 0b - No destination bus error 1b - Last recorded error was bus error on destination write

14.6.2.4 Channel Interrupt Status (CH0_INT - CH31_INT)

Offset

Register	Offset
CH0_INT	8h
CH1_INT	4008h
CH2_INT	8008h
CH3_INT	C008h
CH4_INT	1_0008h
CH5_INT	1_4008h
CH6_INT	1_8008h
CH7_INT	1_C008h

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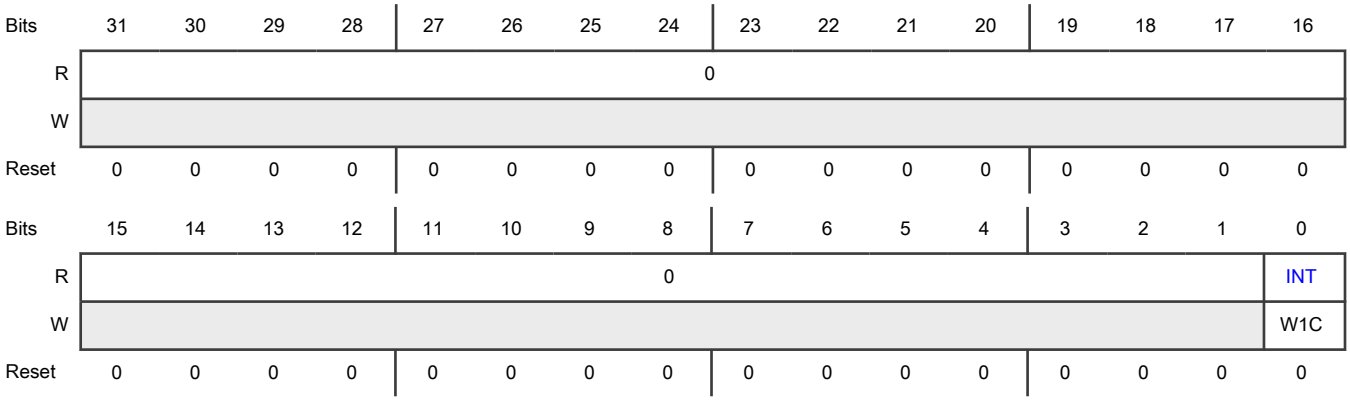
Register	Offset
CH8_INT	2_0008h
CH9_INT	2_4008h
CH10_INT	2_8008h
CH11_INT	2_C008h
CH12_INT	20_0008h
CH13_INT	20_4008h
CH14_INT	20_8008h
CH15_INT	20_C008h
CH16_INT	21_0008h
CH17_INT	21_4008h
CH18_INT	21_8008h
CH19_INT	21_C008h
CH20_INT	22_0008h
CH21_INT	22_4008h
CH22_INT	22_8008h
CH23_INT	22_C008h
CH24_INT	23_0008h
CH25_INT	23_4008h
CH26_INT	23_8008h
CH27_INT	23_C008h
CH28_INT	24_0008h
CH29_INT	24_4008h
CH30_INT	24_8008h
CH31_INT	24_C008h

Function

The INT field signals the presence of an interrupt request for the channel. Depending on the appropriate bit setting in the transfer control descriptors, the eDMA engine generates an interrupt on data transfer completion or an error condition.

The outputs of this register are directly routed to the interrupt controller. During the interrupt service routine associated with any given channel, it is the software's responsibility to clear the appropriate bit, negating the interrupt request. On writes to INT, a 1 clears the channel's interrupt request. A zero has no effect on the channel's current interrupt status.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 INT	Interrupt Request 0b - Interrupt request for corresponding channel cleared 1b - Interrupt request for corresponding channel active

14.6.2.5 Channel System Bus (CH0_SBR - CH31_SBR)

Offset

Register	Offset
CH0_SBR	Ch
CH1_SBR	400Ch
CH2_SBR	800Ch
CH3_SBR	C00Ch
CH4_SBR	1_000Ch
CH5_SBR	1_400Ch
CH6_SBR	1_800Ch
CH7_SBR	1_C00Ch
CH8_SBR	2_000Ch
CH9_SBR	2_400Ch
CH10_SBR	2_800Ch
CH11_SBR	2_C00Ch

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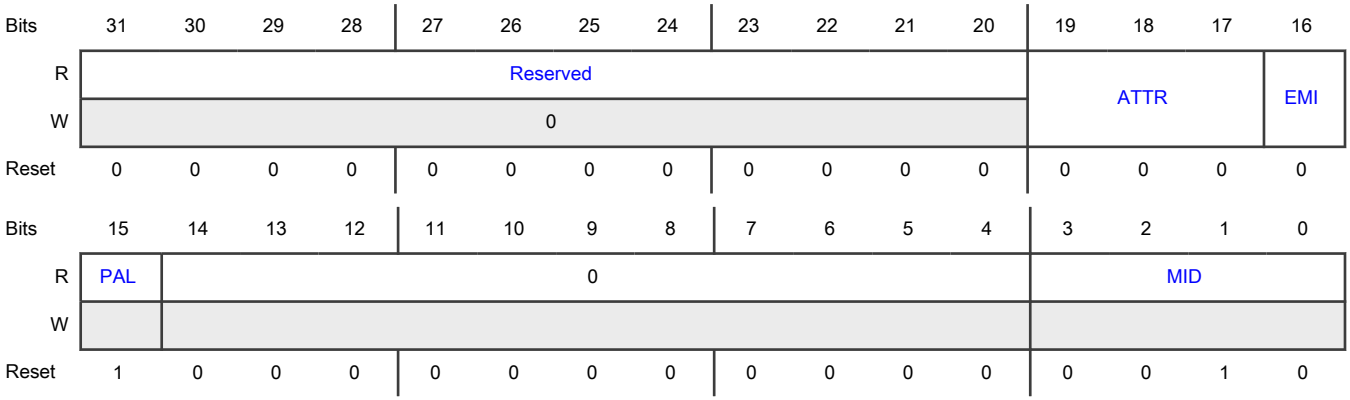
Register	Offset
CH12_SBR	20_000Ch
CH13_SBR	20_400Ch
CH14_SBR	20_800Ch
CH15_SBR	20_C00Ch
CH16_SBR	21_000Ch
CH17_SBR	21_400Ch
CH18_SBR	21_800Ch
CH19_SBR	21_C00Ch
CH20_SBR	22_000Ch
CH21_SBR	22_400Ch
CH22_SBR	22_800Ch
CH23_SBR	22_C00Ch
CH24_SBR	23_000Ch
CH25_SBR	23_400Ch
CH26_SBR	23_800Ch
CH27_SBR	23_C00Ch
CH28_SBR	24_000Ch
CH29_SBR	24_400Ch
CH30_SBR	24_800Ch
CH31_SBR	24_C00Ch

Function

The Channel System Bus register places identification and attribute information on the system bus interface for the eDMA.

Diagram



Fields

Field	Function
31-20 —	Reserved
19-17 ATTR	Attribute Output DMA's system bus attribute output value.
16 EMI	Enable Master ID Replication The eDMA master ID replication field allows the eDMA to use the same protection level and system bus ID of the master programming the eDMA's TCD. When enabled, the eDMA uses the master ID and protection level stored in the CHn_SBR registers, instead of the eDMA's default values. When a master (for example a core) programs a TCD, its master ID and protection level are captured when the TCD*n*_CSR control attributes are written. A scatter/gather operation does not affect the CHn_SBR registers. You can write the EMI only if CSR[GMRC] = 1, which means Global Master ID Replication Control is enabled; otherwise, the EMI is forced to zero. See chip-specific eDMA information for details on ID replication. **NOTE** If master ID replication is disabled, the privileged protection level (Supervisor mode) for DMA transfers is used. 0b - Master ID replication is disabled 1b - Master ID replication is enabled
15 PAL	Privileged Access Level This field controls DMA's protection level on the system bus when the channel is active. **NOTE** When you enable master ID replication, the value captured in this register is the privilege level of the core or other master writing the channel's transfer control descriptor, which is the lower byte of TCD*n*_CSR. 0b - User protection level for DMA transfers 1b - Privileged protection level for DMA transfers
14-4 —	Reserved
3-0 MID	Master ID This field controls the DMA's master ID on the system bus when the channel is active. **NOTE** The ID captured in this register reflects the master ID of the core or other master writing the channel's control attributes, which are in the lower byte of TCD*n*_CSR.

14.6.2.6 Channel Priority (CH0_PRI - CH31_PRI)

Offset

Register	Offset
CH0_PRI	10h
CH1_PRI	4010h
CH2_PRI	8010h
CH3_PRI	C010h
CH4_PRI	1_0010h
CH5_PRI	1_4010h
CH6_PRI	1_8010h
CH7_PRI	1_C010h
CH8_PRI	2_0010h
CH9_PRI	2_4010h
CH10_PRI	2_8010h
CH11_PRI	2_C010h
CH12_PRI	20_0010h
CH13_PRI	20_4010h
CH14_PRI	20_8010h
CH15_PRI	20_C010h
CH16_PRI	21_0010h
CH17_PRI	21_4010h
CH18_PRI	21_8010h
CH19_PRI	21_C010h
CH20_PRI	22_0010h
CH21_PRI	22_4010h
CH22_PRI	22_8010h
CH23_PRI	22_C010h
CH24_PRI	23_0010h
CH25_PRI	23_4010h
CH26_PRI	23_8010h
CH27_PRI	23_C010h
CH28_PRI	24_0010h
CH29_PRI	24_4010h

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Register	Offset
CH30_PRI	24_8010h
CH31_PRI	24_C010h

Function

The contents of these registers define unique priorities associated with each channel within the same channel group. Channel grouping is programmed via Channel Arbitration Group (CH0_GRPRI - CH31_GRPRI).

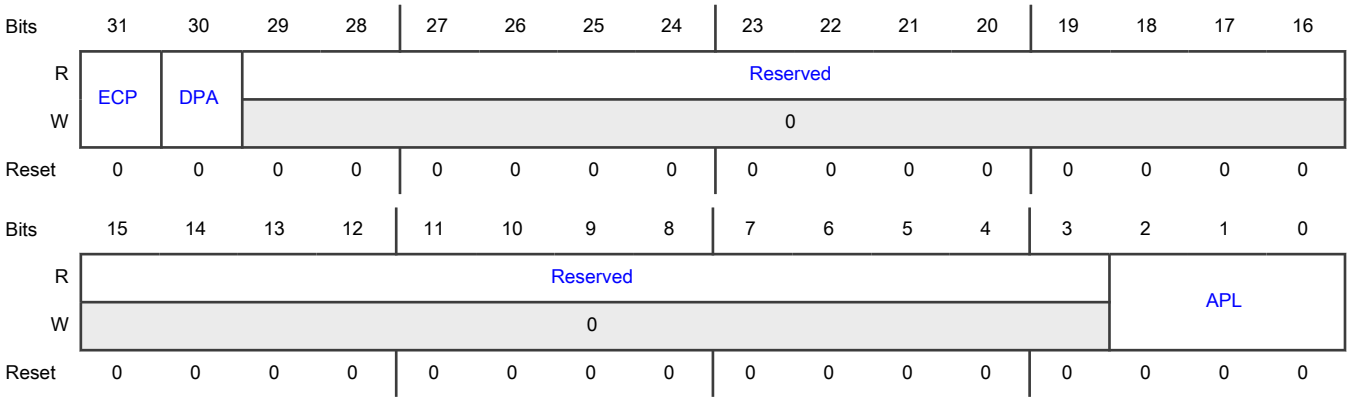
The channel priorities within a group are evaluated by numeric value; for example, 0 is the lowest priority, 1 is the next higher priority, then 2, 3, and so on. Software must program the channel priorities with unique values; otherwise, channel numbers with the same, non-zero value, will be selected based on channel number with the higher channel number having higher priority.

If more than one channel in a group has an arbitration priority level value of zero, then the arbitration mode field CSR[ERCA] is used to determine the arbitration scheme for all channels with APL=0 within a group.

When you enable round-robin channel arbitration (CSR[ERCA] = 1), all channels with APL=0 within a group will use a round-robin arbitration scheme, which rotates among these channels requesting service without regard to priority. Round-robin provides a fairness mechanism within an arbitration group.

When you enable fixed-priority channel arbitration (CSR[ERCA] = 0), eDMA selects channels with APL=0 based on channel number, with the higher channel number having higher priority.

Diagram



Fields

Field	Function
31 ECP	Enable Channel Preemption 0b - Channel cannot be suspended by a higher-priority channel's service request 1b - Channel can be temporarily suspended by a higher-priority channel's service request
30 DPA	Disable Preempt Ability 0b - Channel can suspend a lower-priority channel 1b - Channel cannot suspend any other channel, regardless of channel priority

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Field	Function
29-3 —	Reserved
2-0 APL	Arbitration Priority Level Channel priority level for arbitration within the assigned arbitration group.

14.6.2.7 TCD Source Address (TCD0_SADDR - TCD31_SADDR)

Offset

Register	Offset
TCD0_SADDR	20h
TCD1_SADDR	4020h
TCD2_SADDR	8020h
TCD3_SADDR	C020h
TCD4_SADDR	1_0020h
TCD5_SADDR	1_4020h
TCD6_SADDR	1_8020h
TCD7_SADDR	1_C020h
TCD8_SADDR	2_0020h
TCD9_SADDR	2_4020h
TCD10_SADDR	2_8020h
TCD11_SADDR	2_C020h
TCD12_SADDR	20_0020h
TCD13_SADDR	20_4020h
TCD14_SADDR	20_8020h
TCD15_SADDR	20_C020h
TCD16_SADDR	21_0020h
TCD17_SADDR	21_4020h
TCD18_SADDR	21_8020h
TCD19_SADDR	21_C020h
TCD20_SADDR	22_0020h
TCD21_SADDR	22_4020h

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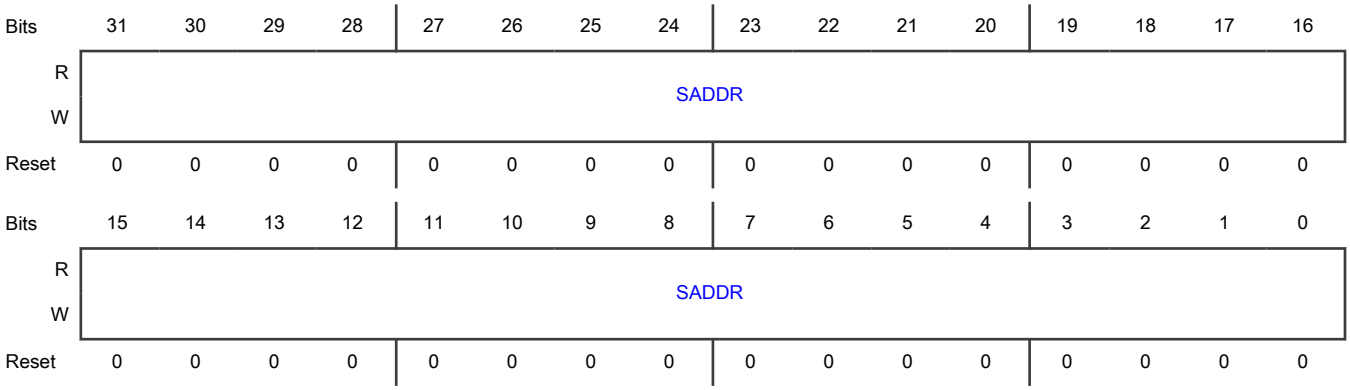
Register	Offset
TCD22_SADDR	22_8020h
TCD23_SADDR	22_C020h
TCD24_SADDR	23_0020h
TCD25_SADDR	23_4020h
TCD26_SADDR	23_8020h
TCD27_SADDR	23_C020h
TCD28_SADDR	24_0020h
TCD29_SADDR	24_4020h
TCD30_SADDR	24_8020h
TCD31_SADDR	24_C020h

Function

This register contains the address for the read transactions.

Diagram



Fields

Field	Function
31-0 SADDR	Source Address Memory address pointing to the source data.

14.6.2.8 TCD Signed Source Address Offset (TCD0_SOFF - TCD31_SOFF)

Offset

Register	Offset
TCD0_SOFF	24h
TCD1_SOFF	4024h
TCD2_SOFF	8024h
TCD3_SOFF	C024h
TCD4_SOFF	1_0024h
TCD5_SOFF	1_4024h
TCD6_SOFF	1_8024h
TCD7_SOFF	1_C024h
TCD8_SOFF	2_0024h
TCD9_SOFF	2_4024h
TCD10_SOFF	2_8024h
TCD11_SOFF	2_C024h
TCD12_SOFF	20_0024h
TCD13_SOFF	20_4024h
TCD14_SOFF	20_8024h
TCD15_SOFF	20_C024h
TCD16_SOFF	21_0024h
TCD17_SOFF	21_4024h
TCD18_SOFF	21_8024h
TCD19_SOFF	21_C024h
TCD20_SOFF	22_0024h
TCD21_SOFF	22_4024h
TCD22_SOFF	22_8024h
TCD23_SOFF	22_C024h
TCD24_SOFF	23_0024h
TCD25_SOFF	23_4024h
TCD26_SOFF	23_8024h
TCD27_SOFF	23_C024h
TCD28_SOFF	24_0024h
TCD29_SOFF	24_4024h

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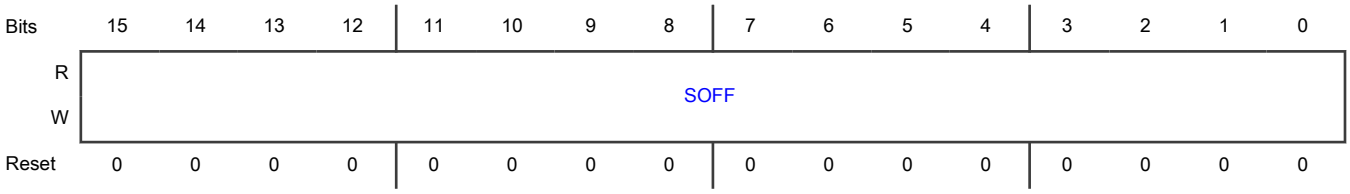
Register	Offset
TCD30_SOFF	24_8024h
TCD31_SOFF	24_C024h

Function

This register contains the sign-extended value added to Source Address register after each read transaction.

Diagram



Fields

Field	Function
15-0 SOFF	Source Address Signed Offset Sign-extended offset applied to the current source address to form the next-state value as each source read is completed.

14.6.2.9 TCD Transfer Attributes (TCD0_ATTR - TCD31_ATTR)

Offset

Register	Offset
TCD0_ATTR	26h
TCD1_ATTR	4026h
TCD2_ATTR	8026h
TCD3_ATTR	C026h
TCD4_ATTR	1_0026h
TCD5_ATTR	1_4026h
TCD6_ATTR	1_8026h
TCD7_ATTR	1_C026h
TCD8_ATTR	2_0026h
TCD9_ATTR	2_4026h
TCD10_ATTR	2_8026h

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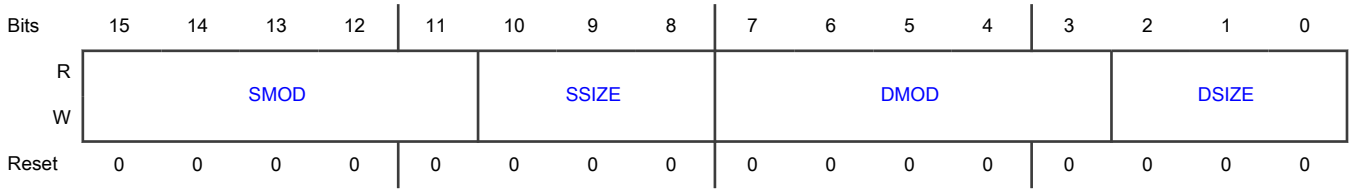
Register	Offset
TCD11_ATTR	2_C026h
TCD12_ATTR	20_0026h
TCD13_ATTR	20_4026h
TCD14_ATTR	20_8026h
TCD15_ATTR	20_C026h
TCD16_ATTR	21_0026h
TCD17_ATTR	21_4026h
TCD18_ATTR	21_8026h
TCD19_ATTR	21_C026h
TCD20_ATTR	22_0026h
TCD21_ATTR	22_4026h
TCD22_ATTR	22_8026h
TCD23_ATTR	22_C026h
TCD24_ATTR	23_0026h
TCD25_ATTR	23_4026h
TCD26_ATTR	23_8026h
TCD27_ATTR	23_C026h
TCD28_ATTR	24_0026h
TCD29_ATTR	24_4026h
TCD30_ATTR	24_8026h
TCD31_ATTR	24_C026h

Function

This register contains size and option modulo addressing information for source and destination addresses.

Diagram



Fields

Field	Function
15-11 SMOD	Source Address Modulo This field defines a specific address range, which is the value after the SADDR + SOFF calculation is performed on the original register value. Setting this field makes it easy to implement a circular data queue. For data queues requiring power-of-2-sized bytes, the queue must start at a 0-modulo-size address and the SMOD field must be set to the appropriate value for the queue, freezing the required number of upper address bits. The value programmed into this field specifies the number of lower address bits that are allowed to change. For a circular queue application, you typically set TCDn_SOFF[SOFF] to the transfer size to implement post-increment addressing, with the SMOD function constraining the addresses to a 0-modulo-size range. 0_0000b - Source address modulo feature disabled 0_0001b - Source address modulo feature enabled for any non-zero value [1-31]
10-8 SSIZE	Source Data Transfer Size 000b - 8-bit 001b - 16-bit 010b - 32-bit 011b - 64-bit 100b - 16-byte 101b - 32-byte 110b - 64-byte 111b - Reserved
7-3 DMOD	Destination Address Modulo See the SMOD definition.
2-0 DSIZE	Destination Data Transfer Size See the SSIZE definition.

14.6.2.10 TCD Transfer Size Without Minor Loop Offsets (TCD0_NBYTES_MLOFFNO - TCD31_NBYTES_MLOFFNO)

Offset

Register	Offset
TCD0_NBYTES_MLOFFNO	28h
TCD1_NBYTES_MLOFFNO	4028h
TCD2_NBYTES_MLOFFNO	8028h
TCD3_NBYTES_MLOFFNO	C028h
TCD4_NBYTES_MLOFFNO	1_0028h
TCD5_NBYTES_MLOFFNO	1_4028h
TCD6_NBYTES_MLOFFNO	1_8028h
TCD7_NBYTES_MLOFFNO	1_C028h
TCD8_NBYTES_MLOFFNO	2_0028h
TCD9_NBYTES_MLOFFNO	2_4028h
TCD10_NBYTES_MLOFFNO	2_8028h
TCD11_NBYTES_MLOFFNO	2_C028h
TCD12_NBYTES_MLOFFNO	20_0028h
TCD13_NBYTES_MLOFFNO	20_4028h
TCD14_NBYTES_MLOFFNO	20_8028h
TCD15_NBYTES_MLOFFNO	20_C028h
TCD16_NBYTES_MLOFFNO	21_0028h
TCD17_NBYTES_MLOFFNO	21_4028h

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Register	Offset
TCD18_NBYTES_MLOFFNO	21_8028h
TCD19_NBYTES_MLOFFNO	21_C028h
TCD20_NBYTES_MLOFFNO	22_0028h
TCD21_NBYTES_MLOFFNO	22_4028h
TCD22_NBYTES_MLOFFNO	22_8028h
TCD23_NBYTES_MLOFFNO	22_C028h
TCD24_NBYTES_MLOFFNO	23_0028h
TCD25_NBYTES_MLOFFNO	23_4028h
TCD26_NBYTES_MLOFFNO	23_8028h
TCD27_NBYTES_MLOFFNO	23_C028h
TCD28_NBYTES_MLOFFNO	24_0028h
TCD29_NBYTES_MLOFFNO	24_4028h
TCD30_NBYTES_MLOFFNO	24_8028h
TCD31_NBYTES_MLOFFNO	24_C028h

Function

The TCDn_NBYTES field defines the number of bytes to transfer per service request.

Minor loop offsets are address offset values added to the final source address (TCDn_SADDR), or destination address (TCDn_DADDR), upon minor loop completion. Minor loop completion is when the channel has finished the service request and has transferred NBYTES. When minor loop offsets are enabled, the minor loop offset value (TCDn_NBYTES_MLOFFYES[MLOFF]) is added to the final source address (TCDn_SADDR), to the final destination address (TCDn_DADDR), or to both, prior to the addresses being written back to the TCD. If the major loop is complete, the minor loop offset is ignored and the major loop address offsets (TCDn_SLAST_SDA and TCDn_DLAST_SGA) are used to compute the next TCDn_SADDR and TCDn_DADDR values.

When minor loop mapping is enabled (SMLOE or DMLOE is 1), TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES is redefined. A portion of TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES is used to specify multiple fields:

- A source enable bit (SMLOE) to specify the minor loop offset must be applied to the source address (TCDn_SADDR) upon minor loop completion
- A destination enable bit (DMLOE) to specify the minor loop offset must be applied to the destination address (TCDn_DADDR) upon minor loop completion
- The sign extended minor loop offset value (MLOFF)

The same offset value (MLOFF) is used for both source and destination minor loop offsets. When either minor loop offset is enabled (SMLOE set or DMLOE set), the NBYTES field is reduced to 10 bits. If both minor loop offsets are disabled (SMLOE cleared and DMLOE cleared), the NBYTES field is a 30-bit vector.

One of two register profiles (this register or TCDn_NBYTES_MLOFFYES), defines the number of bytes to transfer per request. Which register to use depends on whether source or destination minor loop mapping is enabled.

TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES is defined as follows:

- If SMLOE = 0 and DMLOE = 0, then see the TCDn_NBYTES_MLOFFNO register description.
- If either SMLOE or DMLOE is 1, then see the TCDn_NBYTES_MLOFFYES register description.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SMLOE	DMLOE	NBYTES													
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NBYTES															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 SMLOE	Source Minor Loop Offset Enable Selects whether the minor loop offset is applied to the source address upon minor loop completion. 0b - Minor loop offset not applied to SADDR 1b - Minor loop offset applied to SADDR
30 DMLOE	Destination Minor Loop Offset Enable Selects whether the minor loop offset is applied to the destination address upon minor loop completion. 0b - Minor loop offset not applied to DADDR 1b - Minor loop offset applied to DADDR
29-0 NBYTES	Number of Bytes To Transfer Per Service Request Number of bytes to be transferred for each service request of the channel.

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Field	Function
	When a channel activates, the module loads the appropriate TCD contents into the eDMA engine and performs the appropriate reads and writes until the byte transfer count has been reached. This process is normally an indivisible operation and cannot be halted. It can, however, be stalled by using the bandwidth control field, or via preemption. After the byte count is exhausted, the SADDR and DADDR values are written back into the TCD memory, and the major loop iteration count (CITER) is decremented by one and written back to the TCD memory. If the major iteration count is complete, additional processing is performed.

14.6.2.11 TCD Transfer Size with Minor Loop Offsets (TCD0_NBYTES_MLOFFYES - TCD31_NBYTES_MLOFFYES)

Offset

Register	Offset
TCD0_NBYTES_MLOFFYES	28h
TCD1_NBYTES_MLOFFYES	4028h
TCD2_NBYTES_MLOFFYES	8028h
TCD3_NBYTES_MLOFFYES	C028h
TCD4_NBYTES_MLOFFYES	1_0028h
TCD5_NBYTES_MLOFFYES	1_4028h
TCD6_NBYTES_MLOFFYES	1_8028h
TCD7_NBYTES_MLOFFYES	1_C028h
TCD8_NBYTES_MLOFFYES	2_0028h
TCD9_NBYTES_MLOFFYES	2_4028h
TCD10_NBYTES_MLOFFYES	2_8028h
TCD11_NBYTES_MLOFFYES	2_C028h

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Register	Offset
TCD12_NBYTES_MLOFFYES	20_0028h
TCD13_NBYTES_MLOFFYES	20_4028h
TCD14_NBYTES_MLOFFYES	20_8028h
TCD15_NBYTES_MLOFFYES	20_C028h
TCD16_NBYTES_MLOFFYES	21_0028h
TCD17_NBYTES_MLOFFYES	21_4028h
TCD18_NBYTES_MLOFFYES	21_8028h
TCD19_NBYTES_MLOFFYES	21_C028h
TCD20_NBYTES_MLOFFYES	22_0028h
TCD21_NBYTES_MLOFFYES	22_4028h
TCD22_NBYTES_MLOFFYES	22_8028h
TCD23_NBYTES_MLOFFYES	22_C028h
TCD24_NBYTES_MLOFFYES	23_0028h
TCD25_NBYTES_MLOFFYES	23_4028h
TCD26_NBYTES_MLOFFYES	23_8028h
TCD27_NBYTES_MLOFFYES	23_C028h
TCD28_NBYTES_MLOFFYES	24_0028h
TCD29_NBYTES_MLOFFYES	24_4028h
TCD30_NBYTES_MLOFFYES	24_8028h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
TCD31_NBYTES_MLOFFYES	24_C028h

Function

The TCDn_NBYTES field defines the number of bytes to transfer per service request.

Minor loop offset is an address offset value added to the final source address (TCDn_SADDR) or destination address (TCDn_DADDR) upon minor loop completion. Minor loop completion occurs when the channel has finished the service request and has transferred NBYTES. Minor loop offsets are enabled by setting either the source enable bit (SMLOE) or the destination enable bit (DMLOE).

The source enable bit (SMLOE) specifies the minor loop offset value (MLOFF) that is to be applied to the source address (TCDn_SADDR) upon minor loop completion. The destination enable bit (DMLOE) specifies the minor loop offset (MLOFF) that is to be applied to the destination address (TCDn_DADDR) upon minor loop completion.

If the major loop is complete, the minor loop offsets are ignored and the major loop address offsets (TCDn_SLAST_SDA and TCDn_DLAST_SGA) are used to compute the next TCDn_SADDR and TCDn_DADDR values.

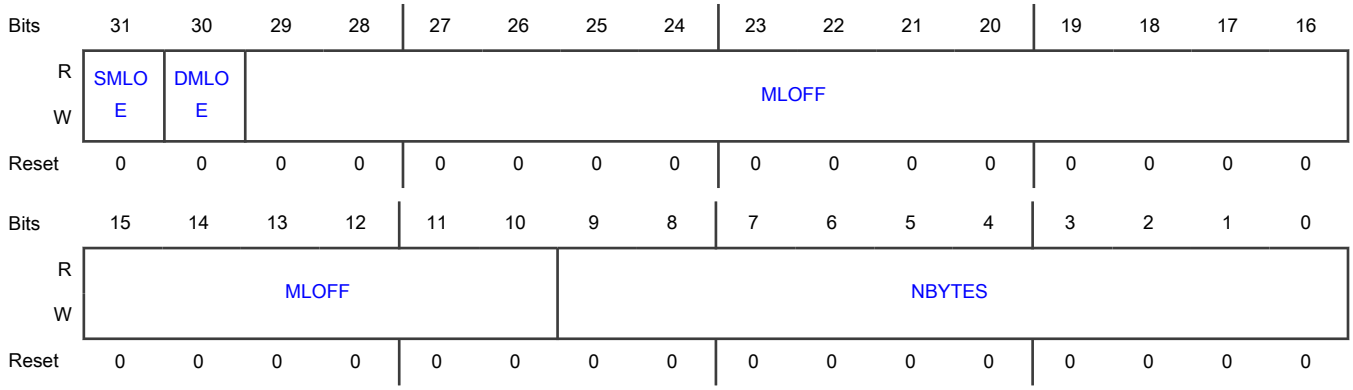
When you enable the minor loop offset overlay (either SMLOE or DMLOE is 1), eDMA redefines TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES. A portion of TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES specifies the sign-extended minor loop offset value (MLOFF). The same offset value (MLOFF) applies to both source and destination minor loop offsets. When the minor loop offset is enabled, you must align it to the transfer size of the source or destination it is associated with. When either minor loop offset is enabled (SMLOE set or DMLOE set), the NBYTES field is reduced to 10 bits. If both minor loop offsets are disabled (SMLOE cleared and DMLOE cleared), the NBYTES field is a 30-bit vector.

One of two register profiles (this register or TCDn_NBYTES_MLOFFNO) defines the number of bytes to transfer per request. Which register to use depends on whether source or destination minor loop mapping is enabled.

TCDn_NBYTES_MLOFFYES is defined as follows:

- If either minor loop offset is enabled (SMLOE or DMLOE = 1), then see the TCDn_NBYTES_MLOFFYES register description.
- If SMLOE and DMLOE are both 0, then see the TCDn_NBYTES_MLOFFNO register description.

Diagram



Fields

Field	Function
31 SMLOE	Source Minor Loop Offset Enable Selects whether the minor loop offset is applied to the source address upon minor loop completion. 0b - Minor loop offset not applied to SADDR 1b - Minor loop offset applied to SADDR
30 DMLOE	Destination Minor Loop Offset Enable Selects whether the minor loop offset is applied to the destination address upon minor loop completion. 0b - Minor loop offset not applied to DADDR 1b - Minor loop offset applied to DADDR
29-10 MLOFF	Minor Loop Offset If SMLOE or DMLOE is 1, this field represents a sign-extended offset applied to the source or destination address to form the next-state value after the minor loop completes.
9-0 NBYTES	Number of Bytes To Transfer Per Service Request The number of bytes to be transferred in each service request of the channel. As a channel activates, the module loads the appropriate TCD contents into the eDMA engine and performs the appropriate reads and writes until the minor byte transfer count has been reached. This is an indivisible operation and cannot be halted. It can, however, be stalled by using the bandwidth control field, or via preemption. After the minor count is exhausted, the SADDR and DADDR values are written back into the TCD memory, and the major iteration count is decremented and restored to the TCD memory. If the major iteration count is complete, additional processing is performed.

14.6.2.12 TCD Last Source Address Adjustment / Store DADDR Address (TCD0_SLAST_SDA - TCD31_SLAST_SDA)

Offset

Register	Offset
TCD0_SLAST_SDA	2Ch
TCD1_SLAST_SDA	402Ch
TCD2_SLAST_SDA	802Ch
TCD3_SLAST_SDA	C02Ch
TCD4_SLAST_SDA	1_002Ch
TCD5_SLAST_SDA	1_402Ch
TCD6_SLAST_SDA	1_802Ch
TCD7_SLAST_SDA	1_C02Ch

Table continues on the next page...

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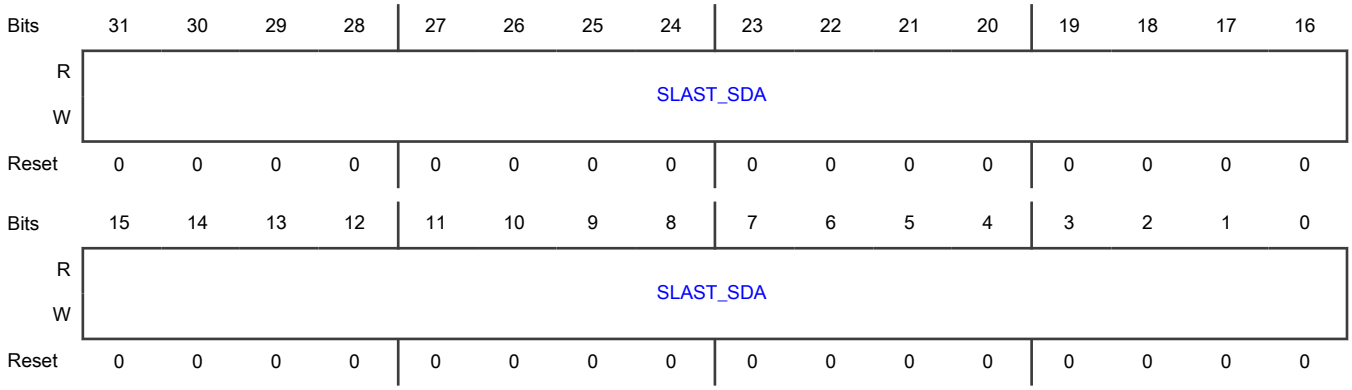
Register	Offset
TCD8_SLAST_SDA	2_002Ch
TCD9_SLAST_SDA	2_402Ch
TCD10_SLAST_SDA	2_802Ch
TCD11_SLAST_SDA	2_C02Ch
TCD12_SLAST_SDA	20_002Ch
TCD13_SLAST_SDA	20_402Ch
TCD14_SLAST_SDA	20_802Ch
TCD15_SLAST_SDA	20_C02Ch
TCD16_SLAST_SDA	21_002Ch
TCD17_SLAST_SDA	21_402Ch
TCD18_SLAST_SDA	21_802Ch
TCD19_SLAST_SDA	21_C02Ch
TCD20_SLAST_SDA	22_002Ch
TCD21_SLAST_SDA	22_402Ch
TCD22_SLAST_SDA	22_802Ch
TCD23_SLAST_SDA	22_C02Ch
TCD24_SLAST_SDA	23_002Ch
TCD25_SLAST_SDA	23_402Ch
TCD26_SLAST_SDA	23_802Ch
TCD27_SLAST_SDA	23_C02Ch
TCD28_SLAST_SDA	24_002Ch
TCD29_SLAST_SDA	24_402Ch
TCD30_SLAST_SDA	24_802Ch
TCD31_SLAST_SDA	24_C02Ch

Function

This register contains the value added to the source address when the major loop is complete. When the store destination address option is enabled, this field provides a pointer to memory for storing the final destination address.

Diagram



Fields

Field	Function
31-0 SLAST_SDA	Last Source Address Adjustment / Store DADDR Address Source last address adjustment or the system memory address for destination address (DADDR) storage. If (TCDn_CSR[ESDA] = 0), then: • Adjustment value is added to the source address at the completion of the major iteration count. This value can be used to restore the source address to the initial value or adjust the address to reference the next data structure. • This field uses two's complement notation for the final source address adjustment. Otherwise: • This address points to the 32-bit-aligned memory location where the destination address (DADDR) is to be stored in system memory. By saving the final destination address in system memory via the ESDA feature, you are able to compute the size of a variable destination data buffer by simply subtracting the beginning DADDR from the final, saved DADDR. This feature is used together with the scatter/gather operation to prevent the loss of the final DADDR, which is overwritten during the scatter/gather operation. The "Store Destination Address" (SDA) value must be a 32-bit-aligned location because the eDMA forces the lower two address bits of the SLAST_SDA field to zero when ESDA is enabled. The module performs this write operation when the major loop is done; that is, when the major iteration count (CITER) decrements to zero.

14.6.2.13 TCD Destination Address (TCD0_DADDR - TCD31_DADDR)

Offset

Register	Offset
TCD0_DADDR	30h
TCD1_DADDR	4030h
TCD2_DADDR	8030h

Table continues on the next page...

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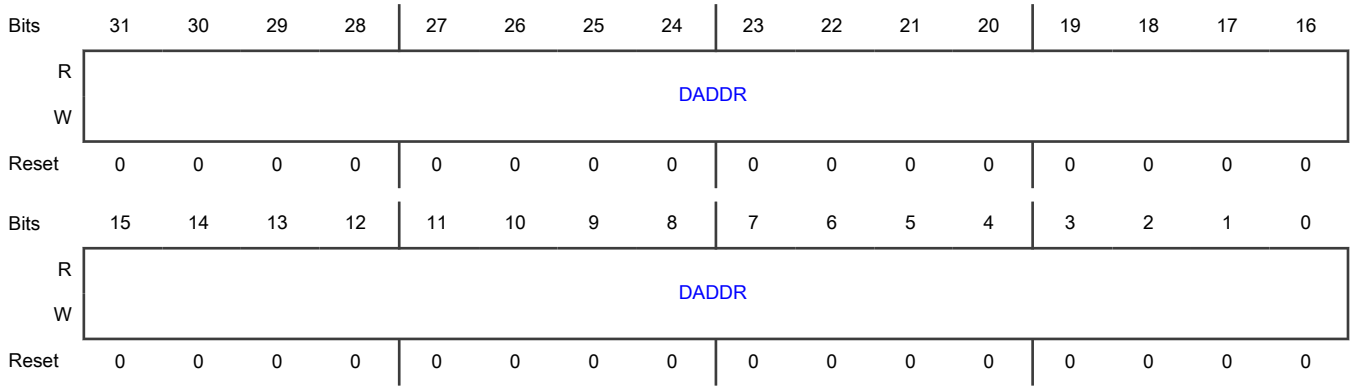
Register	Offset
TCD3_DADDR	C030h
TCD4_DADDR	1_0030h
TCD5_DADDR	1_4030h
TCD6_DADDR	1_8030h
TCD7_DADDR	1_C030h
TCD8_DADDR	2_0030h
TCD9_DADDR	2_4030h
TCD10_DADDR	2_8030h
TCD11_DADDR	2_C030h
TCD12_DADDR	20_0030h
TCD13_DADDR	20_4030h
TCD14_DADDR	20_8030h
TCD15_DADDR	20_C030h
TCD16_DADDR	21_0030h
TCD17_DADDR	21_4030h
TCD18_DADDR	21_8030h
TCD19_DADDR	21_C030h
TCD20_DADDR	22_0030h
TCD21_DADDR	22_4030h
TCD22_DADDR	22_8030h
TCD23_DADDR	22_C030h
TCD24_DADDR	23_0030h
TCD25_DADDR	23_4030h
TCD26_DADDR	23_8030h
TCD27_DADDR	23_C030h
TCD28_DADDR	24_0030h
TCD29_DADDR	24_4030h
TCD30_DADDR	24_8030h
TCD31_DADDR	24_C030h

Function

This register contains the address for the write transactions.

Diagram



Fields

Field	Function
31-0 DADDR	Destination Address Memory address pointing to the destination data.

14.6.2.14 TCD Signed Destination Address Offset (TCD0_DOFF - TCD31_DOFF)

Offset

Register	Offset
TCD0_DOFF	34h
TCD1_DOFF	4034h
TCD2_DOFF	8034h
TCD3_DOFF	C034h
TCD4_DOFF	1_0034h
TCD5_DOFF	1_4034h
TCD6_DOFF	1_8034h
TCD7_DOFF	1_C034h
TCD8_DOFF	2_0034h
TCD9_DOFF	2_4034h
TCD10_DOFF	2_8034h
TCD11_DOFF	2_C034h
TCD12_DOFF	20_0034h
TCD13_DOFF	20_4034h
TCD14_DOFF	20_8034h

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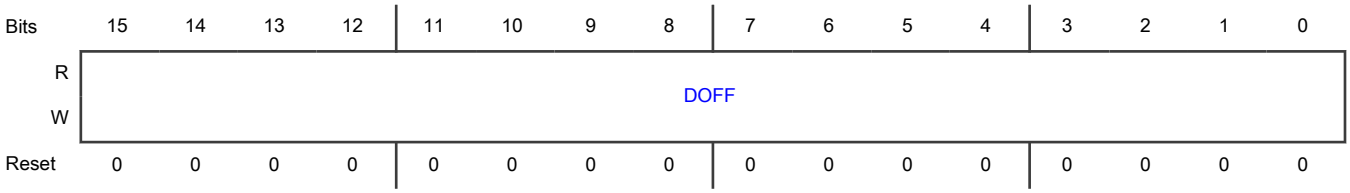
Register	Offset
TCD15_DOFF	20_C034h
TCD16_DOFF	21_0034h
TCD17_DOFF	21_4034h
TCD18_DOFF	21_8034h
TCD19_DOFF	21_C034h
TCD20_DOFF	22_0034h
TCD21_DOFF	22_4034h
TCD22_DOFF	22_8034h
TCD23_DOFF	22_C034h
TCD24_DOFF	23_0034h
TCD25_DOFF	23_4034h
TCD26_DOFF	23_8034h
TCD27_DOFF	23_C034h
TCD28_DOFF	24_0034h
TCD29_DOFF	24_4034h
TCD30_DOFF	24_8034h
TCD31_DOFF	24_C034h

Function

This register contains the sign-extended value added to Destination Address register after each write transaction.

Diagram



Fields

Field	Function
15-0 DOFF	Destination Address Signed Offset Sign-extended offset that is applied to the current destination address to form the next-state value as each destination write is completed.

14.6.2.15 TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_CITER_ELINKNO - TCD31_CITER_ELINKNO)

Offset

Register	Offset
TCD0_CITER_ELINKNO	36h
TCD1_CITER_ELINKNO	4036h
TCD2_CITER_ELINKNO	8036h
TCD3_CITER_ELINKNO	C036h
TCD4_CITER_ELINKNO	1_0036h
TCD5_CITER_ELINKNO	1_4036h
TCD6_CITER_ELINKNO	1_8036h
TCD7_CITER_ELINKNO	1_C036h
TCD8_CITER_ELINKNO	2_0036h
TCD9_CITER_ELINKNO	2_4036h
TCD10_CITER_ELINKNO	2_8036h
TCD11_CITER_ELINKNO	2_C036h
TCD12_CITER_ELINKNO	20_0036h
TCD13_CITER_ELINKNO	20_4036h
TCD14_CITER_ELINKNO	20_8036h
TCD15_CITER_ELINKNO	20_C036h
TCD16_CITER_ELINKNO	21_0036h
TCD17_CITER_ELINKNO	21_4036h
TCD18_CITER_ELINKNO	21_8036h
TCD19_CITER_ELINKNO	21_C036h
TCD20_CITER_ELINKNO	22_0036h
TCD21_CITER_ELINKNO	22_4036h

Table continues on the next page...

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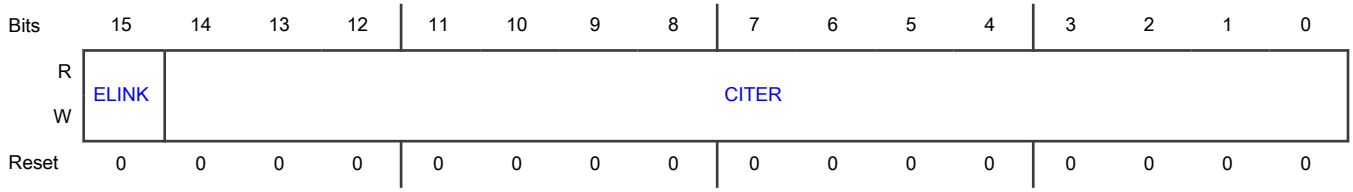
Register	Offset
TCD22_CITER_ELINKNO	22_8036h
TCD23_CITER_ELINKNO	22_C036h
TCD24_CITER_ELINKNO	23_0036h
TCD25_CITER_ELINKNO	23_4036h
TCD26_CITER_ELINKNO	23_8036h
TCD27_CITER_ELINKNO	23_C036h
TCD28_CITER_ELINKNO	24_0036h
TCD29_CITER_ELINKNO	24_4036h
TCD30_CITER_ELINKNO	24_8036h
TCD31_CITER_ELINKNO	24_C036h

Function

If TCDn_CITER[ELINK] is 0, the TCDn_CITER register is defined as follows.

Diagram



Fields

Field	Function
15 ELINK	Enable Link As the channel completes the minor loop, this flag enables linking to another channel as defined by the relevant LINKCH field. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] bit of the specified channel to 1.

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Field	Function
	If channel linking is disabled, the CITER value is extended to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of MAJORELINK channel linking. **NOTE** This field must be equal to the BITER[ELINK] field; otherwise, a configuration error is reported. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14-0 CITER	Current Major Iteration Count This 9-bit (ELINK = 1) or 15-bit (ELINK = 0) count represents the current major loop count for the channel. It is decremented each time the channel finishes a service request and is written back to TCD memory. After the major iteration count is exhausted, the channel performs a number of operations — for example, final source and destination address calculations — and optionally generates an interrupt to signal channel completion before reloading the CITER field from the Beginning Iteration Count (BITER) field. **NOTE** When the CITER field is initially loaded by software, it must be set to the same value as that contained in the BITER field. **NOTE** If the channel is configured to execute a single service request, the initial values of BITER and CITER should be 0x0001.

14.6.2.16 TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_CITER_ELINKYES - TCD31_CITER_ELINKYES)

Offset

Register	Offset
TCD0_CITER_ELINKYES	36h
TCD1_CITER_ELINKYES	4036h
TCD2_CITER_ELINKYES	8036h
TCD3_CITER_ELINKYES	C036h
TCD4_CITER_ELINKYES	1_0036h
TCD5_CITER_ELINKYES	1_4036h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
TCD6_CITER_ELINKYES	1_8036h
TCD7_CITER_ELINKYES	1_C036h
TCD8_CITER_ELINKYES	2_0036h
TCD9_CITER_ELINKYES	2_4036h
TCD10_CITER_ELINKYES	2_8036h
TCD11_CITER_ELINKYES	2_C036h
TCD12_CITER_ELINKYES	20_0036h
TCD13_CITER_ELINKYES	20_4036h
TCD14_CITER_ELINKYES	20_8036h
TCD15_CITER_ELINKYES	20_C036h
TCD16_CITER_ELINKYES	21_0036h
TCD17_CITER_ELINKYES	21_4036h
TCD18_CITER_ELINKYES	21_8036h
TCD19_CITER_ELINKYES	21_C036h
TCD20_CITER_ELINKYES	22_0036h
TCD21_CITER_ELINKYES	22_4036h
TCD22_CITER_ELINKYES	22_8036h
TCD23_CITER_ELINKYES	22_C036h
TCD24_CITER_ELINKYES	23_0036h

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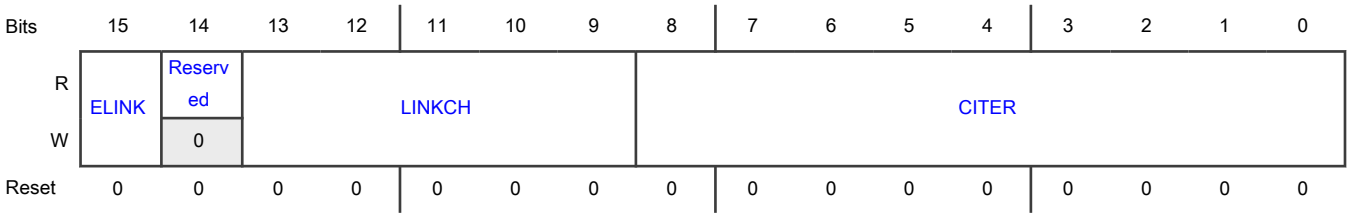
Register	Offset
TCD25_CITER_ELINKYES	23_4036h
TCD26_CITER_ELINKYES	23_8036h
TCD27_CITER_ELINKYES	23_C036h
TCD28_CITER_ELINKYES	24_0036h
TCD29_CITER_ELINKYES	24_4036h
TCD30_CITER_ELINKYES	24_8036h
TCD31_CITER_ELINKYES	24_C036h

Function

If TCDn_CITER[ELINK] is 1, the TCDn_CITER register is defined as follows.

Diagram



Fields

Field	Function
15 ELINK	Enable Link As the channel completes the minor loop, this flag enables linking to another channel as defined by the relevant LINKCH field. When enabled, an internal mechanism sets the TCDn_CSR[START] field of the specified channel (LINKCH) upon minor loop completion. If channel linking is disabled, the CITER value is extended to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of MAJORELINK channel linking. **NOTE** This field must be equal to the BITER[ELINK] field; otherwise, a configuration error is reported.

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Field	Function
	0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14 —	Reserved
13-9 LINKCH	Minor Loop Link Channel Number If channel-to-channel linking is enabled (ELINK = 1), then after the minor loop is exhausted the eDMA engine initiates a channel service request to the channel defined by this field by writing that channel's TCDn_CSR[START] field to 1.
8-0 CITER	Current Major Iteration Count This 9-bit (ELINK = 1) or 15-bit (ELINK = 0) count represents the current major loop count for the channel. It is decremented each time the channel finishes a service request and is written back to the TCD memory. After the major iteration count is exhausted, the channel performs a number of operations — for example, final source and destination address calculations — and optionally generates an interrupt to signal channel completion before reloading the CITER field from the Beginning Iteration Count (BITER) field. **NOTE** When the CITER field is initially loaded by software, it must be set to the same value as that contained in the BITER field. **NOTE** If the channel is configured to execute a single service request, the initial values of BITER and CITER should be 0x0001.

14.6.2.17 TCD Last Destination Address Adjustment / Scatter Gather Address (TCD0_DLAST_SGA - TCD31_DLAST_SGA)

Offset

Register	Offset
TCD0_DLAST_SGA	38h
TCD1_DLAST_SGA	4038h
TCD2_DLAST_SGA	8038h
TCD3_DLAST_SGA	C038h
TCD4_DLAST_SGA	1_0038h
TCD5_DLAST_SGA	1_4038h
TCD6_DLAST_SGA	1_8038h
TCD7_DLAST_SGA	1_C038h

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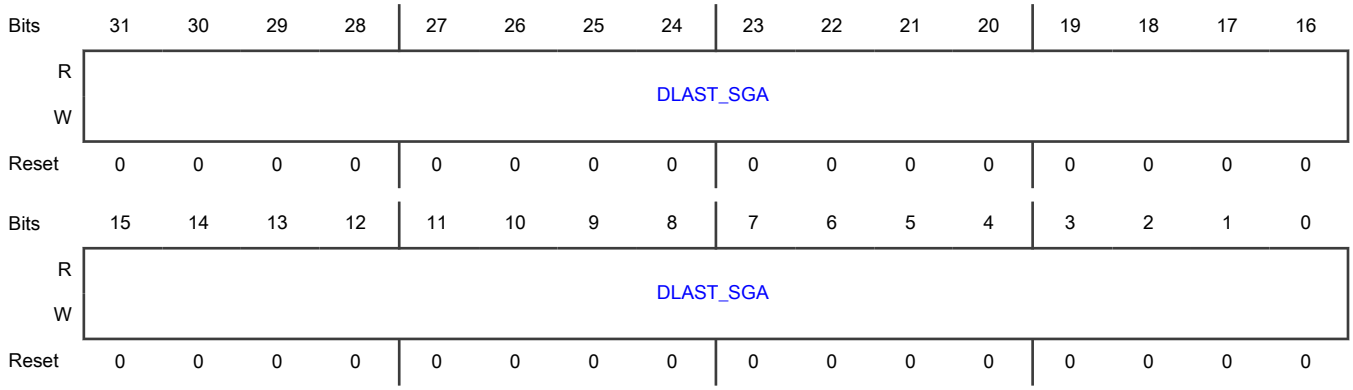
Register	Offset
TCD8_DLAST_SGA	2_0038h
TCD9_DLAST_SGA	2_4038h
TCD10_DLAST_SGA	2_8038h
TCD11_DLAST_SGA	2_C038h
TCD12_DLAST_SGA	20_0038h
TCD13_DLAST_SGA	20_4038h
TCD14_DLAST_SGA	20_8038h
TCD15_DLAST_SGA	20_C038h
TCD16_DLAST_SGA	21_0038h
TCD17_DLAST_SGA	21_4038h
TCD18_DLAST_SGA	21_8038h
TCD19_DLAST_SGA	21_C038h
TCD20_DLAST_SGA	22_0038h
TCD21_DLAST_SGA	22_4038h
TCD22_DLAST_SGA	22_8038h
TCD23_DLAST_SGA	22_C038h
TCD24_DLAST_SGA	23_0038h
TCD25_DLAST_SGA	23_4038h
TCD26_DLAST_SGA	23_8038h
TCD27_DLAST_SGA	23_C038h
TCD28_DLAST_SGA	24_0038h
TCD29_DLAST_SGA	24_4038h
TCD30_DLAST_SGA	24_8038h
TCD31_DLAST_SGA	24_C038h

Function

This register contains the value added to the destination address when the major loop is complete. When the Scatter/Gather option is enabled, this field provides a pointer to memory for fetching a transfer control descriptor to reprogram the channel.

Diagram



Fields

Field	Function
31-0 DLAST_SGA	Last Destination Address Adjustment / Scatter Gather Address Adjustment of the last destination address or the memory address for the next transfer control descriptor to be loaded into this channel (scatter/gather). If (TCDn_CSR[ESG] = 0) then: • Adjustment value is added to the destination address at the completion of the major iteration count. This value can apply to restore the destination address to the initial value or adjust the address to reference the next data structure. • This field uses two's complement notation for the final destination address adjustment. Otherwise: • This address points to the beginning of a 0-modulo 32-byte region containing the next transfer control descriptor to be loaded into this channel. This channel reload is performed as the major iteration count completes. The scatter/gather address must be 0-modulo 32-byte, or else a configuration error is reported.

14.6.2.18 TCD Control and Status (TCD0_CSR - TCD31_CSR)

Offset

Register	Offset
TCD0_CSR	3Ch
TCD1_CSR	403Ch
TCD2_CSR	803Ch
TCD3_CSR	C03Ch
TCD4_CSR	1_003Ch
TCD5_CSR	1_403Ch
TCD6_CSR	1_803Ch

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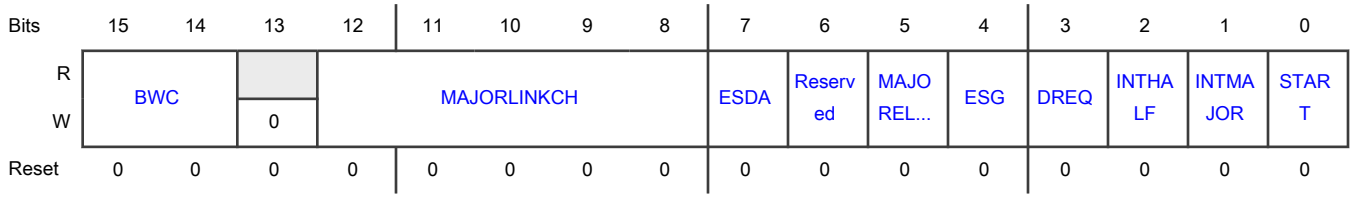
Register	Offset
TCD7_CSR	1_C03Ch
TCD8_CSR	2_003Ch
TCD9_CSR	2_403Ch
TCD10_CSR	2_803Ch
TCD11_CSR	2_C03Ch
TCD12_CSR	20_003Ch
TCD13_CSR	20_403Ch
TCD14_CSR	20_803Ch
TCD15_CSR	20_C03Ch
TCD16_CSR	21_003Ch
TCD17_CSR	21_403Ch
TCD18_CSR	21_803Ch
TCD19_CSR	21_C03Ch
TCD20_CSR	22_003Ch
TCD21_CSR	22_403Ch
TCD22_CSR	22_803Ch
TCD23_CSR	22_C03Ch
TCD24_CSR	23_003Ch
TCD25_CSR	23_403Ch
TCD26_CSR	23_803Ch
TCD27_CSR	23_C03Ch
TCD28_CSR	24_003Ch
TCD29_CSR	24_403Ch
TCD30_CSR	24_803Ch
TCD31_CSR	24_C03Ch

Function

This register is used to enable optional features.

Diagram



Fields

Field	Function
15-14 BWC	Bandwidth Control Throttles the amount of bus bandwidth consumed by the eDMA. Generally, as the eDMA processes the minor loop, it continuously generates read/write sequences until the minor count is exhausted. This field forces eDMA to stall after the completion of each read/write access, to control the bus request bandwidth seen by the system bus interconnect. **NOTE** If the source and destination sizes are equal, this field is ignored between the first and second transfers and after the last write of each minor loop. This behavior is a side effect of reducing start-up latency. 00b - No eDMA engine stalls 01b - Enable eDMA master high-priority elevation (HPE) mode. No eDMA engine stalls. 10b - eDMA engine stalls for 4 cycles after each R/W 11b - eDMA engine stalls for 8 cycles after each R/W
13 —	Reserved
12-8 MAJORLINKCH	Major Loop Link Channel Number If (MAJORELINK = 0) then: • No channel-to-channel linking, or chaining, is performed after the major loop counter is exhausted. Otherwise: • After the major loop counter is exhausted, the eDMA engine initiates a channel service request at the channel defined by this field by setting that channel's TCDn_CSR[START] field to 1.
7 ESDA	Enable Store Destination Address As the channel completes the major loop by either the current iteration counter (CITER) decrementing to 0, this field enables writing the destination address (DADDR) to the address stored in the SLAST_SDA field. The value written to system memory is the last DADDR value prior to the DLAST_SGA offset being applied, or overwritten by an enabled scatter/gather operation. When the SDA bit is 1, SLAST_SDA contains the write pointer instead of the final source address offset. Because this is a pointer and not a final offset, a last source address offset of zero is applied to SADDR instead of the SLAST_SGA value. 0b - Ability to store destination address to system memory disabled 1b - Ability to store destination address to system memory enabled

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Field	Function
6 —	Reserved
5 MAJORELINK	Enable Link When Major Loop Complete As the channel completes the major loop, this flag enables linking to another channel defined by MAJORLINKCH. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] field of the specified channel. **NOTE** To support the dynamic linking coherency model, this field is forced to 0 if written when TCDn_CSR[DONE] is 1. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
4 ESG	Enable Scatter/Gather Processing As the channel completes the major loop, this flag enables scatter/gather processing in the current channel. If enabled, the eDMA engine uses TCDn_DLAST_SGA as a memory pointer to a 0-modulo 32-bit address containing a 32-byte data structure, which is loaded as the transfer control descriptor into local memory. **NOTE** To support the dynamic scatter/gather coherency model, this field is forced to 0 if written when TCDn_CSR[DONE] is 1. 0b - Current channel's TCD is normal format 1b - Current channel's TCD specifies scatter/gather format.
3 DREQ	Disable Request If this flag is 1, the eDMA hardware automatically clears the corresponding ERQ bit when the current major iteration count reaches 0. 0b - No operation. Channel's ERQ field not affected 1b - Clear the ERQ field to 0 upon major loop completion, thus disabling hardware service requests. Channel's ERQ field cleared to 0 when major loop complete
2 INTHALF	Enable Interrupt If Major Counter Half-complete If this flag is 1, the channel generates an interrupt request by setting the appropriate field in the INT register to 1 when the current major iteration count reaches the halfway point. Specifically, the comparison performed by the eDMA engine is (CITER = (BITER/2)). This halfway point interrupt request is provided to support double-buffered, also known as ping-pong, schemes, or other types of data movement where the processor needs an early indication of the transfer's progress. **NOTE** If BITER = 1, do not use INTHALF; use INTMAJOR instead. 0b - Halfway point interrupt disabled

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Field	Function
	1b - Halfway point interrupt enabled
1 INTMAJOR	Enable Interrupt If Major count complete If this flag is 1, the channel generates an interrupt request by setting the appropriate field in the INT register to 1 when the current major iteration count (CITER) reaches 0. 0b - End-of-major loop interrupt disabled 1b - End-of-major loop interrupt enabled
0 START	Channel Start If this flag is 1, the channel is requesting service. The eDMA hardware automatically clears this flag to 0 after the channel begins execution. 0b - Channel not explicitly started 1b - Channel explicitly started via a software-initiated service request

14.6.2.19 TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_BITER_ELINKNO - TCD31_BITER_ELINKNO)

Offset

Register	Offset
TCD0_BITER_ELINKNO	3Eh
TCD1_BITER_ELINKNO	403Eh
TCD2_BITER_ELINKNO	803Eh
TCD3_BITER_ELINKNO	C03Eh
TCD4_BITER_ELINKNO	1_003Eh
TCD5_BITER_ELINKNO	1_403Eh
TCD6_BITER_ELINKNO	1_803Eh
TCD7_BITER_ELINKNO	1_C03Eh
TCD8_BITER_ELINKNO	2_003Eh
TCD9_BITER_ELINKNO	2_403Eh
TCD10_BITER_ELINKNO	2_803Eh
TCD11_BITER_ELINKNO	2_C03Eh
TCD12_BITER_ELINKNO	20_003Eh

Table continues on the next page...

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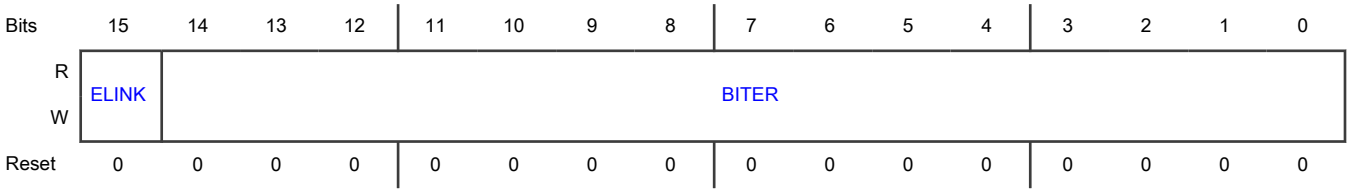
Register	Offset
TCD13_BITER_ELINKNO	20_403Eh
TCD14_BITER_ELINKNO	20_803Eh
TCD15_BITER_ELINKNO	20_C03Eh
TCD16_BITER_ELINKNO	21_003Eh
TCD17_BITER_ELINKNO	21_403Eh
TCD18_BITER_ELINKNO	21_803Eh
TCD19_BITER_ELINKNO	21_C03Eh
TCD20_BITER_ELINKNO	22_003Eh
TCD21_BITER_ELINKNO	22_403Eh
TCD22_BITER_ELINKNO	22_803Eh
TCD23_BITER_ELINKNO	22_C03Eh
TCD24_BITER_ELINKNO	23_003Eh
TCD25_BITER_ELINKNO	23_403Eh
TCD26_BITER_ELINKNO	23_803Eh
TCD27_BITER_ELINKNO	23_C03Eh
TCD28_BITER_ELINKNO	24_003Eh
TCD29_BITER_ELINKNO	24_403Eh
TCD30_BITER_ELINKNO	24_803Eh
TCD31_BITER_ELINKNO	24_C03Eh

Function

If the TCDn_BITER[ELINK] field is 0, the TCDn_BITER register is defined as follows.

Diagram



Fields

Field	Function
15 ELINK	Enables Link As the channel completes the minor loop, this flag enables linking to another channel as defined by BITER[LINKCH]. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] field of the specified channel. If channel linking is disabled, the BITER value extends to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of the MAJORELINK channel linking. **NOTE** When the software loads the TCD, this field must be set equal to the corresponding CITER field; otherwise, a configuration error is reported. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14-0 BITER	Starting Major Iteration Count As the transfer control descriptor is first loaded by software, this 9-bit (ELINK = 1) or 15-bit (ELINK = 0) field must be set equal to the value in the CITER field. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. If the channel is configured to execute a single service request, the initial values of BITER and CITER must be 0x0001.

14.6.2.20 TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_BITER_ELINKYES - TCD31_BITER_ELINKYES)

Offset

Register	Offset
TCD0_BITER_ELINKYES	3Eh
TCD1_BITER_ELINKYES	403Eh

Table continues on the next page...

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Register	Offset
TCD2_BITER_ELINKYES	803Eh
TCD3_BITER_ELINKYES	C03Eh
TCD4_BITER_ELINKYES	1_003Eh
TCD5_BITER_ELINKYES	1_403Eh
TCD6_BITER_ELINKYES	1_803Eh
TCD7_BITER_ELINKYES	1_C03Eh
TCD8_BITER_ELINKYES	2_003Eh
TCD9_BITER_ELINKYES	2_403Eh
TCD10_BITER_ELINKYES	2_803Eh
TCD11_BITER_ELINKYES	2_C03Eh
TCD12_BITER_ELINKYES	20_003Eh
TCD13_BITER_ELINKYES	20_403Eh
TCD14_BITER_ELINKYES	20_803Eh
TCD15_BITER_ELINKYES	20_C03Eh
TCD16_BITER_ELINKYES	21_003Eh
TCD17_BITER_ELINKYES	21_403Eh
TCD18_BITER_ELINKYES	21_803Eh
TCD19_BITER_ELINKYES	21_C03Eh
TCD20_BITER_ELINKYES	22_003Eh

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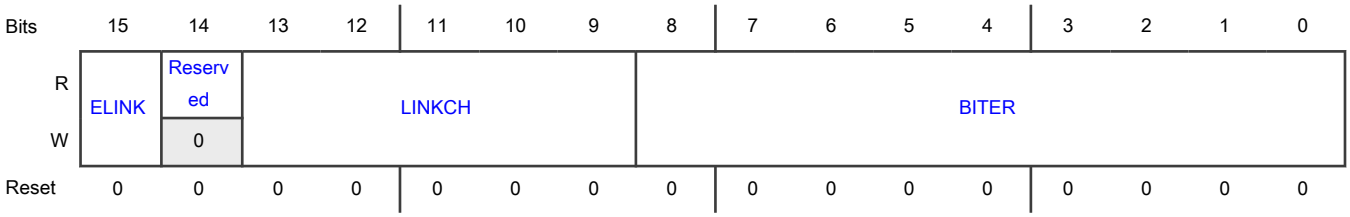
Register	Offset
TCD21_BITER_ELINKYES	22_403Eh
TCD22_BITER_ELINKYES	22_803Eh
TCD23_BITER_ELINKYES	22_C03Eh
TCD24_BITER_ELINKYES	23_003Eh
TCD25_BITER_ELINKYES	23_403Eh
TCD26_BITER_ELINKYES	23_803Eh
TCD27_BITER_ELINKYES	23_C03Eh
TCD28_BITER_ELINKYES	24_003Eh
TCD29_BITER_ELINKYES	24_403Eh
TCD30_BITER_ELINKYES	24_803Eh
TCD31_BITER_ELINKYES	24_C03Eh

Function

If the TCDn_BITER[ELINK] field is set, the TCDn_BITER register is defined as follows.

Diagram



Fields

Field	Function
15 ELINK	Enable Link

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Field	Function
	As the channel completes the minor loop, this flag enables linking to another channel as defined by BITER[LINKCH]. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] field of the specified channel. If channel linking disables, the BITER value extends to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of the MAJORELINK channel linking. **NOTE** When the software loads the TCD, this field must be set equal to the corresponding CITER field; otherwise, a configuration error is reported. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14 —	Reserved
13-9 LINKCH	Link Channel Number If channel-to-channel linking is enabled (ELINK = 1), then after the minor loop is exhausted, the eDMA engine initiates a channel service request at the channel defined by this field by setting that channel's TCDn_CSR[START] field. **NOTE** When the software loads the TCD, this field must be set equal to the corresponding CITER field; otherwise, a configuration error is reported. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field.
8-0 BITER	Starting Major Iteration Count As the transfer control descriptor is first loaded by software, this 9-bit (ELINK = 1) or 15-bit (ELINK = 0) field must be set equal to the value in the CITER field. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. If the channel is configured to execute a single service request, the initial values of BITER and CITER must be 0x0001.

14.6.3 TCD_1 register descriptions

14.6.3.1 TCD_1 memory map

TCD_1 base address: 4001_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Channel Control and Status (CH0_CSR)	32	RW	0000_0000h
4h	Channel Error Status (CH0_ES)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
8h	Channel Interrupt Status (CH0_INT)	32	RW	0000_0000h
Ch	Channel System Bus (CH0_SBR)	32	RW	0000_8006h
10h	Channel Priority (CH0_PRI)	32	RW	0000_0000h
20h	TCD Source Address (TCD0_SADDR)	32	RW	0000_0000h
24h	TCD Signed Source Address Offset (TCD0_SOFF)	16	RW	0000h
26h	TCD Transfer Attributes (TCD0_ATTR)	16	RW	0000h
28h	TCD Transfer Size Without Minor Loop Offsets (TCD0_NBYTES_MLOFFNO)	32	RW	0000_0000h
28h	TCD Transfer Size with Minor Loop Offsets (TCD0_NBYTES_MLOFFYES)	32	RW	0000_0000h
2Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD0_SLAST_SDA)	32	RW	0000_0000h
30h	TCD Destination Address (TCD0_DADDR)	32	RW	0000_0000h
34h	TCD Signed Destination Address Offset (TCD0_DOFF)	16	RW	0000h
36h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_CITER_ELINKNO)	16	RW	0000h
36h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_CITER_ELINKYES)	16	RW	0000h
38h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD0_DLAST_SGA)	32	RW	0000_0000h
3Ch	TCD Control and Status (TCD0_CSR)	16	RW	0000h
3Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_BITER_ELINKNO)	16	RW	0000h
3Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_BITER_ELINKYES)	16	RW	0000h
4000h	Channel Control and Status (CH1_CSR)	32	RW	0000_0000h
4004h	Channel Error Status (CH1_ES)	32	RW	0000_0000h
4008h	Channel Interrupt Status (CH1_INT)	32	RW	0000_0000h
400Ch	Channel System Bus (CH1_SBR)	32	RW	0000_8006h
4010h	Channel Priority (CH1_PRI)	32	RW	0000_0000h
4020h	TCD Source Address (TCD1_SADDR)	32	RW	0000_0000h
4024h	TCD Signed Source Address Offset (TCD1_SOFF)	16	RW	0000h
4026h	TCD Transfer Attributes (TCD1_ATTR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
4028h	TCD Transfer Size Without Minor Loop Offsets (TCD1_NBYTES_MLOFFNO)	32	RW	0000_0000h
4028h	TCD Transfer Size with Minor Loop Offsets (TCD1_NBYTES_MLOFFYES)	32	RW	0000_0000h
402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD1_SLAST_SDA)	32	RW	0000_0000h
4030h	TCD Destination Address (TCD1_DADDR)	32	RW	0000_0000h
4034h	TCD Signed Destination Address Offset (TCD1_DOFF)	16	RW	0000h
4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD1_CITER_ELINKNO)	16	RW	0000h
4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD1_CITER_ELINKYES)	16	RW	0000h
4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD1_DLAST_SGA)	32	RW	0000_0000h
403Ch	TCD Control and Status (TCD1_CSR)	16	RW	0000h
403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD1_BITER_ELINKNO)	16	RW	0000h
403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD1_BITER_ELINKYES)	16	RW	0000h
8000h	Channel Control and Status (CH2_CSR)	32	RW	0000_0000h
8004h	Channel Error Status (CH2_ES)	32	RW	0000_0000h
8008h	Channel Interrupt Status (CH2_INT)	32	RW	0000_0000h
800Ch	Channel System Bus (CH2_SBR)	32	RW	0000_8006h
8010h	Channel Priority (CH2_PRI)	32	RW	0000_0000h
8020h	TCD Source Address (TCD2_SADDR)	32	RW	0000_0000h
8024h	TCD Signed Source Address Offset (TCD2_SOFF)	16	RW	0000h
8026h	TCD Transfer Attributes (TCD2_ATTR)	16	RW	0000h
8028h	TCD Transfer Size Without Minor Loop Offsets (TCD2_NBYTES_MLOFFNO)	32	RW	0000_0000h
8028h	TCD Transfer Size with Minor Loop Offsets (TCD2_NBYTES_MLOFFYES)	32	RW	0000_0000h
802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD2_SLAST_SDA)	32	RW	0000_0000h
8030h	TCD Destination Address (TCD2_DADDR)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
8034h	TCD Signed Destination Address Offset (TCD2_DOFF)	16	RW	0000h
8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD2_CITER_ELINKNO)	16	RW	0000h
8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD2_CITER_ELINKYES)	16	RW	0000h
8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD2_DLAST_SGA)	32	RW	0000_0000h
803Ch	TCD Control and Status (TCD2_CSR)	16	RW	0000h
803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD2_BITER_ELINKNO)	16	RW	0000h
803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD2_BITER_ELINKYES)	16	RW	0000h
C000h	Channel Control and Status (CH3_CSR)	32	RW	0000_0000h
C004h	Channel Error Status (CH3_ES)	32	RW	0000_0000h
C008h	Channel Interrupt Status (CH3_INT)	32	RW	0000_0000h
C00Ch	Channel System Bus (CH3_SBR)	32	RW	0000_8006h
C010h	Channel Priority (CH3_PRI)	32	RW	0000_0000h
C020h	TCD Source Address (TCD3_SADDR)	32	RW	0000_0000h
C024h	TCD Signed Source Address Offset (TCD3_SOFF)	16	RW	0000h
C026h	TCD Transfer Attributes (TCD3_ATTR)	16	RW	0000h
C028h	TCD Transfer Size Without Minor Loop Offsets (TCD3_NBYTES_MLOFFNO)	32	RW	0000_0000h
C028h	TCD Transfer Size with Minor Loop Offsets (TCD3_NBYTES_MLOFFYES)	32	RW	0000_0000h
C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD3_SLAST_SDA)	32	RW	0000_0000h
C030h	TCD Destination Address (TCD3_DADDR)	32	RW	0000_0000h
C034h	TCD Signed Destination Address Offset (TCD3_DOFF)	16	RW	0000h
C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD3_CITER_ELINKNO)	16	RW	0000h
C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD3_CITER_ELINKYES)	16	RW	0000h
C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD3_DLAST_SGA)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
C03Ch	TCD Control and Status (TCD3_CSR)	16	RW	0000h
C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD3_BITER_ELINKNO)	16	RW	0000h
C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD3_BITER_ELINKYES)	16	RW	0000h
1_0000h	Channel Control and Status (CH4_CSR)	32	RW	0000_0000h
1_0004h	Channel Error Status (CH4_ES)	32	RW	0000_0000h
1_0008h	Channel Interrupt Status (CH4_INT)	32	RW	0000_0000h
1_000Ch	Channel System Bus (CH4_SBR)	32	RW	0000_8006h
1_0010h	Channel Priority (CH4_PRI)	32	RW	0000_0000h
1_0020h	TCD Source Address (TCD4_SADDR)	32	RW	0000_0000h
1_0024h	TCD Signed Source Address Offset (TCD4_SOFF)	16	RW	0000h
1_0026h	TCD Transfer Attributes (TCD4_ATTR)	16	RW	0000h
1_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD4_NBYTES_MLOFFNO)	32	RW	0000_0000h
1_0028h	TCD Transfer Size with Minor Loop Offsets (TCD4_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD4_SLAST_SDA)	32	RW	0000_0000h
1_0030h	TCD Destination Address (TCD4_DADDR)	32	RW	0000_0000h
1_0034h	TCD Signed Destination Address Offset (TCD4_DOFF)	16	RW	0000h
1_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD4_CITER_ELINKNO)	16	RW	0000h
1_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD4_CITER_ELINKYES)	16	RW	0000h
1_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD4_DLAST_SGA)	32	RW	0000_0000h
1_003Ch	TCD Control and Status (TCD4_CSR)	16	RW	0000h
1_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD4_BITER_ELINKNO)	16	RW	0000h
1_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD4_BITER_ELINKYES)	16	RW	0000h
1_4000h	Channel Control and Status (CH5_CSR)	32	RW	0000_0000h
1_4004h	Channel Error Status (CH5_ES)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1_4008h	Channel Interrupt Status (CH5_INT)	32	RW	0000_0000h
1_400Ch	Channel System Bus (CH5_SBR)	32	RW	0000_8006h
1_4010h	Channel Priority (CH5_PRI)	32	RW	0000_0000h
1_4020h	TCD Source Address (TCD5_SADDR)	32	RW	0000_0000h
1_4024h	TCD Signed Source Address Offset (TCD5_SOFF)	16	RW	0000h
1_4026h	TCD Transfer Attributes (TCD5_ATTR)	16	RW	0000h
1_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD5_NBYTES_MLOFFNO)	32	RW	0000_0000h
1_4028h	TCD Transfer Size with Minor Loop Offsets (TCD5_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD5_SLAST_SDA)	32	RW	0000_0000h
1_4030h	TCD Destination Address (TCD5_DADDR)	32	RW	0000_0000h
1_4034h	TCD Signed Destination Address Offset (TCD5_DOFF)	16	RW	0000h
1_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD5_CITER_ELINKNO)	16	RW	0000h
1_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD5_CITER_ELINKYES)	16	RW	0000h
1_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD5_DLAST_SGA)	32	RW	0000_0000h
1_403Ch	TCD Control and Status (TCD5_CSR)	16	RW	0000h
1_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD5_BITER_ELINKNO)	16	RW	0000h
1_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD5_BITER_ELINKYES)	16	RW	0000h
1_8000h	Channel Control and Status (CH6_CSR)	32	RW	0000_0000h
1_8004h	Channel Error Status (CH6_ES)	32	RW	0000_0000h
1_8008h	Channel Interrupt Status (CH6_INT)	32	RW	0000_0000h
1_800Ch	Channel System Bus (CH6_SBR)	32	RW	0000_8006h
1_8010h	Channel Priority (CH6_PRI)	32	RW	0000_0000h
1_8020h	TCD Source Address (TCD6_SADDR)	32	RW	0000_0000h
1_8024h	TCD Signed Source Address Offset (TCD6_SOFF)	16	RW	0000h
1_8026h	TCD Transfer Attributes (TCD6_ATTR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
1_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD6_NBYTES_MLOFFNO)	32	RW	0000_0000h
1_8028h	TCD Transfer Size with Minor Loop Offsets (TCD6_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD6_SLAST_SDA)	32	RW	0000_0000h
1_8030h	TCD Destination Address (TCD6_DADDR)	32	RW	0000_0000h
1_8034h	TCD Signed Destination Address Offset (TCD6_DOFF)	16	RW	0000h
1_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD6_CITER_ELINKNO)	16	RW	0000h
1_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD6_CITER_ELINKYES)	16	RW	0000h
1_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD6_DLAST_SGA)	32	RW	0000_0000h
1_803Ch	TCD Control and Status (TCD6_CSR)	16	RW	0000h
1_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD6_BITER_ELINKNO)	16	RW	0000h
1_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD6_BITER_ELINKYES)	16	RW	0000h
1_C000h	Channel Control and Status (CH7_CSR)	32	RW	0000_0000h
1_C004h	Channel Error Status (CH7_ES)	32	RW	0000_0000h
1_C008h	Channel Interrupt Status (CH7_INT)	32	RW	0000_0000h
1_C00Ch	Channel System Bus (CH7_SBR)	32	RW	0000_8006h
1_C010h	Channel Priority (CH7_PRI)	32	RW	0000_0000h
1_C020h	TCD Source Address (TCD7_SADDR)	32	RW	0000_0000h
1_C024h	TCD Signed Source Address Offset (TCD7_SOFF)	16	RW	0000h
1_C026h	TCD Transfer Attributes (TCD7_ATTR)	16	RW	0000h
1_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD7_NBYTES_MLOFFNO)	32	RW	0000_0000h
1_C028h	TCD Transfer Size with Minor Loop Offsets (TCD7_NBYTES_MLOFFYES)	32	RW	0000_0000h
1_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD7_SLAST_SDA)	32	RW	0000_0000h
1_C030h	TCD Destination Address (TCD7_DADDR)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1_C034h	TCD Signed Destination Address Offset (TCD7_DOFF)	16	RW	0000h
1_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD7_CITER_ELINKNO)	16	RW	0000h
1_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD7_CITER_ELINKYES)	16	RW	0000h
1_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD7_DLAST_SGA)	32	RW	0000_0000h
1_C03Ch	TCD Control and Status (TCD7_CSR)	16	RW	0000h
1_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD7_BITER_ELINKNO)	16	RW	0000h
1_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD7_BITER_ELINKYES)	16	RW	0000h
2_0000h	Channel Control and Status (CH8_CSR)	32	RW	0000_0000h
2_0004h	Channel Error Status (CH8_ES)	32	RW	0000_0000h
2_0008h	Channel Interrupt Status (CH8_INT)	32	RW	0000_0000h
2_000Ch	Channel System Bus (CH8_SBR)	32	RW	0000_8006h
2_0010h	Channel Priority (CH8_PRI)	32	RW	0000_0000h
2_0020h	TCD Source Address (TCD8_SADDR)	32	RW	0000_0000h
2_0024h	TCD Signed Source Address Offset (TCD8_SOFF)	16	RW	0000h
2_0026h	TCD Transfer Attributes (TCD8_ATTR)	16	RW	0000h
2_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD8_NBYTES_MLOFFNO)	32	RW	0000_0000h
2_0028h	TCD Transfer Size with Minor Loop Offsets (TCD8_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD8_SLAST_SDA)	32	RW	0000_0000h
2_0030h	TCD Destination Address (TCD8_DADDR)	32	RW	0000_0000h
2_0034h	TCD Signed Destination Address Offset (TCD8_DOFF)	16	RW	0000h
2_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD8_CITER_ELINKNO)	16	RW	0000h
2_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD8_CITER_ELINKYES)	16	RW	0000h
2_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD8_DLAST_SGA)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
2_003Ch	TCD Control and Status (TCD8_CSR)	16	RW	0000h
2_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD8_BITER_ELINKNO)	16	RW	0000h
2_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD8_BITER_ELINKYES)	16	RW	0000h
2_4000h	Channel Control and Status (CH9_CSR)	32	RW	0000_0000h
2_4004h	Channel Error Status (CH9_ES)	32	RW	0000_0000h
2_4008h	Channel Interrupt Status (CH9_INT)	32	RW	0000_0000h
2_400Ch	Channel System Bus (CH9_SBR)	32	RW	0000_8006h
2_4010h	Channel Priority (CH9_PRI)	32	RW	0000_0000h
2_4020h	TCD Source Address (TCD9_SADDR)	32	RW	0000_0000h
2_4024h	TCD Signed Source Address Offset (TCD9_SOFF)	16	RW	0000h
2_4026h	TCD Transfer Attributes (TCD9_ATTR)	16	RW	0000h
2_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD9_NBYTES_MLOFFNO)	32	RW	0000_0000h
2_4028h	TCD Transfer Size with Minor Loop Offsets (TCD9_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD9_SLAST_SDA)	32	RW	0000_0000h
2_4030h	TCD Destination Address (TCD9_DADDR)	32	RW	0000_0000h
2_4034h	TCD Signed Destination Address Offset (TCD9_DOFF)	16	RW	0000h
2_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD9_CITER_ELINKNO)	16	RW	0000h
2_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD9_CITER_ELINKYES)	16	RW	0000h
2_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD9_DLAST_SGA)	32	RW	0000_0000h
2_403Ch	TCD Control and Status (TCD9_CSR)	16	RW	0000h
2_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD9_BITER_ELINKNO)	16	RW	0000h
2_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD9_BITER_ELINKYES)	16	RW	0000h
2_8000h	Channel Control and Status (CH10_CSR)	32	RW	0000_0000h
2_8004h	Channel Error Status (CH10_ES)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
2_8008h	Channel Interrupt Status (CH10_INT)	32	RW	0000_0000h
2_800Ch	Channel System Bus (CH10_SBR)	32	RW	0000_8006h
2_8010h	Channel Priority (CH10_PRI)	32	RW	0000_0000h
2_8020h	TCD Source Address (TCD10_SADDR)	32	RW	0000_0000h
2_8024h	TCD Signed Source Address Offset (TCD10_SOFF)	16	RW	0000h
2_8026h	TCD Transfer Attributes (TCD10_ATTR)	16	RW	0000h
2_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD10_NBYTES_MLOFFNO)	32	RW	0000_0000h
2_8028h	TCD Transfer Size with Minor Loop Offsets (TCD10_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD10_SLAST_SDA)	32	RW	0000_0000h
2_8030h	TCD Destination Address (TCD10_DADDR)	32	RW	0000_0000h
2_8034h	TCD Signed Destination Address Offset (TCD10_DOFF)	16	RW	0000h
2_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD10_CITER_ELINKNO)	16	RW	0000h
2_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD10_CITER_ELINKYES)	16	RW	0000h
2_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD10_DLAST_SGA)	32	RW	0000_0000h
2_803Ch	TCD Control and Status (TCD10_CSR)	16	RW	0000h
2_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD10_BITER_ELINKNO)	16	RW	0000h
2_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD10_BITER_ELINKYES)	16	RW	0000h
2_C000h	Channel Control and Status (CH11_CSR)	32	RW	0000_0000h
2_C004h	Channel Error Status (CH11_ES)	32	RW	0000_0000h
2_C008h	Channel Interrupt Status (CH11_INT)	32	RW	0000_0000h
2_C00Ch	Channel System Bus (CH11_SBR)	32	RW	0000_8006h
2_C010h	Channel Priority (CH11_PRI)	32	RW	0000_0000h
2_C020h	TCD Source Address (TCD11_SADDR)	32	RW	0000_0000h
2_C024h	TCD Signed Source Address Offset (TCD11_SOFF)	16	RW	0000h
2_C026h	TCD Transfer Attributes (TCD11_ATTR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
2_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD11_NBYTES_MLOFFNO)	32	RW	0000_0000h
2_C028h	TCD Transfer Size with Minor Loop Offsets (TCD11_NBYTES_MLOFFYES)	32	RW	0000_0000h
2_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD11_SLAST_SDA)	32	RW	0000_0000h
2_C030h	TCD Destination Address (TCD11_DADDR)	32	RW	0000_0000h
2_C034h	TCD Signed Destination Address Offset (TCD11_DOFF)	16	RW	0000h
2_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD11_CITER_ELINKNO)	16	RW	0000h
2_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD11_CITER_ELINKYES)	16	RW	0000h
2_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD11_DLAST_SGA)	32	RW	0000_0000h
2_C03Ch	TCD Control and Status (TCD11_CSR)	16	RW	0000h
2_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD11_BITER_ELINKNO)	16	RW	0000h
2_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD11_BITER_ELINKYES)	16	RW	0000h
3_0000h	Channel Control and Status (CH12_CSR)	32	RW	0000_0000h
3_0004h	Channel Error Status (CH12_ES)	32	RW	0000_0000h
3_0008h	Channel Interrupt Status (CH12_INT)	32	RW	0000_0000h
3_000Ch	Channel System Bus (CH12_SBR)	32	RW	0000_8006h
3_0010h	Channel Priority (CH12_PRI)	32	RW	0000_0000h
3_0020h	TCD Source Address (TCD12_SADDR)	32	RW	0000_0000h
3_0024h	TCD Signed Source Address Offset (TCD12_SOFF)	16	RW	0000h
3_0026h	TCD Transfer Attributes (TCD12_ATTR)	16	RW	0000h
3_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD12_NBYTES_MLOFFNO)	32	RW	0000_0000h
3_0028h	TCD Transfer Size with Minor Loop Offsets (TCD12_NBYTES_MLOFFYES)	32	RW	0000_0000h
3_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD12_SLAST_SDA)	32	RW	0000_0000h
3_0030h	TCD Destination Address (TCD12_DADDR)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
3_0034h	TCD Signed Destination Address Offset (TCD12_DOFF)	16	RW	0000h
3_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD12_CITER_ELINKNO)	16	RW	0000h
3_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD12_CITER_ELINKYES)	16	RW	0000h
3_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD12_DLAST_SGA)	32	RW	0000_0000h
3_003Ch	TCD Control and Status (TCD12_CSR)	16	RW	0000h
3_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD12_BITER_ELINKNO)	16	RW	0000h
3_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD12_BITER_ELINKYES)	16	RW	0000h
3_4000h	Channel Control and Status (CH13_CSR)	32	RW	0000_0000h
3_4004h	Channel Error Status (CH13_ES)	32	RW	0000_0000h
3_4008h	Channel Interrupt Status (CH13_INT)	32	RW	0000_0000h
3_400Ch	Channel System Bus (CH13_SBR)	32	RW	0000_8006h
3_4010h	Channel Priority (CH13_PRI)	32	RW	0000_0000h
3_4020h	TCD Source Address (TCD13_SADDR)	32	RW	0000_0000h
3_4024h	TCD Signed Source Address Offset (TCD13_SOFF)	16	RW	0000h
3_4026h	TCD Transfer Attributes (TCD13_ATTR)	16	RW	0000h
3_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD13_NBYTES_MLOFFNO)	32	RW	0000_0000h
3_4028h	TCD Transfer Size with Minor Loop Offsets (TCD13_NBYTES_MLOFFYES)	32	RW	0000_0000h
3_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD13_SLAST_SDA)	32	RW	0000_0000h
3_4030h	TCD Destination Address (TCD13_DADDR)	32	RW	0000_0000h
3_4034h	TCD Signed Destination Address Offset (TCD13_DOFF)	16	RW	0000h
3_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD13_CITER_ELINKNO)	16	RW	0000h
3_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD13_CITER_ELINKYES)	16	RW	0000h
3_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD13_DLAST_SGA)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
3_403Ch	TCD Control and Status (TCD13_CSR)	16	RW	0000h
3_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD13_BITER_ELINKNO)	16	RW	0000h
3_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD13_BITER_ELINKYES)	16	RW	0000h
3_8000h	Channel Control and Status (CH14_CSR)	32	RW	0000_0000h
3_8004h	Channel Error Status (CH14_ES)	32	RW	0000_0000h
3_8008h	Channel Interrupt Status (CH14_INT)	32	RW	0000_0000h
3_800Ch	Channel System Bus (CH14_SBR)	32	RW	0000_8006h
3_8010h	Channel Priority (CH14_PRI)	32	RW	0000_0000h
3_8020h	TCD Source Address (TCD14_SADDR)	32	RW	0000_0000h
3_8024h	TCD Signed Source Address Offset (TCD14_SOFF)	16	RW	0000h
3_8026h	TCD Transfer Attributes (TCD14_ATTR)	16	RW	0000h
3_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD14_NBYTES_MLOFFNO)	32	RW	0000_0000h
3_8028h	TCD Transfer Size with Minor Loop Offsets (TCD14_NBYTES_MLOFFYES)	32	RW	0000_0000h
3_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD14_SLAST_SDA)	32	RW	0000_0000h
3_8030h	TCD Destination Address (TCD14_DADDR)	32	RW	0000_0000h
3_8034h	TCD Signed Destination Address Offset (TCD14_DOFF)	16	RW	0000h
3_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD14_CITER_ELINKNO)	16	RW	0000h
3_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD14_CITER_ELINKYES)	16	RW	0000h
3_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD14_DLAST_SGA)	32	RW	0000_0000h
3_803Ch	TCD Control and Status (TCD14_CSR)	16	RW	0000h
3_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD14_BITER_ELINKNO)	16	RW	0000h
3_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD14_BITER_ELINKYES)	16	RW	0000h
3_C000h	Channel Control and Status (CH15_CSR)	32	RW	0000_0000h
3_C004h	Channel Error Status (CH15_ES)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
3_C008h	Channel Interrupt Status (CH15_INT)	32	RW	0000_0000h
3_C00Ch	Channel System Bus (CH15_SBR)	32	RW	0000_8006h
3_C010h	Channel Priority (CH15_PRI)	32	RW	0000_0000h
3_C020h	TCD Source Address (TCD15_SADDR)	32	RW	0000_0000h
3_C024h	TCD Signed Source Address Offset (TCD15_SOFF)	16	RW	0000h
3_C026h	TCD Transfer Attributes (TCD15_ATTR)	16	RW	0000h
3_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD15_NBYTES_MLOFFNO)	32	RW	0000_0000h
3_C028h	TCD Transfer Size with Minor Loop Offsets (TCD15_NBYTES_MLOFFYES)	32	RW	0000_0000h
3_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD15_SLAST_SDA)	32	RW	0000_0000h
3_C030h	TCD Destination Address (TCD15_DADDR)	32	RW	0000_0000h
3_C034h	TCD Signed Destination Address Offset (TCD15_DOFF)	16	RW	0000h
3_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD15_CITER_ELINKNO)	16	RW	0000h
3_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD15_CITER_ELINKYES)	16	RW	0000h
3_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD15_DLAST_SGA)	32	RW	0000_0000h
3_C03Ch	TCD Control and Status (TCD15_CSR)	16	RW	0000h
3_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD15_BITER_ELINKNO)	16	RW	0000h
3_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD15_BITER_ELINKYES)	16	RW	0000h
5E_C000h	Channel Control and Status (CH16_CSR)	32	RW	0000_0000h
5E_C004h	Channel Error Status (CH16_ES)	32	RW	0000_0000h
5E_C008h	Channel Interrupt Status (CH16_INT)	32	RW	0000_0000h
5E_C00Ch	Channel System Bus (CH16_SBR)	32	RW	0000_8006h
5E_C010h	Channel Priority (CH16_PRI)	32	RW	0000_0000h
5E_C020h	TCD Source Address (TCD16_SADDR)	32	RW	0000_0000h
5E_C024h	TCD Signed Source Address Offset (TCD16_SOFF)	16	RW	0000h
5E_C026h	TCD Transfer Attributes (TCD16_ATTR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
5E_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD16_NBYTES_MLOFFNO)	32	RW	0000_0000h
5E_C028h	TCD Transfer Size with Minor Loop Offsets (TCD16_NBYTES_MLOFFYES)	32	RW	0000_0000h
5E_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD16_SLAST_SDA)	32	RW	0000_0000h
5E_C030h	TCD Destination Address (TCD16_DADDR)	32	RW	0000_0000h
5E_C034h	TCD Signed Destination Address Offset (TCD16_DOFF)	16	RW	0000h
5E_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD16_CITER_ELINKNO)	16	RW	0000h
5E_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD16_CITER_ELINKYES)	16	RW	0000h
5E_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD16_DLAST_SGA)	32	RW	0000_0000h
5E_C03Ch	TCD Control and Status (TCD16_CSR)	16	RW	0000h
5E_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD16_BITER_ELINKNO)	16	RW	0000h
5E_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD16_BITER_ELINKYES)	16	RW	0000h
5F_0000h	Channel Control and Status (CH17_CSR)	32	RW	0000_0000h
5F_0004h	Channel Error Status (CH17_ES)	32	RW	0000_0000h
5F_0008h	Channel Interrupt Status (CH17_INT)	32	RW	0000_0000h
5F_000Ch	Channel System Bus (CH17_SBR)	32	RW	0000_8006h
5F_0010h	Channel Priority (CH17_PRI)	32	RW	0000_0000h
5F_0020h	TCD Source Address (TCD17_SADDR)	32	RW	0000_0000h
5F_0024h	TCD Signed Source Address Offset (TCD17_SOFF)	16	RW	0000h
5F_0026h	TCD Transfer Attributes (TCD17_ATTR)	16	RW	0000h
5F_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD17_NBYTES_MLOFFNO)	32	RW	0000_0000h
5F_0028h	TCD Transfer Size with Minor Loop Offsets (TCD17_NBYTES_MLOFFYES)	32	RW	0000_0000h
5F_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD17_SLAST_SDA)	32	RW	0000_0000h
5F_0030h	TCD Destination Address (TCD17_DADDR)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
5F_0034h	TCD Signed Destination Address Offset (TCD17_DOFF)	16	RW	0000h
5F_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD17_CITER_ELINKNO)	16	RW	0000h
5F_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD17_CITER_ELINKYES)	16	RW	0000h
5F_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD17_DLAST_SGA)	32	RW	0000_0000h
5F_003Ch	TCD Control and Status (TCD17_CSR)	16	RW	0000h
5F_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD17_BITER_ELINKNO)	16	RW	0000h
5F_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD17_BITER_ELINKYES)	16	RW	0000h
5F_4000h	Channel Control and Status (CH18_CSR)	32	RW	0000_0000h
5F_4004h	Channel Error Status (CH18_ES)	32	RW	0000_0000h
5F_4008h	Channel Interrupt Status (CH18_INT)	32	RW	0000_0000h
5F_400Ch	Channel System Bus (CH18_SBR)	32	RW	0000_8006h
5F_4010h	Channel Priority (CH18_PRI)	32	RW	0000_0000h
5F_4020h	TCD Source Address (TCD18_SADDR)	32	RW	0000_0000h
5F_4024h	TCD Signed Source Address Offset (TCD18_SOFF)	16	RW	0000h
5F_4026h	TCD Transfer Attributes (TCD18_ATTR)	16	RW	0000h
5F_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD18_NBYTES_MLOFFNO)	32	RW	0000_0000h
5F_4028h	TCD Transfer Size with Minor Loop Offsets (TCD18_NBYTES_MLOFFYES)	32	RW	0000_0000h
5F_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD18_SLAST_SDA)	32	RW	0000_0000h
5F_4030h	TCD Destination Address (TCD18_DADDR)	32	RW	0000_0000h
5F_4034h	TCD Signed Destination Address Offset (TCD18_DOFF)	16	RW	0000h
5F_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD18_CITER_ELINKNO)	16	RW	0000h
5F_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD18_CITER_ELINKYES)	16	RW	0000h
5F_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD18_DLAST_SGA)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
5F_403Ch	TCD Control and Status (TCD18_CSR)	16	RW	0000h
5F_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD18_BITER_ELINKNO)	16	RW	0000h
5F_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD18_BITER_ELINKYES)	16	RW	0000h
5F_8000h	Channel Control and Status (CH19_CSR)	32	RW	0000_0000h
5F_8004h	Channel Error Status (CH19_ES)	32	RW	0000_0000h
5F_8008h	Channel Interrupt Status (CH19_INT)	32	RW	0000_0000h
5F_800Ch	Channel System Bus (CH19_SBR)	32	RW	0000_8006h
5F_8010h	Channel Priority (CH19_PRI)	32	RW	0000_0000h
5F_8020h	TCD Source Address (TCD19_SADDR)	32	RW	0000_0000h
5F_8024h	TCD Signed Source Address Offset (TCD19_SOFF)	16	RW	0000h
5F_8026h	TCD Transfer Attributes (TCD19_ATTR)	16	RW	0000h
5F_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD19_NBYTES_MLOFFNO)	32	RW	0000_0000h
5F_8028h	TCD Transfer Size with Minor Loop Offsets (TCD19_NBYTES_MLOFFYES)	32	RW	0000_0000h
5F_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD19_SLAST_SDA)	32	RW	0000_0000h
5F_8030h	TCD Destination Address (TCD19_DADDR)	32	RW	0000_0000h
5F_8034h	TCD Signed Destination Address Offset (TCD19_DOFF)	16	RW	0000h
5F_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD19_CITER_ELINKNO)	16	RW	0000h
5F_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD19_CITER_ELINKYES)	16	RW	0000h
5F_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD19_DLAST_SGA)	32	RW	0000_0000h
5F_803Ch	TCD Control and Status (TCD19_CSR)	16	RW	0000h
5F_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD19_BITER_ELINKNO)	16	RW	0000h
5F_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD19_BITER_ELINKYES)	16	RW	0000h
5F_C000h	Channel Control and Status (CH20_CSR)	32	RW	0000_0000h
5F_C004h	Channel Error Status (CH20_ES)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
5F_C008h	Channel Interrupt Status (CH20_INT)	32	RW	0000_0000h
5F_C00Ch	Channel System Bus (CH20_SBR)	32	RW	0000_8006h
5F_C010h	Channel Priority (CH20_PRI)	32	RW	0000_0000h
5F_C020h	TCD Source Address (TCD20_SADDR)	32	RW	0000_0000h
5F_C024h	TCD Signed Source Address Offset (TCD20_SOFF)	16	RW	0000h
5F_C026h	TCD Transfer Attributes (TCD20_ATTR)	16	RW	0000h
5F_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD20_NBYTES_MLOFFNO)	32	RW	0000_0000h
5F_C028h	TCD Transfer Size with Minor Loop Offsets (TCD20_NBYTES_MLOFFYES)	32	RW	0000_0000h
5F_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD20_SLAST_SDA)	32	RW	0000_0000h
5F_C030h	TCD Destination Address (TCD20_DADDR)	32	RW	0000_0000h
5F_C034h	TCD Signed Destination Address Offset (TCD20_DOFF)	16	RW	0000h
5F_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD20_CITER_ELINKNO)	16	RW	0000h
5F_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD20_CITER_ELINKYES)	16	RW	0000h
5F_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD20_DLAST_SGA)	32	RW	0000_0000h
5F_C03Ch	TCD Control and Status (TCD20_CSR)	16	RW	0000h
5F_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD20_BITER_ELINKNO)	16	RW	0000h
5F_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD20_BITER_ELINKYES)	16	RW	0000h
60_0000h	Channel Control and Status (CH21_CSR)	32	RW	0000_0000h
60_0004h	Channel Error Status (CH21_ES)	32	RW	0000_0000h
60_0008h	Channel Interrupt Status (CH21_INT)	32	RW	0000_0000h
60_000Ch	Channel System Bus (CH21_SBR)	32	RW	0000_8006h
60_0010h	Channel Priority (CH21_PRI)	32	RW	0000_0000h
60_0020h	TCD Source Address (TCD21_SADDR)	32	RW	0000_0000h
60_0024h	TCD Signed Source Address Offset (TCD21_SOFF)	16	RW	0000h
60_0026h	TCD Transfer Attributes (TCD21_ATTR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
60_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD21_NBYTES_MLOFFNO)	32	RW	0000_0000h
60_0028h	TCD Transfer Size with Minor Loop Offsets (TCD21_NBYTES_MLOFFYES)	32	RW	0000_0000h
60_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD21_SLAST_SDA)	32	RW	0000_0000h
60_0030h	TCD Destination Address (TCD21_DADDR)	32	RW	0000_0000h
60_0034h	TCD Signed Destination Address Offset (TCD21_DOFF)	16	RW	0000h
60_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD21_CITER_ELINKNO)	16	RW	0000h
60_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD21_CITER_ELINKYES)	16	RW	0000h
60_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD21_DLAST_SGA)	32	RW	0000_0000h
60_003Ch	TCD Control and Status (TCD21_CSR)	16	RW	0000h
60_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD21_BITER_ELINKNO)	16	RW	0000h
60_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD21_BITER_ELINKYES)	16	RW	0000h
60_4000h	Channel Control and Status (CH22_CSR)	32	RW	0000_0000h
60_4004h	Channel Error Status (CH22_ES)	32	RW	0000_0000h
60_4008h	Channel Interrupt Status (CH22_INT)	32	RW	0000_0000h
60_400Ch	Channel System Bus (CH22_SBR)	32	RW	0000_8006h
60_4010h	Channel Priority (CH22_PRI)	32	RW	0000_0000h
60_4020h	TCD Source Address (TCD22_SADDR)	32	RW	0000_0000h
60_4024h	TCD Signed Source Address Offset (TCD22_SOFF)	16	RW	0000h
60_4026h	TCD Transfer Attributes (TCD22_ATTR)	16	RW	0000h
60_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD22_NBYTES_MLOFFNO)	32	RW	0000_0000h
60_4028h	TCD Transfer Size with Minor Loop Offsets (TCD22_NBYTES_MLOFFYES)	32	RW	0000_0000h
60_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD22_SLAST_SDA)	32	RW	0000_0000h
60_4030h	TCD Destination Address (TCD22_DADDR)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
60_4034h	TCD Signed Destination Address Offset (TCD22_DOFF)	16	RW	0000h
60_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD22_CITER_ELINKNO)	16	RW	0000h
60_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD22_CITER_ELINKYES)	16	RW	0000h
60_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD22_DLAST_SGA)	32	RW	0000_0000h
60_403Ch	TCD Control and Status (TCD22_CSR)	16	RW	0000h
60_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD22_BITER_ELINKNO)	16	RW	0000h
60_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD22_BITER_ELINKYES)	16	RW	0000h
60_8000h	Channel Control and Status (CH23_CSR)	32	RW	0000_0000h
60_8004h	Channel Error Status (CH23_ES)	32	RW	0000_0000h
60_8008h	Channel Interrupt Status (CH23_INT)	32	RW	0000_0000h
60_800Ch	Channel System Bus (CH23_SBR)	32	RW	0000_8006h
60_8010h	Channel Priority (CH23_PRI)	32	RW	0000_0000h
60_8020h	TCD Source Address (TCD23_SADDR)	32	RW	0000_0000h
60_8024h	TCD Signed Source Address Offset (TCD23_SOFF)	16	RW	0000h
60_8026h	TCD Transfer Attributes (TCD23_ATTR)	16	RW	0000h
60_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD23_NBYTES_MLOFFNO)	32	RW	0000_0000h
60_8028h	TCD Transfer Size with Minor Loop Offsets (TCD23_NBYTES_MLOFFYES)	32	RW	0000_0000h
60_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD23_SLAST_SDA)	32	RW	0000_0000h
60_8030h	TCD Destination Address (TCD23_DADDR)	32	RW	0000_0000h
60_8034h	TCD Signed Destination Address Offset (TCD23_DOFF)	16	RW	0000h
60_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD23_CITER_ELINKNO)	16	RW	0000h
60_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD23_CITER_ELINKYES)	16	RW	0000h
60_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD23_DLAST_SGA)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
60_803Ch	TCD Control and Status (TCD23_CSR)	16	RW	0000h
60_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD23_BITER_ELINKNO)	16	RW	0000h
60_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD23_BITER_ELINKYES)	16	RW	0000h
60_C000h	Channel Control and Status (CH24_CSR)	32	RW	0000_0000h
60_C004h	Channel Error Status (CH24_ES)	32	RW	0000_0000h
60_C008h	Channel Interrupt Status (CH24_INT)	32	RW	0000_0000h
60_C00Ch	Channel System Bus (CH24_SBR)	32	RW	0000_8006h
60_C010h	Channel Priority (CH24_PRI)	32	RW	0000_0000h
60_C020h	TCD Source Address (TCD24_SADDR)	32	RW	0000_0000h
60_C024h	TCD Signed Source Address Offset (TCD24_SOFF)	16	RW	0000h
60_C026h	TCD Transfer Attributes (TCD24_ATTR)	16	RW	0000h
60_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD24_NBYTES_MLOFFNO)	32	RW	0000_0000h
60_C028h	TCD Transfer Size with Minor Loop Offsets (TCD24_NBYTES_MLOFFYES)	32	RW	0000_0000h
60_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD24_SLAST_SDA)	32	RW	0000_0000h
60_C030h	TCD Destination Address (TCD24_DADDR)	32	RW	0000_0000h
60_C034h	TCD Signed Destination Address Offset (TCD24_DOFF)	16	RW	0000h
60_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD24_CITER_ELINKNO)	16	RW	0000h
60_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD24_CITER_ELINKYES)	16	RW	0000h
60_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD24_DLAST_SGA)	32	RW	0000_0000h
60_C03Ch	TCD Control and Status (TCD24_CSR)	16	RW	0000h
60_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD24_BITER_ELINKNO)	16	RW	0000h
60_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD24_BITER_ELINKYES)	16	RW	0000h
61_0000h	Channel Control and Status (CH25_CSR)	32	RW	0000_0000h
61_0004h	Channel Error Status (CH25_ES)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
61_0008h	Channel Interrupt Status (CH25_INT)	32	RW	0000_0000h
61_000Ch	Channel System Bus (CH25_SBR)	32	RW	0000_8006h
61_0010h	Channel Priority (CH25_PRI)	32	RW	0000_0000h
61_0020h	TCD Source Address (TCD25_SADDR)	32	RW	0000_0000h
61_0024h	TCD Signed Source Address Offset (TCD25_SOFF)	16	RW	0000h
61_0026h	TCD Transfer Attributes (TCD25_ATTR)	16	RW	0000h
61_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD25_NBYTES_MLOFFNO)	32	RW	0000_0000h
61_0028h	TCD Transfer Size with Minor Loop Offsets (TCD25_NBYTES_MLOFFYES)	32	RW	0000_0000h
61_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD25_SLAST_SDA)	32	RW	0000_0000h
61_0030h	TCD Destination Address (TCD25_DADDR)	32	RW	0000_0000h
61_0034h	TCD Signed Destination Address Offset (TCD25_DOFF)	16	RW	0000h
61_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD25_CITER_ELINKNO)	16	RW	0000h
61_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD25_CITER_ELINKYES)	16	RW	0000h
61_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD25_DLAST_SGA)	32	RW	0000_0000h
61_003Ch	TCD Control and Status (TCD25_CSR)	16	RW	0000h
61_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD25_BITER_ELINKNO)	16	RW	0000h
61_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD25_BITER_ELINKYES)	16	RW	0000h
61_4000h	Channel Control and Status (CH26_CSR)	32	RW	0000_0000h
61_4004h	Channel Error Status (CH26_ES)	32	RW	0000_0000h
61_4008h	Channel Interrupt Status (CH26_INT)	32	RW	0000_0000h
61_400Ch	Channel System Bus (CH26_SBR)	32	RW	0000_8006h
61_4010h	Channel Priority (CH26_PRI)	32	RW	0000_0000h
61_4020h	TCD Source Address (TCD26_SADDR)	32	RW	0000_0000h
61_4024h	TCD Signed Source Address Offset (TCD26_SOFF)	16	RW	0000h
61_4026h	TCD Transfer Attributes (TCD26_ATTR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
61_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD26_NBYTES_MLOFFNO)	32	RW	0000_0000h
61_4028h	TCD Transfer Size with Minor Loop Offsets (TCD26_NBYTES_MLOFFYES)	32	RW	0000_0000h
61_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD26_SLAST_SDA)	32	RW	0000_0000h
61_4030h	TCD Destination Address (TCD26_DADDR)	32	RW	0000_0000h
61_4034h	TCD Signed Destination Address Offset (TCD26_DOFF)	16	RW	0000h
61_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD26_CITER_ELINKNO)	16	RW	0000h
61_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD26_CITER_ELINKYES)	16	RW	0000h
61_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD26_DLAST_SGA)	32	RW	0000_0000h
61_403Ch	TCD Control and Status (TCD26_CSR)	16	RW	0000h
61_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD26_BITER_ELINKNO)	16	RW	0000h
61_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD26_BITER_ELINKYES)	16	RW	0000h
61_8000h	Channel Control and Status (CH27_CSR)	32	RW	0000_0000h
61_8004h	Channel Error Status (CH27_ES)	32	RW	0000_0000h
61_8008h	Channel Interrupt Status (CH27_INT)	32	RW	0000_0000h
61_800Ch	Channel System Bus (CH27_SBR)	32	RW	0000_8006h
61_8010h	Channel Priority (CH27_PRI)	32	RW	0000_0000h
61_8020h	TCD Source Address (TCD27_SADDR)	32	RW	0000_0000h
61_8024h	TCD Signed Source Address Offset (TCD27_SOFF)	16	RW	0000h
61_8026h	TCD Transfer Attributes (TCD27_ATTR)	16	RW	0000h
61_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD27_NBYTES_MLOFFNO)	32	RW	0000_0000h
61_8028h	TCD Transfer Size with Minor Loop Offsets (TCD27_NBYTES_MLOFFYES)	32	RW	0000_0000h
61_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD27_SLAST_SDA)	32	RW	0000_0000h
61_8030h	TCD Destination Address (TCD27_DADDR)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
61_8034h	TCD Signed Destination Address Offset (TCD27_DOFF)	16	RW	0000h
61_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD27_CITER_ELINKNO)	16	RW	0000h
61_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD27_CITER_ELINKYES)	16	RW	0000h
61_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD27_DLAST_SGA)	32	RW	0000_0000h
61_803Ch	TCD Control and Status (TCD27_CSR)	16	RW	0000h
61_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD27_BITER_ELINKNO)	16	RW	0000h
61_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD27_BITER_ELINKYES)	16	RW	0000h
61_C000h	Channel Control and Status (CH28_CSR)	32	RW	0000_0000h
61_C004h	Channel Error Status (CH28_ES)	32	RW	0000_0000h
61_C008h	Channel Interrupt Status (CH28_INT)	32	RW	0000_0000h
61_C00Ch	Channel System Bus (CH28_SBR)	32	RW	0000_8006h
61_C010h	Channel Priority (CH28_PRI)	32	RW	0000_0000h
61_C020h	TCD Source Address (TCD28_SADDR)	32	RW	0000_0000h
61_C024h	TCD Signed Source Address Offset (TCD28_SOFF)	16	RW	0000h
61_C026h	TCD Transfer Attributes (TCD28_ATTR)	16	RW	0000h
61_C028h	TCD Transfer Size Without Minor Loop Offsets (TCD28_NBYTES_MLOFFNO)	32	RW	0000_0000h
61_C028h	TCD Transfer Size with Minor Loop Offsets (TCD28_NBYTES_MLOFFYES)	32	RW	0000_0000h
61_C02Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD28_SLAST_SDA)	32	RW	0000_0000h
61_C030h	TCD Destination Address (TCD28_DADDR)	32	RW	0000_0000h
61_C034h	TCD Signed Destination Address Offset (TCD28_DOFF)	16	RW	0000h
61_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD28_CITER_ELINKNO)	16	RW	0000h
61_C036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD28_CITER_ELINKYES)	16	RW	0000h
61_C038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD28_DLAST_SGA)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
61_C03Ch	TCD Control and Status (TCD28_CSR)	16	RW	0000h
61_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD28_BITER_ELINKNO)	16	RW	0000h
61_C03Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD28_BITER_ELINKYES)	16	RW	0000h
62_0000h	Channel Control and Status (CH29_CSR)	32	RW	0000_0000h
62_0004h	Channel Error Status (CH29_ES)	32	RW	0000_0000h
62_0008h	Channel Interrupt Status (CH29_INT)	32	RW	0000_0000h
62_000Ch	Channel System Bus (CH29_SBR)	32	RW	0000_8006h
62_0010h	Channel Priority (CH29_PRI)	32	RW	0000_0000h
62_0020h	TCD Source Address (TCD29_SADDR)	32	RW	0000_0000h
62_0024h	TCD Signed Source Address Offset (TCD29_SOFF)	16	RW	0000h
62_0026h	TCD Transfer Attributes (TCD29_ATTR)	16	RW	0000h
62_0028h	TCD Transfer Size Without Minor Loop Offsets (TCD29_NBYTES_MLOFFNO)	32	RW	0000_0000h
62_0028h	TCD Transfer Size with Minor Loop Offsets (TCD29_NBYTES_MLOFFYES)	32	RW	0000_0000h
62_002Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD29_SLAST_SDA)	32	RW	0000_0000h
62_0030h	TCD Destination Address (TCD29_DADDR)	32	RW	0000_0000h
62_0034h	TCD Signed Destination Address Offset (TCD29_DOFF)	16	RW	0000h
62_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD29_CITER_ELINKNO)	16	RW	0000h
62_0036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD29_CITER_ELINKYES)	16	RW	0000h
62_0038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD29_DLAST_SGA)	32	RW	0000_0000h
62_003Ch	TCD Control and Status (TCD29_CSR)	16	RW	0000h
62_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD29_BITER_ELINKNO)	16	RW	0000h
62_003Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD29_BITER_ELINKYES)	16	RW	0000h
62_4000h	Channel Control and Status (CH30_CSR)	32	RW	0000_0000h
62_4004h	Channel Error Status (CH30_ES)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
62_4008h	Channel Interrupt Status (CH30_INT)	32	RW	0000_0000h
62_400Ch	Channel System Bus (CH30_SBR)	32	RW	0000_8006h
62_4010h	Channel Priority (CH30_PRI)	32	RW	0000_0000h
62_4020h	TCD Source Address (TCD30_SADDR)	32	RW	0000_0000h
62_4024h	TCD Signed Source Address Offset (TCD30_SOFF)	16	RW	0000h
62_4026h	TCD Transfer Attributes (TCD30_ATTR)	16	RW	0000h
62_4028h	TCD Transfer Size Without Minor Loop Offsets (TCD30_NBYTES_MLOFFNO)	32	RW	0000_0000h
62_4028h	TCD Transfer Size with Minor Loop Offsets (TCD30_NBYTES_MLOFFYES)	32	RW	0000_0000h
62_402Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD30_SLAST_SDA)	32	RW	0000_0000h
62_4030h	TCD Destination Address (TCD30_DADDR)	32	RW	0000_0000h
62_4034h	TCD Signed Destination Address Offset (TCD30_DOFF)	16	RW	0000h
62_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD30_CITER_ELINKNO)	16	RW	0000h
62_4036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD30_CITER_ELINKYES)	16	RW	0000h
62_4038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD30_DLAST_SGA)	32	RW	0000_0000h
62_403Ch	TCD Control and Status (TCD30_CSR)	16	RW	0000h
62_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD30_BITER_ELINKNO)	16	RW	0000h
62_403Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD30_BITER_ELINKYES)	16	RW	0000h
62_8000h	Channel Control and Status (CH31_CSR)	32	RW	0000_0000h
62_8004h	Channel Error Status (CH31_ES)	32	RW	0000_0000h
62_8008h	Channel Interrupt Status (CH31_INT)	32	RW	0000_0000h
62_800Ch	Channel System Bus (CH31_SBR)	32	RW	0000_8006h
62_8010h	Channel Priority (CH31_PRI)	32	RW	0000_0000h
62_8020h	TCD Source Address (TCD31_SADDR)	32	RW	0000_0000h
62_8024h	TCD Signed Source Address Offset (TCD31_SOFF)	16	RW	0000h
62_8026h	TCD Transfer Attributes (TCD31_ATTR)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
62_8028h	TCD Transfer Size Without Minor Loop Offsets (TCD31_NBYTES_MLOFFNO)	32	RW	0000_0000h
62_8028h	TCD Transfer Size with Minor Loop Offsets (TCD31_NBYTES_MLOFFYES)	32	RW	0000_0000h
62_802Ch	TCD Last Source Address Adjustment / Store DADDR Address (TCD31_SLAST_SDA)	32	RW	0000_0000h
62_8030h	TCD Destination Address (TCD31_DADDR)	32	RW	0000_0000h
62_8034h	TCD Signed Destination Address Offset (TCD31_DOFF)	16	RW	0000h
62_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD31_CITER_ELINKNO)	16	RW	0000h
62_8036h	TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD31_CITER_ELINKYES)	16	RW	0000h
62_8038h	TCD Last Destination Address Adjustment / Scatter Gather Address (TCD31_DLAST_SGA)	32	RW	0000_0000h
62_803Ch	TCD Control and Status (TCD31_CSR)	16	RW	0000h
62_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD31_BITER_ELINKNO)	16	RW	0000h
62_803Eh	TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD31_BITER_ELINKYES)	16	RW	0000h

14.6.3.2 Channel Control and Status (CH0_CSR - CH31_CSR)

Offset

Register	Offset
CH0_CSR	0h
CH1_CSR	4000h
CH2_CSR	8000h
CH3_CSR	C000h
CH4_CSR	1_0000h
CH5_CSR	1_4000h
CH6_CSR	1_8000h
CH7_CSR	1_C000h
CH8_CSR	2_0000h

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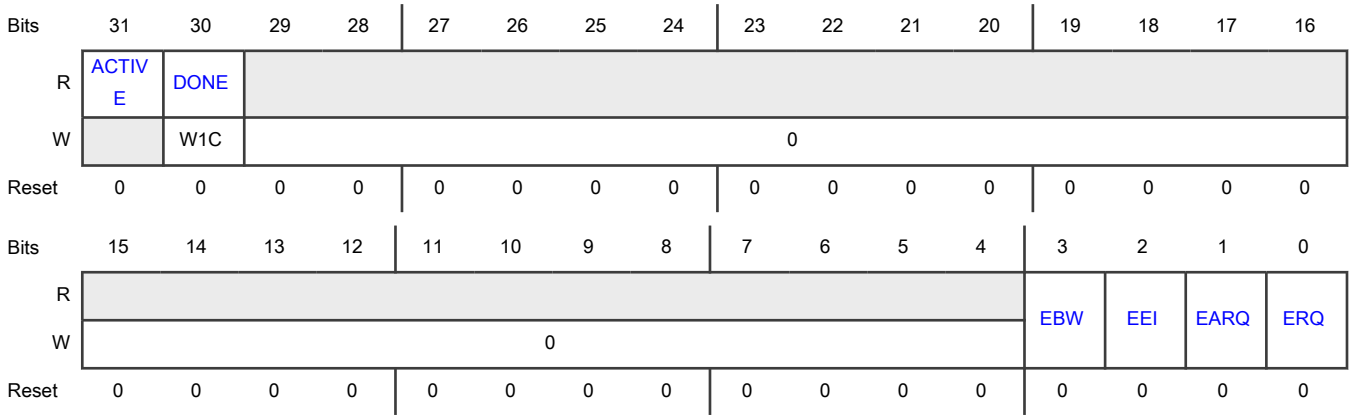
Register	Offset
CH9_CSR	2_4000h
CH10_CSR	2_8000h
CH11_CSR	2_C000h
CH12_CSR	3_0000h
CH13_CSR	3_4000h
CH14_CSR	3_8000h
CH15_CSR	3_C000h
CH16_CSR	5E_C000h
CH17_CSR	5F_0000h
CH18_CSR	5F_4000h
CH19_CSR	5F_8000h
CH20_CSR	5F_C000h
CH21_CSR	60_0000h
CH22_CSR	60_4000h
CH23_CSR	60_8000h
CH24_CSR	60_C000h
CH25_CSR	61_0000h
CH26_CSR	61_4000h
CH27_CSR	61_8000h
CH28_CSR	61_C000h
CH29_CSR	62_0000h
CH30_CSR	62_4000h
CH31_CSR	62_8000h

Function

This register contains several fields related to hardware and interrupt requests, configuration, and status for the given channel.

Diagram



Fields

Field	Function
31 ACTIVE	Channel Active The ACTIVE field indicates the channel was selected by arbitration and is executing the prescribed transfers. The eDMA sets it to 1 when channel service begins, and clears it to 0 as the minor loop completes or when any error condition is detected. Except for dynamic scatter/gather or dynamic channel linking, you must not modify the transfer control descriptor when a channel is active.
30 DONE	Channel Done The DONE field indicates the eDMA has completed the major loop. The eDMA engine sets this field as the CITER count reaches zero. If enabled, the eDMA generates an interrupt request corresponding to this completed channel. The software clears it, or the hardware clears it when the channel is activated. **NOTE** This field must be cleared to 0 before writing the MAJORELINK or ESG fields.
29-4 —	Reserved
3 EBW	Enable Buffered Writes When buffered writes are enabled, all writes except for the last write sequence of the minor loop are signaled by the eDMA as bufferable. 0b - Buffered writes on system bus disabled. Buffered writes on system bus disabled 1b - Buffered writes on system bus enabled. Bufferable write signal asserted on all system bus writes except during last write sequence
2 EEI	Enable Error Interrupt The EEI field enables the error interrupt signal for the channel. The DMA error indicator and the error interrupt enable flag must be asserted before an error interrupt request for a given channel is asserted to the interrupt controller. 0b - Error signal for corresponding channel does not generate error interrupt

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Field	Function
	1b - Assertion of error signal for corresponding channel generates error interrupt request
1 EARQ	Enable Asynchronous DMA Request In Stop Mode For Channel The enable asynchronous DMA request field (EARQ) does not affect DMA operations. When set to 1, this field allows the hardware service request enable field (ERQ) to propagate out of the DMA to the power controller. When cleared to 0, this field masks the hardware service request enable field to the power controller. 0b - Disable asynchronous DMA request for the channel 1b - Enable asynchronous DMA request for the channel
0 ERQ	Enable DMA Request Disable a channel's hardware service request at the source before clearing the channel's ERQ field. The DMA hardware request input signal and the enable request field (ERQ) must be asserted before a channel's hardware service request is accepted. The state of the eDMA enable request field does not affect a channel service request made explicitly through software or channel linking. The state of the ERQ field does not affect the channel's START field. 0b - DMA hardware request signal for corresponding channel disabled 1b - DMA hardware request signal for corresponding channel enabled

14.6.3.3 Channel Error Status (CH0_ES - CH31_ES)

Offset

Register	Offset
CH0_ES	4h
CH1_ES	4004h
CH2_ES	8004h
CH3_ES	C004h
CH4_ES	1_0004h
CH5_ES	1_4004h
CH6_ES	1_8004h
CH7_ES	1_C004h
CH8_ES	2_0004h
CH9_ES	2_4004h
CH10_ES	2_8004h
CH11_ES	2_C004h
CH12_ES	3_0004h

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Register	Offset
CH13_ES	3_4004h
CH14_ES	3_8004h
CH15_ES	3_C004h
CH16_ES	5E_C004h
CH17_ES	5F_0004h
CH18_ES	5F_4004h
CH19_ES	5F_8004h
CH20_ES	5F_C004h
CH21_ES	60_0004h
CH22_ES	60_4004h
CH23_ES	60_8004h
CH24_ES	60_C004h
CH25_ES	61_0004h
CH26_ES	61_4004h
CH27_ES	61_8004h
CH28_ES	61_C004h
CH29_ES	62_0004h
CH30_ES	62_4004h
CH31_ES	62_8004h

Function

The ES provides information concerning the last recorded channel error. Channel errors can be caused by:

- An illegal setting in the transfer control descriptor
- An error termination to a bus master read or write cycle

The ERR field signals the presence of an error for the channel. The eDMA engine signals the occurrence of an error condition by setting the appropriate field in this register. The outputs of this register are enabled by the contents of the CHn_CSR[EEI] field, then logically summed across all channels to form an error interrupt request, which may be routed to the interrupt controller. In addition, this enabled error status is logically OR'd onto the channel done interrupt, CHn_INT[INT], thus forming a done or error interrupt on a per channel basis.

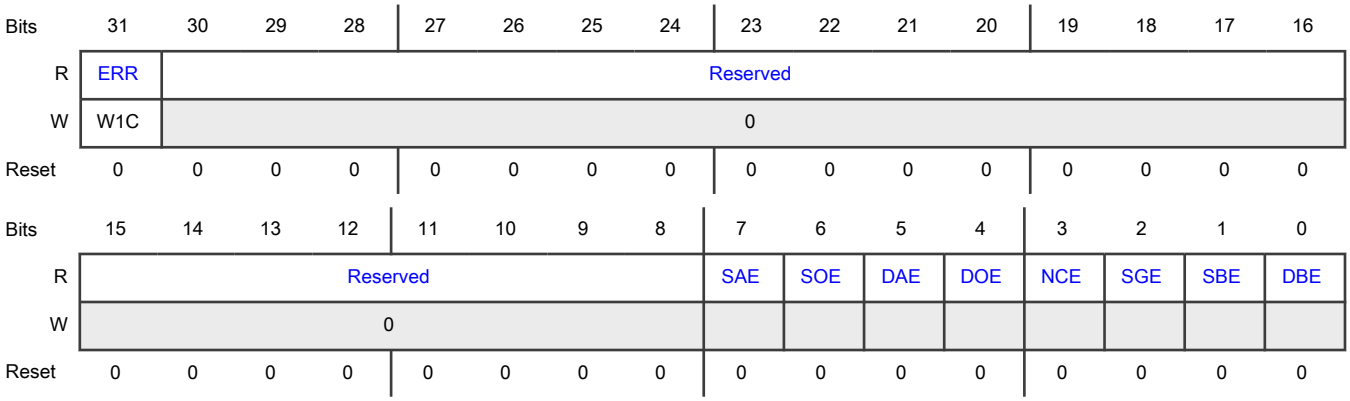
During the execution of the interrupt service routine associated with any DMA errors, it is software's responsibility to clear the appropriate bit, negating the error-interrupt request. The normal DMA channel completion indicators (setting the transfer control descriptor DONE flag and the possible assertion of an interrupt request) are not affected when eDMA detects an error. The contents of this ERR register field can also be polled because a non-zero value indicates the presence of a channel error, regardless of the state of the EEI mask.

The state of any given channel's error indicators is affected by writes to this register. Writing a 1 to the ERR field clears the channel's error status, and writing a 0 has no effect.

An unspecified error, where only the ERR field is set to 1, indicates that either a transfer was cancelled with an error or else an uncorrectable TCD error occurred. The Management Page Error Status register has full view of the error condition.

See Fault reporting and handling for more details.

Diagram



Fields

Field	Function
31 ERR	Error In Channel 0b - An error in this channel has not occurred 1b - An error in this channel has occurred
30-8 —	Reserved
7 SAE	Source Address Error TCDn_SADDR is inconsistent with TCDn_ATTR[SSIZE]. 0b - No source address configuration error 1b - Last recorded error was a configuration error detected in the TCDn_SADDR field
6 SOE	Source Offset Error TCDn_SOFF is inconsistent with TCDn_ATTR[SSIZE]. 0b - No source offset configuration error 1b - Last recorded error was a configuration error detected in the TCDn_SOFF field
5 DAE	Destination Address Error TCDn_DADDR is inconsistent with TCDn_ATTR[DSIZE]. 0b - No destination address configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DADDR field
4	Destination Offset Error TCDn_DOFF is inconsistent with TCDn_ATTR[DSIZE].

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Field	Function
DOE	0b - No destination offset configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DOFF field
3 NCE	NBYTES/CITER Configuration Error This error indicates that one of the following has occurred: • TCDn_NBYTES is not a multiple of TCDn_ATTR[SSIZE] and TCDn_ATTR[DSIZE] • TCDn_CITER[CITER] is equal to zero • TCDn_CITER[ELINK] is not equal to TCDn_BITER[ELINK] 0b - No NBYTES/CITER configuration error 1b - Last recorded error was a configuration error detected in the TCDn_NBYTES or TCDn_CITER fields
2 SGE	Scatter/Gather Configuration Error When this field is 1, it indicates that TCDn_DLAST_SGA is not on a 32-byte boundary. This field is checked at the beginning of a scatter/gather operation after major loop completion if TCDn_CSR[ESG]is enabled. 0b - No scatter/gather configuration error 1b - Last recorded error was a configuration error detected in the TCDn_DLAST_SGA field
1 SBE	Source Bus Error 0b - No source bus error 1b - Last recorded error was bus error on source read
0 DBE	Destination Bus Error 0b - No destination bus error 1b - Last recorded error was bus error on destination write

14.6.3.4 Channel Interrupt Status (CH0_INT - CH31_INT)

Offset

Register	Offset
CH0_INT	8h
CH1_INT	4008h
CH2_INT	8008h
CH3_INT	C008h
CH4_INT	1_0008h
CH5_INT	1_4008h

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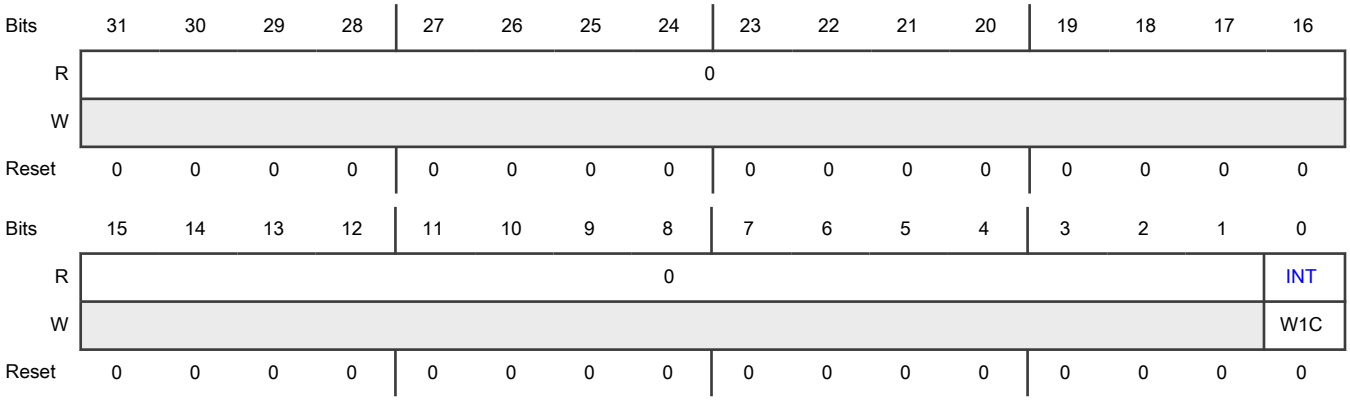
Register	Offset
CH6_INT	1_8008h
CH7_INT	1_C008h
CH8_INT	2_0008h
CH9_INT	2_4008h
CH10_INT	2_8008h
CH11_INT	2_C008h
CH12_INT	3_0008h
CH13_INT	3_4008h
CH14_INT	3_8008h
CH15_INT	3_C008h
CH16_INT	5E_C008h
CH17_INT	5F_0008h
CH18_INT	5F_4008h
CH19_INT	5F_8008h
CH20_INT	5F_C008h
CH21_INT	60_0008h
CH22_INT	60_4008h
CH23_INT	60_8008h
CH24_INT	60_C008h
CH25_INT	61_0008h
CH26_INT	61_4008h
CH27_INT	61_8008h
CH28_INT	61_C008h
CH29_INT	62_0008h
CH30_INT	62_4008h
CH31_INT	62_8008h

Function

The INT field signals the presence of an interrupt request for the channel. Depending on the appropriate bit setting in the transfer control descriptors, the eDMA engine generates an interrupt on data transfer completion or an error condition.

The outputs of this register are directly routed to the interrupt controller. During the interrupt service routine associated with any given channel, it is the software's responsibility to clear the appropriate bit, negating the interrupt request. On writes to INT, a 1 clears the channel's interrupt request. A zero has no effect on the channel's current interrupt status.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 INT	Interrupt Request 0b - Interrupt request for corresponding channel cleared 1b - Interrupt request for corresponding channel active

14.6.3.5 Channel System Bus (CH0_SBR - CH31_SBR)

Offset

Register	Offset
CH0_SBR	Ch
CH1_SBR	400Ch
CH2_SBR	800Ch
CH3_SBR	C00Ch
CH4_SBR	1_000Ch
CH5_SBR	1_400Ch
CH6_SBR	1_800Ch
CH7_SBR	1_C00Ch
CH8_SBR	2_000Ch
CH9_SBR	2_400Ch
CH10_SBR	2_800Ch
CH11_SBR	2_C00Ch

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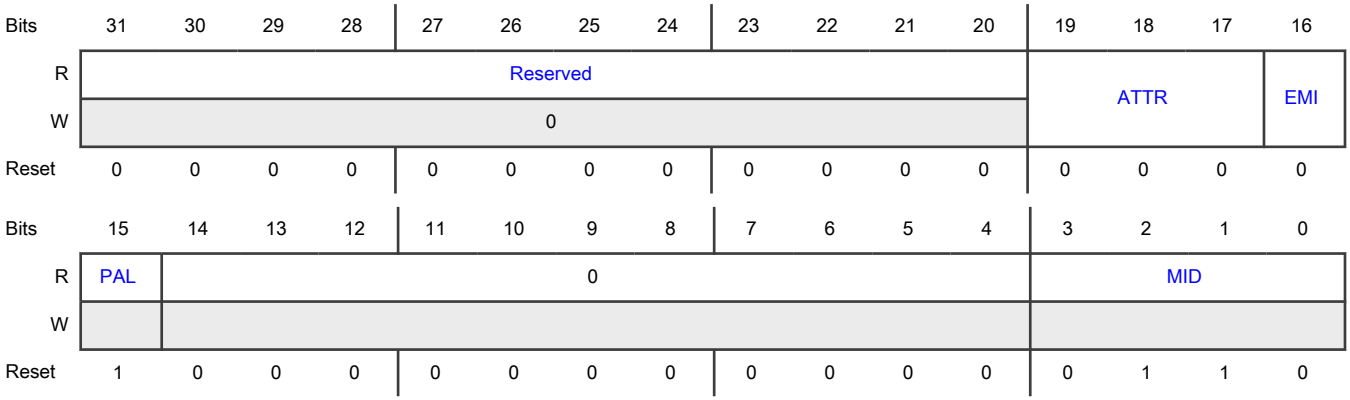
Register	Offset
CH12_SBR	3_000Ch
CH13_SBR	3_400Ch
CH14_SBR	3_800Ch
CH15_SBR	3_C00Ch
CH16_SBR	5E_C00Ch
CH17_SBR	5F_000Ch
CH18_SBR	5F_400Ch
CH19_SBR	5F_800Ch
CH20_SBR	5F_C00Ch
CH21_SBR	60_000Ch
CH22_SBR	60_400Ch
CH23_SBR	60_800Ch
CH24_SBR	60_C00Ch
CH25_SBR	61_000Ch
CH26_SBR	61_400Ch
CH27_SBR	61_800Ch
CH28_SBR	61_C00Ch
CH29_SBR	62_000Ch
CH30_SBR	62_400Ch
CH31_SBR	62_800Ch

Function

The Channel System Bus register places identification and attribute information on the system bus interface for the eDMA.

Diagram



Fields

Field	Function
31-20 —	Reserved
19-17 ATTR	Attribute Output DMA's system bus attribute output value.
16 EMI	Enable Master ID Replication The eDMA master ID replication field allows the eDMA to use the same protection level and system bus ID of the master programming the eDMA's TCD. When enabled, the eDMA uses the master ID and protection level stored in the CHn_SBR registers, instead of the eDMA's default values. When a master (for example a core) programs a TCD, its master ID and protection level are captured when the TCD*n*_CSR control attributes are written. A scatter/gather operation does not affect the CHn_SBR registers. You can write the EMI only if CSR[GMRC] = 1, which means Global Master ID Replication Control is enabled; otherwise, the EMI is forced to zero. See chip-specific eDMA information for details on ID replication. **NOTE** If master ID replication is disabled, the privileged protection level (Supervisor mode) for DMA transfers is used. 0b - Master ID replication is disabled 1b - Master ID replication is enabled
15 PAL	Privileged Access Level This field controls DMA's protection level on the system bus when the channel is active. **NOTE** When you enable master ID replication, the value captured in this register is the privilege level of the core or other master writing the channel's transfer control descriptor, which is the lower byte of TCD*n*_CSR. 0b - User protection level for DMA transfers 1b - Privileged protection level for DMA transfers
14-4 —	Reserved
3-0 MID	Master ID This field controls the DMA's master ID on the system bus when the channel is active. **NOTE** The ID captured in this register reflects the master ID of the core or other master writing the channel's control attributes, which are in the lower byte of TCD*n*_CSR.

14.6.3.6 Channel Priority (CH0_PRI - CH31_PRI)

Offset

Register	Offset
CH0_PRI	10h
CH1_PRI	4010h
CH2_PRI	8010h
CH3_PRI	C010h
CH4_PRI	1_0010h
CH5_PRI	1_4010h
CH6_PRI	1_8010h
CH7_PRI	1_C010h
CH8_PRI	2_0010h
CH9_PRI	2_4010h
CH10_PRI	2_8010h
CH11_PRI	2_C010h
CH12_PRI	3_0010h
CH13_PRI	3_4010h
CH14_PRI	3_8010h
CH15_PRI	3_C010h
CH16_PRI	5E_C010h
CH17_PRI	5F_0010h
CH18_PRI	5F_4010h
CH19_PRI	5F_8010h
CH20_PRI	5F_C010h
CH21_PRI	60_0010h
CH22_PRI	60_4010h
CH23_PRI	60_8010h
CH24_PRI	60_C010h
CH25_PRI	61_0010h
CH26_PRI	61_4010h
CH27_PRI	61_8010h
CH28_PRI	61_C010h
CH29_PRI	62_0010h

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Register	Offset
CH30_PRI	62_4010h
CH31_PRI	62_8010h

Function

The contents of these registers define unique priorities associated with each channel within the same channel group. Channel grouping is programmed via Channel Arbitration Group (CH0_GRPRI - CH31_GRPRI).

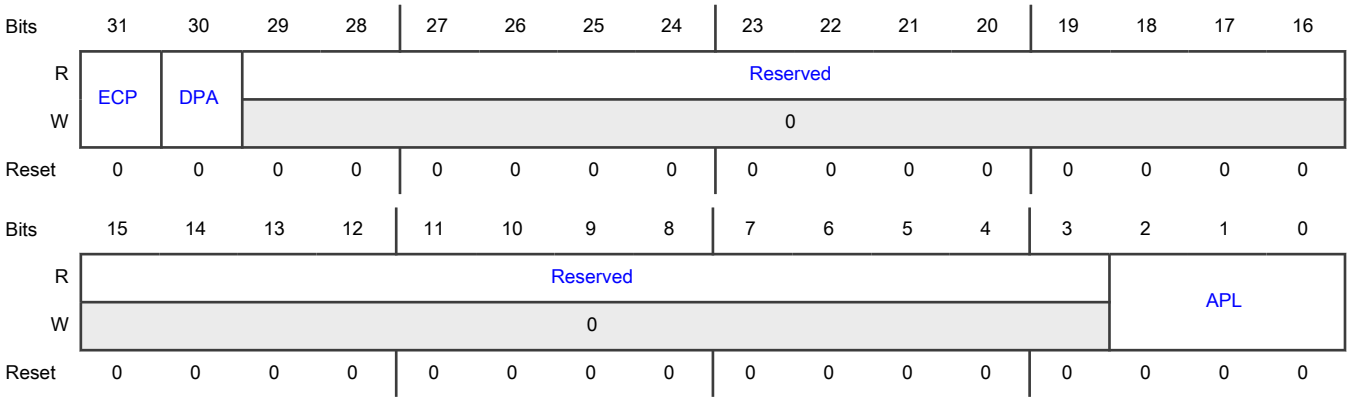
The channel priorities within a group are evaluated by numeric value; for example, 0 is the lowest priority, 1 is the next higher priority, then 2, 3, and so on. Software must program the channel priorities with unique values; otherwise, channel numbers with the same, non-zero value, will be selected based on channel number with the higher channel number having higher priority.

If more than one channel in a group has an arbitration priority level value of zero, then the arbitration mode field CSR[ERCA] is used to determine the arbitration scheme for all channels with APL=0 within a group.

When you enable round-robin channel arbitration (CSR[ERCA] = 1), all channels with APL=0 within a group will use a round-robin arbitration scheme, which rotates among these channels requesting service without regard to priority. Round-robin provides a fairness mechanism within an arbitration group.

When you enable fixed-priority channel arbitration (CSR[ERCA] = 0), eDMA selects channels with APL=0 based on channel number, with the higher channel number having higher priority.

Diagram



Fields

Field	Function
31 ECP	Enable Channel Preemption 0b - Channel cannot be suspended by a higher-priority channel's service request 1b - Channel can be temporarily suspended by a higher-priority channel's service request
30 DPA	Disable Preempt Ability 0b - Channel can suspend a lower-priority channel 1b - Channel cannot suspend any other channel, regardless of channel priority

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Field	Function
29-3 —	Reserved
2-0 APL	Arbitration Priority Level Channel priority level for arbitration within the assigned arbitration group.

14.6.3.7 TCD Source Address (TCD0_SADDR - TCD31_SADDR)

Offset

Register	Offset
TCD0_SADDR	20h
TCD1_SADDR	4020h
TCD2_SADDR	8020h
TCD3_SADDR	C020h
TCD4_SADDR	1_0020h
TCD5_SADDR	1_4020h
TCD6_SADDR	1_8020h
TCD7_SADDR	1_C020h
TCD8_SADDR	2_0020h
TCD9_SADDR	2_4020h
TCD10_SADDR	2_8020h
TCD11_SADDR	2_C020h
TCD12_SADDR	3_0020h
TCD13_SADDR	3_4020h
TCD14_SADDR	3_8020h
TCD15_SADDR	3_C020h
TCD16_SADDR	5E_C020h
TCD17_SADDR	5F_0020h
TCD18_SADDR	5F_4020h
TCD19_SADDR	5F_8020h
TCD20_SADDR	5F_C020h
TCD21_SADDR	60_0020h

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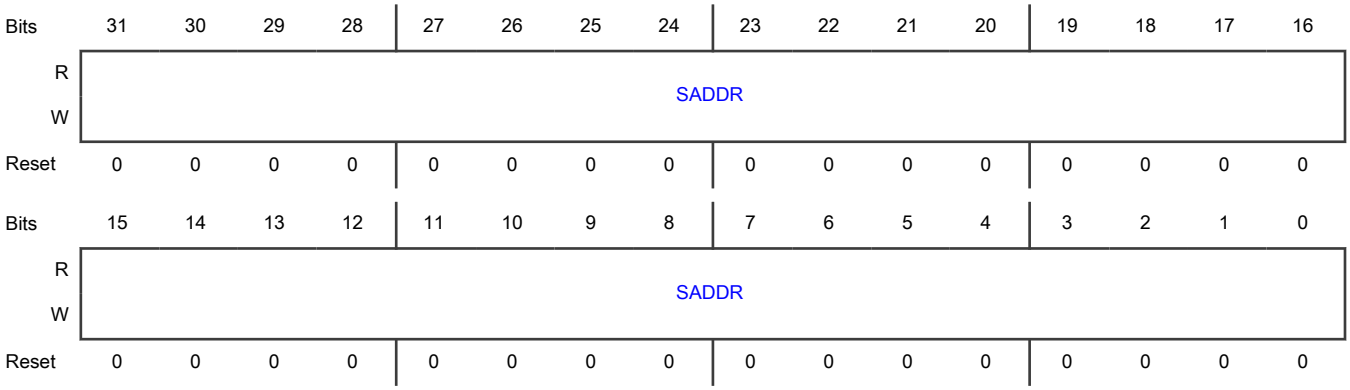
Register	Offset
TCD22_SADDR	60_4020h
TCD23_SADDR	60_8020h
TCD24_SADDR	60_C020h
TCD25_SADDR	61_0020h
TCD26_SADDR	61_4020h
TCD27_SADDR	61_8020h
TCD28_SADDR	61_C020h
TCD29_SADDR	62_0020h
TCD30_SADDR	62_4020h
TCD31_SADDR	62_8020h

Function

This register contains the address for the read transactions.

Diagram



Fields

Field	Function
31-0 SADDR	Source Address Memory address pointing to the source data.

14.6.3.8 TCD Signed Source Address Offset (TCD0_SOFF - TCD31_SOFF)

Offset

Register	Offset
TCD0_SOFF	24h
TCD1_SOFF	4024h
TCD2_SOFF	8024h
TCD3_SOFF	C024h
TCD4_SOFF	1_0024h
TCD5_SOFF	1_4024h
TCD6_SOFF	1_8024h
TCD7_SOFF	1_C024h
TCD8_SOFF	2_0024h
TCD9_SOFF	2_4024h
TCD10_SOFF	2_8024h
TCD11_SOFF	2_C024h
TCD12_SOFF	3_0024h
TCD13_SOFF	3_4024h
TCD14_SOFF	3_8024h
TCD15_SOFF	3_C024h
TCD16_SOFF	5E_C024h
TCD17_SOFF	5F_0024h
TCD18_SOFF	5F_4024h
TCD19_SOFF	5F_8024h
TCD20_SOFF	5F_C024h
TCD21_SOFF	60_0024h
TCD22_SOFF	60_4024h
TCD23_SOFF	60_8024h
TCD24_SOFF	60_C024h
TCD25_SOFF	61_0024h
TCD26_SOFF	61_4024h
TCD27_SOFF	61_8024h
TCD28_SOFF	61_C024h
TCD29_SOFF	62_0024h

Table continues on the next page...

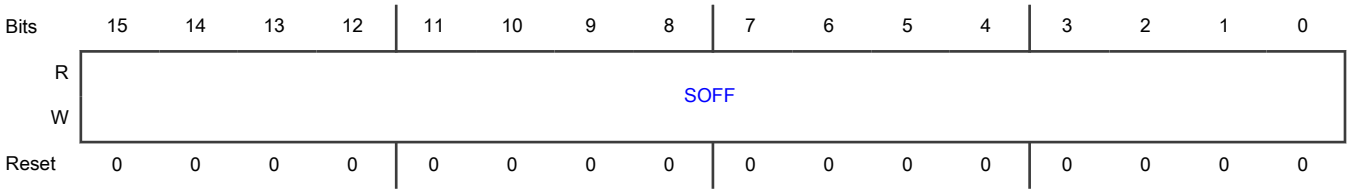
Table continued from the previous page...

Register	Offset
TCD30_SOFF	62_4024h
TCD31_SOFF	62_8024h

Function

This register contains the sign-extended value added to Source Address register after each read transaction.

Diagram



Fields

Field	Function
15-0 SOFF	Source Address Signed Offset Sign-extended offset applied to the current source address to form the next-state value as each source read is completed.

14.6.3.9 TCD Transfer Attributes (TCD0_ATTR - TCD31_ATTR)

Offset

Register	Offset
TCD0_ATTR	26h
TCD1_ATTR	4026h
TCD2_ATTR	8026h
TCD3_ATTR	C026h
TCD4_ATTR	1_0026h
TCD5_ATTR	1_4026h
TCD6_ATTR	1_8026h
TCD7_ATTR	1_C026h
TCD8_ATTR	2_0026h
TCD9_ATTR	2_4026h
TCD10_ATTR	2_8026h

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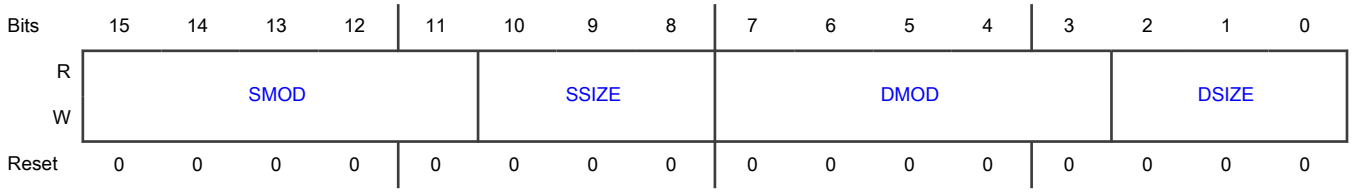
Register	Offset
TCD11_ATTR	2_C026h
TCD12_ATTR	3_0026h
TCD13_ATTR	3_4026h
TCD14_ATTR	3_8026h
TCD15_ATTR	3_C026h
TCD16_ATTR	5E_C026h
TCD17_ATTR	5F_0026h
TCD18_ATTR	5F_4026h
TCD19_ATTR	5F_8026h
TCD20_ATTR	5F_C026h
TCD21_ATTR	60_0026h
TCD22_ATTR	60_4026h
TCD23_ATTR	60_8026h
TCD24_ATTR	60_C026h
TCD25_ATTR	61_0026h
TCD26_ATTR	61_4026h
TCD27_ATTR	61_8026h
TCD28_ATTR	61_C026h
TCD29_ATTR	62_0026h
TCD30_ATTR	62_4026h
TCD31_ATTR	62_8026h

Function

This register contains size and option modulo addressing information for source and destination addresses.

Diagram



Fields

Field	Function
15-11 SMOD	Source Address Modulo This field defines a specific address range, which is the value after the SADDR + SOFF calculation is performed on the original register value. Setting this field makes it easy to implement a circular data queue. For data queues requiring power-of-2-sized bytes, the queue must start at a 0-modulo-size address and the SMOD field must be set to the appropriate value for the queue, freezing the required number of upper address bits. The value programmed into this field specifies the number of lower address bits that are allowed to change. For a circular queue application, you typically set TCDn_SOFF[SOFF] to the transfer size to implement post-increment addressing, with the SMOD function constraining the addresses to a 0-modulo-size range. 0_0000b - Source address modulo feature disabled 0_0001b - Source address modulo feature enabled for any non-zero value [1-31]
10-8 SSIZE	Source Data Transfer Size 000b - 8-bit 001b - 16-bit 010b - 32-bit 011b - 64-bit 100b - 16-byte 101b - 32-byte 110b - 64-byte 111b - Reserved
7-3 DMOD	Destination Address Modulo See the SMOD definition.
2-0 DSIZE	Destination Data Transfer Size See the SSIZE definition.

14.6.3.10 TCD Transfer Size Without Minor Loop Offsets (TCD0_NBYTES_MLOFFNO - TCD31_NBYTES_MLOFFNO)

Offset

Register	Offset
TCD0_NBYTES_MLOFFNO	28h
TCD1_NBYTES_MLOFFNO	4028h
TCD2_NBYTES_MLOFFNO	8028h
TCD3_NBYTES_MLOFFNO	C028h
TCD4_NBYTES_MLOFFNO	1_0028h
TCD5_NBYTES_MLOFFNO	1_4028h
TCD6_NBYTES_MLOFFNO	1_8028h
TCD7_NBYTES_MLOFFNO	1_C028h
TCD8_NBYTES_MLOFFNO	2_0028h
TCD9_NBYTES_MLOFFNO	2_4028h
TCD10_NBYTES_MLOFFNO	2_8028h
TCD11_NBYTES_MLOFFNO	2_C028h
TCD12_NBYTES_MLOFFNO	3_0028h
TCD13_NBYTES_MLOFFNO	3_4028h
TCD14_NBYTES_MLOFFNO	3_8028h
TCD15_NBYTES_MLOFFNO	3_C028h
TCD16_NBYTES_MLOFFNO	5E_C028h
TCD17_NBYTES_MLOFFNO	5F_0028h

Table continues on the next page...

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Register	Offset
TCD18_NBYTES_MLOFFNO	5F_4028h
TCD19_NBYTES_MLOFFNO	5F_8028h
TCD20_NBYTES_MLOFFNO	5F_C028h
TCD21_NBYTES_MLOFFNO	60_0028h
TCD22_NBYTES_MLOFFNO	60_4028h
TCD23_NBYTES_MLOFFNO	60_8028h
TCD24_NBYTES_MLOFFNO	60_C028h
TCD25_NBYTES_MLOFFNO	61_0028h
TCD26_NBYTES_MLOFFNO	61_4028h
TCD27_NBYTES_MLOFFNO	61_8028h
TCD28_NBYTES_MLOFFNO	61_C028h
TCD29_NBYTES_MLOFFNO	62_0028h
TCD30_NBYTES_MLOFFNO	62_4028h
TCD31_NBYTES_MLOFFNO	62_8028h

Function

The TCDn_NBYTES field defines the number of bytes to transfer per service request.

Minor loop offsets are address offset values added to the final source address (TCDn_SADDR), or destination address (TCDn_DADDR), upon minor loop completion. Minor loop completion is when the channel has finished the service request and has transferred NBYTES. When minor loop offsets are enabled, the minor loop offset value (TCDn_NBYTES_MLOFFYES[MLOFF]) is added to the final source address (TCDn_SADDR), to the final destination address (TCDn_DADDR), or to both, prior to the addresses being written back to the TCD. If the major loop is complete, the minor loop offset is ignored and the major loop address offsets (TCDn_SLAST_SDA and TCDn_DLAST_SGA) are used to compute the next TCDn_SADDR and TCDn_DADDR values.

When minor loop mapping is enabled (SMLOE or DMLOE is 1), TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES is redefined. A portion of TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES is used to specify multiple fields:

- A source enable bit (SMLOE) to specify the minor loop offset must be applied to the source address (TCDn_SADDR) upon minor loop completion
- A destination enable bit (DMLOE) to specify the minor loop offset must be applied to the destination address (TCDn_DADDR) upon minor loop completion
- The sign extended minor loop offset value (MLOFF)

The same offset value (MLOFF) is used for both source and destination minor loop offsets. When either minor loop offset is enabled (SMLOE set or DMLOE set), the NBYTES field is reduced to 10 bits. If both minor loop offsets are disabled (SMLOE cleared and DMLOE cleared), the NBYTES field is a 30-bit vector.

One of two register profiles (this register or TCDn_NBYTES_MLOFFYES), defines the number of bytes to transfer per request. Which register to use depends on whether source or destination minor loop mapping is enabled.

TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES is defined as follows:

- If SMLOE = 0 and DMLOE = 0, then see the TCDn_NBYTES_MLOFFNO register description.
- If either SMLOE or DMLOE is 1, then see the TCDn_NBYTES_MLOFFYES register description.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SMLOE	DMLOE	NBYTES													
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NBYTES															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 SMLOE	Source Minor Loop Offset Enable Selects whether the minor loop offset is applied to the source address upon minor loop completion. 0b - Minor loop offset not applied to SADDR 1b - Minor loop offset applied to SADDR
30 DMLOE	Destination Minor Loop Offset Enable Selects whether the minor loop offset is applied to the destination address upon minor loop completion. 0b - Minor loop offset not applied to DADDR 1b - Minor loop offset applied to DADDR
29-0 NBYTES	Number of Bytes To Transfer Per Service Request Number of bytes to be transferred for each service request of the channel.

Table continues on the next page...

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Field	Function
	When a channel activates, the module loads the appropriate TCD contents into the eDMA engine and performs the appropriate reads and writes until the byte transfer count has been reached. This process is normally an indivisible operation and cannot be halted. It can, however, be stalled by using the bandwidth control field, or via preemption. After the byte count is exhausted, the SADDR and DADDR values are written back into the TCD memory, and the major loop iteration count (CITER) is decremented by one and written back to the TCD memory. If the major iteration count is complete, additional processing is performed.

14.6.3.11 TCD Transfer Size with Minor Loop Offsets (TCD0_NBYTES_MLOFFYES - TCD31_NBYTES_MLOFFYES)

Offset

Register	Offset
TCD0_NBYTES_MLOFFYES	28h
TCD1_NBYTES_MLOFFYES	4028h
TCD2_NBYTES_MLOFFYES	8028h
TCD3_NBYTES_MLOFFYES	C028h
TCD4_NBYTES_MLOFFYES	1_0028h
TCD5_NBYTES_MLOFFYES	1_4028h
TCD6_NBYTES_MLOFFYES	1_8028h
TCD7_NBYTES_MLOFFYES	1_C028h
TCD8_NBYTES_MLOFFYES	2_0028h
TCD9_NBYTES_MLOFFYES	2_4028h
TCD10_NBYTES_MLOFFYES	2_8028h
TCD11_NBYTES_MLOFFYES	2_C028h

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Register	Offset
TCD12_NBYTES_MLOFFYES	3_0028h
TCD13_NBYTES_MLOFFYES	3_4028h
TCD14_NBYTES_MLOFFYES	3_8028h
TCD15_NBYTES_MLOFFYES	3_C028h
TCD16_NBYTES_MLOFFYES	5E_C028h
TCD17_NBYTES_MLOFFYES	5F_0028h
TCD18_NBYTES_MLOFFYES	5F_4028h
TCD19_NBYTES_MLOFFYES	5F_8028h
TCD20_NBYTES_MLOFFYES	5F_C028h
TCD21_NBYTES_MLOFFYES	60_0028h
TCD22_NBYTES_MLOFFYES	60_4028h
TCD23_NBYTES_MLOFFYES	60_8028h
TCD24_NBYTES_MLOFFYES	60_C028h
TCD25_NBYTES_MLOFFYES	61_0028h
TCD26_NBYTES_MLOFFYES	61_4028h
TCD27_NBYTES_MLOFFYES	61_8028h
TCD28_NBYTES_MLOFFYES	61_C028h
TCD29_NBYTES_MLOFFYES	62_0028h
TCD30_NBYTES_MLOFFYES	62_4028h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
TCD31_NBYTES_MLOFFYES	62_8028h

Function

The TCDn_NBYTES field defines the number of bytes to transfer per service request.

Minor loop offset is an address offset value added to the final source address (TCDn_SADDR) or destination address (TCDn_DADDR) upon minor loop completion. Minor loop completion occurs when the channel has finished the service request and has transferred NBYTES. Minor loop offsets are enabled by setting either the source enable bit (SMLOE) or the destination enable bit (DMLOE).

The source enable bit (SMLOE) specifies the minor loop offset value (MLOFF) that is to be applied to the source address (TCDn_SADDR) upon minor loop completion. The destination enable bit (DMLOE) specifies the minor loop offset (MLOFF) that is to be applied to the destination address (TCDn_DADDR) upon minor loop completion.

If the major loop is complete, the minor loop offsets are ignored and the major loop address offsets (TCDn_SLAST_SDA and TCDn_DLAST_SGA) are used to compute the next TCDn_SADDR and TCDn_DADDR values.

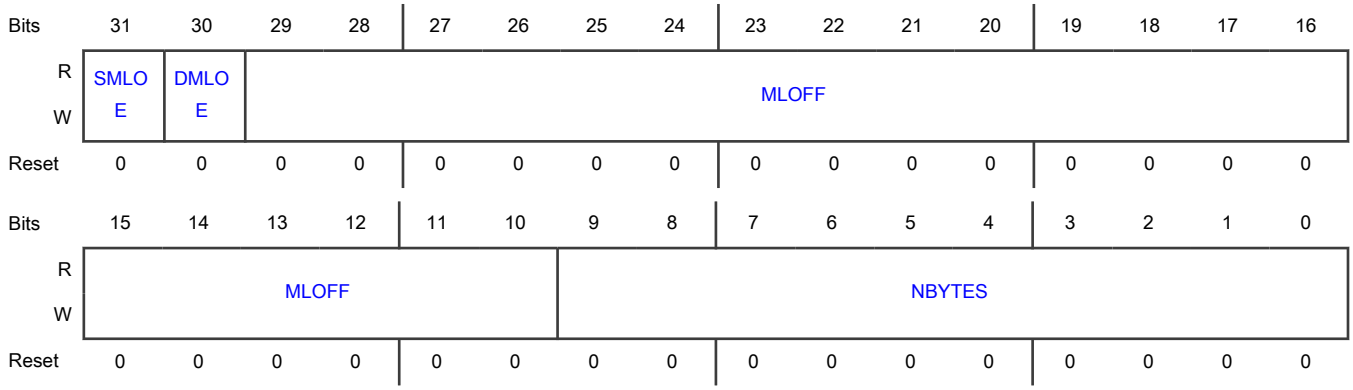
When you enable the minor loop offset overlay (either SMLOE or DMLOE is 1), eDMA redefines TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES. A portion of TCDn_NBYTES_MLOFFNO/TCDn_NBYTES_MLOFFYES specifies the sign-extended minor loop offset value (MLOFF). The same offset value (MLOFF) applies to both source and destination minor loop offsets. When the minor loop offset is enabled, you must align it to the transfer size of the source or destination it is associated with. When either minor loop offset is enabled (SMLOE set or DMLOE set), the NBYTES field is reduced to 10 bits. If both minor loop offsets are disabled (SMLOE cleared and DMLOE cleared), the NBYTES field is a 30-bit vector.

One of two register profiles (this register or TCDn_NBYTES_MLOFFNO) defines the number of bytes to transfer per request. Which register to use depends on whether source or destination minor loop mapping is enabled.

TCDn_NBYTES_MLOFFYES is defined as follows:

- If either minor loop offset is enabled (SMLOE or DMLOE = 1), then see the TCDn_NBYTES_MLOFFYES register description.
- If SMLOE and DMLOE are both 0, then see the TCDn_NBYTES_MLOFFNO register description.

Diagram



Fields

Field	Function
31 SMLOE	Source Minor Loop Offset Enable Selects whether the minor loop offset is applied to the source address upon minor loop completion. 0b - Minor loop offset not applied to SADDR 1b - Minor loop offset applied to SADDR
30 DMLOE	Destination Minor Loop Offset Enable Selects whether the minor loop offset is applied to the destination address upon minor loop completion. 0b - Minor loop offset not applied to DADDR 1b - Minor loop offset applied to DADDR
29-10 MLOFF	Minor Loop Offset If SMLOE or DMLOE is 1, this field represents a sign-extended offset applied to the source or destination address to form the next-state value after the minor loop completes.
9-0 NBYTES	Number of Bytes To Transfer Per Service Request The number of bytes to be transferred in each service request of the channel. As a channel activates, the module loads the appropriate TCD contents into the eDMA engine and performs the appropriate reads and writes until the minor byte transfer count has been reached. This is an indivisible operation and cannot be halted. It can, however, be stalled by using the bandwidth control field, or via preemption. After the minor count is exhausted, the SADDR and DADDR values are written back into the TCD memory, and the major iteration count is decremented and restored to the TCD memory. If the major iteration count is complete, additional processing is performed.

14.6.3.12 TCD Last Source Address Adjustment / Store DADDR Address (TCD0_SLAST_SDA - TCD31_SLAST_SDA)

Offset

Register	Offset
TCD0_SLAST_SDA	2Ch
TCD1_SLAST_SDA	402Ch
TCD2_SLAST_SDA	802Ch
TCD3_SLAST_SDA	C02Ch
TCD4_SLAST_SDA	1_002Ch
TCD5_SLAST_SDA	1_402Ch
TCD6_SLAST_SDA	1_802Ch
TCD7_SLAST_SDA	1_C02Ch

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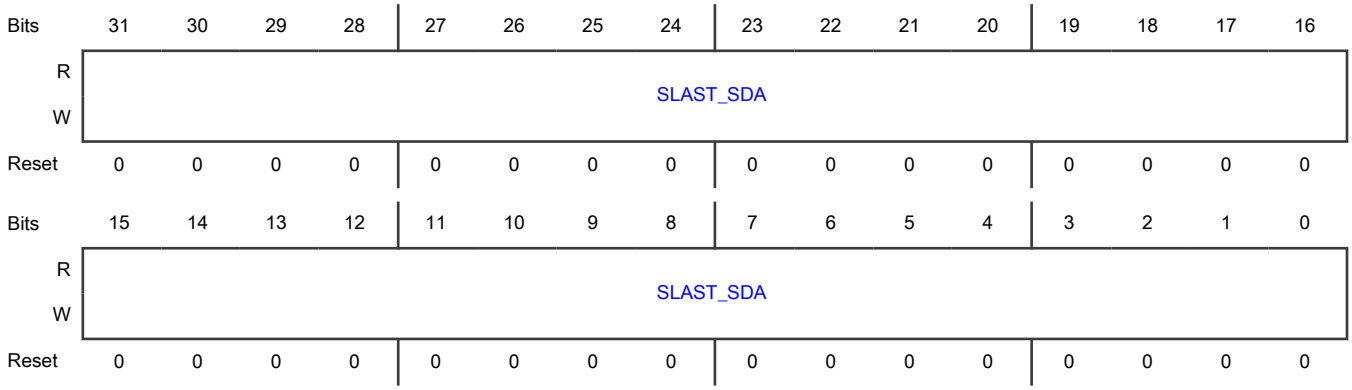
Register	Offset
TCD8_SLAST_SDA	2_002Ch
TCD9_SLAST_SDA	2_402Ch
TCD10_SLAST_SDA	2_802Ch
TCD11_SLAST_SDA	2_C02Ch
TCD12_SLAST_SDA	3_002Ch
TCD13_SLAST_SDA	3_402Ch
TCD14_SLAST_SDA	3_802Ch
TCD15_SLAST_SDA	3_C02Ch
TCD16_SLAST_SDA	5E_C02Ch
TCD17_SLAST_SDA	5F_002Ch
TCD18_SLAST_SDA	5F_402Ch
TCD19_SLAST_SDA	5F_802Ch
TCD20_SLAST_SDA	5F_C02Ch
TCD21_SLAST_SDA	60_002Ch
TCD22_SLAST_SDA	60_402Ch
TCD23_SLAST_SDA	60_802Ch
TCD24_SLAST_SDA	60_C02Ch
TCD25_SLAST_SDA	61_002Ch
TCD26_SLAST_SDA	61_402Ch
TCD27_SLAST_SDA	61_802Ch
TCD28_SLAST_SDA	61_C02Ch
TCD29_SLAST_SDA	62_002Ch
TCD30_SLAST_SDA	62_402Ch
TCD31_SLAST_SDA	62_802Ch

Function

This register contains the value added to the source address when the major loop is complete. When the store destination address option is enabled, this field provides a pointer to memory for storing the final destination address.

Diagram



Fields

Field	Function
31-0 SLAST_SDA	Last Source Address Adjustment / Store DADDR Address Source last address adjustment or the system memory address for destination address (DADDR) storage. If (TCDn_CSR[ESDA] = 0), then: • Adjustment value is added to the source address at the completion of the major iteration count. This value can be used to restore the source address to the initial value or adjust the address to reference the next data structure. • This field uses two's complement notation for the final source address adjustment. Otherwise: • This address points to the 32-bit-aligned memory location where the destination address (DADDR) is to be stored in system memory. By saving the final destination address in system memory via the ESDA feature, you are able to compute the size of a variable destination data buffer by simply subtracting the beginning DADDR from the final, saved DADDR. This feature is used together with the scatter/gather operation to prevent the loss of the final DADDR, which is overwritten during the scatter/gather operation. The "Store Destination Address" (SDA) value must be a 32-bit-aligned location because the eDMA forces the lower two address bits of the SLAST_SDA field to zero when ESDA is enabled. The module performs this write operation when the major loop is done; that is, when the major iteration count (CITER) decrements to zero.

14.6.3.13 TCD Destination Address (TCD0_DADDR - TCD31_DADDR)

Offset

Register	Offset
TCD0_DADDR	30h
TCD1_DADDR	4030h
TCD2_DADDR	8030h

Table continues on the next page...

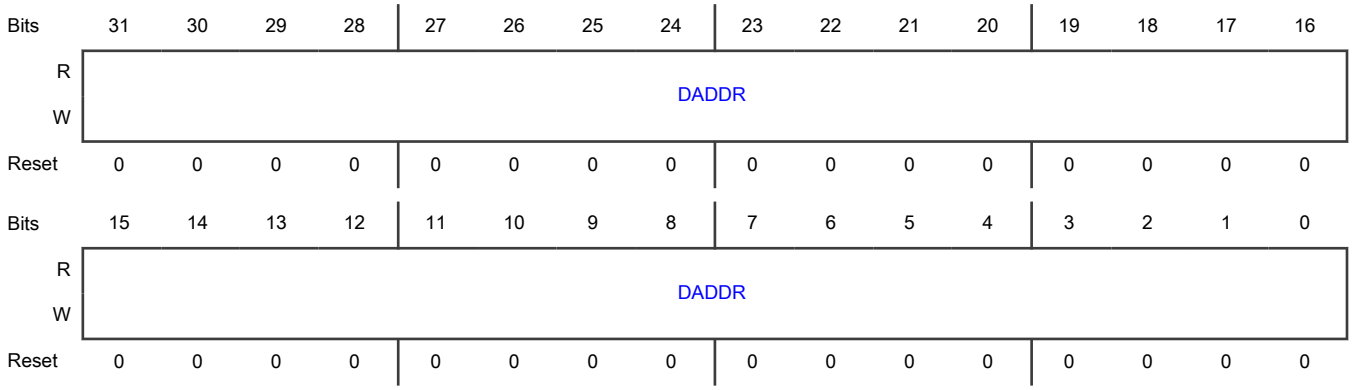
Table continued from the previous page...

Register	Offset
TCD3_DADDR	C030h
TCD4_DADDR	1_0030h
TCD5_DADDR	1_4030h
TCD6_DADDR	1_8030h
TCD7_DADDR	1_C030h
TCD8_DADDR	2_0030h
TCD9_DADDR	2_4030h
TCD10_DADDR	2_8030h
TCD11_DADDR	2_C030h
TCD12_DADDR	3_0030h
TCD13_DADDR	3_4030h
TCD14_DADDR	3_8030h
TCD15_DADDR	3_C030h
TCD16_DADDR	5E_C030h
TCD17_DADDR	5F_0030h
TCD18_DADDR	5F_4030h
TCD19_DADDR	5F_8030h
TCD20_DADDR	5F_C030h
TCD21_DADDR	60_0030h
TCD22_DADDR	60_4030h
TCD23_DADDR	60_8030h
TCD24_DADDR	60_C030h
TCD25_DADDR	61_0030h
TCD26_DADDR	61_4030h
TCD27_DADDR	61_8030h
TCD28_DADDR	61_C030h
TCD29_DADDR	62_0030h
TCD30_DADDR	62_4030h
TCD31_DADDR	62_8030h

Function

This register contains the address for the write transactions.

Diagram



Fields

Field	Function
31-0 DADDR	Destination Address Memory address pointing to the destination data.

14.6.3.14 TCD Signed Destination Address Offset (TCD0_DOFF - TCD31_DOFF)

Offset

Register	Offset
TCD0_DOFF	34h
TCD1_DOFF	4034h
TCD2_DOFF	8034h
TCD3_DOFF	C034h
TCD4_DOFF	1_0034h
TCD5_DOFF	1_4034h
TCD6_DOFF	1_8034h
TCD7_DOFF	1_C034h
TCD8_DOFF	2_0034h
TCD9_DOFF	2_4034h
TCD10_DOFF	2_8034h
TCD11_DOFF	2_C034h
TCD12_DOFF	3_0034h
TCD13_DOFF	3_4034h
TCD14_DOFF	3_8034h

Table continues on the next page...

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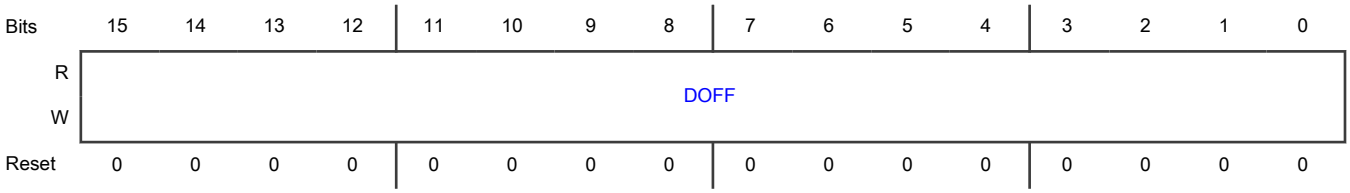
Register	Offset
TCD15_DOFF	3_C034h
TCD16_DOFF	5E_C034h
TCD17_DOFF	5F_0034h
TCD18_DOFF	5F_4034h
TCD19_DOFF	5F_8034h
TCD20_DOFF	5F_C034h
TCD21_DOFF	60_0034h
TCD22_DOFF	60_4034h
TCD23_DOFF	60_8034h
TCD24_DOFF	60_C034h
TCD25_DOFF	61_0034h
TCD26_DOFF	61_4034h
TCD27_DOFF	61_8034h
TCD28_DOFF	61_C034h
TCD29_DOFF	62_0034h
TCD30_DOFF	62_4034h
TCD31_DOFF	62_8034h

Function

This register contains the sign-extended value added to Destination Address register after each write transaction.

Diagram



Fields

Field	Function
15-0 DOFF	Destination Address Signed Offset Sign-extended offset that is applied to the current destination address to form the next-state value as each destination write is completed.

14.6.3.15 TCD Current Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_CITER_ELINKNO - TCD31_CITER_ELINKNO)

Offset

Register	Offset
TCD0_CITER_ELINKNO	36h
TCD1_CITER_ELINKNO	4036h
TCD2_CITER_ELINKNO	8036h
TCD3_CITER_ELINKNO	C036h
TCD4_CITER_ELINKNO	1_0036h
TCD5_CITER_ELINKNO	1_4036h
TCD6_CITER_ELINKNO	1_8036h
TCD7_CITER_ELINKNO	1_C036h
TCD8_CITER_ELINKNO	2_0036h
TCD9_CITER_ELINKNO	2_4036h
TCD10_CITER_ELINKNO	2_8036h
TCD11_CITER_ELINKNO	2_C036h
TCD12_CITER_ELINKNO	3_0036h
TCD13_CITER_ELINKNO	3_4036h
TCD14_CITER_ELINKNO	3_8036h
TCD15_CITER_ELINKNO	3_C036h
TCD16_CITER_ELINKNO	5E_C036h
TCD17_CITER_ELINKNO	5F_0036h
TCD18_CITER_ELINKNO	5F_4036h
TCD19_CITER_ELINKNO	5F_8036h
TCD20_CITER_ELINKNO	5F_C036h
TCD21_CITER_ELINKNO	60_0036h

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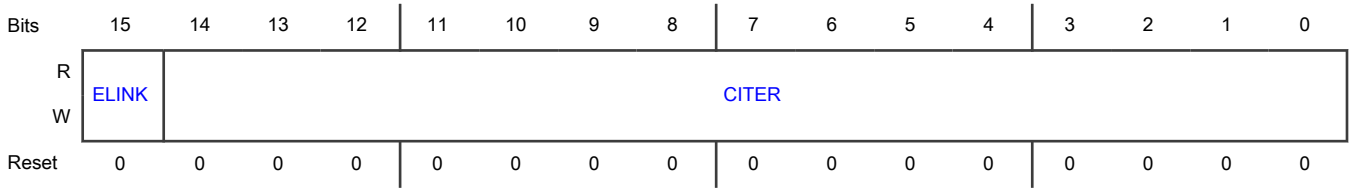
Register	Offset
TCD22_CITER_ELINKNO	60_4036h
TCD23_CITER_ELINKNO	60_8036h
TCD24_CITER_ELINKNO	60_C036h
TCD25_CITER_ELINKNO	61_0036h
TCD26_CITER_ELINKNO	61_4036h
TCD27_CITER_ELINKNO	61_8036h
TCD28_CITER_ELINKNO	61_C036h
TCD29_CITER_ELINKNO	62_0036h
TCD30_CITER_ELINKNO	62_4036h
TCD31_CITER_ELINKNO	62_8036h

Function

If TCDn_CITER[ELINK] is 0, the TCDn_CITER register is defined as follows.

Diagram



Fields

Field	Function
15 ELINK	Enable Link As the channel completes the minor loop, this flag enables linking to another channel as defined by the relevant LINKCH field. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] bit of the specified channel to 1.

Table continues on the next page...

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Field	Function
	If channel linking is disabled, the CITER value is extended to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of MAJORELINK channel linking. **NOTE** This field must be equal to the BITER[ELINK] field; otherwise, a configuration error is reported. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14-0 CITER	Current Major Iteration Count This 9-bit (ELINK = 1) or 15-bit (ELINK = 0) count represents the current major loop count for the channel. It is decremented each time the channel finishes a service request and is written back to TCD memory. After the major iteration count is exhausted, the channel performs a number of operations — for example, final source and destination address calculations — and optionally generates an interrupt to signal channel completion before reloading the CITER field from the Beginning Iteration Count (BITER) field. **NOTE** When the CITER field is initially loaded by software, it must be set to the same value as that contained in the BITER field. **NOTE** If the channel is configured to execute a single service request, the initial values of BITER and CITER should be 0x0001.

14.6.3.16 TCD Current Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_CITER_ELINKYES - TCD31_CITER_ELINKYES)

Offset

Register	Offset
TCD0_CITER_ELINKYES	36h
TCD1_CITER_ELINKYES	4036h
TCD2_CITER_ELINKYES	8036h
TCD3_CITER_ELINKYES	C036h
TCD4_CITER_ELINKYES	1_0036h
TCD5_CITER_ELINKYES	1_4036h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
TCD6_CITER_ELINKYES	1_8036h
TCD7_CITER_ELINKYES	1_C036h
TCD8_CITER_ELINKYES	2_0036h
TCD9_CITER_ELINKYES	2_4036h
TCD10_CITER_ELINKYES	2_8036h
TCD11_CITER_ELINKYES	2_C036h
TCD12_CITER_ELINKYES	3_0036h
TCD13_CITER_ELINKYES	3_4036h
TCD14_CITER_ELINKYES	3_8036h
TCD15_CITER_ELINKYES	3_C036h
TCD16_CITER_ELINKYES	5E_C036h
TCD17_CITER_ELINKYES	5F_0036h
TCD18_CITER_ELINKYES	5F_4036h
TCD19_CITER_ELINKYES	5F_8036h
TCD20_CITER_ELINKYES	5F_C036h
TCD21_CITER_ELINKYES	60_0036h
TCD22_CITER_ELINKYES	60_4036h
TCD23_CITER_ELINKYES	60_8036h
TCD24_CITER_ELINKYES	60_C036h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
TCD25_CITER_ELINKYES	61_0036h
TCD26_CITER_ELINKYES	61_4036h
TCD27_CITER_ELINKYES	61_8036h
TCD28_CITER_ELINKYES	61_C036h
TCD29_CITER_ELINKYES	62_0036h
TCD30_CITER_ELINKYES	62_4036h
TCD31_CITER_ELINKYES	62_8036h

Function

If TCDn_CITER[ELINK] is 1, the TCDn_CITER register is defined as follows.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ELINK	Reserved	LINKCH						CITER							
W		0														
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 ELINK	Enable Link As the channel completes the minor loop, this flag enables linking to another channel as defined by the relevant LINKCH field. When enabled, an internal mechanism sets the TCDn_CSR[START] field of the specified channel (LINKCH) upon minor loop completion. If channel linking is disabled, the CITER value is extended to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of MAJORELINK channel linking. **NOTE** This field must be equal to the BITER[ELINK] field; otherwise, a configuration error is reported.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14 —	Reserved
13-9 LINKCH	Minor Loop Link Channel Number If channel-to-channel linking is enabled (ELINK = 1), then after the minor loop is exhausted the eDMA engine initiates a channel service request to the channel defined by this field by writing that channel's TCDn_CSR[START] field to 1.
8-0 CITER	Current Major Iteration Count This 9-bit (ELINK = 1) or 15-bit (ELINK = 0) count represents the current major loop count for the channel. It is decremented each time the channel finishes a service request and is written back to the TCD memory. After the major iteration count is exhausted, the channel performs a number of operations — for example, final source and destination address calculations — and optionally generates an interrupt to signal channel completion before reloading the CITER field from the Beginning Iteration Count (BITER) field. **NOTE** When the CITER field is initially loaded by software, it must be set to the same value as that contained in the BITER field. **NOTE** If the channel is configured to execute a single service request, the initial values of BITER and CITER should be 0x0001.

14.6.3.17 TCD Last Destination Address Adjustment / Scatter Gather Address (TCD0_DLAST_SGA - TCD31_DLAST_SGA)

Offset

Register	Offset
TCD0_DLAST_SGA	38h
TCD1_DLAST_SGA	4038h
TCD2_DLAST_SGA	8038h
TCD3_DLAST_SGA	C038h
TCD4_DLAST_SGA	1_0038h
TCD5_DLAST_SGA	1_4038h
TCD6_DLAST_SGA	1_8038h
TCD7_DLAST_SGA	1_C038h

Table continues on the next page...

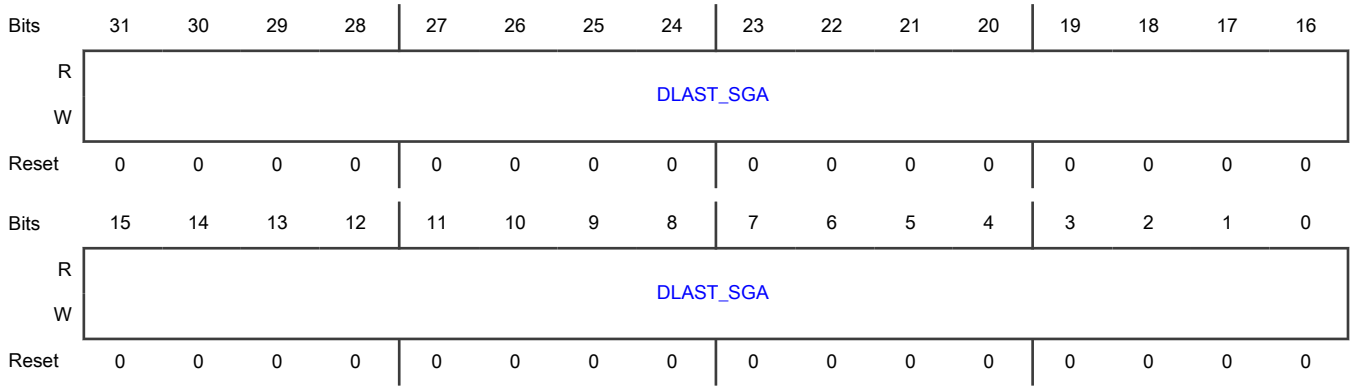
Table continued from the previous page...

Register	Offset
TCD8_DLAST_SGA	2_0038h
TCD9_DLAST_SGA	2_4038h
TCD10_DLAST_SGA	2_8038h
TCD11_DLAST_SGA	2_C038h
TCD12_DLAST_SGA	3_0038h
TCD13_DLAST_SGA	3_4038h
TCD14_DLAST_SGA	3_8038h
TCD15_DLAST_SGA	3_C038h
TCD16_DLAST_SGA	5E_C038h
TCD17_DLAST_SGA	5F_0038h
TCD18_DLAST_SGA	5F_4038h
TCD19_DLAST_SGA	5F_8038h
TCD20_DLAST_SGA	5F_C038h
TCD21_DLAST_SGA	60_0038h
TCD22_DLAST_SGA	60_4038h
TCD23_DLAST_SGA	60_8038h
TCD24_DLAST_SGA	60_C038h
TCD25_DLAST_SGA	61_0038h
TCD26_DLAST_SGA	61_4038h
TCD27_DLAST_SGA	61_8038h
TCD28_DLAST_SGA	61_C038h
TCD29_DLAST_SGA	62_0038h
TCD30_DLAST_SGA	62_4038h
TCD31_DLAST_SGA	62_8038h

Function

This register contains the value added to the destination address when the major loop is complete. When the Scatter/Gather option is enabled, this field provides a pointer to memory for fetching a transfer control descriptor to reprogram the channel.

Diagram



Fields

Field	Function
31-0 DLAST_SGA	Last Destination Address Adjustment / Scatter Gather Address Adjustment of the last destination address or the memory address for the next transfer control descriptor to be loaded into this channel (scatter/gather). If (TCDn_CSR[ESG] = 0) then: • Adjustment value is added to the destination address at the completion of the major iteration count. This value can apply to restore the destination address to the initial value or adjust the address to reference the next data structure. • This field uses two's complement notation for the final destination address adjustment. Otherwise: • This address points to the beginning of a 0-modulo 32-byte region containing the next transfer control descriptor to be loaded into this channel. This channel reload is performed as the major iteration count completes. The scatter/gather address must be 0-modulo 32-byte, or else a configuration error is reported.

14.6.3.18 TCD Control and Status (TCD0_CSR - TCD31_CSR)

Offset

Register	Offset
TCD0_CSR	3Ch
TCD1_CSR	403Ch
TCD2_CSR	803Ch
TCD3_CSR	C03Ch
TCD4_CSR	1_003Ch
TCD5_CSR	1_403Ch
TCD6_CSR	1_803Ch

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Register	Offset
TCD7_CSR	1_C03Ch
TCD8_CSR	2_003Ch
TCD9_CSR	2_403Ch
TCD10_CSR	2_803Ch
TCD11_CSR	2_C03Ch
TCD12_CSR	3_003Ch
TCD13_CSR	3_403Ch
TCD14_CSR	3_803Ch
TCD15_CSR	3_C03Ch
TCD16_CSR	5E_C03Ch
TCD17_CSR	5F_003Ch
TCD18_CSR	5F_403Ch
TCD19_CSR	5F_803Ch
TCD20_CSR	5F_C03Ch
TCD21_CSR	60_003Ch
TCD22_CSR	60_403Ch
TCD23_CSR	60_803Ch
TCD24_CSR	60_C03Ch
TCD25_CSR	61_003Ch
TCD26_CSR	61_403Ch
TCD27_CSR	61_803Ch
TCD28_CSR	61_C03Ch
TCD29_CSR	62_003Ch
TCD30_CSR	62_403Ch
TCD31_CSR	62_803Ch

Function

This register is used to enable optional features.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BWC			MAJORLINKCH					ESDA	Reserved	MAJOREL...	ESG	DREQ	INTHALF	INTMAJOR	START
W			0													
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-14 BWC	Bandwidth Control Throttles the amount of bus bandwidth consumed by the eDMA. Generally, as the eDMA processes the minor loop, it continuously generates read/write sequences until the minor count is exhausted. This field forces eDMA to stall after the completion of each read/write access, to control the bus request bandwidth seen by the system bus interconnect. **NOTE** If the source and destination sizes are equal, this field is ignored between the first and second transfers and after the last write of each minor loop. This behavior is a side effect of reducing start-up latency. 00b - No eDMA engine stalls 01b - Enable eDMA master high-priority elevation (HPE) mode. No eDMA engine stalls. 10b - eDMA engine stalls for 4 cycles after each R/W 11b - eDMA engine stalls for 8 cycles after each R/W
13 —	Reserved
12-8 MAJORLINKCH	Major Loop Link Channel Number If (MAJORELINK = 0) then: • No channel-to-channel linking, or chaining, is performed after the major loop counter is exhausted. Otherwise: • After the major loop counter is exhausted, the eDMA engine initiates a channel service request at the channel defined by this field by setting that channel's TCDn_CSR[START] field to 1.
7 ESDA	Enable Store Destination Address As the channel completes the major loop by either the current iteration counter (CITER) decrementing to 0, this field enables writing the destination address (DADDR) to the address stored in the SLAST_SDA field. The value written to system memory is the last DADDR value prior to the DLAST_SGA offset being applied, or overwritten by an enabled scatter/gather operation. When the SDA bit is 1, SLAST_SDA contains the write pointer instead of the final source address offset. Because this is a pointer and not a final offset, a last source address offset of zero is applied to SADDR instead of the SLAST_SGA value. 0b - Ability to store destination address to system memory disabled 1b - Ability to store destination address to system memory enabled

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Field	Function
6 —	Reserved
5 MAJORELINK	Enable Link When Major Loop Complete As the channel completes the major loop, this flag enables linking to another channel defined by MAJORLINKCH. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] field of the specified channel. **NOTE** To support the dynamic linking coherency model, this field is forced to 0 if written when TCDn_CSR[DONE] is 1. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
4 ESG	Enable Scatter/Gather Processing As the channel completes the major loop, this flag enables scatter/gather processing in the current channel. If enabled, the eDMA engine uses TCDn_DLAST_SGA as a memory pointer to a 0-modulo 32-bit address containing a 32-byte data structure, which is loaded as the transfer control descriptor into local memory. **NOTE** To support the dynamic scatter/gather coherency model, this field is forced to 0 if written when TCDn_CSR[DONE] is 1. 0b - Current channel's TCD is normal format 1b - Current channel's TCD specifies scatter/gather format.
3 DREQ	Disable Request If this flag is 1, the eDMA hardware automatically clears the corresponding ERQ bit when the current major iteration count reaches 0. 0b - No operation. Channel's ERQ field not affected 1b - Clear the ERQ field to 0 upon major loop completion, thus disabling hardware service requests. Channel's ERQ field cleared to 0 when major loop complete
2 INTHALF	Enable Interrupt If Major Counter Half-complete If this flag is 1, the channel generates an interrupt request by setting the appropriate field in the INT register to 1 when the current major iteration count reaches the halfway point. Specifically, the comparison performed by the eDMA engine is (CITER = (BITER/2)). This halfway point interrupt request is provided to support double-buffered, also known as ping-pong, schemes, or other types of data movement where the processor needs an early indication of the transfer's progress. **NOTE** If BITER = 1, do not use INTHALF; use INTMAJOR instead. 0b - Halfway point interrupt disabled

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Field	Function
	1b - Halfway point interrupt enabled
1 INTMAJOR	Enable Interrupt If Major count complete If this flag is 1, the channel generates an interrupt request by setting the appropriate field in the INT register to 1 when the current major iteration count (CITER) reaches 0. 0b - End-of-major loop interrupt disabled 1b - End-of-major loop interrupt enabled
0 START	Channel Start If this flag is 1, the channel is requesting service. The eDMA hardware automatically clears this flag to 0 after the channel begins execution. 0b - Channel not explicitly started 1b - Channel explicitly started via a software-initiated service request

14.6.3.19 TCD Beginning Major Loop Count (Minor Loop Channel Linking Disabled) (TCD0_BITER_ELINKNO - TCD31_BITER_ELINKNO)

Offset

Register	Offset
TCD0_BITER_ELINKNO	3Eh
TCD1_BITER_ELINKNO	403Eh
TCD2_BITER_ELINKNO	803Eh
TCD3_BITER_ELINKNO	C03Eh
TCD4_BITER_ELINKNO	1_003Eh
TCD5_BITER_ELINKNO	1_403Eh
TCD6_BITER_ELINKNO	1_803Eh
TCD7_BITER_ELINKNO	1_C03Eh
TCD8_BITER_ELINKNO	2_003Eh
TCD9_BITER_ELINKNO	2_403Eh
TCD10_BITER_ELINKNO	2_803Eh
TCD11_BITER_ELINKNO	2_C03Eh
TCD12_BITER_ELINKNO	3_003Eh

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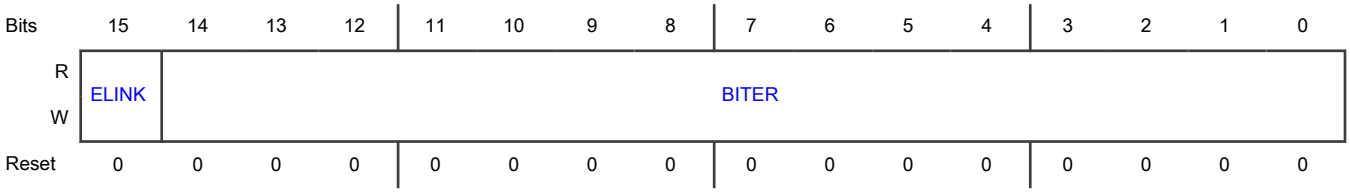
Register	Offset
TCD13_BITER_ELINKNO	3_403Eh
TCD14_BITER_ELINKNO	3_803Eh
TCD15_BITER_ELINKNO	3_C03Eh
TCD16_BITER_ELINKNO	5E_C03Eh
TCD17_BITER_ELINKNO	5F_003Eh
TCD18_BITER_ELINKNO	5F_403Eh
TCD19_BITER_ELINKNO	5F_803Eh
TCD20_BITER_ELINKNO	5F_C03Eh
TCD21_BITER_ELINKNO	60_003Eh
TCD22_BITER_ELINKNO	60_403Eh
TCD23_BITER_ELINKNO	60_803Eh
TCD24_BITER_ELINKNO	60_C03Eh
TCD25_BITER_ELINKNO	61_003Eh
TCD26_BITER_ELINKNO	61_403Eh
TCD27_BITER_ELINKNO	61_803Eh
TCD28_BITER_ELINKNO	61_C03Eh
TCD29_BITER_ELINKNO	62_003Eh
TCD30_BITER_ELINKNO	62_403Eh
TCD31_BITER_ELINKNO	62_803Eh

Function

If the TCDn_BITER[ELINK] field is 0, the TCDn_BITER register is defined as follows.

Diagram



Fields

Field	Function
15 ELINK	Enables Link As the channel completes the minor loop, this flag enables linking to another channel as defined by BITER[LINKCH]. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] field of the specified channel. If channel linking is disabled, the BITER value extends to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of the MAJORELINK channel linking. **NOTE** When the software loads the TCD, this field must be set equal to the corresponding CITER field; otherwise, a configuration error is reported. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14-0 BITER	Starting Major Iteration Count As the transfer control descriptor is first loaded by software, this 9-bit (ELINK = 1) or 15-bit (ELINK = 0) field must be set equal to the value in the CITER field. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. If the channel is configured to execute a single service request, the initial values of BITER and CITER must be 0x0001.

14.6.3.20 TCD Beginning Major Loop Count (Minor Loop Channel Linking Enabled) (TCD0_BITER_ELINKYES - TCD31_BITER_ELINKYES)

Offset

Register	Offset
TCD0_BITER_ELINKYES	3Eh
TCD1_BITER_ELINKYES	403Eh

Table continues on the next page...

Table continued from the previous page...

Register	Offset
TCD2_BITER_ELINKYES	803Eh
TCD3_BITER_ELINKYES	C03Eh
TCD4_BITER_ELINKYES	1_003Eh
TCD5_BITER_ELINKYES	1_403Eh
TCD6_BITER_ELINKYES	1_803Eh
TCD7_BITER_ELINKYES	1_C03Eh
TCD8_BITER_ELINKYES	2_003Eh
TCD9_BITER_ELINKYES	2_403Eh
TCD10_BITER_ELINKYES	2_803Eh
TCD11_BITER_ELINKYES	2_C03Eh
TCD12_BITER_ELINKYES	3_003Eh
TCD13_BITER_ELINKYES	3_403Eh
TCD14_BITER_ELINKYES	3_803Eh
TCD15_BITER_ELINKYES	3_C03Eh
TCD16_BITER_ELINKYES	5E_C03Eh
TCD17_BITER_ELINKYES	5F_003Eh
TCD18_BITER_ELINKYES	5F_403Eh
TCD19_BITER_ELINKYES	5F_803Eh
TCD20_BITER_ELINKYES	5F_C03Eh

Table continues on the next page...

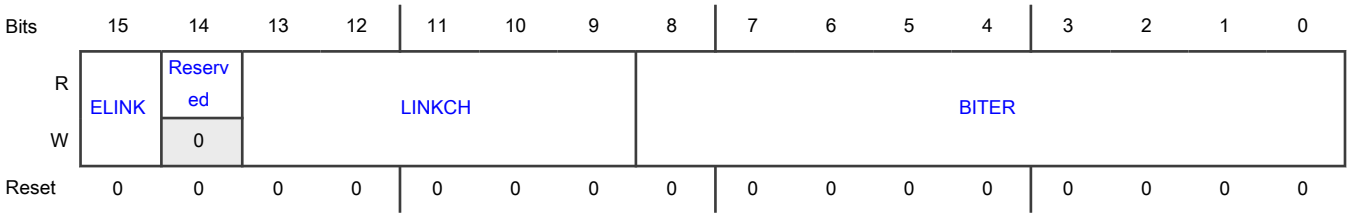
Table continued from the previous page...

Register	Offset
TCD21_BITER_ELINKYES	60_003Eh
TCD22_BITER_ELINKYES	60_403Eh
TCD23_BITER_ELINKYES	60_803Eh
TCD24_BITER_ELINKYES	60_C03Eh
TCD25_BITER_ELINKYES	61_003Eh
TCD26_BITER_ELINKYES	61_403Eh
TCD27_BITER_ELINKYES	61_803Eh
TCD28_BITER_ELINKYES	61_C03Eh
TCD29_BITER_ELINKYES	62_003Eh
TCD30_BITER_ELINKYES	62_403Eh
TCD31_BITER_ELINKYES	62_803Eh

Function

If the TCDn_BITER[ELINK] field is set, the TCDn_BITER register is defined as follows.

Diagram



Fields

Field	Function
15 ELINK	Enable Link

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Field	Function
	As the channel completes the minor loop, this flag enables linking to another channel as defined by BITER[LINKCH]. The link target channel initiates a channel service request via an internal mechanism that sets the TCDn_CSR[START] field of the specified channel. If channel linking disables, the BITER value extends to 15 bits in place of a link channel number. If the major loop is exhausted, this link mechanism is suppressed in favor of the MAJORELINK channel linking. **NOTE** When the software loads the TCD, this field must be set equal to the corresponding CITER field; otherwise, a configuration error is reported. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. 0b - Channel-to-channel linking disabled 1b - Channel-to-channel linking enabled
14 —	Reserved
13-9 LINKCH	Link Channel Number If channel-to-channel linking is enabled (ELINK = 1), then after the minor loop is exhausted, the eDMA engine initiates a channel service request at the channel defined by this field by setting that channel's TCDn_CSR[START] field. **NOTE** When the software loads the TCD, this field must be set equal to the corresponding CITER field; otherwise, a configuration error is reported. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field.
8-0 BITER	Starting Major Iteration Count As the transfer control descriptor is first loaded by software, this 9-bit (ELINK = 1) or 15-bit (ELINK = 0) field must be set equal to the value in the CITER field. As the major iteration count is exhausted, eDMA reloads the contents of this field into the CITER field. If the channel is configured to execute a single service request, the initial values of BITER and CITER must be 0x0001.

14.7 Glossary

TCD Transfer control descriptor

Chapter 15
Interrupt Monitor (INTM)

15.1 Overview

INTM provides a mechanism to monitor the latency of the responses on interrupt requests to ensure that the processing of these critical interrupts executes within the expected time frame, increasing the reliability of the device.

15.1.1 Block diagram

The following block diagram shows the major registers involved in monitoring the interrupt sources.

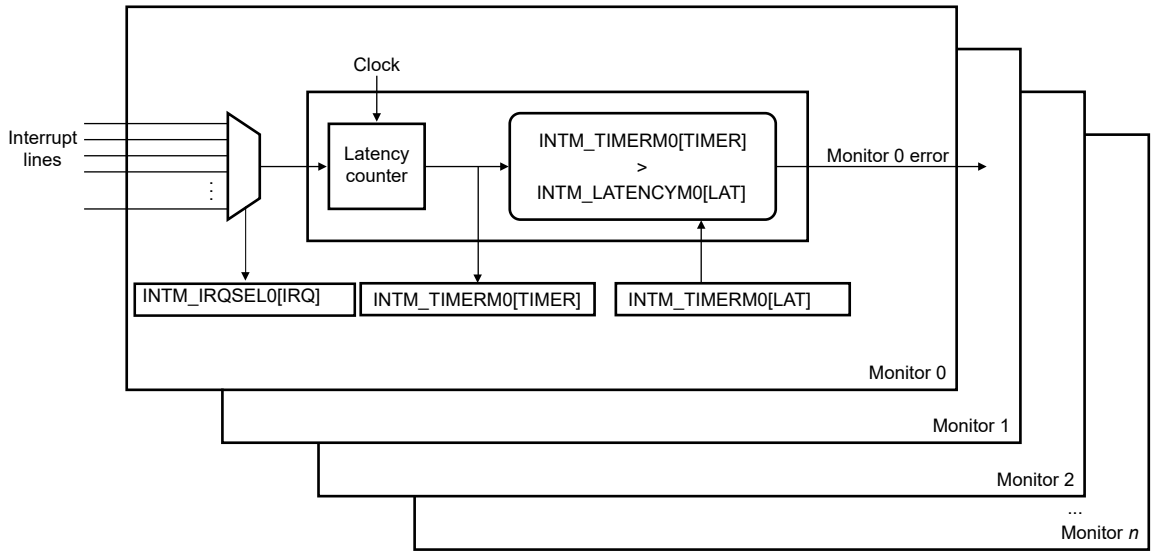


Figure 36. INTM block diagram

15.1.2 Features

INTM supports the following features:

- 4 programmable interrupt monitors
- Programmable interrupt source per monitor
- Programmable 24-bit maximum latency counter per monitor
- Timer expired status bit per monitor
- One interrupt acknowledge for all monitors

15.2 Functional description

Interrupt Request Select for Monitor a (INTM_IRQSEL0 - INTM_IRQSEL3) provides selection of the source, Monitor Mode (INTM_MM) enables the monitor, Interrupt Acknowledge (INTM_IACK) captures the event when the interrupt is acknowledged, Interrupt Latency for Monitor a (INTM_LATENCY0 - INTM_LATENCY3) can be programmed to trigger a monitor error when a threshold value is exceeded, Status for Monitor a (INTM_STATUS0 - INTM_STATUS3) is available to read the monitor error over peripheral bus.

NOTE

INTM supports only level-type interrupts. Hence, the pulse-type interrupts are converted into level-type interrupts for INTM.

15.2.1 Clocking

This module has no clocking considerations.

15.2.2 Interrupts

This module has no interrupts.

15.3 External signals

This module has no external signals.

15.4 Initialization

To monitor a subset of interrupt sources:

1. Program Interrupt Request Select for Monitor a (INTM_IRQSEL0 - INTM_IRQSEL3) with a value corresponding to the interrupt source number to be monitored.
   - You can monitor only defined interrupt sources.
2. Program Interrupt Latency for Monitor a (INTM_LATENCY0 - INTM_LATENCY3) to the maximum expected latency time for each monitored interrupt source.
3. Write 1 to INTM_MM[MM] to monitor the registers.
4. During the interrupt service routine, write the IRQ of the ISR to Interrupt Acknowledge (INTM_IACK).
5. If the maximum expected latency time exceeds the limit defined in Interrupt Latency for Monitor a (INTM_LATENCY0 - INTM_LATENCY3), then an error indication is sent to Fault Collection Control Unit(FCCU). You can also read Status for Monitor a (INTM_STATUS0 - INTM_STATUS3) to see this information.

To clear an error condition, write 0 to the corresponding INTM_TIMERa[TIMER] field for which the interrupt source exceeded the programmed latency value. In case the source is unknown, NXP recommends you to write 0 to all INTM_TIMERa[TIMER] fields.

15.5 INTM register descriptions

INTM allows you to set a maximum timer count for the interrupt latency from interrupt request to interrupt acknowledge. This mechanism monitors the latency of interrupt sources to ensure that these critical interrupts execute within the expected time frame, increasing the reliability of the chip. The hardware for this function is isolated in its own hierarchy to decrease the risk of fault interference.

An error indication is sent to FCCU if the interrupt processing latency exceeds the programmed threshold of the expected latency. The error indication can be read from INTM_STATUSa[STATUS].

15.5.1 INTM memory map

INTM base address: 4027_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Monitor Mode (INTM_MM)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
4h	Interrupt Acknowledge (INTM_IACK)	32	RW	0000_0000h
8h	Interrupt Request Select for Monitor 0 (INTM_IRQSEL0)	32	RW	0000_0000h
Ch	Interrupt Latency for Monitor 0 (INTM_LATENCY0)	32	RW	0000_0000h
10h	Timer for Monitor 0 (INTM_TIMER0)	32	RW	0000_0000h
14h	Status for Monitor 0 (INTM_STATUS0)	32	R	0000_0000h
18h	Interrupt Request Select for Monitor 1 (INTM_IRQSEL1)	32	RW	0000_0000h
1Ch	Interrupt Latency for Monitor 1 (INTM_LATENCY1)	32	RW	0000_0000h
20h	Timer for Monitor 1 (INTM_TIMER1)	32	RW	0000_0000h
24h	Status for Monitor 1 (INTM_STATUS1)	32	R	0000_0000h
28h	Interrupt Request Select for Monitor 2 (INTM_IRQSEL2)	32	RW	0000_0000h
2Ch	Interrupt Latency for Monitor 2 (INTM_LATENCY2)	32	RW	0000_0000h
30h	Timer for Monitor 2 (INTM_TIMER2)	32	RW	0000_0000h
34h	Status for Monitor 2 (INTM_STATUS2)	32	R	0000_0000h
38h	Interrupt Request Select for Monitor 3 (INTM_IRQSEL3)	32	RW	0000_0000h
3Ch	Interrupt Latency for Monitor 3 (INTM_LATENCY3)	32	RW	0000_0000h
40h	Timer for Monitor 3 (INTM_TIMER3)	32	RW	0000_0000h
44h	Status for Monitor 3 (INTM_STATUS3)	32	R	0000_0000h

15.5.2 Monitor Mode (INTM_MM)

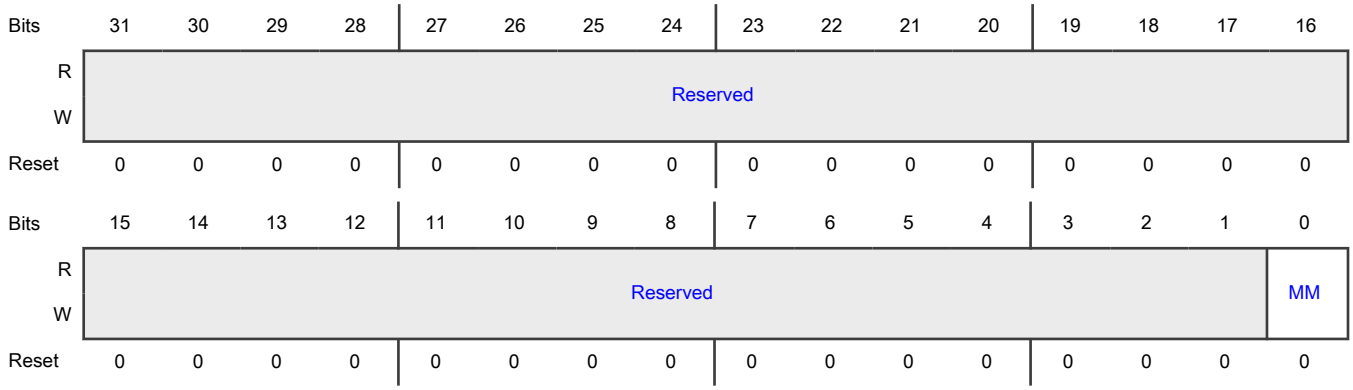
Offset

Register	Offset
INTM_MM	0h

Function

Enables the cycle count timer on a monitored interrupt request for comparison to the latency register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 MM	Monitor Mode Controls whether the INTM monitors the latency of an interrupt response. 0b - Disable 1b - Enable

15.5.3 Interrupt Acknowledge (INTM_IACK)

Offset

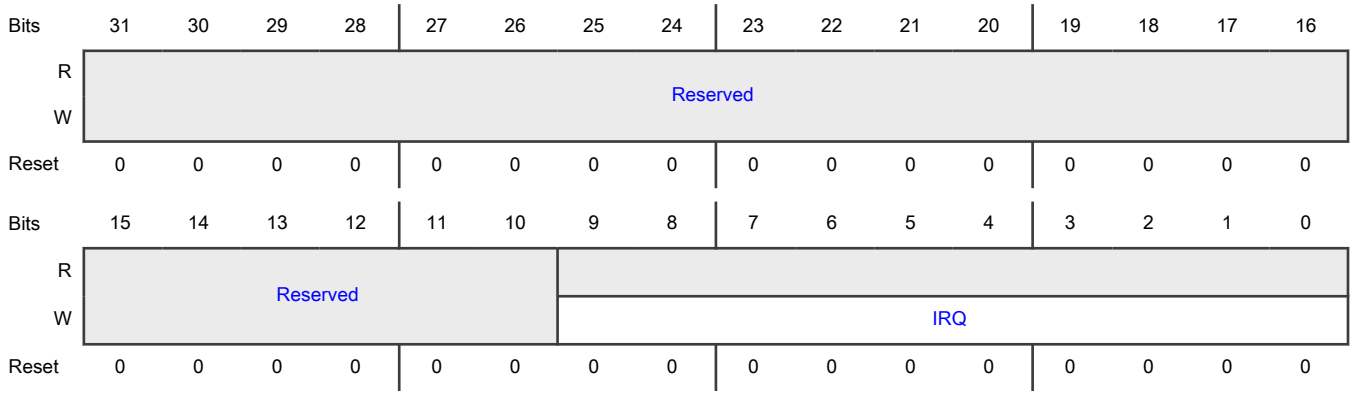
Register	Offset
INTM_IACK	4h

Function

Acknowledges the interrupt processing.

The Interrupt service routine writes to this register after the register acknowledges interrupt processing. This write operation must provide the number of the processed interrupt, which is compared with the interrupt request number in each Interrupt Request Select for Monitor a (INTM_IRQSEL0 - INTM_IRQSEL3) and stops the corresponding Timer for Monitor a (INTM_TIMER0 - INTM_TIMER3) when it found a match.

Diagram



Fields

Field	Function
31-10 —	Reserved
9-0 IRQ	Interrupt Request Specifies the interrupt request number to stop Timer for Monitor a (INTM_TIMER0 - INTM_TIMER3).

15.5.4 Interrupt Request Select for Monitor a (INTM_IRQSEL0 - INTM_IRQSEL3)

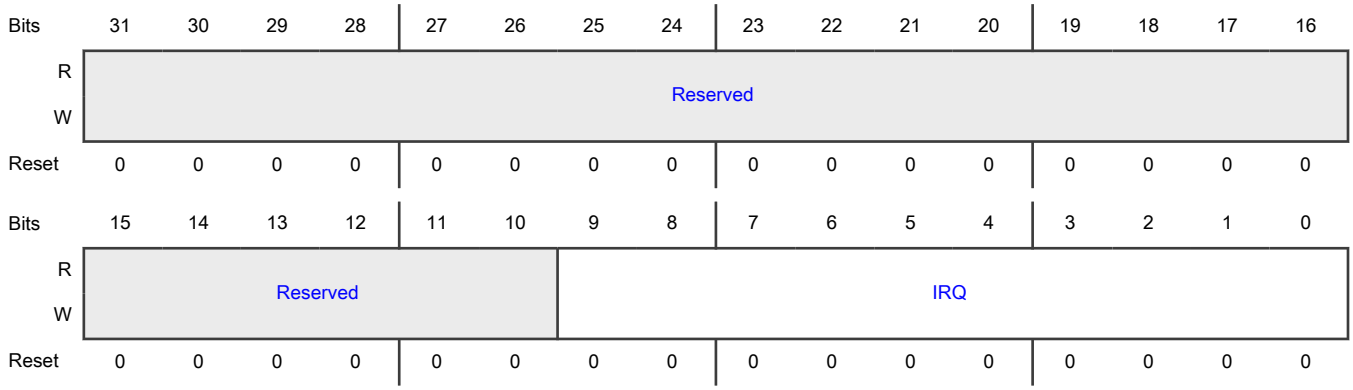
Offset

Register	Offset
INTM_IRQSEL0	8h
INTM_IRQSEL1	18h
INTM_IRQSEL2	28h
INTM_IRQSEL3	38h

Function

Indicates which interrupt request must be monitored or checked.

Diagram



Fields

Field	Function
31-10 —	Reserved
9-0 IRQ	Interrupt Request Selects the interrupt request number to monitor.

15.5.5 Interrupt Latency for Monitor a (INTM_LATENCY0 - INTM_LATENCY3)

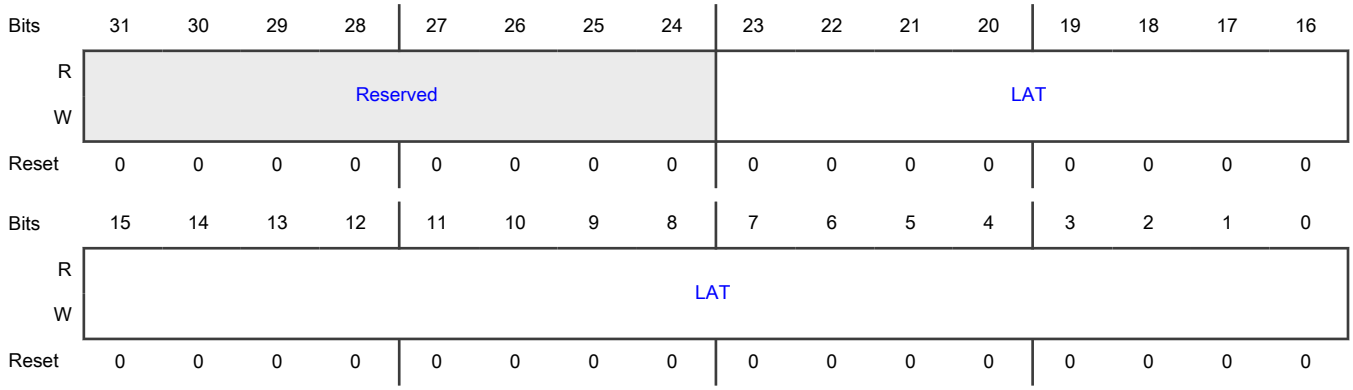
Offset

Register	Offset
INTM_LATENCY0	Ch
INTM_LATENCY1	1Ch
INTM_LATENCY2	2Ch
INTM_LATENCY3	3Ch

Function

Indicates the maximum time before an error signal is asserted for a detected interrupt request to interrupt acknowledge.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 LAT	Latency Specifies the maximum number of INTM clock cycles allowed for the monitored interrupt request. Maximum programmed value must not exceed FF_FFFDh to allow for proper timer error capture.

15.5.6 Timer for Monitor a (INTM_TIMER0 - INTM_TIMER3)

Offset

Register	Offset
INTM_TIMER0	10h
INTM_TIMER1	20h
INTM_TIMER2	30h
INTM_TIMER3	40h

Function

Counts the number of INTM clock cycles for a detected interrupt request to an acknowledged interrupt processing.

Initializes to 1 in following conditions:

- Interrupt Latency for Monitor a (INTM_LATENCY0 - INTM_LATENCY3) is nonzero
- Monitor error is not asserted
- Zero to one transition on the monitored interrupt request

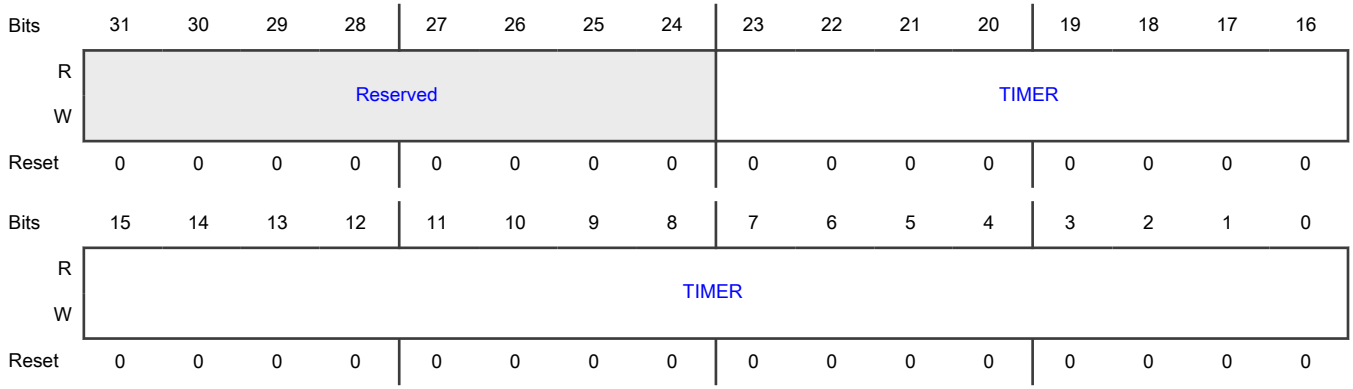
Following are the conditions to enable Timer for Monitor a (INTM_TIMER0 - INTM_TIMER3):

- INTM_MM = 1 and zero-to-one transition on the monitored interrupt source

Following are the conditions to disable Timer for Monitor a (INTM_TIMER0 - INTM_TIMER3):

- Reset
- INTM_MM = 1 and monitor error
- INTM_MM = 1 and monitored interrupt request is not asserted
- Interrupt acknowledge for corresponding interrupt request
- After the timer is enabled, writing 0 to INTM_MM[MM] has no effect.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 TIMER	Timer Counts the number of INTM clock cycles up to 24 bits of resolution.

15.5.7 Status for Monitor a (INTM_STATUS0 - INTM_STATUS3)

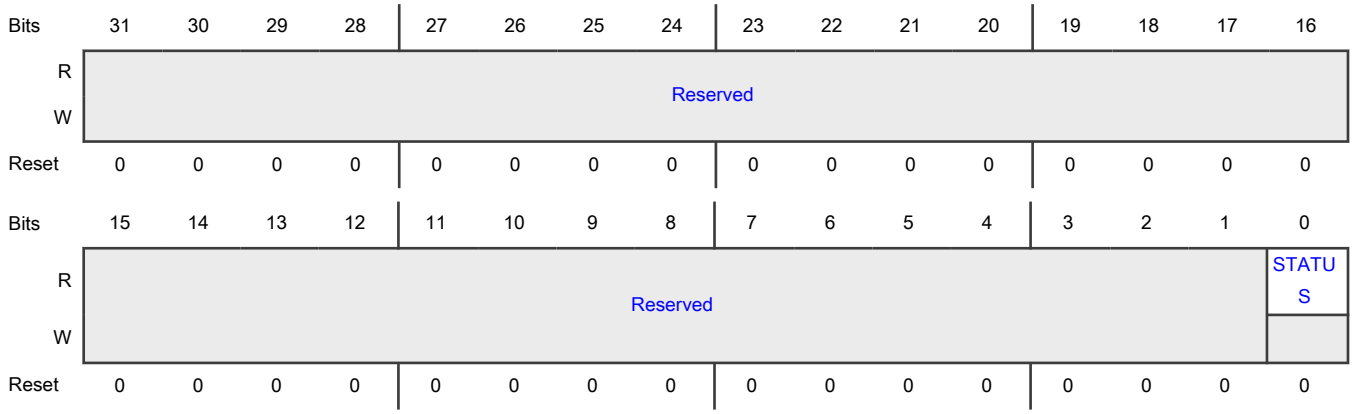
Offset

Register	Offset
INTM_STATUS0	14h
INTM_STATUS1	24h
INTM_STATUS2	34h
INTM_STATUS3	44h

Function

Defines the monitor status. Indicates whether Timer for Monitor a (INTM_TIMER0 - INTM_TIMER3) value has exceeded Interrupt Latency for Monitor a (INTM_LATENCY0 - INTM_LATENCY3) value. You can clear the monitor status by writing 0 to the corresponding INTM_TIMERa[TIMER].

Diagram



Fields

Field	Function
31-1 —	Reserved
0 STATUS	Monitor status Indicates whether Timer for Monitor a (INTM_TIMER0 - INTM_TIMER3) value has exceeded the Interrupt Latency for Monitor a (INTM_LATENCY0 - INTM_LATENCY3) value. 0b - Did not exceed 1b - Exceeded

Chapter 16
Semaphores2 (SEMA42)

16.1 Chip-specific SEMA42 information

16.1.1 SEMA42 configuration

This chip has one instance of SEMA42 with 4 domains.

See the chip-specific XRDC information for the domain ID of each master.

16.2 Overview

SEMA42 is a memory-mapped module that provides robust hardware support needed in multi-core systems for implementing semaphores and provides a simple mechanism to achieve "lock and unlock" operations via a single - write access. The hardware semaphore module provides hardware-enforced gates as well as other useful system functions related to the gating mechanisms.

16.2.1 Block diagram

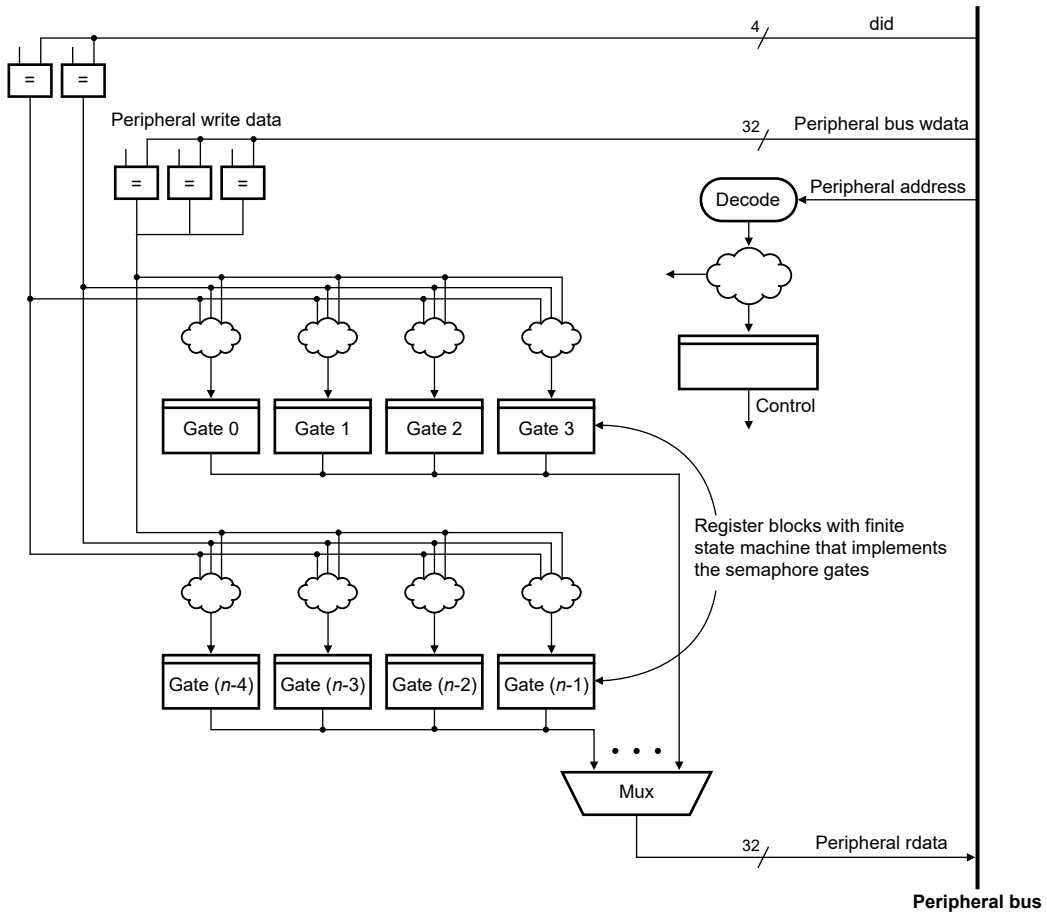


Figure 37. SEMA42 block diagram

16.2.2 Features

SEMA42 implements hardware-enforced semaphores as an IPS-mapped slave peripheral device. The feature set includes:

- Support for 16 hardware-enforced gates in a multi-domain configuration that supports up to 15 domains.
- Each hardware gate appears as a 16-state, 4-bit state machine.
- Support for secure reset mechanisms to clear the contents of individual gates, as well as a clear-all capability.
- Memory-mapped slave peripheral that offers programming-model accesses.

16.3 Functional description

The intent of the hardware gate implementation is to specify a protocol where the locking domain must unlock the gate. However, some systems may require a reset function to re-initialize the state of any gate(s) without requiring a system-level reset. To support this special gate reset requirement, SEMA42 implements a secure reset mechanism that allows you to initialize a hardware gate (or all the gates) by following a specific dual-write access pattern. The secure-gate reset:

- Uses a technique similar to that required for the servicing of a software watchdog timer
- Requires two consecutive writes with pre-defined data patterns from the same domain

You must do this to force the clearing of the specified gate(s). The required access pattern as follows:

1. A domain performs a 16-bit write to the RSTGT memory location. The most significant byte (RSTGT_W[RSTGDP]) must be E2h. The value of least significant byte is irrelevant for this reference and can be anything.
2. The same domain then performs a second 16-bit write to the RSTGT location. For this write, the upper byte (RSTGT_W[RSTGDP]) is the logical complement of the first data pattern (1Dh) and the lower byte (RSTGT_W[RSTGTN]) specifies the gate(s) to be reset. This gate field can specify a single gate or all gates to be cleared. If the same domain writes incorrect data on the second access or another domain performs the second write access, SEMA42 aborts the special gate reset sequence and does not assert an error signal.
3. Reads of the RSTGT location return information on the 2-bit reset state machine (RSTGT_R[RSTGSM]) that implements these functions:
   - The domain performing the reset (RSTGT_R[RSTGMS])
   - The last-cleared gate number(s) (RSTGT_R[RSTGTN])

   Reads of the RSTGT register do not affect the secure-reset finite state machine in any manner.

16.3.1 Multi-core programming: software gates

Multi-processor systems require a function that can be used to safely and easily provide a locking mechanism for system software to control access to shared data structures, shared hardware resources, and so on. The software uses the gating mechanisms to serialize (and synchronize) accesses to shared data and/or resources to prevent race conditions and preserve memory coherency between different processes and domains.

Consider the following description of a typical use-case: dm*X* enters a section of code, where shared data values are to be updated. The domain must first acquire a semaphore. Think of this as the locking (or closing) of a software gate. After the gate locks, a properly-architected software system does not allow other processes (or domains) to execute the same code segment or modify the shared data structure protected by the gate. In other words, the system locks out other processes/domains. Many software implementations include a spin-wait loop within the lock function until the gate locks. After domain X obtains the lock, domain X continues execution and updates the data values protected by the particular lock. After domain X completes the updates, it unlocks (or opens) the software gate, allowing other processes/domains access to the updated data values.

A correctly-implemented system solution must follow these important rules:

- A gate variable must protect all writes to shared data values or shared hardware resources.
- After a domain locks a gate, the system must block other processes/domains from accessing the shared data or resources. Software conventions enforce this.
- The domain that locks a particular gate is the only domain that can open (unlock) that gate.

Information in the hardware gate identifying the locking domain can be extremely useful for system-level debugging.

16.3.2 16 Hardware-enforced gates

Gates appear as a 16-entry byte-size array with read and write accesses.

Domains lock gates by writing "domainID_number+1" to the appropriate gate and must read back the gate value to verify that the lock operation succeeded.

After the gate locks, the locking domain unlocks the gate by writing zeroes.

- 16-state implementation

  If gate = 0h, then state = unlocked

  if gate = 1h, then state = locked by domain (master) 0

  if gate = 2h, then state = locked by domain (master) 1

  …

  if gate = Fh, then state = locked by domain (master) 14

SEMA42 uses the logical domain number and the specified data patterns as reference attributes to validate all write operation.

After a gate locks, the locking domain must unlock the gate by writing zeroes.

16.3.3 State machine of the GATE*n* registers

This section describes more about the SEMA42 functional operation and specific details of the state machines of the GATE*n* registers.

As described previously, each of the GATE*n* registers implements a 4-bit, 16-state machine. The following figure shows a simplified diagram of the state transitions for each gate.

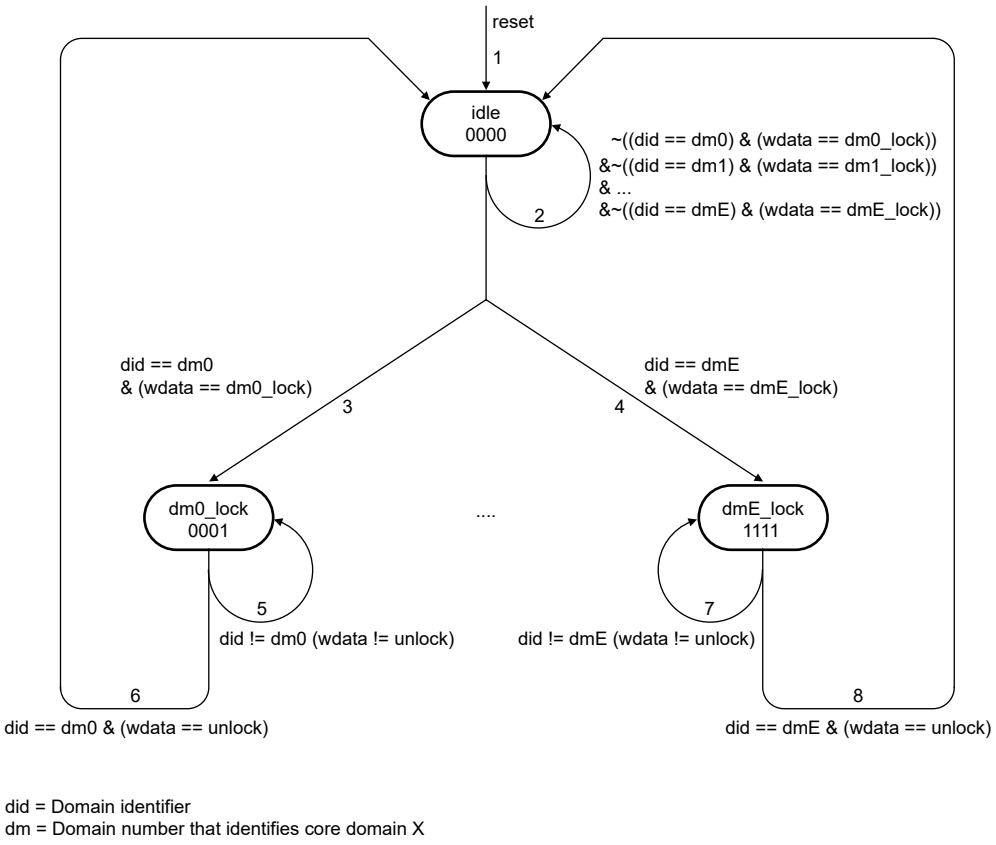


Figure 38. GATE*n* state machine

In the figure above, "dmE" represents domain 14 (E in hexadecimal). The platform passes the domain number to SEMA42.

The following table defines the GATE*n* state transitions.

Table 50. GATE*n* state transitions

Current state	Next state	Transition	Description
–	idle	1	Any reset, whether a system reset or a software-initiated gate reset, unconditionally forces the gate into the idle state.
idle	idle	2	Unless a write of the appropriate lock value from the corresponding domain occurs, the gate remains in the idle state.
idle	dm0_lock	3	When domain 0h initiates a write of the dm0_lock data value, the gate transitions into the dm0_lock state.
idle	dmE_lock	4	When domain Eh initiates a write of the dmE_lock value, the gate transitions into the dmE_lock state.
dm0_lock	dm0_lock	5	When in this state, the gate remains here if any attempted write is not from domain 0h with the unlock data value.
dm0_lock	idle	6	The gate returns to the idle (unlocked) state after a write from domain 0h with the unlock data value occurs.

Table continues on the next page...

Table 50. GATE*n* state transitions (continued)

Current state	Next state	Transition	Description
dmE_lock	dmE_lock	7	When in this state, the gate remains here if any attempted write is not from domain Eh with the unlock data value.
dmE_lock	idle	8	The gate returns to the idle (unlocked) state after a write from domain Eh with the unlock data value occurs.

SEMA42 uses these gate data values:

- The lock data value is (domain number) + 1.
- The unlock data value is 00h.

16.3.4 Clocking

Type of clock	Description
Module clock (clk)	Functions the module and controls the access to the registers.

16.3.5 Interrupts

This module has no interrupts.

16.4 External signals

This module has no external signals.

16.5 Initialization

This module does not require initialization.

16.6 Memory map/register definition

You can access these registers only in Supervisor mode. User accesses terminate with an error.

16.6.1 SEMA42 register descriptions

16.6.1.1 SEMA42 memory map

SEMA42 base address: 4046_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h - Fh	Gate (GATE0 - GATE15) [1]	8	RW	00h
42h	Reset Gate Read (RSTGT_R)	16	R	0000h
42h	Reset Gate Write (RSTGT_W)	16	W	See section

1. In this array, the index and offset values of the registers do not increment in direct alignment. For details, see the register description.

16.6.1.2 Gate (GATE0 - GATE15)

Offset

For n = 0 to 15:

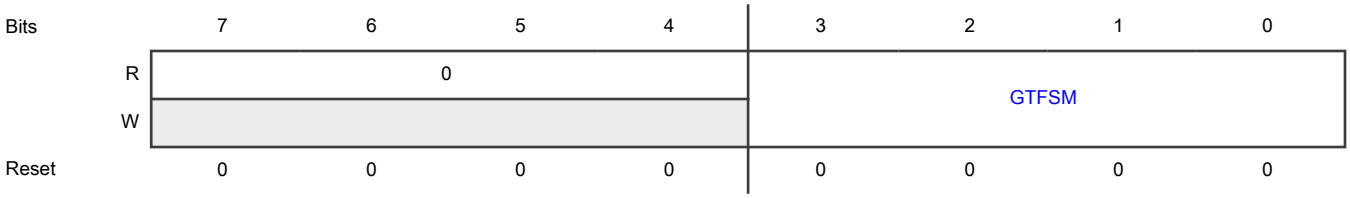
Register	Offset
GATEn	0h + (n + 3 - 2 × (n mod 4))

Function

Implements each semaphore gate in a 4-bit finite state machine, right-justified in a byte data structure. The hardware uses the logical domain-identifier number in conjunction with the data patterns to validate all attempted write operations. Only domain masters can modify the gate registers. After a gate locks, only the locking domain must open (unlock) the gate.

You can read multiple gate values in a single access. However, you can update only a single gate at a time, via a write operation. If you attempt to write a byte-wide value that is neither the unlock value (00h) nor the appropriate lock value (domainID_number + 1), SEMA42 considers this as "no operation" and does not change any gate state. Attempts to write multiple gates in a single-aligned access with a size larger than 8 bits (byte) generate an error termination and do not allow any gate state changes.

Diagram



Fields

Field	Function
7-4 —	Reserved
3-0 GTFSM	Gate Finite State Machine Indicates the state of the gate for the last domain that locked the gate. This can be useful during system debug. The hardware gate has a 16-state implementation, defined as: 0000b - The gate is unlocked (free). 0001b - Domain 0 locked the gate. 0010b - Domain 1 locked the gate. 0011b - Domain 2 locked the gate. 0100b - Domain 3 locked the gate. 0101b - Domain 4 locked the gate. 0110b - Domain 5 locked the gate.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0111b - Domain 6 locked the gate. 1000b - Domain 7 locked the gate. 1001b - Domain 8 locked the gate. 1010b - Domain 9 locked the gate. 1011b - Domain 10 locked the gate. 1100b - Domain 11 locked the gate. 1101b - Domain 12 locked the gate. 1110b - Domain 13 locked the gate. 1111b - Domain 14 locked the gate.

16.6.1.3 Reset Gate Read (RSTGT_R)

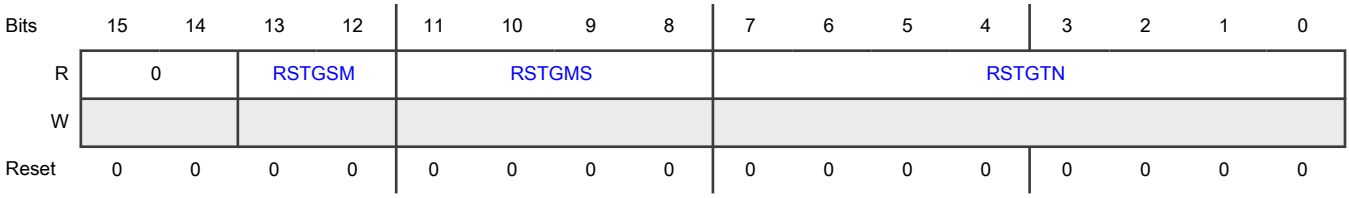
Offset

Register	Offset
RSTGT_R	42h

Function

Describes the specific hardware gate to be reset and records the logic number of domain. Reset Gate Write (RSTGT_W) also describe the same register showing the fields when you write it.

Diagram



Fields

Field	Function
15-14 —	Reserved
13-12 RSTGSM	Reset Gate Finite State Machine

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates the encoded state machine value when you read the register. RSTGSM = 10b is valid for only a single machine cycle, so a read can never return this value. SEMA42 maintains the reset state machine in a 2-bit, 3-state implementation, defined as follows: 00b - Idle, waiting for the first data pattern write. 01b - Waiting for the second data pattern write 10b - The 2-write sequence has completed. Generate the specified gate reset(s). After the reset is performed, this machine returns to the idle (waiting for first data pattern write) state. 11b - This state encoding is never used and therefore reserved.
11-8 RSTGMS	Reset Gate Domain Records the logical number of the domain performing the gate reset function. The logical number is the domain number. This domain number is determined by the XRDC's Master Domain Assignment Controller (XRDC_MDAC). To succeed, this function requires that the same domain initiate the two consecutive writes to this register. SEMA42 updates the field each time a write to this register occurs.
7-0 RSTGTN	Reset Gate Number Specifies the specific hardware gate to be reset. The second write updates this field. If RSTGTN < 64, SEMA42 resets the single gate defined by RSTGTN. Otherwise, SEMA42 resets all the gates.

16.6.1.4 Reset Gate Write (RSTGT_W)

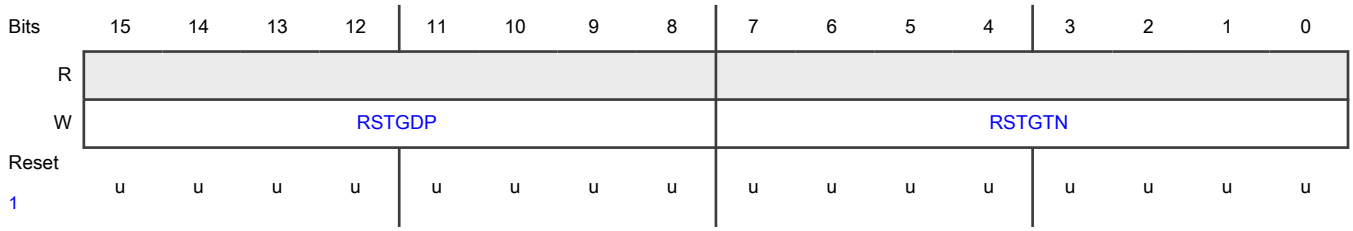
Offset

Register	Offset
RSTGT_W	42h

Function

Specifies the hardware gate to reset when data patterns are specified.

Diagram



1. Reset value is not applicable for writes.

Fields

Field	Function
15-8 RSTGDP	Reset Gate Data Pattern You access this field with the specified data patterns on the two consecutive writes to enable the gate-reset mechanism. For the first write, RSTGDP must be E2h. For the second write, RSTGDP must be 1Dh.
7-0 RSTGTN	Reset Gate Number Specifies the specific hardware gate to be reset. The second write updates this field. If RSTGTN < 64, SEMA42 resets the single gate defined by RSTGTN. Otherwise, SEMA42 resets all the gates.

16.7 Glossary

IPS Protocol used for peripheral accesses to the programming model

dm*X* Domain X

Chapter 17
Crossbar Integrity Checker (XBIC)

17.1 Chip-specific XBIC information

17.1.1 XBIC instances and configuration

This chip has 6 instances of XBIC. The following describes the instances and their configuration:

- XBIC_0
- XBIC_1
- XBIC_2
- XBIC_3
- XBIC_4
- XBIC_5

Table 51. XBIC configuration

<table>
<tr><th>Instance</th><th>Available on crossbar</th><th>Master and slave assignments</th></tr>
<tr><td>XBIC_0</td><td>System_XBAR</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th></th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>Cortex-M7_0 AHBM</td><td></td><td>S0</td><td>Flash memory port 0</td></tr>
<tr><td>M1</td><td>DMA0</td><td></td><td>S1</td><td>Flash memory port 1</td></tr>
<tr><td>M2</td><td>HSE_B</td><td></td><td>S2</td><td>PRAM_0</td></tr>
<tr><td>M3</td><td>ENET</td><td></td><td>S3</td><td>Cortex-M7 TCM</td></tr>
<tr><td>M4</td><td>Cortex-M7_1 AHBM</td><td></td><td>S4</td><td>Flash memory port 2</td></tr>
<tr><td>M5</td><td>Cortex-M7_2 AHBM</td><td></td><td>S5</td><td>QuadSPI</td></tr>
<tr><td>M6</td><td>DMA1</td><td></td><td>S6</td><td>PRAM_1</td></tr>
<tr><td>M7</td><td>Zipwire</td><td></td><td>S7</td><td>Flash memory port 3</td></tr>
</table>
</td></tr>
<tr><td>XBIC_1</td><td>Peripheral_XBAR</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th></th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>Cortex-M7_0 AHBP</td><td></td><td>S0</td><td>AIPS_0</td></tr>
<tr><td>M1</td><td>DMA</td><td></td><td>S1</td><td>AIPS_1</td></tr>
<tr><td></td><td></td><td></td><td>S2</td><td>AIPS_2</td></tr>
<tr><td>M2</td><td>HSE_B</td><td></td><td>S3</td><td>AIPS_3</td></tr>
<tr><td>M3</td><td>Cortex-M7_1 AHBP</td><td></td><td></td><td></td></tr>
<tr><td>M4</td><td>Cortex-M7_2 AHBP</td><td></td><td></td><td></td></tr>
<tr><td>M5</td><td>--</td><td></td><td></td><td></td></tr>
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</td></tr>
</table>

<table>
<tr><th>Instance</th><th>Available on crossbar</th><th>Master and slave assignments</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><td>M6</td><td>DMA1</td></tr>
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</td></tr>
<tr><td>XBIC_2</td><td>eDMA_XBAR</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>eDMA</td><td>S0</td><td>System XBAR</td></tr>
<tr><td></td><td></td><td>S1</td><td>Peripheral XBAR</td></tr>
</table>
</td></tr>
<tr><td>XBIC_3</td><td>TCM_XBAR</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>System XBAR</td><td>S0</td><td>Cortex-M7_0 TCM</td></tr>
<tr><td></td><td></td><td>S1</td><td>Cortex-M7_1 TCM</td></tr>
<tr><td></td><td></td><td>S2</td><td>Cortex-M7_2 TCM</td></tr>
</table>
</td></tr>
<tr><td>XBIC_4</td><td>EDMA1_XBAR</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>eDMA_1</td><td>S0</td><td>System XBAR</td></tr>
<tr><td></td><td></td><td>S1</td><td>Peripheral XBAR</td></tr>
</table>
</td></tr>
<tr><td>XBIC_5</td><td>ZIPWIRE_XBAR</td><td>
<table>
<tr><th>Master port</th><th>Master module</th><th>Slave port</th><th>Slave module</th></tr>
<tr><td>M0</td><td>Zipwire</td><td>S0</td><td>System XBAR</td></tr>
<tr><td></td><td></td><td>S1</td><td>Peripheral XBAR</td></tr>
</table>
</td></tr>
</table>

17.1.2 Target master IDs

See "Chip-specific XRDC information" for master IDs.

17.2 Overview

XBIC is a safety module that verifies the integrity of crossbar transfers.

17.2.1 Block diagram

The chip routes crossbar transfer attribute information for all mapped master and slave ports to XBIC, which calculates and checks the EDC value of the attribute information, as shown in the following diagram.

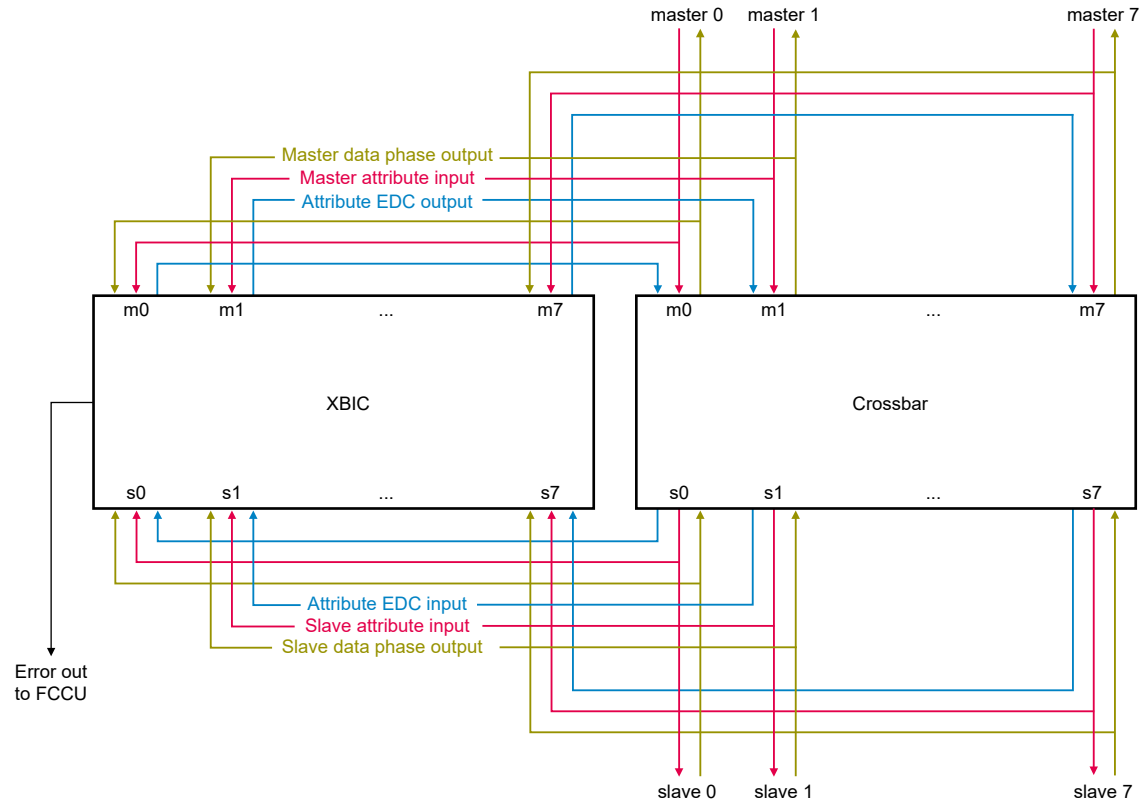

Figure 39. XBIC system block diagram

The above figure illustrates one of many possible XBIC and crossbar configurations. See the Chip-specific XBIC information section for actual port mappings.

17.2.2 Features

XBIC includes the following features:

- Verification of attribute information for crossbar transfers [1],[2]
  - EDC detects single-bit and double-bit errors
- Verification of feedback information for each data phase during crossbar transfers
- Error injection for testing
  - Programmable master and slave port specifiers
  - Programmable 8-bit toggle vector to insert error in master EDC value
  - Address, EDC syndrome, master, and slave port information are captured when error is detected
- Crossbar transfer attribute integrity check programmable on a per-slave-port basis
- Feedback integrity check programmable on a per-master-port basis

17.3 Functional description

XBIC verifies the integrity of the crossbar interface on an individual port basis according to the configuration specified via the MCR register. When XBIC detects an error, it reports relevant information and sends an error signal to the FCCU module, but does

[1] See Table 52 for a list of crossbar attribute signals verified.
[2] The chip verifies read and write data separately, via the end-to-end ECC architecture.

not generate a bus error. XBIC integrity checking is independent of end-to-end ECC, which monitors the integrity of the transfer address and data.

During the address phase of a transfer, XBIC verifies the crossbar attribute information using an 8-bit EDC, which detects any single-bit or double-bit errors. When XBIC detects an error (an attribute integrity error), due to either hardware fault or error injection, it reports information related to the error in ESR and EAR.

During the data phase of a data transfer, XBIC verifies the integrity of response signals from slave to master as they pass through the crossbar. When XBIC detects an error in the response signals (a feedback integrity error), it reports the XBIC slave and master ports in ESR[DPSE0] - ESR[DPSE7] and ESR[DPME0] - ESR[DPME7], respectively.

During the data phase, XBIC sends an alarm to the FCCU module if a master port attempts back-to-back accesses in which:

1. The first access terminates normally.
2. The second attempts access to an address space not mapped to any slave on the crossbar.

The resultant 'absent slave error' causes the crossbar to generate a bus error response to the requesting master. XBIC detects the bus error response as a difference because the bus error did not originate from the slave port.

You can program XBIC to inject EDC errors for testing purposes. Error injection targets a single slave port and a single master port, as specified by the configuration settings in the EIR register. When XBIC inserts an error, it changes the EDC syndrome, causing the XBIC to assert an error indication to the FCCU module. Otherwise, transfers are unaffected by error injection. This enables verification of the check logic without compromising the integrity of the data transfer. After you enable error injection function by writing 1 to EIR[EIE], XBIC induces errors on all subsequent targeted transactions until you write a 0 to the field. After the FCCU error indication asserts, it remains asserted even after you write 0 to EIR[EIE]. The error indication deasserts after FCCU specifically clears the existing error. After FCCU clears the XBIC error, additional error injection testing can continue.

To trace a fault reported by the XBIC to the FCCU:

1. Note the error reported by the FCCU. For example, "NCF[46]".
2. Locate the source module and error description in the attached fault mapping spreadsheet. For example:
   - Channel number: NCF[46]
   - Source module: AXBS_1 integrity checker
   - Description: Instruction crossbar error indication to FCCU if syndrome calculated using EDC on the data is not zero
3. Refer to the Chip-specific XBIC information section for the source XBIC module to determine the specific XBIC module instance—"XBIC_1", for example.
4. Determine the type of error (attribute integrity error or feedback integrity error) and the XBIC port(s) involved by reading the information reported in the ESR register of the reported XBIC instance.
5. For attribute integrity check errors, read the XBIC EAR register for the target address of the requested transfer.
6. Refer to the Chip-specific XBIC information section and possibly the Chip-specific AXBS information section for port mapping of XBIC ports to AXBS ports.

Decode a single-bit error syndrome value reported in ESR[SYN] by finding the value in the following table. Any syndrome value not included in the table indicates a multi-bit error.

Table 52. Hexadecimal attribute single-bit error syndromes

Signal	SYN	Signal	SYN	Signal	SYN	Signal	SYN
hwrite	07	hbstrb[7]	70	hdecor[31]	25	hdecor[15]	23
htrans[0]	0b	hbstrb[6]	32	hdecor[30]	68	hdecor[14]	51
hsize[2]	0d	hbstrb[5]	52	hdecor[29]	c7	hdecor[13]	54

Table continues on the next page...

Table 52. Hexadecimal attribute single-bit error syndromes (continued)

Signal	SYN	Signal	SYN	Signal	SYN	Signal	SYN
hsize[1]	0e	hbstrb[4]	a8	hdecor[28]	83	hdecor[12]	61
hsize[0]	13	hbstrb[3]	43	hdecor[27]	85	hdecor[11]	e3
hprot[5]	15	hbstrb[2]	45	hdecor[26]	86	hdecor[10]	e6
hprot[4]	16	hbstrb[1]	4c	hdecor[25]	89	hdecor[9]	f8
hprot[3]	19	hbstrb[0]	a4	hdecor[24]	8a	hdecor[8]	38
hprot[2]	1a	hmaster[3]	a2	hdecor[23]	8c	hdecor[7]	58
hprot[1]	1c	hmaster[2]	b0	hdecor[22]	49	hdecor[6]	37
hprot[0]	91	hmaster[1]	c1	hdecor[21]	92	hdecor[5]	f1
hburst[2]	a1	hmaster[0]	c2	hdecor[20]	94	hdecor[4]	3b
hburst[1]	64	hslave[2]	c4	hdecor[19]	98	hdecor[3]	3d
hburst[0]	29	hslave[1]	c8	hdecor[18]	46	hdecor[2]	3e
hmastlock	2a	hslave[0]	d0	hdecor[17]	34	hdecor[1]	4f
hunalign	2c	hdecorated	e0	hdecor[16]	4a	hdecor[0]	6e
edc[7]	80	edc[6]	40	edc[5]	20	edc[4]	10
edc[3]	08	edc[2]	04	edc[1]	02	edc[0]	01

17.3.1 Interrupts

This module has no interrupts.

17.4 External signals

XBIC has no external interface signals.

17.5 Initialization

This module does not require initialization.

17.6 XBIC register descriptions

The XBIC programming model consists of four 32-bit registers. Software can access this model only in supervisor mode using 32-bit (word) accesses. Each of the following generates a transfer error back to the requesting master. Such errors could cause core exceptions apart from other problems.

- Access size other than 32-bit
- Access to an undefined (reserved) address
- Access in user mode

17.6.1 XBIC memory map

XBIC_AXBS base address: 4020_4000h

XBIC_AXBS_PERI base address: 4020_8000h

XBIC_AXBS_TCM base address: 4040_0000h

XBIC_AXBS_eDMA base address: 4040_4000h

Zipwire_XBIC base address: 4067_8000h

eDMA1_XBIC base address: 4067_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	XBIC Module Control (MCR)	32	RW	See section
4h	XBIC Error Injection Attributes (EIR)	32	RW	0000_0000h
8h	XBIC Error Status Attributes (ESR)	32	RW	0000_0000h
Ch	XBIC Error Address (EAR)	32	R	0000_0000h

17.6.2 XBIC Module Control (MCR)

Offset

Register	Offset
MCR	0h

Function

Use this register to turn attribute integrity checking and feedback integrity checking on or off on a per-port basis.

- Turn on attribute integrity checking on one or more XBIC slave ports by ensuring that the associated SE*n* field(s) have a value of 1. For example, setting field SE*0* enables attribute integrity checking for slave port 0. The default (reset) behavior is for attribute integrity checking to be performed for all slave ports. XBIC performs EDC-based checks on all transfer requests targeting the selected slave port(s). The signals verified are transfer attribute signals going from master to slave. When XBIC detects an attribute integrity error, it reports relevant information in the ESR and EAR registers.
- Turn on feedback integrity checking on one or more XBIC master ports by ensuring that the associated ME*n* field(s) have a value of 1. For example, setting field ME*0* to 1 enables feedback integrity checking for master port 0. The default (reset) behavior is for feedback integrity checking to be performed for all master ports. XBIC checks slave-to-master feedback signals for transfer requests originating from the selected XBIC master port(s). If any feedback signal value is different at the master and slave ports during the data phase, XBIC reports the relevant master and slave ports in the ESR register.

Each field in this register references a specific master or slave port using XBIC port numbering. Referring to Figure 39, "slave port 0" refers to XBIC port "s0" in the figure, "slave port 1" refers to port "s1", and so on. Similarly, "master port 0" refers to XBIC port "m0", "master port 1" refers to port "m1", and so on. See the "Chip-specific XBIC information" section in this document for the mapping of XBIC instances to AXBS instances and XBIC ports to AXBS ports. See the "Chip-specific AXBS information" section in this document for the device component(s) mapped to each port of an AXBS instance.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SE0	SE1	SE2	SE3	SE4	SE5	SE6	SE7	ME0	ME1	ME2	ME3	ME4	ME5	ME6	ME7
W																
Reset	See Register reset values.															

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	See Register reset values.															

Register reset values

Register	Reset value
MCR	XBIC_AXBS: FFFF_0000h XBIC_AXBS_PERI: F0FB_0000h XBIC_AXBS_TCM: E080_0000h XBIC_AXBS_eDMA: C0C0_0000h Zipwire_XBIC,eDMA1_XBIC: C080_0000h

Fields

Field	Function
31 SE0	Slave port EDC Error Detection Enable 0b - Attribute integrity checking disabled for slave port 0 1b - Attribute integrity checking enabled for slave port 0
30 SE1	Slave port EDC Error Detection Enable 0b - Attribute integrity checking disabled for slave port 1 1b - Attribute integrity checking enabled for slave port 1
29 SE2	Slave port EDC Error Detection Enable **NOTE** This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
XBIC_AXBS	MCR	—
XBIC_AXBS_PERI	MCR	—
XBIC_AXBS_TCM	MCR	—

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Attribute integrity checking disabled for slave port 2
1b - Attribute integrity checking enabled for slave port 2
</td></tr>
<tr><td>28
SE3</td><td>Slave port EDC Error Detection Enable
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Attribute integrity checking disabled for slave port 3
1b - Attribute integrity checking enabled for slave port 3
</td></tr>
<tr><td>27
SE4</td><td>Slave port EDC Error Detection Enable
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>—</td><td>MCR</td></tr>
</table>
</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Attribute integrity checking disabled for slave port 4
1b - Attribute integrity checking enabled for slave port 4
</td></tr>
<tr><td>26
SE5</td><td>Slave port EDC Error Detection Enable
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Attribute integrity checking disabled for slave port 5
1b - Attribute integrity checking enabled for slave port 5
</td></tr>
<tr><td>25
SE6</td><td>Slave port EDC Error Detection Enable
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Attribute integrity checking disabled for slave port 6
1b - Attribute integrity checking enabled for slave port 6
</td></tr>
<tr><td>24
SE7</td><td>Slave Port EDC Error Detection Enable
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Attribute integrity checking disabled for slave port 7
1b - Attribute integrity checking enabled for slave port 7
</td></tr>
<tr><td>23
ME0</td><td>Master Port Enable For Feedback Integrity Check
0b - Feedback integrity checking disabled for master port 0
1b - Feedback integrity checking enabled for master port 0</td></tr>
<tr><td>22</td><td>Master Port Enable For Feedback Integrity Check</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
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NOTE
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<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>MCR</td><td>—</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Feedback integrity checking disabled for master port 1
1b - Feedback integrity checking enabled for master port 1
</td></tr>
<tr><td>21
ME2</td><td>Master Port Enable For Feedback Integrity Check
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Feedback integrity checking disabled for master port 2
1b - Feedback integrity checking enabled for master port 2
</td></tr>
<tr><td>20</td><td>Master Port Enable For Feedback Integrity Check</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>ME3</td><td>
NOTE
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<tr><td>XBIC_AXBS_PERI</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Feedback integrity checking disabled for master port 3
1b - Feedback integrity checking enabled for master port 3
</td></tr>
<tr><td>19
ME4</td><td>
Master Port Enable For Feedback Integrity Check
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Feedback integrity checking disabled for master port 4
1b - Feedback integrity checking enabled for master port 4
</td></tr>
<tr><td>18</td><td>Master Port Enable For Feedback Integrity Check</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>ME5</td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Feedback integrity checking disabled for master port 5
1b - Feedback integrity checking enabled for master port 5
</td></tr>
<tr><td>17
ME6</td><td>
Master Port Enable For Feedback Integrity Check
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Feedback integrity checking disabled for master port 6
1b - Feedback integrity checking enabled for master port 6
</td></tr>
<tr><td>16</td><td>Master Port Enable For Feedback Integrity Check</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>ME7</td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>XBIC_AXBS</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_PERI</td><td>MCR</td><td>—</td></tr>
<tr><td>XBIC_AXBS_TCM</td><td>—</td><td>MCR</td></tr>
<tr><td>XBIC_AXBS_eDMA</td><td>—</td><td>MCR</td></tr>
<tr><td>Zipwire_XBIC</td><td>—</td><td>MCR</td></tr>
<tr><td>eDMA1_XBIC</td><td>—</td><td>MCR</td></tr>
</table>
0b - Feedback integrity checking disabled for master port 7
1b - Feedback integrity checking enabled for master port 7
</td></tr>
<tr><td>15-0
—</td><td>Reserved</td></tr>
</table>

17.6.3 XBIC Error Injection Attributes (EIR)

Offset

Register	Offset
EIR	4h

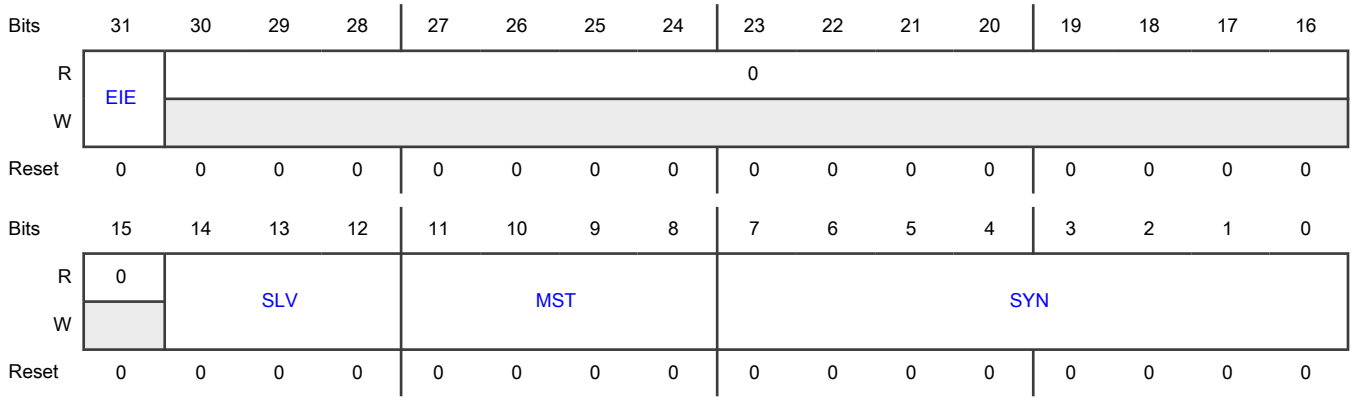
Function

Use this register to configure the XBIC error injection function and turn it on or off. When enabled, the XBIC error injection function inserts an attribute integrity error when the targeted master requests a transaction of the targeted slave port. The inserted error changes the calculated EDC syndrome value, causing XBIC to:

- Capture transfer information in the ESR and EAR registers
- Assert an error signal to the FCCU module

Otherwise, XBIC error injection does not affect transfers.

Diagram



Fields

Field	Function
31 EIE	Error Injection Enable **NOTE** This field automatically clears after an error is generated and acknowledged by FCCU. 0b - Error injection disabled 1b - Error injection enabled
30-15 —	Reserved
14-12 SLV	Target Slave Port Specifies the target slave port for error injection—other slave ports are unaffected. Specify the target slave port by its XBIC slave port number (0–7). See the "Chip-specific XBIC information" section in this document for the mapping of XBIC instances to AXBS instances and XBIC ports to AXBS ports. See the "Chip-specific AXBS information" section in this document for the device component(s) mapped to each port of an AXBS instance.
11-8 MST	Target Master ID Specifies the target master port for error injection—transfers with other masters are unaffected. Specify the target master port using the logical master ID number of the target bus master. See the "Chip-specific XBIC information" section in this document for the master IDs and their corresponding components.
7-0 SYN	Syndrome XBIC performs an exclusive OR operation on the value in this field and the calculated syndrome, to generate an error with the specified syndrome. A value of zero does not generate an error. See Table 52 for a list of transfer attribute single-bit error syndromes, noting that the values given in the table are hexadecimal.

17.6.4 XBIC Error Status Attributes (ESR)

Offset

Register	Offset
ESR	8h

Function

In this register, XBIC reports information about the most recent transfer with an error detected. If XBIC detects an attribute integrity check error, it reports:

- The slave port identifier (SLV)
- The master port identifier (MST) and the error syndrome (SYN)

If XBIC detects a mismatch among feedback signals during the data phase:

- The DPSE0 - DPSE7 field with a value of 1 indicates the XBIC slave port. In the DPSE0-DPSE7 field descriptions, the slave port number refers to the XBIC slave port number. Referring to Figure 39, "slave port 0" refers to XBIC port "s0" in the figure, "slave port 1" refers to port "s1", and so on. See the "Chip-specific XBIC information" section in this document for the mapping of XBIC instances to AXBS instances and XBIC ports to AXBS ports. See the "Chip-specific AXBS information" section in this document for the device component(s) mapped to each port of an AXBS instance.
- The DPME0 - DPME7 field with a value of 1 indicates the XBIC master port. In the DPME0-DPME7 field descriptions, the master port number refers to the XBIC master port number. Referring to Figure 39, "master port 0" refers to XBIC port "m0" in the figure, "master port 1" refers to port "m1", and so on. See the "Chip-specific XBIC information" section in this document for the mapping of XBIC instances to AXBS instances and XBIC ports to AXBS ports. See the "Chip-specific AXBS information" section in this document for the device component(s) mapped to each port of an AXBS instance.

XBIC sets this register to all 0s only on reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	VLD	DPSE 0	DPSE 1	DPSE 2	DPSE 3	DPSE 4	DPSE 5	DPSE 6	DPSE 7	DPME 0	DPME 1	DPME 2	DPME 3	DPME 4	DPME 5	DPME 6
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DPME 7	SLV			MST				SYN							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31	Error Status Valid

Table continues on the next page...

Table continued from the previous page...

Field	Function
VLD	0b - No error detected—other fields of the ESR and EAR registers are invalid 1b - Error detected—all fields of the ESR and EAR registers are valid
30 DPSE0	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 0 1b - Feedback integrity error detected on slave port 0
29 DPSE1	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 1 1b - Feedback integrity error detected on slave port 1
28 DPSE2	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 2 1b - Feedback integrity error detected on slave port 2
27 DPSE3	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 3 1b - Feedback integrity error detected on slave port 3
26 DPSE4	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 4 1b - Feedback integrity error detected on slave port 4
25 DPSE5	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 5 1b - Feedback integrity error detected on slave port 5
24 DPSE6	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 6 1b - Feedback integrity error detected on slave port 6
23 DPSE7	Data Phase Slave Port Error 0b - No feedback integrity error detected on slave port 7 1b - Feedback integrity error detected on slave port 7
22 DPME0	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 0 1b - Feedback integrity error detected on master port 0
21 DPME1	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 1 1b - Feedback integrity error detected on master port 1

Table continues on the next page...

Table continued from the previous page...

Field	Function
20 DPME2	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 2 1b - Feedback integrity error detected on master port 2
19 DPME3	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 3 1b - Feedback integrity error detected on master port 3
18 DPME4	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 4 1b - Feedback integrity error detected on master port 4
17 DPME5	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 5 1b - Feedback integrity error detected on master port 5
16 DPME6	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 6 1b - Feedback integrity error detected on master port 6
15 DPME7	Data Phase Master Port Error 0b - No feedback integrity error detected on master port 7 1b - Feedback integrity error detected on master port 7
14-12 SLV	Slave Port Slave port targeted by the most recent transfer with an attribute integrity check error detected. The value in this field is the XBIC slave port number (0–7). See the "Chip-specific XBIC information" section in this document for the mapping of XBIC instances to AXBS instances and XBIC ports to AXBS ports. See the "Chip-specific AXBS information" section in this document for the device component(s) mapped to each port of an AXBS instance.
11-8 MST	Master ID Master port that requested the most recent transfer with an attribute integrity check error detected. The value in this field is the logical master ID number of the bus master. See the "Chip-specific XBIC information" section in this document for the master IDs and their corresponding components.
7-0 SYN	Syndrome Syndrome calculated for the most recent transfer with an attribute integrity check error detected. For single-bit errors, identify the signal in error by matching the SYN value in Table 52, noting that the syndrome (SYN) values in the table are hexadecimal.

17.6.5 XBIC Error Address (EAR)

Offset

Register	Offset
EAR	Ch

Function

In this register, XBIC reports the address of the most recent transfer with an attribute integrity check error detected—either because of a hardware fault or error injection. XBIC sets this register to all 0s only on reset.

NOTE

An attempted write to this read-only register results in a transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ADDR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ADDR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 ADDR	Error Address Address of the most recent transfer with an attribute integrity check error detected.

17.7 Glossary

EDC Error Detection Code

hdecor[31:0] Non-standard AHB address phase signal for transporting optional decorated storage instruction information

hdecorated Non-standard AHB address phase signal for transporting optional decorated storage instruction information

Chapter 18
Extended Resource Domain Controller (XRDC)

18.1 Chip-specific XRDC information

18.1.1 MDAC configuration

All MDACs with DID = 0 use the default DID parameter.

Table 53. MDAC configuration

Submodule instance	Configuration	XRDC MDACFG#	Bus master	Master ID value	Default DID	PID	Nonsecure input
XRDC_MDAC0	Processor	1	Cortex-M7_0, AXI, AHBP Cortex-M7_0 debug	0h	0h	PID0	0b
XRDC_MDAC1	Nonprocessor	1	eDMA AHB	2h	0h	-	1b
XRDC_MDAC4	Processor	1	Cortex-M7_1, AXI, AHBP Cortex-M7_1 debug	1h 1h	0h	PID4	0b
XRDC_MDAC5	Nonprocessor	1	EMAC AHB	4h	0h	-	1b
XRDC_MDAC6	Processor	1	CortexM7_2, AXI, AHBP Cortex-M7_2 debug	7h 7h	0h	PID6	0b
XRDC_MDAC7	Nonprocessor	1	EDMA1 AHB	6h	0h	-	1b
XRDC_MDAC8	Nonprocessor	1	ZIPWIRE AHB	5h	0h	-	1b

NOTE

- In case of XRDC_MDAC1 and XRDC_MDAC7, the Default DID input is software configurable and is coming from eDMA IP. See section "eDMA ID replication".
- XRDC_MDAC4 is reserved in K36x.

18.1.2 MRC configuration

Table 54. MRC configuration

Submodule instance	Region format	Number of region descriptors	Slaves protected (port number)
XRDC_MRC0	Auto	16	PFLASH_0 (0) PFLASH_1 (1) PFLASH_2 (2)

Table continues on the next page...

Table 54. MRC configuration (continued)

Submodule instance	Region format	Number of region descriptors	Slaves protected (port number)
			PFLASH_3 (3) PFLASH_WR (4)
XRDC_MRC1	Auto	16	PRAM0 (0) PRAM1 (1)
XRDC_MRC2	Auto	4	QuadSPI (0)
XRDC_MRC3	Auto	16	TCM backdoor (0)

18.1.3 PAC configuration

Table 55. PAC configuration

Module name	Slaves protected
XRDC_PAC0	AIPS_0
XRDC_PAC1	AIPS_1
XRDC_PAC2	AIPS_2
XRDC_PAC3	AIPS_3

NOTE

For PDAC registers assignment to peripherals, see the memory map file attached to this document.

18.1.4 Exceptions and violations

A write attempt by a noncore bus master outside the defined ranges leads to an exception in case the XRDC region is defined to prevent noncore master access. The chip generates a bus error if you violate XRDC policies.

18.1.5 Configuration using SBAF

SBAF must protect access to its own resources. Hence, XRDC is configured during initialization. SBAF provides the mechanism for you to configure XRDC during boot. You must program the configuration data in the application flash memory region.

18.1.5.1 PDAC default configuration

SBAF configures and lock the following peripherals for its exclusive use. Read and write access to these peripheral are not provided to application domains.

Table 56. PDAC default configuration

Peripheral	Peripheral PDAC number	Remarks
Flash memory controller alternate	155	HSE_B uses the alternate interface exclusively.
Flash memory alternate	188	HSE_B uses the alternate interface exclusively.

18.1.6 Configuration when HSE_B firmware-feature flag is cleared

When the HSE_B firmware-feature flag is cleared, SBAF:

- Does not permit XRDC configuration.

- Locks the aforementioned configurations.

18.2 Overview

XRDC manages access control between masters (cores and noncore masters) and targets (memories and peripherals) by placing them in virtual groups called domains.

Conceptually, a domain is one or more masters and memories and peripherals, that are isolated from others. It may help to look at a domain as a permissions group within a computing environment. All masters in a domain have the same access to chip resources such as memory and peripherals. See Introduction to domains for more information on domains.

The protection provided by XRDC access control is in addition to the local memory protection unit contained within each core.

18.2.1 Features

- Enables you to partition chip resources (master and target) into access-controlled domain .
  - Each domain has a unique DID .
  - The DID is an attribute of every system bus transaction.
- Provides a four-level hierarchical access control scheme for defining an ACP for each target in a domain. See Access control model for more information.
  - Memory region descriptors define access policies for address ranges within memories.
  - Peripheral access control registers define access policies for individual peripherals.
- Supports optional hardware semaphores to dynamically modify access rights for target resources.

18.2.2 Block diagram

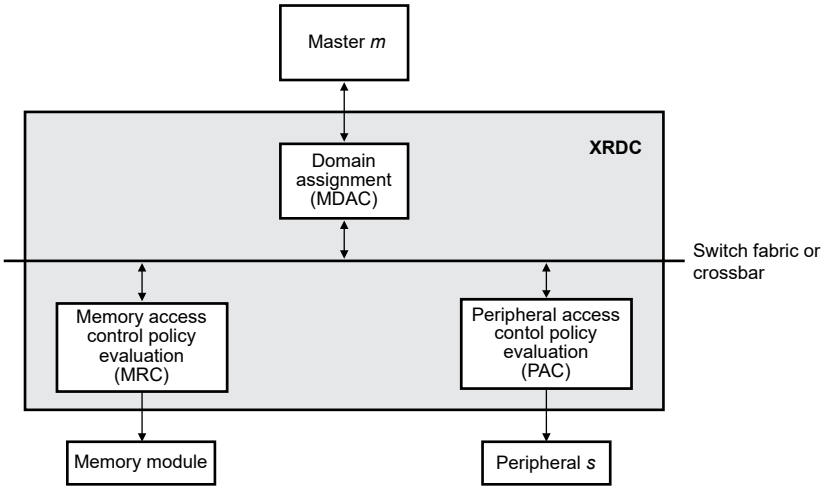


Figure 40. Block diagram

18.2.3 Block descriptions

Block	Description
Domain assignment	A process that adds information to transactions, including:

Table continues on the next page...

Table continued from the previous page...

Block	Description
	• DID • Privileged attribute • Secure attribute Domain assignment is performed by the MDAC submodule. See: • Domain assignment • Master domain assignment controller (MDAC)
Master	A core or noncore (for example, DMA) module that can initiate transactions with memory or peripheral resources.
Memory	A block of flash memory, RAM, or other memory.
Memory access control policy evaluation	A process that determines whether the domain associated with a transaction has access rights to a memory location. The process is performed by the MRC submodule. See: • Memory region ACP evaluation • Memory region controller (MRC)
Peripheral	A nonmemory resource module within the chip—an ADC, timer module, or communications module, for example.
Peripheral access control policy evaluation	A process that determines whether the domain associated with a transaction has access rights to a peripheral. The process is performed by the PAC submodule. See Peripheral access controller (PAC).
Crossbar	The chip's module and I/O interconnect infrastructure.

18.2.4 Indexes used in this chapter

Table 57. Indexes used in this chapter

Index	Description
c	Memory controller number. For example, MRC*c*.
d	Domain number. For example, PDAC_W0_6[D*d*ACP].
m	Master number. For example, PID*m*.
r	Memory region number. For example, RGD_W0_*r*.
s	PDAC slot number. For example, PDAC_W0_*s*[D0ACP].
w	Word number. In a group of registers consisting of consecutive 32-bit registers, *w* is the 0-indexed register number. For example, MRGD_W*w*_0.

18.2.5 Exceptions and violations

A write attempt by a noncore bus master outside the defined ranges leads to an exception in case the XRDC region is defined to prevent noncore master access. The chip generates a bus error if you violate XRDC policies.

18.3 Modes of operation

XRDC does not support any special modes of operation.

18.4 External signal description

XRDC does not have any external signals.

18.5 Functional description

18.5.1 Introduction to domains

A domain typically consists of one or more master, along with the memories and peripherals those masters are allowed to access. Because it is access-controlled, a domain acts as an independent computing environment.

Domains enable applications to coexist on the same silicon with a firewall between them, enforcing absolute interference protection.

Generally, you create each domain to meet a specific need. Examples of XRDC domain usage include:

- Isolation of real-time from non-real-time applications to ensure resource availability
- Isolation of safety-critical code from non-safety-critical code
- Isolation of third-party untrusted applications from trusted software
- Isolation of memory regions to ensure data security or to prevent accidental overwrites
- Limiting write access for a specific area of system memory to a single DMA module instance
- Limiting read access for a specific area of system memory to a specific processor core

You can assign a core to multiple domains but only one of those domains can be active at a given time.

Within each XRDC instance, each domain has a unique identifier, known as its DID. If an XRDC instance has 16 DIDs, that means the instance has 16 available domains.

You control which masters can access a peripheral by configuring the domain ACP for each peripheral. Similarly, you control which masters can access a memory region by configuring the ACP for each memory region.

18.5.2 Submodules

XRDC implements its functionality through its hardware submodules:

- Master domain assignment controller (MDAC)
- Memory region controller (MRC)
- Peripheral access controller (PAC)

18.5.2.1 Master domain assignment controller (MDAC)

The MDAC submodule performs domain assignment logic. XRDC contains an MDAC submodule for each XRDC-protected master. Each MDAC assigns a DID to every transaction from its associated master. You configure the domain assignment activity for each MDAC through a set of registers, in one of two formats:

- DFMT0 core domain assignment registers
- DFMT1 noncore domain assignment registers

To understand the role of domains in XRDC protection, see Introduction to domains.

For a full explanation of the domain assignment process, see Domain assignment.

18.5.2.2 Memory region controller (MRC)

The MRC submodule performs memory region access control. Each XRDC instance contains the number of MRCs indicated in HWCFG0[NMRC]. Each MRC is associated with one or more memories (see the chip-specific XRDC information for details). The MRC controls memory access using memory region descriptors. MRCFG*c*[NMRGD] indicates the number of region descriptors available for MRC *c*.

Each memory region descriptor defines a memory address range and a configurable access control policy for each domain using a set of four or five 32-bit registers (see Memory ACP evaluation registers).

Memory region descriptors also support including an optional hardware semaphore in the ACP evaluation for memory regions shared by multiple domains (see Hardware semaphores and dynamic access rights).

For a full explanation of the memory region ACP evaluation process, see Memory region ACP evaluation.

18.5.2.3 Peripheral access controller (PAC)

The PAC submodule provides domain access control for all peripherals connected to a single peripheral bus. Each XRDC contains the number of PACs indicated in HWCFG0[NPAC]. Each PAC supports up to 128 peripheral slots (see Finding the PDAC slot number for a peripheral). You configure the ACP for each peripheral using a set of PDAC_W*w_s* registers (see Peripheral ACP evaluation registers).

Peripheral access control also enable a hardware semaphore to be included in the access control policy evaluation for peripherals shared by multiple domains. See Hardware semaphores and dynamic access rights for more details.

For a full explanation of the peripheral ACP evaluation process, see Peripheral ACP evaluation process.

18.5.3 Transaction protection

During application execution, high-level chip modules such as cores or DMA, Ethernet, Zipwire, or FlexRay, known as masters, initiate transaction requests to memory and peripheral resources. XRDC adds protection capabilities to ensure the requesting master accesses only the resources that it is authorized to access. These capabilities support security and safety requirements.

XRDC provides this protection by adding two steps to the unprotected transaction flow, as shown in XRDC transaction flow.

XRDC transaction processing differs depending on:

- The type of master making the request (see Transaction request sources).
- The type of target receiving the request (see Transaction targets).

NOTE

See chip-specific XRDC information for the domain ID of each master on chip.

18.5.4 XRDC transaction flow

Table 58. XRDC transaction flow

Step	Operation	Performed by	Description
1	Transaction request	Master	A master requests a read or write transaction targeting memory or a peripheral.
2	Domain assignment	XRDC	XRDC MDAC submodule intercepts the request and performs domain assignment, which adds this metadata to the transaction: • DID • Privileged attribute • Secure attribute

Table continues on the next page...

Table 58. XRDC transaction flow (continued)

Step	Operation	Performed by	Description
3	Interconnect	Chip	The chip transmits the domain-assigned transaction request across the interconnect (crossbar).
4	ACP evaluation	XRDC	XRDC MRC or PAC submodule intercepts the transaction request and evaluates it against the target's ACP to determine whether the requesting master has sufficient access rights to the target. If it does, the transaction continues. Otherwise, XRDC generates an access violation error and the transaction terminates.
5	Transaction response	Target resource	If the previous step does not generate an access violation error, the target resource processes the transaction request and transmits data (for read transactions) and transaction status information (for all transactions) back across the interconnect to the requesting master. XRDC is not involved in the flow of information from the target resource back to the requesting master.

18.5.5 Domain assignment

18.5.5.1 Overview

Domain assignment associates a DID with each transaction request from a master. To determine the DID for a transaction, XRDC evaluates the domain-specific configuration data in the set of MDAC registers (MDA_W*n*_*m*_DFMT0 or MDA_W*n*_*m*_DFMT1) associated with the requesting master. The exact process depends on the source of the request (see Transaction request sources).

If the value of MDACFG*m*[NMDAR] is 1, which means a single W*w* register for a given master, the specified domain identifier is used directly. In case this value is more than 1, which means there are multiple W*w* registers for a given master, MDAC evaluates the conditional terms to determine a "hit". For all W*w* hits, their corresponding domain identifiers are logically summed together (boolean OR). Use cases are typically expected to hit in a single W*w*. Special care is needed if none of the conditional terms hit in any Wn evaluation; in this case, the generated DID = 0 and you must be aware of any potential access rights granted for this DID.

The number of MDAC registers can vary for each master. See the chip-specific information. MDACFG*m*[NMDAR] indicates the number of MDA registers, where *m* is the master number. You need *m* to locate the registers relevant for domain assignment. See the chip-specific XRDC information for more on master numbers. See:

- Register settings for DFMT0 direct domain assignment transactions
- Register settings for DFMT0 PID-based transactions
- Register settings for DFMT1 direct domain assignment transactions

Domain assignment also assigns the secure and privileged attributes to the transaction.

18.5.5.2 PID-based domain assignment

To provide more flexibility in routing core tasks to chip resources in different access-controlled domains, XRDC supports the use of a PID. If the core master contains a built-in PID register, indicated by HWCFG2[PIDP*m*] = 1 , XRDC reflects the core PID value in PID*m*[PID], and bit 5 of that field indicates the secure attribute for the transaction request. Otherwise, an application can mimic PID-based domain assignment by writing a value to that field.

18.5.5.3 Transaction request sources

The domain assignment process for an XRDC-protected transaction request depends on the source of the request.

Table 59. Transaction request sources

Request source	Topic	Brief description
Core master	DFMT0 direct domain assignment example	Direct domain assignment using a DFMT0 master domain assignment register.
Core master	DFMT0 PID-based domain assignment example	PID-based domain assignment using a DFMT0 master domain assignment register.
Core master	DFMT1 direct domain assignment example-single MDA	Direct domain assignment using a DFMT1 master domain assignment register with single MDA.

18.5.5.4 DFMT0 core domain assignment registers

Table 60. DFMT0 core domain assignment registers

Register	Index
MDACFG*m*	*m* = master number. See the chip-specific XRDC information for the available list of masters with their IDs.
MDA_W*w*_*m*_DFMT0[1]	*m* = master number. *w* = word (see MDA register structure). MDACFG*m*[NMDAR] indicates the number of MDA registers (words) per master.
PID*m*	*m* = master number.

1. See MDA register structure.

18.5.5.5 DFMT1 noncore domain assignment registers

Table 61. DFMT1 noncore domain assignment registers

Register	Index
MDACFG*m*	*m* = master number. See the chip-specific XRDC information for the available list of masters and their IDs.
MDA_W*w*_*m*_DFMT1[1]	*m* = master number. *w* = word. MDACFG*m*[NMDAR] indicates the number of MDA registers (words) per master.

1. See MDA register structure.

18.5.5.6 MDA register structure

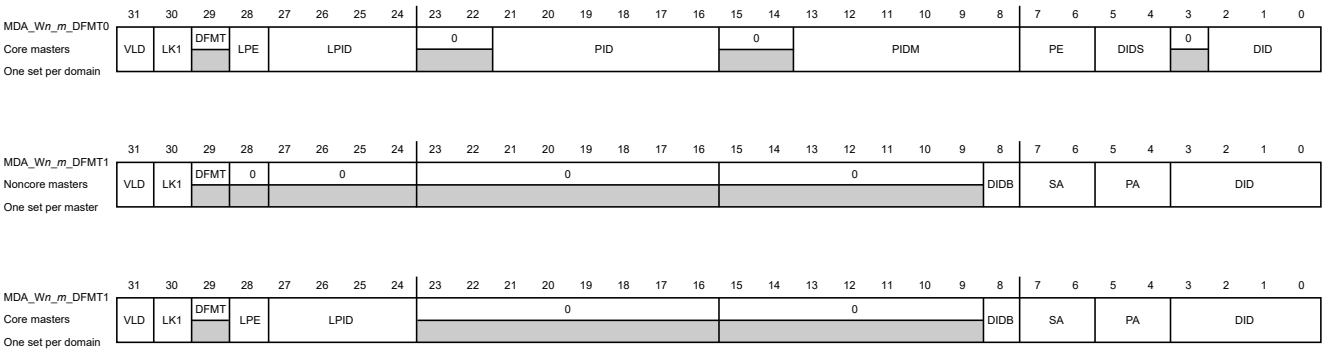


Figure 41. MDA register structure

NOTE

This XRDC configuration does not have LPE and LPID fields and should be considered as reserved fields.

18.5.6 ACP evaluation

18.5.6.1 Overview

When XRDC is not enabled, all peripherals and memories allow unrestricted access. XRDC allows you to limit that access to requests from a particular domain or domains with an application-specified ACP. XRDC intercepts the transaction request and evaluates it against the target's ACP to determine whether the requesting master has sufficient access rights to the target, based on the:

- Domain ID assignment (DID)
- Privileged attribute
- Secured attribute

XRDC obtains the target resource's domain ACP from the associated Domain Access Control Policy (D*d*ACP) field (see Domain ACP specification) in the appropriate register set:

- Peripheral ACP evaluation registers
- Memory ACP evaluation registers

If ACP evaluation determines that the transaction request has sufficient access rights to the target resource, XRDC allows the transaction to continue. Otherwise, it terminates the request with an error and captures the address and attribute information in the appropriate error registers.

The exact process depends on the target of the request (see Transaction targets).

XRDC optionally supports the inclusion of a hardware semaphore to dynamically alter the ACP of a memory region or peripheral (see Hardware semaphores and dynamic access rights).

18.5.6.2 Transaction targets

The ACP evaluation for an XRDC-protected transaction request depends on the target of the request.

Table 62. Transaction targets

Request target	Topic	Brief description
Peripheral	Peripheral ACP evaluation example	Process for a transaction request to a target peripheral that is within a protected domain, with ACP evaluation configured by PDAC_W*w*_*s*.
Memory	Memory ACP evaluation example	Process for a transaction request to a target memory region that is within a protected domain, with ACP evaluation configured by MRGD_W*w*_*r*.

18.5.6.3 Peripheral ACP evaluation registers

Table 63. Peripheral ACP evaluation registers

Register	Index	Brief description
PDAC_W0_*s*[1]	*s* = peripheral slot	Specifies the ACP for an XRDC-protected peripheral, and an optional hardware semaphore.
PDAC_W1_*s*[1]	*s* = peripheral slot	Enables the set of PDAC registers for the associated peripheral and locks the set. Typically, you configure the peripheral by writing to the PDAC registers and then limiting their respective domains from making updates to the D*d*ACP fields or by locking the set for all updates.

1. See PDAC register structure.

18.5.6.4 PDAC register structure

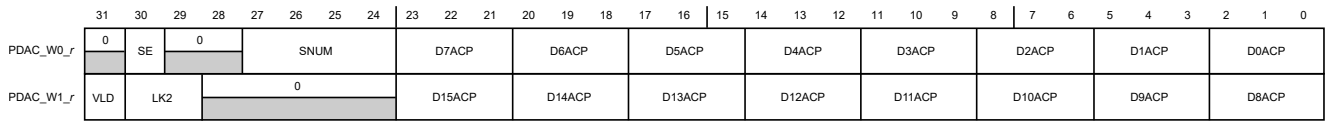


Figure 42. PDAC register structure

18.5.6.5 Memory ACP evaluation registers

When XRDC is enabled (CR[GVLD] = 1), you cannot access any XRDC-protected memory unless you configure at least one set of memory region descriptors (see MRGD_W*w*_*r*) that includes the targeted memory.

Table 64. Memory ACP evaluation registers

Register	Index	Brief description
MRCFG*c*	*c* = memory controller instance	Indicates the number of memory regions per memory controller (NMRGD). Each memory region is configured by a set of memory region descriptor registers (MRGD_W*w*_*r*) described below.
MRGD_W0_*r*[1]	*r* = memory region	Specifies starting address for the memory region.
MRGD_W1_*r*[1]	*r* = memory region	Specifies ending address for the memory region.
MRGD_W2_*r*[1]	*r* = memory region	Specifies the ACP for each supported domain, and an optional hardware semaphore.

Table continues on the next page...

Table 64. Memory ACP evaluation registers (continued)

Register	Index	Brief description
MRGD_W3_*r*[1]	*r* = memory region	Enables the set of MRGD registers for the associated region and locks the set. Typically, you define the memory region by writing to the MRGD registers and then limiting their respective domains from updating the D*d*ACP fields or by locking the set for all updates.

1. See MRGD register structure.

18.5.6.6 MRGD register structure

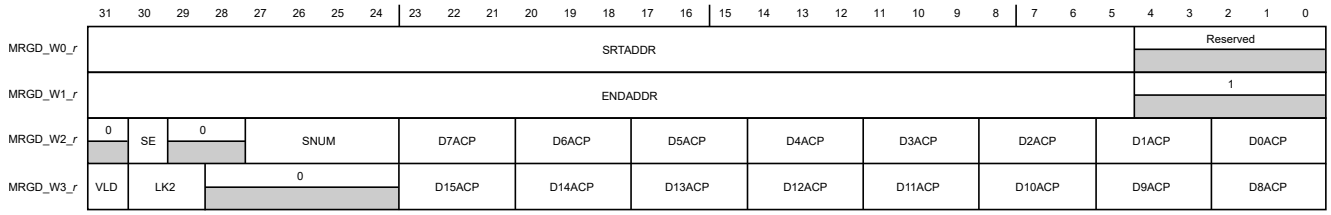


Figure 43. MRGD register structure

18.5.6.7 Access control model

XRDC supports a four-level hierarchical access control model. This model combines the traditional privileged (also known as supervisor) and user access levels with an additional signal for the secure attribute of each memory reference, as shown in Access control model levels.

Each level has different access control policies that specify the read and write accessibility for a target. XRDC combines the privileged and secure attributes with the DID assigned to each system bus transaction to form the hardware basis for the access control mechanism. You specify the ACP for target resources using the D*d*ACP fields (see Domain ACP specification) found in the configuration registers shown in Peripheral ACP evaluation registers and Memory ACP evaluation registers.

You can dynamically control access to shared memory regions and target peripherals with the optional inclusion of a hardware semaphore (see Hardware semaphores and dynamic access rights). If you enable this semaphore for a given address space or peripheral, XRDC allows writes to the target resource only if the requesting domain owns the semaphore.

For cores that support only the three-state access control model (Secure Privileged, Secure User, Nonsecure User), XRDC forces the nonsecure output signal from the MDAC submodule to 0 in privileged mode. This change enables precise state transitions between user and privileged modes. Specifically, the MDAC logic for master *m* generates the nonsecure attribute output signal as a function of the Three-State Model (PID*m*[TSM]) and PID Present (HWCFG2[PIDP*m*]) fields, as shown in Generation of secure attribute).

18.5.6.7.1 Access control model levels

Table 65. Access control model levels

Secure	Nonsecure	Privileged (supervisor)	Not privileged (user)	Level
Yes	Not applicable	Yes	Not applicable	Most restricted
Yes	Not applicable	Not applicable	Yes	More restricted
Not applicable	Yes	Yes	Not applicable	Less restricted
Not applicable	Yes	Not applicable	Yes	Least restricted

18.5.6.7.2 Generation of secure attribute

This table shows how XRDC generates the secure attribute for a transaction.

Table 66. Generation of secure attribute

Access levels [1]	PID*m*[TSM] (b)	PID present [2]	Secure attribute determined by
4	0	No	Master secure attribute
4	0	Yes	Master secure attribute && ~master privileged attribute
3	1	No	PID*m*[5] && ~master privileged attribute
3	1	Yes	Local secure attribute && ~master privileged attribute

1. XRDC assumes a core master supports the four-level access model. If a core supports only the three-state access control model, you must write 1 to PID*m*[TSM] before loading any nonsecure value into the PID.
2. Indicated in HWCFG2–3[PIDP*m*].

18.5.6.8 Domain ACP specification

Table 67. Domain ACP specification

D*d*ACP	Allowable accesses			
	Secure Privileged	Secure User	Nonsecure Privileged	Nonsecure User
111b	R, W	R, W	R, W	R, W
110b	R, W	R, W	R, W	None
101b	R, W	R, W	R	R
100b	R, W	R, W	R	None
011b	R, W	R, W	None	None
010b	R, W	None	None	None
001b	R	R	None	None
000b	None	None	None	None

18.5.6.9 Memory region ACP evaluation

During ACP evaluation of a memory transaction request, if the target memory location falls within the address range specified by any XRDC memory region descriptor, then XRDC identifies the request as a memory region hit. For each memory region hit, XRDC compares the DID, privileged attribute, and secured attribute of the transaction to the associated domain ACP (MRGD_W{2,3}_*r*[D*d*ACP]) in the memory region descriptor. See ACP evaluation for additional details on this function.

The following conditions cause XRDC to report an access error:

- The target memory location does not fall within any defined memory regions; in other words, the transaction request is not a hit.
- The transaction request does not have the appropriate access permissions for the region, which triggers a domain violation.
- The transaction request hits multiple (overlapping) regions, and all of those regions signal access violations.

Unimplemented domain identifiers default to no access privileges, and therefore the access type of a D*d*ACP field for an unimplemented domain is read-as-zero/writes-ignored (RAZ/WI).

18.5.6.10 Hardware semaphores and dynamic access rights

XRDC memory region descriptors and peripheral access control support an optional hardware semaphore in their access evaluations. This hardware semaphore allows hardware enforcement of dynamic access rights, based on the state of the semaphore for shared memory regions or shared peripherals.

If enabled, the state of the semaphore dynamically modifies the access control policies so that only the domain owning it has write access to the resource. The write permissions for all other domains are revoked based on the semaphore state. If no domain owns the semaphore, the PAC and MRC submodules evaluate DdACP normally.

If you enable a hardware semaphore (by writing 1 to MRGD_W2_*r*[SE] or PDAC_W0_*r*[SE]) then, before the normal DdACP evaluation, XRDC checks the state of the hardware semaphore specified in MRGD_W2_*r*[SNUM] or PDAC_W0_*r*[SNUM].

On a write transaction, if the semaphore is not idle (the semaphore state is non-zero) and the requesting domain does not own the semaphore, the memory or peripheral access terminates with an error. In other words, writes into a semaphore-enabled address space or peripheral are allowed only if the semaphore is idle or the requesting domain owns the semaphore.

18.5.7 XRDC transaction examples

To see the complete transaction process for an XRDC-protected transaction request from a master to target:

1. Follow one of these examples of domain assignment:
   - DFMT0 direct domain assignment example
   - DFMT0 PID-based domain assignment example
   - DFMT1 direct domain assignment example-single MDA
2. Then follow one of these examples of ACP evaluation:
   - Peripheral ACP evaluation example
   - Memory ACP evaluation example

18.5.7.1 DFMT0 direct domain assignment example

This configuration assigns a specific domain to all incoming transactions.

- A core master has master number = 6.
- The core has one MDAC register (MDACFG6[NMDAR] = 1), configured as shown in Register settings for DFMT0 direct domain assignment transactions.

MDAC_W*w_m*_DFMT0 registers do not include fields for secure and privileged attributes. Those attributes are part of the transaction data from core masters and are forwarded with the transaction after domain assignment.

18.5.7.1.1 Register settings for DFMT0 direct domain assignment transactions

Table 68. Register settings for DFMT0 direct domain assignment transactions

Field	MDA_W0_6_DFMT0	Comments
VLD	1	Enables this register for use in domain assignment.
LK1	1	Locks the settings in this register until the next module reset.
DFMT	0	Indicates that this is a DFMT0 register.
PID	00_0000b	Not used because PE = 00b.

Table continues on the next page...

Table 68. Register settings for DFMT0 direct domain assignment transactions (continued)

Field	MDA_W0_6_DFMT0	Comments
PIDM	00_0000b	Not used because PE = 00b.
PE	00b	Disables PID-based filtering.
DIDS	00b	All incoming transactions are to be assigned to the domain specified by the DID field.
DID	01b	Because PE = 00b and DIDS = 00b, all incoming transactions are to be assigned DID value 01b.

18.5.7.1.2 DFMT0 direct domain assignment process

The application configures XRDC as it boots. After application boot completes, a core issues a read request to a target peripheral.

1. XRDC intercepts the request and performs domain assignment using the configuration in MDA_W0_6_DFMT0. In this example, XRDC assigns DID = 01b to all incoming transactions.
2. The transaction proceeds with DID = 01b and the privileged and secure attributes provided by the core.

18.5.7.2 DFMT0 PID-based domain assignment example

This example configuration demonstrates PID-based domain assignment:

- A core master with master number = 4 processes both safety-critical tasks and routine tasks, using two domains:
  - Domain 0 is reserved for safety-critical tasks (PID = 0–15).
  - Domain 1 is reserved for routine tasks (PID > 15).
- The core has eight MDAC registers (MDACFG4[NMDAR] = 8), configured as follows (see Register settings for DFMT0 PID-based transactions):
  - MDA_W0_4_DFMT0 assigns safety-critical tasks (PID = 0–15) to domain 0.
  - MDA_W1_4_DFMT0 assigns routine tasks (PID = 16–31) to domain 1.
  - MDA_W2_4_DFMT0 assigns routine tasks (PID = 32–63) to domain 1.
  - MDA_W3_4_DFMT0 through MDA_W7_4_DFMT0 are not used.

MDAC_W*w_m*_DFMT0 registers do not include fields for secure and privileged attributes. Those attributes are part of the transaction data from core masters and are forwarded with the transaction after domain assignment.

18.5.7.2.1 Register settings for DFMT0 PID-based transactions

Table 69. Register settings for PID-based transactions

Field	Registers				
	MDA_W0_4_DFMT0	MDA_W1_4_DFMT0	MDA_W2_4_DFMT0	MDA_W[3–7]_4_DFMT0	Comments
VLD	1	1	1	0	Enables this register for use when assigning domains.
LK1	1	1	1	1	Locks the settings in each register until the next device reset.
DFMT	0	0	0	0	Indicates that these registers apply to domain assignment for core masters.

Table continues on the next page...

Table 69. Register settings for PID-based transactions (continued)

Field	Registers				
	MDA_W0_4_DFMT0	MDA_W1_4_DFMT0	MDA_W2_4_DFMT0	MDA_W[3–7]_4_DFMT0	Comments
PID	00_0000b	01_0000b	10_0000b	—	Constant match value to be used for PID-based filtering.
PIDM	00_1111b	10_1111b	01_1111b	—	Each 0 bit causes the corresponding PID bit to be considered in domain assignment.
PE	10b	10b	10b	—	Specifies the type of pattern matching used for PID evaluation.
DIDS	00b	00b	00b	—	Assign all incoming transactions with PIDs that pass the filtering criteria to the domain specified by the DID field.
DID	00b	01b	01b	—	This DID value is assigned to incoming transactions with PIDs that pass the filtering criteria.

18.5.7.2.2 DFMT0 PID-based domain assignment process

The application configures XRDC as it boots. After booting completes, a core issues a read request to a target peripheral. The task making the request has PID = 6, indicating that it is a safety-critical task.

1. XRDC intercepts the request and performs domain assignment using each enabled MDA_W*n*_4_DFMT0 register, regardless of whether it has already found a match. In this example, XRDC performs the domain assignments as shown in DFMT0 PID-based domain assignment evaluation.
2. After XRDC completes all domain assignment evaluations, it logically ORs the assigned DIDs to determine the final DID assigned to the transaction. In this example, only one evaluation results in a DID assignment, so there is no OR operation.
3. The transaction proceeds with DID 00b and the privilege and secure attributes provided by the core.

18.5.7.2.3 DFMT0 PID-based domain assignment evaluation

Table 70. DFMT0 PID-based domain assignment evaluation

Register	Evaluation steps	Boolean math	Result
MDA_W0_4_DFMT0	1. Bitwise AND of PID with inverted PIDM.	00_0000b & 11_0000b	00_0000b
	2. Bitwise AND of transaction PID (PID4[PID]) with inverted PIDM.	000110b & 11_0000b	00_0000b
	3. Compare the results of steps 1 and 2.	00_0000b == 000000b	True: Assign DID 0
MDA_W1_4_DFMT0	1. Bitwise AND of PID with inverted PIDM.	01_0000b & 01_0000b	01_0000b
	2. Bitwise AND of transaction PID (PID4[PID]) with inverted PIDM.	00_0110b & 01_0000b	00_0000b
	3. Compare the results of steps 1 and 2.	01_0000b == 00_0000b	False: No DID assignment
MDA_W2_4_DFMT0	1. Bitwise AND of PID with inverted PIDM.	10_0000b & 10_0000b	10_0000b

Table continues on the next page...

Table 70. DFMT0 PID-based domain assignment evaluation (continued)

Register	Evaluation steps	Boolean math	Result
	2. Bitwise AND of transaction PID (PID4[PID]) with inverted PIDM.	00_0110b & 10_0000b	00_0000b
	3. Compare the results of steps 1 and 2.	10_0000b == 00_0000b	False: No DID assignment

18.5.7.3 DFMT1 direct domain assignment example-single MDA

This configuration assigns a specific domain to all incoming transactions.

- A master has master number = 6.
- The master has one MDAC register (MDACFG6[NMDAR] = 1) as shown in Register settings for DFMT1 direct domain assignment transactions.

18.5.7.3.1 Register settings for DFMT1 direct domain assignment transactions

Table 71. Register settings for DFMT1 direct domain assignment transactions

Field	MDA_W0_6_DFMT1	Comments
VLD	1	Enables this register for use in domain assignment.
LK1	1	Locks the settings in this register until the next chip reset.
DFMT	1	Indicates that this is a DFMT1 register.
DIDB	0b	All incoming transactions are to be assigned to the domain that the DID field specifies.
SA	10b	All incoming transactions retain their Secure attribute value.
PA	10b	All incoming transactions retain their Privileged attribute value.
DID	01b	Because DIDB = 0b, all incoming transactions are to be assigned DID value 01b.

18.5.7.3.2 DFMT1 direct domain assignment process

The application configures XRDC as it boots. After application boot completes, a master issues a read request to a target peripheral.

1. XRDC intercepts the request and assigns a domain using the configuration in MDA_W0_6_DFMT1. In this example, XRDC assigns DID = 01b to all incoming transactions.
2. The transaction proceeds with DID = 01b and the privileged and secure attributes provided by the master.

18.5.7.4 Peripheral ACP evaluation example

This example configuration demonstrates ACP evaluation for a target peripheral.

- The core master must have highly available, exclusive access to the ADC0 peripheral for safety-critical tasks in domain 0.
- The core master supports 8 domains (HWCFG0[NDID] = 111b).
- ADC occupies PDAC slot 40 in the chip, as defined in the memory map file attached to this document (see Finding the PDAC slot number for a peripheral).
- Given 8 domains and PDAC slot 40, the PDAC registers associated with ADC0 are PDAC_W0_40 and PDAC_W1_40.

The following sections describe the register configurations for this example.

18.5.7.4.1 Finding the PDAC slot number for a peripheral

This topic shows how to find the PDAC slot number for a peripheral, but it is a generic example. Memory map file organization and appearance can vary.

To find the PDAC slot number for a peripheral:

1. Open the memory map file attached to this document and view the peripherals page.
2. Locate the peripheral in the "Instance" column.
3. The PDAC slot number for the peripheral is at the intersection of the "PDAC slot number" column and the peripheral row.

In this figure, for peripheral ADC_0, the PDAC slot number is 40. Therefore, the PDAC registers for ADC0 are PDAC_W*w*_40.

	A	B	D	E	I	J
1	Instance	Description	Start address	End address	PDAC slot number	AIPS instance
8	LCU_0	Logic Control Unit 0	0x40098000	0x4009BFFF	38	AIPS_0
9	LCU_1	Logic Control Unit 1	0x4009C000	0x4009FFFF	39	AIPS_0
10	ADC_0	Analog-to-digital converter 0	0x400A0000	0x400A3FFF	40	AIPS_0
11	ADC_1	Analog-to-digital converter 1	0x400A4000	0x400A7FFF	41	AIPS_0
12	ADC_2	Analog-to-digital converter 2	0x400A8000	0x400ABFFF	42	AIPS_0

Figure 44. Finding the PDAC slot number for a peripheral

18.5.7.4.2 Register settings for peripheral ACP evaluation

This table shows the PDAC_W*w*_40 settings for a safety-critical task assigned to domain 0.

Table 72. Register settings for peripheral ACP evaluation

Register	Field	Value (b)	Comments
PDAC_W0_40	SE	0	The hardware semaphore (see the SEMA42 chapter) is disabled.
	SNUM	(don't care)	The hardware semaphore is not used in this example.
	D7ACP	000	Domain 7 has no access to the peripheral.
	D6ACP	000	Domain 6 has no access to the peripheral.
	D5ACP	000	Domain 5 has no access to the peripheral.
	D4ACP	000	Domain 4 has no access to the peripheral.
	D3ACP	000	Domain 3 has no access to the peripheral.
	D2ACP	000	Domain 2 has no access to the peripheral.
	D1ACP	000	Domain 1 has no access to the peripheral.
	D0ACP	010	Only privileged, secure transactions from domain 0 have access.
PDAC_W1_40	VLD	1	Use this register set in domain ACP evaluations.
	LK2	11	Lock the settings in this register until the next device reset.

18.5.7.4.3 Peripheral ACP evaluation process

XRDC performs the following process for ACP evaluation:

1. When the application is running, the core issues a read request to a target peripheral. The task making the request has PID = 0, indicating that it is a safety-critical task. The transaction request is privileged and secured.
2. Between the chip interconnect and ADC0, XRDC intercepts the request and compares its DID, privileged attribute, and secured attribute to the configuration in PDAC_W0_40 and PDAC_W1_40.
3. Because the ADC0 D0ACP field is 010b for privileged, secured access, XRDC grants access to the transaction.
4. The transaction proceeds normally without any further intervention from XRDC.

18.5.7.5 Memory ACP evaluation example

This example configuration demonstrates ACP evaluation for a target memory. Following are the desired features:

- The core master must have highly available, exclusive access to the memory region for safety-critical tasks in domain 0.
- The target memory is the address range 1B00_0000h–1B00_1FFFh, protected by memory controller 0 (MRC0).
- Access to the entire memory range will be controlled by the memory region descriptor defined by MRGD_W*w*_0.
- The requested transaction is secure privileged.

With the configuration settings shown in Register settings for memory ACP evaluation, XRDC grants access and the transaction proceeds normally. There is no further XRDC intervention.

18.5.7.5.1 Register settings for memory ACP evaluation

Table 73. Register settings for memory ACP evaluation

Register	Field	Value	Comments
MRGD_W0_0	SRTADDR	1B00_0000h	Starting address of the memory region.
MRGD_W1_0	ENDADDR	1B00_1FFFh	Ending address of the memory region.
MRGD_W2_0	SE	0	The hardware semaphore (see the SEMA42 chapter) is disabled.
	SNUM	(don't care)	The hardware semaphore is not used in this example.
	D7ACP	000b	Domain 7 has no access to the peripheral.
	D6ACP	000b	Domain 6 has no access to the peripheral.
	D5ACP	000b	Domain 5 has no access to the peripheral.
	D4ACP	000b	Domain 4 has no access to the peripheral.
	D3ACP	000b	Domain 3 has no access to the peripheral.
	D2ACP	000b	Domain 2 has no access to the peripheral.
	D1ACP	000b	Domain 1 has no access to the peripheral.
	D0ACP	010b	Only privileged, secure transactions from domain 0 have access.
MRGD_W3_0	VLD	1	Use this register set in domain ACP evaluations.
	LK2	11b	Lock the settings in this register until the next device reset.

18.5.7.5.2 Memory ACP evaluation process

In this example, XRDC performs the following process for ACP evaluation:

1. When the application is running, the core issues a read request to address 1B00_0100h. The transaction request is secure privileged.

2. Between the chip interconnect and the memory, XRDC intercepts the request and compares its DID, memory location of the address, privileged attribute, and secured attribute to the configuration in MRGD_W0_0, MRGD_W1_0, MRGD_W2_0 and MRGD_W3_0.
3. Because the address 1B00_0100h is in the memory range 1B00_0000h–1B00_1FFFh and its D0ACP field is 010b for privileged, secured access, XRDC grants access to the transaction.
4. The transaction proceeds normally without any no further intervention from XRDC.

18.5.8 Clocking

This module has no clocking considerations.

18.5.9 Interrupts

This module outputs an interrupt signal which can be connected to interrupt controller. Check chip-specific interrupt assignment for details. Interrupt is asserted on detection of access violation by any checker, and it remains asserted until DERRLOC registers are cleared.

18.6 Initialization information

Out of reset, XRDC is disabled (CR[GVLD] = 0), which allows secure privileged startup code to configure the entire programming model.

18.6.1 Initialization procedure

1. Read the hardware configuration registers to obtain the implemented XRDC hardware capabilities for the chip:
   - HWCFG0
   - HWCFG1
   - HWCFG2
   - MDACFG*m* (one for each supported bus master—number indicated in HWCFG0[NMSTR])
   - MRCFG*c* (one for each supported memory controller—number indicated in HWCFG0[NMRC])
2. Use the information retrieved in step 1 and the desired domain architecture to configure:
   - Domain assignments (MDA_W*w_m*_DFMT0 and MDA_W*w_m*_DFMT1)
   - Memory region descriptors (MRGD_W*w_n*)
   - Peripheral access control (PDAC_W*w_s*)

   Ensure that you enable the necessary registers and register sets using the appropriate VLD fields. Also, you can limit access to these registers or lock them after you configure them, by using the appropriate LK1 fields.
3. Enable XRDC (write 1 to CR[GVLD]).

XRDC is now fully operational.

18.6.2 Minimize access errors

When you configure and enable XRDC, it begins generating DIDs for transaction requests and evaluating access rights at the target memory and peripheral resources. Because of the distributed design hierarchy and the pipelined nature of the hardware system bus fabric, it can take multiple cycles for a generated DID to propagate. Until that happens, XRDC uses the master's default DID. Depending on the programmed ACPs, the default DID might generate an access error response.

If XRDC generates incorrect error responses, you can use the following approaches to minimize or eliminate these extraneous access errors:

- Minimize the amount of system bus traffic when XRDC is enabled (CR[GVLD] = 1).

- Ensure that all target memory addresses provide sufficient access rights for any default DIDs and for the newly programmed DIDs. After XRDC is fully operational, as confirmed by a read of HWCFG1, you can remove the permissions for the default DIDs.
- Try to have the bus master that programs and configures XRDC use the same DID, that is, its default DID, for both initialization and configuration, besides normal system operation. You do this when you define the DID assignments for the system.

18.7 Application information

18.7.1 Master domain assignments

The typical use case for master domain assignments is to include one or more core bus masters in a single domain, possibly combined with other noncore bus master modules such as DMA. This configuration may be static or may be changed dynamically to select between a small number of domains. HWCFG0[NDID] indicates the maximum number of supported domains. XRDC also supports the optional use of PIDs to create multiple classes of cores, each in different domains.

For example, you can group critical tasks—safety-critical, performance-critical, and so on—into one domain and all other tasks into a second domain. Typically, you assign the DID at initialization, but you can also reconfigure domain assignment while the application is running.

A core bus master typically has multiple MDA_W*w_m*_DFMT0 registers associated with it.

A noncore bus master typically has a single MDA_W*w_m*_DFMT1 register associated with it.

The master domain assignment, memory region descriptor, and peripheral domain access control registers have lock fields that enable you to limit access to, or to lock, the registers. These actions protect the configuration.

18.7.2 Memory region descriptor management

There are two important concepts to consider for managing the memory region descriptors.

Each MRC*c* configuration is chip-specific. See the chip-specific XRDC information for the number of implemented memory region descriptors (MRGD_W*w_n*) in a given MRC*c* instance, and the specific port numbers associated with the target memories being monitored.

Second, as detailed in Memory region ACP evaluation, after you enable the XRDC, a memory reference must hit one or more of the configured regions. Otherwise, the transaction results in an access violation. Two other conditions also result in access errors:

- The access hits a single region descriptor and that region signals a domain violation.
- The access hits multiple (overlapping) regions and all regions signal violations.

The second condition reflects that XRDC gives priority to permission granting over access denying for overlapping regions. This approach provides more flexibility to system software in memory region descriptor assignments.

18.7.3 Domain error capture management

18.7.3.1 Domain error capture registers

When an MRC or PAC detects a domain access violation, XRDC captures information about the transaction in the following registers:

Table 74. Domain error capture registers

Register[field]	Index	Information
DERRLOC*d*[MRCINST]	*d* = DID	Domain error location for MRC instances, with asserted bits indicating which MRC instance numbers are reporting an error

Table continues on the next page...

Table 74. Domain error capture registers (continued)

Register[field]	Index	Information
DERRLOC*d*[PACINST]	*d* = DID	Domain error location for PAC instances, with asserted bits indicating which PAC instance numbers are reporting an error
DERR_W0_*i*	*i* = instance number	Transaction target address
DERR_W1_*i*	*i* = instance number	Additional information about the transaction
DERR_W3_*i*	*i* = instance number	Reset and rearm domain error capture for the instance

18.7.3.2 Handling domain access violation errors

When an MRC or PAC instance detects a domain access violation, it reports the error by asserting the associated bit in DERRLOCd[MRCINST] or [PACINST], and XRDC asserts the error interrupt output. To retrieve information about the error, the error handler must:

1. Read each DERRLOC*d* register until it finds a non-zero MRCINST or PACINST value.

   The index of the DERRLOC*d* register is the DID for the domain in which the error occurred.

2. Configure the domain assignment for the master executing the exception handler (MDA_Ww_m_DFMTf[DID]) to assign the DID that corresponds to the DERRLOC*d* register index, such that the DERR_Ww_i registers show the error for that domain.

3. Read HWCFG1[DID] to be sure the error handler is now operating in the correct domain. In other words, make sure HWCFG1[DID] equals the value written to MDA_Ww_m_DFMTf[DID].

4. Find the number of an MRC or PAC instance reporting an error by parsing DERRLOC*d*[MRCINST] and DERRLOC*d*[PACINST] for an asserted bit.

   There may be multiple access violations, across multiple MRC or PAC instances, pending for a given domain. To quickly find the lowest numbered instance reporting an access violation, execute a "find first one bit" instruction (alternatively known as "count leading zeroes") on the MRCINST and PACINST fields.

5. Retrieve the error address (DERR_W0_*i*[EADDR]).

6. Retrieve the error information (DERR_W1_*i*).

   More than one error may have occurred in the MRC or PAC instance, as indicated by the error status (DERR_W1_*i*[EST] = 11b). If more than one error has occurred in the instance, XRDC captures data only for the first error.

7. Use the error address and information to handle the error (whatever that may require).

8. Reset the DERR_W*w_i* registers and rearm error capture (write 1b to DERR_W3_*i*[RECR]).

   Rearming error capture deasserts the instance bit in DERRLOC*d*.

9. Repeat steps 1 and 8 for each asserted bit in PACINST and MRCINST until there are no more asserted bits.

Domain error retrieval illustrates an example error retrieval.

18.7.3.3 Domain error retrieval

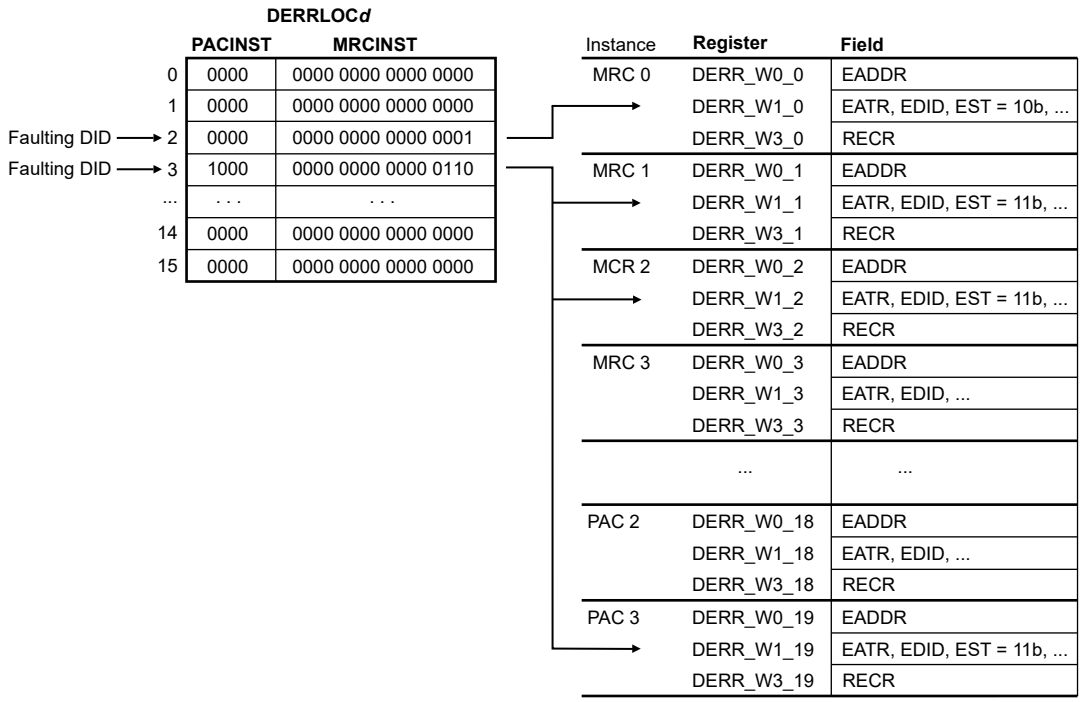


Figure 45. Domain error retrieval

18.8 Memory map and register definitions

18.8.1 Register organization

XRDC registers are partitioned into these groups:

- Basic hardware control and configuration
- Domain errors (including location and details)
- Master domain assignments
- Peripheral domain access controls
- Memory region descriptors

18.8.2 Register access guidelines

The following guidelines apply to XRDC register access:

- You can access the XRDC registers only in secure, privileged access mode.
- Unless stated otherwise, the registers support 8-, 16-, and 32-bit reads, and 32-bit writes.
- Unless stated otherwise, XRDC terminates the following access attempts with an error:
  - Accesses in a different access mode
  - Unsupported write data size
  - Writes to read-only resources
  - Writes to reserved address spaces

- Accesses to these memory map holes return an error:
  - Any access to a register that does not exist
  - Holes in the 0–F0h and DERR to PID register space
  - For MDAC, gaps in the master domain assignment (MDA_W*w*_*m*_DFMT*n*) registers
  - For MRCs, any gap in the MRGD_W*w*_*r* registers (for example, if there are four memory region descriptors, attempted access to a fifth descriptor fails)
- Accesses to these memory map holes do not return a bus error:
  - MRCs: Memory region descriptors occupy only four words but have an additional four words of address available: words 4–7
  - PDAC: Registers associated with unimplemented PDAC slots
- Read accesses to these memory map holes do not return a bus error:
  - Offset F8h and FCh
  - Offset 100–13Fh
  - Offset 140–14Fh
  - Offset 200–23Ch

18.8.3 XRDC register descriptions

18.8.3.1 XRDC memory map

XRDC base address: 4027_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Control (CR)	32	RW	0000_008Ah
F0h	Hardware Configuration 0 (HWCFG0)	32	R	1303_0803h
F4h	Hardware Configuration 1 (HWCFG1)	32	R	See section
F8h	Hardware Configuration 2 (HWCFG2)	32	R	0000_0000h
100h	Master Domain Assignment Configuration (MDACFG0)	8	R	01h
101h	Master Domain Assignment Configuration (MDACFG1)	8	R	81h
102h	Master Domain Assignment Configuration (MDACFG2)	8	R	81h
103h	Master Domain Assignment Configuration (MDACFG3)	8	R	01h
104h	Master Domain Assignment Configuration (MDACFG4)	8	R	01h
105h	Master Domain Assignment Configuration (MDACFG5)	8	R	81h
106h	Master Domain Assignment Configuration (MDACFG6)	8	R	01h
107h	Master Domain Assignment Configuration (MDACFG7)	8	R	81h
108h	Master Domain Assignment Configuration (MDACFG8)	8	R	81h
140h	Memory Region Configuration (MRCFG0)	8	R	10h

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Offset	Register	Width (In bits)	Access	Reset value
141h	Memory Region Configuration (MRCFG1)	8	R	10h
142h	Memory Region Configuration (MRCFG2)	8	R	04h
143h	Memory Region Configuration (MRCFG3)	8	R	10h
200h - 20Ch	Domain Error Location (DERRLOC0 - DERRLOC3)	32	R	0000_0000h
400h	Domain Error Word 0 (DERR_W0_0)	32	R	0000_0000h
404h	Domain Error Word 1 (DERR_W1_0)	32	R	0000_0000h
40Ch	Domain Error Word 3 (DERR_W3_0)	32	RW	0000_0000h
410h	Domain Error Word 0 (DERR_W0_1)	32	R	0000_0000h
414h	Domain Error Word 1 (DERR_W1_1)	32	R	0000_0000h
41Ch	Domain Error Word 3 (DERR_W3_1)	32	RW	0000_0000h
420h	Domain Error Word 0 (DERR_W0_2)	32	R	0000_0000h
424h	Domain Error Word 1 (DERR_W1_2)	32	R	0000_0000h
42Ch	Domain Error Word 3 (DERR_W3_2)	32	RW	0000_0000h
430h	Domain Error Word 0 (DERR_W0_3)	32	R	0000_0000h
434h	Domain Error Word 1 (DERR_W1_3)	32	R	0000_0000h
43Ch	Domain Error Word 3 (DERR_W3_3)	32	RW	0000_0000h
500h	Domain Error Word 0 (DERR_W0_16)	32	R	0000_0000h
504h	Domain Error Word 1 (DERR_W1_16)	32	R	0000_0000h
50Ch	Domain Error Word 3 (DERR_W3_16)	32	RW	0000_0000h
510h	Domain Error Word 0 (DERR_W0_17)	32	R	0000_0000h
514h	Domain Error Word 1 (DERR_W1_17)	32	R	0000_0000h
51Ch	Domain Error Word 3 (DERR_W3_17)	32	RW	0000_0000h
520h	Domain Error Word 0 (DERR_W0_18)	32	R	0000_0000h
524h	Domain Error Word 1 (DERR_W1_18)	32	R	0000_0000h
52Ch	Domain Error Word 3 (DERR_W3_18)	32	RW	0000_0000h
530h	Domain Error Word 0 (DERR_W0_19)	32	R	0000_0000h
534h	Domain Error Word 1 (DERR_W1_19)	32	R	0000_0000h
53Ch	Domain Error Word 3 (DERR_W3_19)	32	RW	0000_0000h
700h	Process Identifier (PID0)	32	RW	0000_0000h
70Ch	Process Identifier (PID3)	32	RW	0000_0000h
710h	Process Identifier (PID4)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
718h	Process Identifier (PID6)	32	RW	0000_0000h
800h	Master Domain Assignment (MDA_W0_0_DFMT0)	32	RW	0000_0000h
820h	Master Domain Assignment (MDA_W0_1_DFMT1)	32	RW	2000_0000h
840h	Master Domain Assignment (MDA_W0_2_DFMT1)	32	RW	2000_0000h
860h	Master Domain Assignment (MDA_W0_3_DFMT0)	32	RW	0000_0000h
880h	Master Domain Assignment (MDA_W0_4_DFMT0)	32	RW	0000_0000h
8A0h	Master Domain Assignment (MDA_W0_5_DFMT1)	32	RW	2000_0000h
8C0h	Master Domain Assignment (MDA_W0_6_DFMT0)	32	RW	0000_0000h
8E0h	Master Domain Assignment (MDA_W0_7_DFMT1)	32	RW	2000_0000h
900h	Master Domain Assignment (MDA_W0_8_DFMT1)	32	RW	2000_0000h
1018h	Peripheral Domain Access Control Word 0 (PDAC_W0_3)	32	RW	0000_0000h
101Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_3)	32	RW	0000_0000h
1020h	Peripheral Domain Access Control Word 0 (PDAC_W0_4)	32	RW	0000_0000h
1024h	Peripheral Domain Access Control Word 1 (PDAC_W1_4)	32	RW	0000_0000h
1028h	Peripheral Domain Access Control Word 0 (PDAC_W0_5)	32	RW	0000_0000h
102Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_5)	32	RW	0000_0000h
1030h	Peripheral Domain Access Control Word 0 (PDAC_W0_6)	32	RW	0000_0000h
1034h	Peripheral Domain Access Control Word 1 (PDAC_W1_6)	32	RW	0000_0000h
1038h	Peripheral Domain Access Control Word 0 (PDAC_W0_7)	32	RW	0000_0000h
103Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_7)	32	RW	0000_0000h
1040h	Peripheral Domain Access Control Word 0 (PDAC_W0_8)	32	RW	0000_0000h
1044h	Peripheral Domain Access Control Word 1 (PDAC_W1_8)	32	RW	0000_0000h
1048h	Peripheral Domain Access Control Word 0 (PDAC_W0_9)	32	RW	0000_0000h
104Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_9)	32	RW	0000_0000h
1050h	Peripheral Domain Access Control Word 0 (PDAC_W0_10)	32	RW	0000_0000h
1054h	Peripheral Domain Access Control Word 1 (PDAC_W1_10)	32	RW	0000_0000h
1058h	Peripheral Domain Access Control Word 0 (PDAC_W0_11)	32	RW	0000_0000h
105Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_11)	32	RW	0000_0000h
1060h	Peripheral Domain Access Control Word 0 (PDAC_W0_12)	32	RW	0000_0000h
1064h	Peripheral Domain Access Control Word 1 (PDAC_W1_12)	32	RW	0000_0000h
1068h	Peripheral Domain Access Control Word 0 (PDAC_W0_13)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
106Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_13)	32	RW	0000_0000h
1070h	Peripheral Domain Access Control Word 0 (PDAC_W0_14)	32	RW	0000_0000h
1074h	Peripheral Domain Access Control Word 1 (PDAC_W1_14)	32	RW	0000_0000h
1078h	Peripheral Domain Access Control Word 0 (PDAC_W0_15)	32	RW	0000_0000h
107Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_15)	32	RW	0000_0000h
1080h	Peripheral Domain Access Control Word 0 (PDAC_W0_16)	32	RW	0000_0000h
1084h	Peripheral Domain Access Control Word 1 (PDAC_W1_16)	32	RW	0000_0000h
1088h	Peripheral Domain Access Control Word 0 (PDAC_W0_17)	32	RW	0000_0000h
108Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_17)	32	RW	0000_0000h
1090h	Peripheral Domain Access Control Word 0 (PDAC_W0_18)	32	RW	0000_0000h
1094h	Peripheral Domain Access Control Word 1 (PDAC_W1_18)	32	RW	0000_0000h
1098h	Peripheral Domain Access Control Word 0 (PDAC_W0_19)	32	RW	0000_0000h
109Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_19)	32	RW	0000_0000h
10A0h	Peripheral Domain Access Control Word 0 (PDAC_W0_20)	32	RW	0000_0000h
10A4h	Peripheral Domain Access Control Word 1 (PDAC_W1_20)	32	RW	0000_0000h
1100h	Peripheral Domain Access Control Word 0 (PDAC_W0_32)	32	RW	0000_0000h
1104h	Peripheral Domain Access Control Word 1 (PDAC_W1_32)	32	RW	0000_0000h
1108h	Peripheral Domain Access Control Word 0 (PDAC_W0_33)	32	RW	0000_0000h
110Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_33)	32	RW	0000_0000h
1110h	Peripheral Domain Access Control Word 0 (PDAC_W0_34)	32	RW	0000_0000h
1114h	Peripheral Domain Access Control Word 1 (PDAC_W1_34)	32	RW	0000_0000h
1130h	Peripheral Domain Access Control Word 0 (PDAC_W0_38)	32	RW	0000_0000h
1134h	Peripheral Domain Access Control Word 1 (PDAC_W1_38)	32	RW	0000_0000h
1138h	Peripheral Domain Access Control Word 0 (PDAC_W0_39)	32	RW	0000_0000h
113Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_39)	32	RW	0000_0000h
1140h	Peripheral Domain Access Control Word 0 (PDAC_W0_40)	32	RW	0000_0000h
1144h	Peripheral Domain Access Control Word 1 (PDAC_W1_40)	32	RW	0000_0000h
1148h	Peripheral Domain Access Control Word 0 (PDAC_W0_41)	32	RW	0000_0000h
114Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_41)	32	RW	0000_0000h
1150h	Peripheral Domain Access Control Word 0 (PDAC_W0_42)	32	RW	0000_0000h
1154h	Peripheral Domain Access Control Word 1 (PDAC_W1_42)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1158h	Peripheral Domain Access Control Word 0 (PDAC_W0_43)	32	RW	0000_0000h
115Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_43)	32	RW	0000_0000h
1160h	Peripheral Domain Access Control Word 0 (PDAC_W0_44)	32	RW	0000_0000h
1164h	Peripheral Domain Access Control Word 1 (PDAC_W1_44)	32	RW	0000_0000h
1168h	Peripheral Domain Access Control Word 0 (PDAC_W0_45)	32	RW	0000_0000h
116Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_45)	32	RW	0000_0000h
1170h	Peripheral Domain Access Control Word 0 (PDAC_W0_46)	32	RW	0000_0000h
1174h	Peripheral Domain Access Control Word 1 (PDAC_W1_46)	32	RW	0000_0000h
1178h	Peripheral Domain Access Control Word 0 (PDAC_W0_47)	32	RW	0000_0000h
117Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_47)	32	RW	0000_0000h
1180h	Peripheral Domain Access Control Word 0 (PDAC_W0_48)	32	RW	0000_0000h
1184h	Peripheral Domain Access Control Word 1 (PDAC_W1_48)	32	RW	0000_0000h
1188h	Peripheral Domain Access Control Word 0 (PDAC_W0_49)	32	RW	0000_0000h
118Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_49)	32	RW	0000_0000h
1400h	Peripheral Domain Access Control Word 0 (PDAC_W0_128)	32	RW	0000_0000h
1404h	Peripheral Domain Access Control Word 1 (PDAC_W1_128)	32	RW	0000_0000h
1408h	Peripheral Domain Access Control Word 0 (PDAC_W0_129)	32	RW	0000_0000h
140Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_129)	32	RW	0000_0000h
1410h	Peripheral Domain Access Control Word 0 (PDAC_W0_130)	32	RW	0000_0000h
1414h	Peripheral Domain Access Control Word 1 (PDAC_W1_130)	32	RW	0000_0000h
1418h	Peripheral Domain Access Control Word 0 (PDAC_W0_131)	32	RW	0000_0000h
141Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_131)	32	RW	0000_0000h
1420h	Peripheral Domain Access Control Word 0 (PDAC_W0_132)	32	RW	0000_0000h
1424h	Peripheral Domain Access Control Word 1 (PDAC_W1_132)	32	RW	0000_0000h
1428h	Peripheral Domain Access Control Word 0 (PDAC_W0_133)	32	RW	0000_0000h
142Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_133)	32	RW	0000_0000h
1430h	Peripheral Domain Access Control Word 0 (PDAC_W0_134)	32	RW	0000_0000h
1434h	Peripheral Domain Access Control Word 1 (PDAC_W1_134)	32	RW	0000_0000h
1438h	Peripheral Domain Access Control Word 0 (PDAC_W0_135)	32	RW	0000_0000h
143Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_135)	32	RW	0000_0000h
1440h	Peripheral Domain Access Control Word 0 (PDAC_W0_136)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1444h	Peripheral Domain Access Control Word 1 (PDAC_W1_136)	32	RW	0000_0000h
1448h	Peripheral Domain Access Control Word 0 (PDAC_W0_137)	32	RW	0000_0000h
144Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_137)	32	RW	0000_0000h
1450h	Peripheral Domain Access Control Word 0 (PDAC_W0_138)	32	RW	0000_0000h
1454h	Peripheral Domain Access Control Word 1 (PDAC_W1_138)	32	RW	0000_0000h
1458h	Peripheral Domain Access Control Word 0 (PDAC_W0_139)	32	RW	0000_0000h
145Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_139)	32	RW	0000_0000h
1460h	Peripheral Domain Access Control Word 0 (PDAC_W0_140)	32	RW	0000_0000h
1464h	Peripheral Domain Access Control Word 1 (PDAC_W1_140)	32	RW	0000_0000h
1468h	Peripheral Domain Access Control Word 0 (PDAC_W0_141)	32	RW	0000_0000h
146Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_141)	32	RW	0000_0000h
1470h	Peripheral Domain Access Control Word 0 (PDAC_W0_142)	32	RW	0000_0000h
1474h	Peripheral Domain Access Control Word 1 (PDAC_W1_142)	32	RW	0000_0000h
1478h	Peripheral Domain Access Control Word 0 (PDAC_W0_143)	32	RW	0000_0000h
147Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_143)	32	RW	0000_0000h
1480h	Peripheral Domain Access Control Word 0 (PDAC_W0_144)	32	RW	0000_0000h
1484h	Peripheral Domain Access Control Word 1 (PDAC_W1_144)	32	RW	0000_0000h
1488h	Peripheral Domain Access Control Word 0 (PDAC_W0_145)	32	RW	0000_0000h
148Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_145)	32	RW	0000_0000h
1490h	Peripheral Domain Access Control Word 0 (PDAC_W0_146)	32	RW	0000_0000h
1494h	Peripheral Domain Access Control Word 1 (PDAC_W1_146)	32	RW	0000_0000h
1498h	Peripheral Domain Access Control Word 0 (PDAC_W0_147)	32	RW	0000_0000h
149Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_147)	32	RW	0000_0000h
14A0h	Peripheral Domain Access Control Word 0 (PDAC_W0_148)	32	RW	0000_0000h
14A4h	Peripheral Domain Access Control Word 1 (PDAC_W1_148)	32	RW	0000_0000h
14A8h	Peripheral Domain Access Control Word 0 (PDAC_W0_149)	32	RW	0000_0000h
14ACh	Peripheral Domain Access Control Word 1 (PDAC_W1_149)	32	RW	0000_0000h
14B8h	Peripheral Domain Access Control Word 0 (PDAC_W0_151)	32	RW	0000_0000h
14BCh	Peripheral Domain Access Control Word 1 (PDAC_W1_151)	32	RW	0000_0000h
14C0h	Peripheral Domain Access Control Word 0 (PDAC_W0_152)	32	RW	0000_0000h
14C4h	Peripheral Domain Access Control Word 1 (PDAC_W1_152)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
14C8h	Peripheral Domain Access Control Word 0 (PDAC_W0_153)	32	RW	0000_0000h
14CCh	Peripheral Domain Access Control Word 1 (PDAC_W1_153)	32	RW	0000_0000h
14D0h	Peripheral Domain Access Control Word 0 (PDAC_W0_154)	32	RW	0000_0000h
14D4h	Peripheral Domain Access Control Word 1 (PDAC_W1_154)	32	RW	0000_0000h
14D8h	Peripheral Domain Access Control Word 0 (PDAC_W0_155)	32	RW	0000_0000h
14DCh	Peripheral Domain Access Control Word 1 (PDAC_W1_155)	32	RW	0000_0000h
14E0h	Peripheral Domain Access Control Word 0 (PDAC_W0_156)	32	RW	0000_0000h
14E4h	Peripheral Domain Access Control Word 1 (PDAC_W1_156)	32	RW	0000_0000h
14E8h	Peripheral Domain Access Control Word 0 (PDAC_W0_157)	32	RW	0000_0000h
14ECh	Peripheral Domain Access Control Word 1 (PDAC_W1_157)	32	RW	0000_0000h
14F0h	Peripheral Domain Access Control Word 0 (PDAC_W0_158)	32	RW	0000_0000h
14F4h	Peripheral Domain Access Control Word 1 (PDAC_W1_158)	32	RW	0000_0000h
14F8h	Peripheral Domain Access Control Word 0 (PDAC_W0_159)	32	RW	0000_0000h
14FCh	Peripheral Domain Access Control Word 1 (PDAC_W1_159)	32	RW	0000_0000h
1500h	Peripheral Domain Access Control Word 0 (PDAC_W0_160)	32	RW	0000_0000h
1504h	Peripheral Domain Access Control Word 1 (PDAC_W1_160)	32	RW	0000_0000h
1508h	Peripheral Domain Access Control Word 0 (PDAC_W0_161)	32	RW	0000_0000h
150Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_161)	32	RW	0000_0000h
1510h	Peripheral Domain Access Control Word 0 (PDAC_W0_162)	32	RW	0000_0000h
1514h	Peripheral Domain Access Control Word 1 (PDAC_W1_162)	32	RW	0000_0000h
1518h	Peripheral Domain Access Control Word 0 (PDAC_W0_163)	32	RW	0000_0000h
151Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_163)	32	RW	0000_0000h
1520h	Peripheral Domain Access Control Word 0 (PDAC_W0_164)	32	RW	0000_0000h
1524h	Peripheral Domain Access Control Word 1 (PDAC_W1_164)	32	RW	0000_0000h
1528h	Peripheral Domain Access Control Word 0 (PDAC_W0_165)	32	RW	0000_0000h
152Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_165)	32	RW	0000_0000h
1530h	Peripheral Domain Access Control Word 0 (PDAC_W0_166)	32	RW	0000_0000h
1534h	Peripheral Domain Access Control Word 1 (PDAC_W1_166)	32	RW	0000_0000h
1538h	Peripheral Domain Access Control Word 0 (PDAC_W0_167)	32	RW	0000_0000h
153Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_167)	32	RW	0000_0000h
1540h	Peripheral Domain Access Control Word 0 (PDAC_W0_168)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1544h	Peripheral Domain Access Control Word 1 (PDAC_W1_168)	32	RW	0000_0000h
1548h	Peripheral Domain Access Control Word 0 (PDAC_W0_169)	32	RW	0000_0000h
154Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_169)	32	RW	0000_0000h
1550h	Peripheral Domain Access Control Word 0 (PDAC_W0_170)	32	RW	0000_0000h
1554h	Peripheral Domain Access Control Word 1 (PDAC_W1_170)	32	RW	0000_0000h
1558h	Peripheral Domain Access Control Word 0 (PDAC_W0_171)	32	RW	0000_0000h
155Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_171)	32	RW	0000_0000h
1568h	Peripheral Domain Access Control Word 0 (PDAC_W0_173)	32	RW	0000_0000h
156Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_173)	32	RW	0000_0000h
1578h	Peripheral Domain Access Control Word 0 (PDAC_W0_175)	32	RW	0000_0000h
157Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_175)	32	RW	0000_0000h
1590h	Peripheral Domain Access Control Word 0 (PDAC_W0_178)	32	RW	0000_0000h
1594h	Peripheral Domain Access Control Word 1 (PDAC_W1_178)	32	RW	0000_0000h
15A0h	Peripheral Domain Access Control Word 0 (PDAC_W0_180)	32	RW	0000_0000h
15A4h	Peripheral Domain Access Control Word 1 (PDAC_W1_180)	32	RW	0000_0000h
15A8h	Peripheral Domain Access Control Word 0 (PDAC_W0_181)	32	RW	0000_0000h
15ACh	Peripheral Domain Access Control Word 1 (PDAC_W1_181)	32	RW	0000_0000h
15B0h	Peripheral Domain Access Control Word 0 (PDAC_W0_182)	32	RW	0000_0000h
15B4h	Peripheral Domain Access Control Word 1 (PDAC_W1_182)	32	RW	0000_0000h
15B8h	Peripheral Domain Access Control Word 0 (PDAC_W0_183)	32	RW	0000_0000h
15BCh	Peripheral Domain Access Control Word 1 (PDAC_W1_183)	32	RW	0000_0000h
15C0h	Peripheral Domain Access Control Word 0 (PDAC_W0_184)	32	RW	0000_0000h
15C4h	Peripheral Domain Access Control Word 1 (PDAC_W1_184)	32	RW	0000_0000h
15D0h	Peripheral Domain Access Control Word 0 (PDAC_W0_186)	32	RW	0000_0000h
15D4h	Peripheral Domain Access Control Word 1 (PDAC_W1_186)	32	RW	0000_0000h
15D8h	Peripheral Domain Access Control Word 0 (PDAC_W0_187)	32	RW	0000_0000h
15DCh	Peripheral Domain Access Control Word 1 (PDAC_W1_187)	32	RW	0000_0000h
15E0h	Peripheral Domain Access Control Word 0 (PDAC_W0_188)	32	RW	0000_0000h
15E4h	Peripheral Domain Access Control Word 1 (PDAC_W1_188)	32	RW	0000_0000h
15E8h	Peripheral Domain Access Control Word 0 (PDAC_W0_189)	32	RW	0000_0000h
15ECh	Peripheral Domain Access Control Word 1 (PDAC_W1_189)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
15F0h	Peripheral Domain Access Control Word 0 (PDAC_W0_190)	32	RW	0000_0000h
15F4h	Peripheral Domain Access Control Word 1 (PDAC_W1_190)	32	RW	0000_0000h
15F8h	Peripheral Domain Access Control Word 0 (PDAC_W0_191)	32	RW	0000_0000h
15FCh	Peripheral Domain Access Control Word 1 (PDAC_W1_191)	32	RW	0000_0000h
1608h	Peripheral Domain Access Control Word 0 (PDAC_W0_193)	32	RW	0000_0000h
160Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_193)	32	RW	0000_0000h
1610h	Peripheral Domain Access Control Word 0 (PDAC_W0_194)	32	RW	0000_0000h
1614h	Peripheral Domain Access Control Word 1 (PDAC_W1_194)	32	RW	0000_0000h
1618h	Peripheral Domain Access Control Word 0 (PDAC_W0_195)	32	RW	0000_0000h
161Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_195)	32	RW	0000_0000h
1620h	Peripheral Domain Access Control Word 0 (PDAC_W0_196)	32	RW	0000_0000h
1624h	Peripheral Domain Access Control Word 1 (PDAC_W1_196)	32	RW	0000_0000h
1628h	Peripheral Domain Access Control Word 0 (PDAC_W0_197)	32	RW	0000_0000h
162Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_197)	32	RW	0000_0000h
1630h	Peripheral Domain Access Control Word 0 (PDAC_W0_198)	32	RW	0000_0000h
1634h	Peripheral Domain Access Control Word 1 (PDAC_W1_198)	32	RW	0000_0000h
1648h	Peripheral Domain Access Control Word 0 (PDAC_W0_201)	32	RW	0000_0000h
164Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_201)	32	RW	0000_0000h
1650h	Peripheral Domain Access Control Word 0 (PDAC_W0_202)	32	RW	0000_0000h
1654h	Peripheral Domain Access Control Word 1 (PDAC_W1_202)	32	RW	0000_0000h
1658h	Peripheral Domain Access Control Word 0 (PDAC_W0_203)	32	RW	0000_0000h
165Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_203)	32	RW	0000_0000h
1660h	Peripheral Domain Access Control Word 0 (PDAC_W0_204)	32	RW	0000_0000h
1664h	Peripheral Domain Access Control Word 1 (PDAC_W1_204)	32	RW	0000_0000h
1668h	Peripheral Domain Access Control Word 0 (PDAC_W0_205)	32	RW	0000_0000h
166Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_205)	32	RW	0000_0000h
16A0h	Peripheral Domain Access Control Word 0 (PDAC_W0_212)	32	RW	0000_0000h
16A4h	Peripheral Domain Access Control Word 1 (PDAC_W1_212)	32	RW	0000_0000h
16A8h	Peripheral Domain Access Control Word 0 (PDAC_W0_213)	32	RW	0000_0000h
16ACh	Peripheral Domain Access Control Word 1 (PDAC_W1_213)	32	RW	0000_0000h
16B0h	Peripheral Domain Access Control Word 0 (PDAC_W0_214)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
16B4h	Peripheral Domain Access Control Word 1 (PDAC_W1_214)	32	RW	0000_0000h
16B8h	Peripheral Domain Access Control Word 0 (PDAC_W0_215)	32	RW	0000_0000h
16BCh	Peripheral Domain Access Control Word 1 (PDAC_W1_215)	32	RW	0000_0000h
16C0h	Peripheral Domain Access Control Word 0 (PDAC_W0_216)	32	RW	0000_0000h
16C4h	Peripheral Domain Access Control Word 1 (PDAC_W1_216)	32	RW	0000_0000h
16C8h	Peripheral Domain Access Control Word 0 (PDAC_W0_217)	32	RW	0000_0000h
16CCh	Peripheral Domain Access Control Word 1 (PDAC_W1_217)	32	RW	0000_0000h
16E0h	Peripheral Domain Access Control Word 0 (PDAC_W0_220)	32	RW	0000_0000h
16E4h	Peripheral Domain Access Control Word 1 (PDAC_W1_220)	32	RW	0000_0000h
16E8h	Peripheral Domain Access Control Word 0 (PDAC_W0_221)	32	RW	0000_0000h
16ECh	Peripheral Domain Access Control Word 1 (PDAC_W1_221)	32	RW	0000_0000h
16F8h	Peripheral Domain Access Control Word 0 (PDAC_W0_223)	32	RW	0000_0000h
16FCh	Peripheral Domain Access Control Word 1 (PDAC_W1_223)	32	RW	0000_0000h
1700h	Peripheral Domain Access Control Word 0 (PDAC_W0_224)	32	RW	0000_0000h
1704h	Peripheral Domain Access Control Word 1 (PDAC_W1_224)	32	RW	0000_0000h
1708h	Peripheral Domain Access Control Word 0 (PDAC_W0_225)	32	RW	0000_0000h
170Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_225)	32	RW	0000_0000h
1710h	Peripheral Domain Access Control Word 0 (PDAC_W0_226)	32	RW	0000_0000h
1714h	Peripheral Domain Access Control Word 1 (PDAC_W1_226)	32	RW	0000_0000h
1718h	Peripheral Domain Access Control Word 0 (PDAC_W0_227)	32	RW	0000_0000h
171Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_227)	32	RW	0000_0000h
1728h	Peripheral Domain Access Control Word 0 (PDAC_W0_229)	32	RW	0000_0000h
172Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_229)	32	RW	0000_0000h
1730h	Peripheral Domain Access Control Word 0 (PDAC_W0_230)	32	RW	0000_0000h
1734h	Peripheral Domain Access Control Word 1 (PDAC_W1_230)	32	RW	0000_0000h
1738h	Peripheral Domain Access Control Word 0 (PDAC_W0_231)	32	RW	0000_0000h
173Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_231)	32	RW	0000_0000h
1740h	Peripheral Domain Access Control Word 0 (PDAC_W0_232)	32	RW	0000_0000h
1744h	Peripheral Domain Access Control Word 1 (PDAC_W1_232)	32	RW	0000_0000h
1748h	Peripheral Domain Access Control Word 0 (PDAC_W0_233)	32	RW	0000_0000h
174Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_233)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1750h	Peripheral Domain Access Control Word 0 (PDAC_W0_234)	32	RW	0000_0000h
1754h	Peripheral Domain Access Control Word 1 (PDAC_W1_234)	32	RW	0000_0000h
1758h	Peripheral Domain Access Control Word 0 (PDAC_W0_235)	32	RW	0000_0000h
175Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_235)	32	RW	0000_0000h
1760h	Peripheral Domain Access Control Word 0 (PDAC_W0_236)	32	RW	0000_0000h
1764h	Peripheral Domain Access Control Word 1 (PDAC_W1_236)	32	RW	0000_0000h
1770h	Peripheral Domain Access Control Word 0 (PDAC_W0_238)	32	RW	0000_0000h
1774h	Peripheral Domain Access Control Word 1 (PDAC_W1_238)	32	RW	0000_0000h
1800h	Peripheral Domain Access Control Word 0 (PDAC_W0_256)	32	RW	0000_0000h
1804h	Peripheral Domain Access Control Word 1 (PDAC_W1_256)	32	RW	0000_0000h
1808h	Peripheral Domain Access Control Word 0 (PDAC_W0_257)	32	RW	0000_0000h
180Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_257)	32	RW	0000_0000h
1820h	Peripheral Domain Access Control Word 0 (PDAC_W0_260)	32	RW	0000_0000h
1824h	Peripheral Domain Access Control Word 1 (PDAC_W1_260)	32	RW	0000_0000h
1828h	Peripheral Domain Access Control Word 0 (PDAC_W0_261)	32	RW	0000_0000h
182Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_261)	32	RW	0000_0000h
1830h	Peripheral Domain Access Control Word 0 (PDAC_W0_262)	32	RW	0000_0000h
1834h	Peripheral Domain Access Control Word 1 (PDAC_W1_262)	32	RW	0000_0000h
1838h	Peripheral Domain Access Control Word 0 (PDAC_W0_263)	32	RW	0000_0000h
183Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_263)	32	RW	0000_0000h
1840h	Peripheral Domain Access Control Word 0 (PDAC_W0_264)	32	RW	0000_0000h
1844h	Peripheral Domain Access Control Word 1 (PDAC_W1_264)	32	RW	0000_0000h
1848h	Peripheral Domain Access Control Word 0 (PDAC_W0_265)	32	RW	0000_0000h
184Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_265)	32	RW	0000_0000h
1850h	Peripheral Domain Access Control Word 0 (PDAC_W0_266)	32	RW	0000_0000h
1854h	Peripheral Domain Access Control Word 1 (PDAC_W1_266)	32	RW	0000_0000h
1858h	Peripheral Domain Access Control Word 0 (PDAC_W0_267)	32	RW	0000_0000h
185Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_267)	32	RW	0000_0000h
1860h	Peripheral Domain Access Control Word 0 (PDAC_W0_268)	32	RW	0000_0000h
1864h	Peripheral Domain Access Control Word 1 (PDAC_W1_268)	32	RW	0000_0000h
1868h	Peripheral Domain Access Control Word 0 (PDAC_W0_269)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
186Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_269)	32	RW	0000_0000h
1870h	Peripheral Domain Access Control Word 0 (PDAC_W0_270)	32	RW	0000_0000h
1874h	Peripheral Domain Access Control Word 1 (PDAC_W1_270)	32	RW	0000_0000h
1878h	Peripheral Domain Access Control Word 0 (PDAC_W0_271)	32	RW	0000_0000h
187Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_271)	32	RW	0000_0000h
1880h	Peripheral Domain Access Control Word 0 (PDAC_W0_272)	32	RW	0000_0000h
1884h	Peripheral Domain Access Control Word 1 (PDAC_W1_272)	32	RW	0000_0000h
1888h	Peripheral Domain Access Control Word 0 (PDAC_W0_273)	32	RW	0000_0000h
188Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_273)	32	RW	0000_0000h
1890h	Peripheral Domain Access Control Word 0 (PDAC_W0_274)	32	RW	0000_0000h
1894h	Peripheral Domain Access Control Word 1 (PDAC_W1_274)	32	RW	0000_0000h
1898h	Peripheral Domain Access Control Word 0 (PDAC_W0_275)	32	RW	0000_0000h
189Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_275)	32	RW	0000_0000h
18A0h	Peripheral Domain Access Control Word 0 (PDAC_W0_276)	32	RW	0000_0000h
18A4h	Peripheral Domain Access Control Word 1 (PDAC_W1_276)	32	RW	0000_0000h
18A8h	Peripheral Domain Access Control Word 0 (PDAC_W0_277)	32	RW	0000_0000h
18ACh	Peripheral Domain Access Control Word 1 (PDAC_W1_277)	32	RW	0000_0000h
18B0h	Peripheral Domain Access Control Word 0 (PDAC_W0_278)	32	RW	0000_0000h
18B4h	Peripheral Domain Access Control Word 1 (PDAC_W1_278)	32	RW	0000_0000h
18B8h	Peripheral Domain Access Control Word 0 (PDAC_W0_279)	32	RW	0000_0000h
18BCh	Peripheral Domain Access Control Word 1 (PDAC_W1_279)	32	RW	0000_0000h
18C0h	Peripheral Domain Access Control Word 0 (PDAC_W0_280)	32	RW	0000_0000h
18C4h	Peripheral Domain Access Control Word 1 (PDAC_W1_280)	32	RW	0000_0000h
18C8h	Peripheral Domain Access Control Word 0 (PDAC_W0_281)	32	RW	0000_0000h
18CCh	Peripheral Domain Access Control Word 1 (PDAC_W1_281)	32	RW	0000_0000h
18D8h	Peripheral Domain Access Control Word 0 (PDAC_W0_283)	32	RW	0000_0000h
18DCh	Peripheral Domain Access Control Word 1 (PDAC_W1_283)	32	RW	0000_0000h
18E0h	Peripheral Domain Access Control Word 0 (PDAC_W0_284)	32	RW	0000_0000h
18E4h	Peripheral Domain Access Control Word 1 (PDAC_W1_284)	32	RW	0000_0000h
18E8h	Peripheral Domain Access Control Word 0 (PDAC_W0_285)	32	RW	0000_0000h
18ECh	Peripheral Domain Access Control Word 1 (PDAC_W1_285)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
18F0h	Peripheral Domain Access Control Word 0 (PDAC_W0_286)	32	RW	0000_0000h
18F4h	Peripheral Domain Access Control Word 1 (PDAC_W1_286)	32	RW	0000_0000h
1900h	Peripheral Domain Access Control Word 0 (PDAC_W0_288)	32	RW	0000_0000h
1904h	Peripheral Domain Access Control Word 1 (PDAC_W1_288)	32	RW	0000_0000h
1978h	Peripheral Domain Access Control Word 0 (PDAC_W0_303)	32	RW	0000_0000h
197Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_303)	32	RW	0000_0000h
1980h	Peripheral Domain Access Control Word 0 (PDAC_W0_304)	32	RW	0000_0000h
1984h	Peripheral Domain Access Control Word 1 (PDAC_W1_304)	32	RW	0000_0000h
1998h	Peripheral Domain Access Control Word 0 (PDAC_W0_307)	32	RW	0000_0000h
199Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_307)	32	RW	0000_0000h
19D8h	Peripheral Domain Access Control Word 0 (PDAC_W0_315)	32	RW	0000_0000h
19DCh	Peripheral Domain Access Control Word 1 (PDAC_W1_315)	32	RW	0000_0000h
19E0h	Peripheral Domain Access Control Word 0 (PDAC_W0_316)	32	RW	0000_0000h
19E4h	Peripheral Domain Access Control Word 1 (PDAC_W1_316)	32	RW	0000_0000h
19E8h	Peripheral Domain Access Control Word 0 (PDAC_W0_317)	32	RW	0000_0000h
19ECh	Peripheral Domain Access Control Word 1 (PDAC_W1_317)	32	RW	0000_0000h
1A08h	Peripheral Domain Access Control Word 0 (PDAC_W0_321)	32	RW	0000_0000h
1A0Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_321)	32	RW	0000_0000h
1A10h	Peripheral Domain Access Control Word 0 (PDAC_W0_322)	32	RW	0000_0000h
1A14h	Peripheral Domain Access Control Word 1 (PDAC_W1_322)	32	RW	0000_0000h
1A18h	Peripheral Domain Access Control Word 0 (PDAC_W0_323)	32	RW	0000_0000h
1A1Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_323)	32	RW	0000_0000h
1A20h	Peripheral Domain Access Control Word 0 (PDAC_W0_324)	32	RW	0000_0000h
1A24h	Peripheral Domain Access Control Word 1 (PDAC_W1_324)	32	RW	0000_0000h
1A28h	Peripheral Domain Access Control Word 0 (PDAC_W0_325)	32	RW	0000_0000h
1A2Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_325)	32	RW	0000_0000h
1A30h	Peripheral Domain Access Control Word 0 (PDAC_W0_326)	32	RW	0000_0000h
1A34h	Peripheral Domain Access Control Word 1 (PDAC_W1_326)	32	RW	0000_0000h
1A38h	Peripheral Domain Access Control Word 0 (PDAC_W0_327)	32	RW	0000_0000h
1A3Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_327)	32	RW	0000_0000h
1A40h	Peripheral Domain Access Control Word 0 (PDAC_W0_328)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1A44h	Peripheral Domain Access Control Word 1 (PDAC_W1_328)	32	RW	0000_0000h
1A48h	Peripheral Domain Access Control Word 0 (PDAC_W0_329)	32	RW	0000_0000h
1A4Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_329)	32	RW	0000_0000h
1A50h	Peripheral Domain Access Control Word 0 (PDAC_W0_330)	32	RW	0000_0000h
1A54h	Peripheral Domain Access Control Word 1 (PDAC_W1_330)	32	RW	0000_0000h
1A58h	Peripheral Domain Access Control Word 0 (PDAC_W0_331)	32	RW	0000_0000h
1A5Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_331)	32	RW	0000_0000h
1C00h	Peripheral Domain Access Control Word 0 (PDAC_W0_384)	32	RW	0000_0000h
1C04h	Peripheral Domain Access Control Word 1 (PDAC_W1_384)	32	RW	0000_0000h
1C08h	Peripheral Domain Access Control Word 0 (PDAC_W0_385)	32	RW	0000_0000h
1C0Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_385)	32	RW	0000_0000h
1C10h	Peripheral Domain Access Control Word 0 (PDAC_W0_386)	32	RW	0000_0000h
1C14h	Peripheral Domain Access Control Word 1 (PDAC_W1_386)	32	RW	0000_0000h
1C18h	Peripheral Domain Access Control Word 0 (PDAC_W0_387)	32	RW	0000_0000h
1C1Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_387)	32	RW	0000_0000h
1C20h	Peripheral Domain Access Control Word 0 (PDAC_W0_388)	32	RW	0000_0000h
1C24h	Peripheral Domain Access Control Word 1 (PDAC_W1_388)	32	RW	0000_0000h
1C28h	Peripheral Domain Access Control Word 0 (PDAC_W0_389)	32	RW	0000_0000h
1C2Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_389)	32	RW	0000_0000h
1C30h	Peripheral Domain Access Control Word 0 (PDAC_W0_390)	32	RW	0000_0000h
1C34h	Peripheral Domain Access Control Word 1 (PDAC_W1_390)	32	RW	0000_0000h
1C38h	Peripheral Domain Access Control Word 0 (PDAC_W0_391)	32	RW	0000_0000h
1C3Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_391)	32	RW	0000_0000h
1C40h	Peripheral Domain Access Control Word 0 (PDAC_W0_392)	32	RW	0000_0000h
1C44h	Peripheral Domain Access Control Word 1 (PDAC_W1_392)	32	RW	0000_0000h
1C48h	Peripheral Domain Access Control Word 0 (PDAC_W0_393)	32	RW	0000_0000h
1C4Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_393)	32	RW	0000_0000h
1C50h	Peripheral Domain Access Control Word 0 (PDAC_W0_394)	32	RW	0000_0000h
1C54h	Peripheral Domain Access Control Word 1 (PDAC_W1_394)	32	RW	0000_0000h
1C58h	Peripheral Domain Access Control Word 0 (PDAC_W0_395)	32	RW	0000_0000h
1C5Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_395)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1C60h	Peripheral Domain Access Control Word 0 (PDAC_W0_396)	32	RW	0000_0000h
1C64h	Peripheral Domain Access Control Word 1 (PDAC_W1_396)	32	RW	0000_0000h
1C68h	Peripheral Domain Access Control Word 0 (PDAC_W0_397)	32	RW	0000_0000h
1C6Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_397)	32	RW	0000_0000h
1C70h	Peripheral Domain Access Control Word 0 (PDAC_W0_398)	32	RW	0000_0000h
1C74h	Peripheral Domain Access Control Word 1 (PDAC_W1_398)	32	RW	0000_0000h
1C78h	Peripheral Domain Access Control Word 0 (PDAC_W0_399)	32	RW	0000_0000h
1C7Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_399)	32	RW	0000_0000h
1CE8h	Peripheral Domain Access Control Word 0 (PDAC_W0_413)	32	RW	0000_0000h
1CECh	Peripheral Domain Access Control Word 1 (PDAC_W1_413)	32	RW	0000_0000h
1CF0h	Peripheral Domain Access Control Word 0 (PDAC_W0_414)	32	RW	0000_0000h
1CF4h	Peripheral Domain Access Control Word 1 (PDAC_W1_414)	32	RW	0000_0000h
1D00h	Peripheral Domain Access Control Word 0 (PDAC_W0_416)	32	RW	0000_0000h
1D04h	Peripheral Domain Access Control Word 1 (PDAC_W1_416)	32	RW	0000_0000h
1D10h	Peripheral Domain Access Control Word 0 (PDAC_W0_418)	32	RW	0000_0000h
1D14h	Peripheral Domain Access Control Word 1 (PDAC_W1_418)	32	RW	0000_0000h
1D18h	Peripheral Domain Access Control Word 0 (PDAC_W0_419)	32	RW	0000_0000h
1D1Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_419)	32	RW	0000_0000h
1D20h	Peripheral Domain Access Control Word 0 (PDAC_W0_420)	32	RW	0000_0000h
1D24h	Peripheral Domain Access Control Word 1 (PDAC_W1_420)	32	RW	0000_0000h
1D28h	Peripheral Domain Access Control Word 0 (PDAC_W0_421)	32	RW	0000_0000h
1D2Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_421)	32	RW	0000_0000h
1D40h	Peripheral Domain Access Control Word 0 (PDAC_W0_424)	32	RW	0000_0000h
1D44h	Peripheral Domain Access Control Word 1 (PDAC_W1_424)	32	RW	0000_0000h
1D48h	Peripheral Domain Access Control Word 0 (PDAC_W0_425)	32	RW	0000_0000h
1D4Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_425)	32	RW	0000_0000h
1D60h	Peripheral Domain Access Control Word 0 (PDAC_W0_428)	32	RW	0000_0000h
1D64h	Peripheral Domain Access Control Word 1 (PDAC_W1_428)	32	RW	0000_0000h
1D70h	Peripheral Domain Access Control Word 0 (PDAC_W0_430)	32	RW	0000_0000h
1D74h	Peripheral Domain Access Control Word 1 (PDAC_W1_430)	32	RW	0000_0000h
1D78h	Peripheral Domain Access Control Word 0 (PDAC_W0_431)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1D7Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_431)	32	RW	0000_0000h
1D80h	Peripheral Domain Access Control Word 0 (PDAC_W0_432)	32	RW	0000_0000h
1D84h	Peripheral Domain Access Control Word 1 (PDAC_W1_432)	32	RW	0000_0000h
1D88h	Peripheral Domain Access Control Word 0 (PDAC_W0_433)	32	RW	0000_0000h
1D8Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_433)	32	RW	0000_0000h
1D90h	Peripheral Domain Access Control Word 0 (PDAC_W0_434)	32	RW	0000_0000h
1D94h	Peripheral Domain Access Control Word 1 (PDAC_W1_434)	32	RW	0000_0000h
1D98h	Peripheral Domain Access Control Word 0 (PDAC_W0_435)	32	RW	0000_0000h
1D9Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_435)	32	RW	0000_0000h
1DA0h	Peripheral Domain Access Control Word 0 (PDAC_W0_436)	32	RW	0000_0000h
1DA4h	Peripheral Domain Access Control Word 1 (PDAC_W1_436)	32	RW	0000_0000h
1DA8h	Peripheral Domain Access Control Word 0 (PDAC_W0_437)	32	RW	0000_0000h
1DACh	Peripheral Domain Access Control Word 1 (PDAC_W1_437)	32	RW	0000_0000h
1DB0h	Peripheral Domain Access Control Word 0 (PDAC_W0_438)	32	RW	0000_0000h
1DB4h	Peripheral Domain Access Control Word 1 (PDAC_W1_438)	32	RW	0000_0000h
1DB8h	Peripheral Domain Access Control Word 0 (PDAC_W0_439)	32	RW	0000_0000h
1DBCh	Peripheral Domain Access Control Word 1 (PDAC_W1_439)	32	RW	0000_0000h
1DC0h	Peripheral Domain Access Control Word 0 (PDAC_W0_440)	32	RW	0000_0000h
1DC4h	Peripheral Domain Access Control Word 1 (PDAC_W1_440)	32	RW	0000_0000h
1DC8h	Peripheral Domain Access Control Word 0 (PDAC_W0_441)	32	RW	0000_0000h
1DCCh	Peripheral Domain Access Control Word 1 (PDAC_W1_441)	32	RW	0000_0000h
1DD0h	Peripheral Domain Access Control Word 0 (PDAC_W0_442)	32	RW	0000_0000h
1DD4h	Peripheral Domain Access Control Word 1 (PDAC_W1_442)	32	RW	0000_0000h
1DD8h	Peripheral Domain Access Control Word 0 (PDAC_W0_443)	32	RW	0000_0000h
1DDCh	Peripheral Domain Access Control Word 1 (PDAC_W1_443)	32	RW	0000_0000h
1DE8h	Peripheral Domain Access Control Word 0 (PDAC_W0_445)	32	RW	0000_0000h
1DECh	Peripheral Domain Access Control Word 1 (PDAC_W1_445)	32	RW	0000_0000h
1DF0h	Peripheral Domain Access Control Word 0 (PDAC_W0_446)	32	RW	0000_0000h
1DF4h	Peripheral Domain Access Control Word 1 (PDAC_W1_446)	32	RW	0000_0000h
1DF8h	Peripheral Domain Access Control Word 0 (PDAC_W0_447)	32	RW	0000_0000h
1DFCh	Peripheral Domain Access Control Word 1 (PDAC_W1_447)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1E00h	Peripheral Domain Access Control Word 0 (PDAC_W0_448)	32	RW	0000_0000h
1E04h	Peripheral Domain Access Control Word 1 (PDAC_W1_448)	32	RW	0000_0000h
1E08h	Peripheral Domain Access Control Word 0 (PDAC_W0_449)	32	RW	0000_0000h
1E0Ch	Peripheral Domain Access Control Word 1 (PDAC_W1_449)	32	RW	0000_0000h
2000h	Memory Region Descriptor Word 0 (MRGD_W0_0)	32	RW	0000_0001h
2004h	Memory Region Descriptor Word 1 (MRGD_W1_0)	32	RW	0000_001Fh
2008h	Memory Region Descriptor Word 2 (MRGD_W2_0)	32	RW	0000_0000h
200Ch	Memory Region Descriptor Word 3 (MRGD_W3_0)	32	RW	0000_0000h
2020h	Memory Region Descriptor Word 0 (MRGD_W0_1)	32	RW	0000_0001h
2024h	Memory Region Descriptor Word 1 (MRGD_W1_1)	32	RW	0000_001Fh
2028h	Memory Region Descriptor Word 2 (MRGD_W2_1)	32	RW	0000_0000h
202Ch	Memory Region Descriptor Word 3 (MRGD_W3_1)	32	RW	0000_0000h
2040h	Memory Region Descriptor Word 0 (MRGD_W0_2)	32	RW	0000_0001h
2044h	Memory Region Descriptor Word 1 (MRGD_W1_2)	32	RW	0000_001Fh
2048h	Memory Region Descriptor Word 2 (MRGD_W2_2)	32	RW	0000_0000h
204Ch	Memory Region Descriptor Word 3 (MRGD_W3_2)	32	RW	0000_0000h
2060h	Memory Region Descriptor Word 0 (MRGD_W0_3)	32	RW	0000_0001h
2064h	Memory Region Descriptor Word 1 (MRGD_W1_3)	32	RW	0000_001Fh
2068h	Memory Region Descriptor Word 2 (MRGD_W2_3)	32	RW	0000_0000h
206Ch	Memory Region Descriptor Word 3 (MRGD_W3_3)	32	RW	0000_0000h
2080h	Memory Region Descriptor Word 0 (MRGD_W0_4)	32	RW	0000_0001h
2084h	Memory Region Descriptor Word 1 (MRGD_W1_4)	32	RW	0000_001Fh
2088h	Memory Region Descriptor Word 2 (MRGD_W2_4)	32	RW	0000_0000h
208Ch	Memory Region Descriptor Word 3 (MRGD_W3_4)	32	RW	0000_0000h
20A0h	Memory Region Descriptor Word 0 (MRGD_W0_5)	32	RW	0000_0001h
20A4h	Memory Region Descriptor Word 1 (MRGD_W1_5)	32	RW	0000_001Fh
20A8h	Memory Region Descriptor Word 2 (MRGD_W2_5)	32	RW	0000_0000h
20ACh	Memory Region Descriptor Word 3 (MRGD_W3_5)	32	RW	0000_0000h
20C0h	Memory Region Descriptor Word 0 (MRGD_W0_6)	32	RW	0000_0001h
20C4h	Memory Region Descriptor Word 1 (MRGD_W1_6)	32	RW	0000_001Fh
20C8h	Memory Region Descriptor Word 2 (MRGD_W2_6)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
20CCh	Memory Region Descriptor Word 3 (MRGD_W3_6)	32	RW	0000_0000h
20E0h	Memory Region Descriptor Word 0 (MRGD_W0_7)	32	RW	0000_0001h
20E4h	Memory Region Descriptor Word 1 (MRGD_W1_7)	32	RW	0000_001Fh
20E8h	Memory Region Descriptor Word 2 (MRGD_W2_7)	32	RW	0000_0000h
20ECh	Memory Region Descriptor Word 3 (MRGD_W3_7)	32	RW	0000_0000h
2100h	Memory Region Descriptor Word 0 (MRGD_W0_8)	32	RW	0000_0001h
2104h	Memory Region Descriptor Word 1 (MRGD_W1_8)	32	RW	0000_001Fh
2108h	Memory Region Descriptor Word 2 (MRGD_W2_8)	32	RW	0000_0000h
210Ch	Memory Region Descriptor Word 3 (MRGD_W3_8)	32	RW	0000_0000h
2120h	Memory Region Descriptor Word 0 (MRGD_W0_9)	32	RW	0000_0001h
2124h	Memory Region Descriptor Word 1 (MRGD_W1_9)	32	RW	0000_001Fh
2128h	Memory Region Descriptor Word 2 (MRGD_W2_9)	32	RW	0000_0000h
212Ch	Memory Region Descriptor Word 3 (MRGD_W3_9)	32	RW	0000_0000h
2140h	Memory Region Descriptor Word 0 (MRGD_W0_10)	32	RW	0000_0001h
2144h	Memory Region Descriptor Word 1 (MRGD_W1_10)	32	RW	0000_001Fh
2148h	Memory Region Descriptor Word 2 (MRGD_W2_10)	32	RW	0000_0000h
214Ch	Memory Region Descriptor Word 3 (MRGD_W3_10)	32	RW	0000_0000h
2160h	Memory Region Descriptor Word 0 (MRGD_W0_11)	32	RW	0000_0001h
2164h	Memory Region Descriptor Word 1 (MRGD_W1_11)	32	RW	0000_001Fh
2168h	Memory Region Descriptor Word 2 (MRGD_W2_11)	32	RW	0000_0000h
216Ch	Memory Region Descriptor Word 3 (MRGD_W3_11)	32	RW	0000_0000h
2180h	Memory Region Descriptor Word 0 (MRGD_W0_12)	32	RW	0000_0001h
2184h	Memory Region Descriptor Word 1 (MRGD_W1_12)	32	RW	0000_001Fh
2188h	Memory Region Descriptor Word 2 (MRGD_W2_12)	32	RW	0000_0000h
218Ch	Memory Region Descriptor Word 3 (MRGD_W3_12)	32	RW	0000_0000h
21A0h	Memory Region Descriptor Word 0 (MRGD_W0_13)	32	RW	0000_0001h
21A4h	Memory Region Descriptor Word 1 (MRGD_W1_13)	32	RW	0000_001Fh
21A8h	Memory Region Descriptor Word 2 (MRGD_W2_13)	32	RW	0000_0000h
21ACh	Memory Region Descriptor Word 3 (MRGD_W3_13)	32	RW	0000_0000h
21C0h	Memory Region Descriptor Word 0 (MRGD_W0_14)	32	RW	0000_0001h
21C4h	Memory Region Descriptor Word 1 (MRGD_W1_14)	32	RW	0000_001Fh

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
21C8h	Memory Region Descriptor Word 2 (MRGD_W2_14)	32	RW	0000_0000h
21CCh	Memory Region Descriptor Word 3 (MRGD_W3_14)	32	RW	0000_0000h
21E0h	Memory Region Descriptor Word 0 (MRGD_W0_15)	32	RW	0000_0001h
21E4h	Memory Region Descriptor Word 1 (MRGD_W1_15)	32	RW	0000_001Fh
21E8h	Memory Region Descriptor Word 2 (MRGD_W2_15)	32	RW	0000_0000h
21ECh	Memory Region Descriptor Word 3 (MRGD_W3_15)	32	RW	0000_0000h
2200h	Memory Region Descriptor Word 0 (MRGD_W0_16)	32	RW	0000_0001h
2204h	Memory Region Descriptor Word 1 (MRGD_W1_16)	32	RW	0000_001Fh
2208h	Memory Region Descriptor Word 2 (MRGD_W2_16)	32	RW	0000_0000h
220Ch	Memory Region Descriptor Word 3 (MRGD_W3_16)	32	RW	0000_0000h
2220h	Memory Region Descriptor Word 0 (MRGD_W0_17)	32	RW	0000_0001h
2224h	Memory Region Descriptor Word 1 (MRGD_W1_17)	32	RW	0000_001Fh
2228h	Memory Region Descriptor Word 2 (MRGD_W2_17)	32	RW	0000_0000h
222Ch	Memory Region Descriptor Word 3 (MRGD_W3_17)	32	RW	0000_0000h
2240h	Memory Region Descriptor Word 0 (MRGD_W0_18)	32	RW	0000_0001h
2244h	Memory Region Descriptor Word 1 (MRGD_W1_18)	32	RW	0000_001Fh
2248h	Memory Region Descriptor Word 2 (MRGD_W2_18)	32	RW	0000_0000h
224Ch	Memory Region Descriptor Word 3 (MRGD_W3_18)	32	RW	0000_0000h
2260h	Memory Region Descriptor Word 0 (MRGD_W0_19)	32	RW	0000_0001h
2264h	Memory Region Descriptor Word 1 (MRGD_W1_19)	32	RW	0000_001Fh
2268h	Memory Region Descriptor Word 2 (MRGD_W2_19)	32	RW	0000_0000h
226Ch	Memory Region Descriptor Word 3 (MRGD_W3_19)	32	RW	0000_0000h
2280h	Memory Region Descriptor Word 0 (MRGD_W0_20)	32	RW	0000_0001h
2284h	Memory Region Descriptor Word 1 (MRGD_W1_20)	32	RW	0000_001Fh
2288h	Memory Region Descriptor Word 2 (MRGD_W2_20)	32	RW	0000_0000h
228Ch	Memory Region Descriptor Word 3 (MRGD_W3_20)	32	RW	0000_0000h
22A0h	Memory Region Descriptor Word 0 (MRGD_W0_21)	32	RW	0000_0001h
22A4h	Memory Region Descriptor Word 1 (MRGD_W1_21)	32	RW	0000_001Fh
22A8h	Memory Region Descriptor Word 2 (MRGD_W2_21)	32	RW	0000_0000h
22ACh	Memory Region Descriptor Word 3 (MRGD_W3_21)	32	RW	0000_0000h
22C0h	Memory Region Descriptor Word 0 (MRGD_W0_22)	32	RW	0000_0001h

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Offset	Register	Width (In bits)	Access	Reset value
22C4h	Memory Region Descriptor Word 1 (MRGD_W1_22)	32	RW	0000_001Fh
22C8h	Memory Region Descriptor Word 2 (MRGD_W2_22)	32	RW	0000_0000h
22CCh	Memory Region Descriptor Word 3 (MRGD_W3_22)	32	RW	0000_0000h
22E0h	Memory Region Descriptor Word 0 (MRGD_W0_23)	32	RW	0000_0001h
22E4h	Memory Region Descriptor Word 1 (MRGD_W1_23)	32	RW	0000_001Fh
22E8h	Memory Region Descriptor Word 2 (MRGD_W2_23)	32	RW	0000_0000h
22ECh	Memory Region Descriptor Word 3 (MRGD_W3_23)	32	RW	0000_0000h
2300h	Memory Region Descriptor Word 0 (MRGD_W0_24)	32	RW	0000_0001h
2304h	Memory Region Descriptor Word 1 (MRGD_W1_24)	32	RW	0000_001Fh
2308h	Memory Region Descriptor Word 2 (MRGD_W2_24)	32	RW	0000_0000h
230Ch	Memory Region Descriptor Word 3 (MRGD_W3_24)	32	RW	0000_0000h
2320h	Memory Region Descriptor Word 0 (MRGD_W0_25)	32	RW	0000_0001h
2324h	Memory Region Descriptor Word 1 (MRGD_W1_25)	32	RW	0000_001Fh
2328h	Memory Region Descriptor Word 2 (MRGD_W2_25)	32	RW	0000_0000h
232Ch	Memory Region Descriptor Word 3 (MRGD_W3_25)	32	RW	0000_0000h
2340h	Memory Region Descriptor Word 0 (MRGD_W0_26)	32	RW	0000_0001h
2344h	Memory Region Descriptor Word 1 (MRGD_W1_26)	32	RW	0000_001Fh
2348h	Memory Region Descriptor Word 2 (MRGD_W2_26)	32	RW	0000_0000h
234Ch	Memory Region Descriptor Word 3 (MRGD_W3_26)	32	RW	0000_0000h
2360h	Memory Region Descriptor Word 0 (MRGD_W0_27)	32	RW	0000_0001h
2364h	Memory Region Descriptor Word 1 (MRGD_W1_27)	32	RW	0000_001Fh
2368h	Memory Region Descriptor Word 2 (MRGD_W2_27)	32	RW	0000_0000h
236Ch	Memory Region Descriptor Word 3 (MRGD_W3_27)	32	RW	0000_0000h
2380h	Memory Region Descriptor Word 0 (MRGD_W0_28)	32	RW	0000_0001h
2384h	Memory Region Descriptor Word 1 (MRGD_W1_28)	32	RW	0000_001Fh
2388h	Memory Region Descriptor Word 2 (MRGD_W2_28)	32	RW	0000_0000h
238Ch	Memory Region Descriptor Word 3 (MRGD_W3_28)	32	RW	0000_0000h
23A0h	Memory Region Descriptor Word 0 (MRGD_W0_29)	32	RW	0000_0001h
23A4h	Memory Region Descriptor Word 1 (MRGD_W1_29)	32	RW	0000_001Fh
23A8h	Memory Region Descriptor Word 2 (MRGD_W2_29)	32	RW	0000_0000h
23ACh	Memory Region Descriptor Word 3 (MRGD_W3_29)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
23C0h	Memory Region Descriptor Word 0 (MRGD_W0_30)	32	RW	0000_0001h
23C4h	Memory Region Descriptor Word 1 (MRGD_W1_30)	32	RW	0000_001Fh
23C8h	Memory Region Descriptor Word 2 (MRGD_W2_30)	32	RW	0000_0000h
23CCh	Memory Region Descriptor Word 3 (MRGD_W3_30)	32	RW	0000_0000h
23E0h	Memory Region Descriptor Word 0 (MRGD_W0_31)	32	RW	0000_0001h
23E4h	Memory Region Descriptor Word 1 (MRGD_W1_31)	32	RW	0000_001Fh
23E8h	Memory Region Descriptor Word 2 (MRGD_W2_31)	32	RW	0000_0000h
23ECh	Memory Region Descriptor Word 3 (MRGD_W3_31)	32	RW	0000_0000h
2400h	Memory Region Descriptor Word 0 (MRGD_W0_32)	32	RW	0000_0001h
2404h	Memory Region Descriptor Word 1 (MRGD_W1_32)	32	RW	0000_001Fh
2408h	Memory Region Descriptor Word 2 (MRGD_W2_32)	32	RW	0000_0000h
240Ch	Memory Region Descriptor Word 3 (MRGD_W3_32)	32	RW	0000_0000h
2420h	Memory Region Descriptor Word 0 (MRGD_W0_33)	32	RW	0000_0001h
2424h	Memory Region Descriptor Word 1 (MRGD_W1_33)	32	RW	0000_001Fh
2428h	Memory Region Descriptor Word 2 (MRGD_W2_33)	32	RW	0000_0000h
242Ch	Memory Region Descriptor Word 3 (MRGD_W3_33)	32	RW	0000_0000h
2440h	Memory Region Descriptor Word 0 (MRGD_W0_34)	32	RW	0000_0001h
2444h	Memory Region Descriptor Word 1 (MRGD_W1_34)	32	RW	0000_001Fh
2448h	Memory Region Descriptor Word 2 (MRGD_W2_34)	32	RW	0000_0000h
244Ch	Memory Region Descriptor Word 3 (MRGD_W3_34)	32	RW	0000_0000h
2460h	Memory Region Descriptor Word 0 (MRGD_W0_35)	32	RW	0000_0001h
2464h	Memory Region Descriptor Word 1 (MRGD_W1_35)	32	RW	0000_001Fh
2468h	Memory Region Descriptor Word 2 (MRGD_W2_35)	32	RW	0000_0000h
246Ch	Memory Region Descriptor Word 3 (MRGD_W3_35)	32	RW	0000_0000h
2600h	Memory Region Descriptor Word 0 (MRGD_W0_48)	32	RW	0000_0001h
2604h	Memory Region Descriptor Word 1 (MRGD_W1_48)	32	RW	0000_001Fh
2608h	Memory Region Descriptor Word 2 (MRGD_W2_48)	32	RW	0000_0000h
260Ch	Memory Region Descriptor Word 3 (MRGD_W3_48)	32	RW	0000_0000h
2620h	Memory Region Descriptor Word 0 (MRGD_W0_49)	32	RW	0000_0001h
2624h	Memory Region Descriptor Word 1 (MRGD_W1_49)	32	RW	0000_001Fh
2628h	Memory Region Descriptor Word 2 (MRGD_W2_49)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
262Ch	Memory Region Descriptor Word 3 (MRGD_W3_49)	32	RW	0000_0000h
2640h	Memory Region Descriptor Word 0 (MRGD_W0_50)	32	RW	0000_0001h
2644h	Memory Region Descriptor Word 1 (MRGD_W1_50)	32	RW	0000_001Fh
2648h	Memory Region Descriptor Word 2 (MRGD_W2_50)	32	RW	0000_0000h
264Ch	Memory Region Descriptor Word 3 (MRGD_W3_50)	32	RW	0000_0000h
2660h	Memory Region Descriptor Word 0 (MRGD_W0_51)	32	RW	0000_0001h
2664h	Memory Region Descriptor Word 1 (MRGD_W1_51)	32	RW	0000_001Fh
2668h	Memory Region Descriptor Word 2 (MRGD_W2_51)	32	RW	0000_0000h
266Ch	Memory Region Descriptor Word 3 (MRGD_W3_51)	32	RW	0000_0000h
2680h	Memory Region Descriptor Word 0 (MRGD_W0_52)	32	RW	0000_0001h
2684h	Memory Region Descriptor Word 1 (MRGD_W1_52)	32	RW	0000_001Fh
2688h	Memory Region Descriptor Word 2 (MRGD_W2_52)	32	RW	0000_0000h
268Ch	Memory Region Descriptor Word 3 (MRGD_W3_52)	32	RW	0000_0000h
26A0h	Memory Region Descriptor Word 0 (MRGD_W0_53)	32	RW	0000_0001h
26A4h	Memory Region Descriptor Word 1 (MRGD_W1_53)	32	RW	0000_001Fh
26A8h	Memory Region Descriptor Word 2 (MRGD_W2_53)	32	RW	0000_0000h
26ACh	Memory Region Descriptor Word 3 (MRGD_W3_53)	32	RW	0000_0000h
26C0h	Memory Region Descriptor Word 0 (MRGD_W0_54)	32	RW	0000_0001h
26C4h	Memory Region Descriptor Word 1 (MRGD_W1_54)	32	RW	0000_001Fh
26C8h	Memory Region Descriptor Word 2 (MRGD_W2_54)	32	RW	0000_0000h
26CCh	Memory Region Descriptor Word 3 (MRGD_W3_54)	32	RW	0000_0000h
26E0h	Memory Region Descriptor Word 0 (MRGD_W0_55)	32	RW	0000_0001h
26E4h	Memory Region Descriptor Word 1 (MRGD_W1_55)	32	RW	0000_001Fh
26E8h	Memory Region Descriptor Word 2 (MRGD_W2_55)	32	RW	0000_0000h
26ECh	Memory Region Descriptor Word 3 (MRGD_W3_55)	32	RW	0000_0000h
2700h	Memory Region Descriptor Word 0 (MRGD_W0_56)	32	RW	0000_0001h
2704h	Memory Region Descriptor Word 1 (MRGD_W1_56)	32	RW	0000_001Fh
2708h	Memory Region Descriptor Word 2 (MRGD_W2_56)	32	RW	0000_0000h
270Ch	Memory Region Descriptor Word 3 (MRGD_W3_56)	32	RW	0000_0000h
2720h	Memory Region Descriptor Word 0 (MRGD_W0_57)	32	RW	0000_0001h
2724h	Memory Region Descriptor Word 1 (MRGD_W1_57)	32	RW	0000_001Fh

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Offset	Register	Width (In bits)	Access	Reset value
2728h	Memory Region Descriptor Word 2 (MRGD_W2_57)	32	RW	0000_0000h
272Ch	Memory Region Descriptor Word 3 (MRGD_W3_57)	32	RW	0000_0000h
2740h	Memory Region Descriptor Word 0 (MRGD_W0_58)	32	RW	0000_0001h
2744h	Memory Region Descriptor Word 1 (MRGD_W1_58)	32	RW	0000_001Fh
2748h	Memory Region Descriptor Word 2 (MRGD_W2_58)	32	RW	0000_0000h
274Ch	Memory Region Descriptor Word 3 (MRGD_W3_58)	32	RW	0000_0000h
2760h	Memory Region Descriptor Word 0 (MRGD_W0_59)	32	RW	0000_0001h
2764h	Memory Region Descriptor Word 1 (MRGD_W1_59)	32	RW	0000_001Fh
2768h	Memory Region Descriptor Word 2 (MRGD_W2_59)	32	RW	0000_0000h
276Ch	Memory Region Descriptor Word 3 (MRGD_W3_59)	32	RW	0000_0000h
2780h	Memory Region Descriptor Word 0 (MRGD_W0_60)	32	RW	0000_0001h
2784h	Memory Region Descriptor Word 1 (MRGD_W1_60)	32	RW	0000_001Fh
2788h	Memory Region Descriptor Word 2 (MRGD_W2_60)	32	RW	0000_0000h
278Ch	Memory Region Descriptor Word 3 (MRGD_W3_60)	32	RW	0000_0000h
27A0h	Memory Region Descriptor Word 0 (MRGD_W0_61)	32	RW	0000_0001h
27A4h	Memory Region Descriptor Word 1 (MRGD_W1_61)	32	RW	0000_001Fh
27A8h	Memory Region Descriptor Word 2 (MRGD_W2_61)	32	RW	0000_0000h
27ACh	Memory Region Descriptor Word 3 (MRGD_W3_61)	32	RW	0000_0000h
27C0h	Memory Region Descriptor Word 0 (MRGD_W0_62)	32	RW	0000_0001h
27C4h	Memory Region Descriptor Word 1 (MRGD_W1_62)	32	RW	0000_001Fh
27C8h	Memory Region Descriptor Word 2 (MRGD_W2_62)	32	RW	0000_0000h
27CCh	Memory Region Descriptor Word 3 (MRGD_W3_62)	32	RW	0000_0000h
27E0h	Memory Region Descriptor Word 0 (MRGD_W0_63)	32	RW	0000_0001h
27E4h	Memory Region Descriptor Word 1 (MRGD_W1_63)	32	RW	0000_001Fh
27E8h	Memory Region Descriptor Word 2 (MRGD_W2_63)	32	RW	0000_0000h
27ECh	Memory Region Descriptor Word 3 (MRGD_W3_63)	32	RW	0000_0000h

18.8.3.2 Control (CR)

Offset

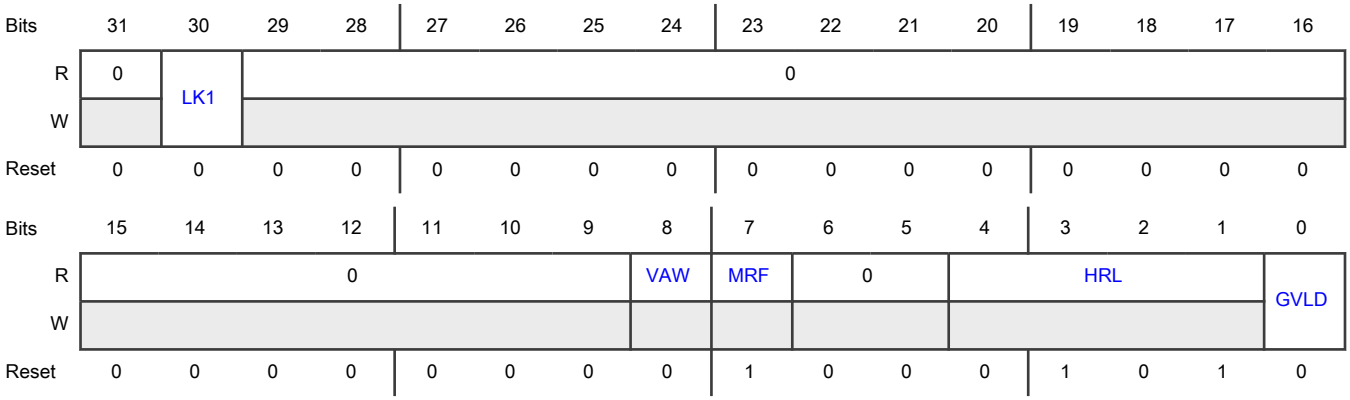
Register	Offset
CR	0h

Function

Provides XRDC status and enables XRDC operation.

Access: Secure privileged read/write

Diagram



Fields

Field	Function
31 —	Reserved
30 LK1	Lock Prohibits writes to this register. • If unlocked, this register accepts any secure privileged write. • If locked, you cannot write to this register and it remains read-only until after the next reset. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Unlocked 1b - Locks When writing 0b - No effect 1b - Locks
29-9 —	Reserved
8 VAW	Virtualization Aware Indicates whether domain assignments support the optional inclusion of a logical partition identifier, which is also known as an operating system number or Arm virtual machine identifier (VMID).

Table continues on the next page...

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Field	Function
	0b - Not virtualization-aware 1b - Virtualization-aware
7 MRF	Memory Region Format Indicates the format of memory region descriptors. 0b - Reserved 1b - SMPU family format
6-5 —	Reserved
4-1 HRL	Hardware Revision Level Indicates the XRDC hardware revision level, which is associated with a set of functional characteristics of the module.
0 GVLD	Global Valid (XRDC Global Enable/Disable) Enables XRDC. When XRDC is disabled, all bus masters can access all targets. 0b - Disables 1b - Enables

18.8.3.3 Hardware Configuration 0 (HWCFG0)

Offset

Register	Offset
HWCFG0	F0h

Function

Indicates XRDC configuration details, including:

- XRDC module ID
- Number of implemented domains
- Number of bus masters
- Number of MRCs
- Number of PACs

Attempting to write to this register causes an error.

Access: Secure privileged read

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MID				NPAC				NMRC							
W																
Reset	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NMSTR								NDID							
W																
Reset	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-28 MID	Module ID
27-24 NPAC	Number Of PACs Indicates the number of PACs minus 1. In other words, the actual number of PACs is NPAC + 1.
23-16 NMRC	Number of MRCs Indicates the number of MRCs minus 1. In other words, the actual number of MRCs is NMRC + 1.
15-8 NMSTR	Number Of Bus Masters Indicates the number of bus masters minus 1. In other words, the actual number of bus masters is NMSTR + 1.
7-0 NDID	Number Of DIDs Indicates the number of domains (DIDs) minus 1. In other words, the actual number of DIDs is NDID + 1.

18.8.3.4 Hardware Configuration 1 (HWCFG1)

Offset

Register	Offset
HWCFG1	F4h

Function

Indicates the DID of the bus master making the current transaction request. See Domain error capture management for information about typical usage.

Attempting to write to this register causes an error.

Access: Secure privileged read

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												DID			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	u[1]	u	u	u

1. The reset value is determined by the current configuration of the accessing master.

Fields

Field	Function
31-4 —	Reserved
3-0 DID	Domain Identifier Indicates the DID of the requesting bus master.

18.8.3.5 Hardware Configuration 2 (HWCFG2)

Offset

Register	Offset
HWCFG2	F8h

Function

For masters 0–31, indicates whether a given master has a built-in PID register as part of its programming model. If not, you must use the corresponding PIDm register to mimic the functionality of a built-in PID register.

Each bit corresponds to the same numbered master. For example, if PIDP18 is 1, bus master 18 has its own PID register. If PIDP18 is 0, then master 18 does not have its own PID register and you must use PID18.

Attempting to write to this register causes an error.

Access: Secure privileged read

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PIDP31	PIDP30	PIDP29	PIDP28	PIDP27	PIDP26	PIDP25	PIDP24	PIDP23	PIDP22	PIDP21	PIDP20	PIDP19	PIDP18	PIDP17	PIDP16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PIDP15	PIDP14	PIDP13	PIDP12	PIDP11	PIDP10	PIDP9	PIDP8	PIDP7	PIDP6	PIDP5	PIDP4	PIDP3	PIDP2	PIDP1	PIDP0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PIDPn	Process Identifier Present 0b - Does not have PID register 1b - Has PID register

18.8.3.6 Master Domain Assignment Configuration (MDACFG0 - MDACFG8)

Offset

For m = 0 to 8:

Register	Offset
MDACFGm	100h + (m × 1h)

Function

Indicates the number of implemented master domain assignment registers (MDA_W*w*_*m*_DFMT0 or MDA_W*w*_*m*_DFMT1) for master *m*, where *m* ranges from 0 to 63. You can read these registers using 8-, 16-, or 32-bit accesses.

If NMDAR is 0, the associated master does not exist.

Attempting to write to this register causes an error.

Access: Secure privileged read

Diagram

Bits	7	6	5	4	3	2	1	0
R	NCM	0			NMDAR			
W								
Reset	See Register reset values.							

Register reset values

Register	Reset value
MDACFG0	01h
MDACFG1–MDACFG2	81h
MDACFG3–MDACFG4	01h
MDACFG5	81h
MDACFG6	01h
MDACFG7–MDACFG8	81h

Fields

Field	Function
7 NCM	Noncore Master If NMDAR is greater than zero, indicates whether master *m* uses MDA_W*w*_*m*_DFMT0 or MDA_W*w*_*m*_DFMT1 to configure domain assignment. This field is 0 for a non-existent master. 0b - Core master or master does not exist 1b - Noncore master
6-4 —	Reserved
3-0 NMDAR	Number Of Master Domain Assignment Registers Indicates the number of master domain assignment registers (MDA_W*w*_*m*_DFMT0 or MDA_W*w*_*m*_DFMT1) associated with master *m*. 0000b - Master does not exist 0001b-1000b - Number of registers All other values are reserved.

18.8.3.7 Memory Region Configuration (MRCFG0 - MRCFG3)

Offset

Register	Offset
MRCFG0	140h
MRCFG1	141h
MRCFG2	142h
MRCFG3	143h

Function

Indicates the number of memory region descriptors (*r*) for MRC*c*, from 4 to 16 in increments of four, with 0 indicating a non-existent MRC. These registers are organized as byte-sized data arrays and can be read using 8-, 16-, or 32-bit accesses.

Attempting to write to this register causes an error.

Access: Secure Privileged Read

Diagram

Bits	7	6	5	4	3	2	1	0
R	0				NMRGD			
W								
Reset	See Register reset values.							

Register reset values

Register	Reset value
MRCFG0–MRCFG1	10h
MRCFG2	04h
MRCFG3	10h

Fields

Field	Function
7-5 —	Reserved
4-0 NMRGD	Number Of Memory Region Descriptors Indicates the number of memory region descriptors associated with the MRC. 0_0000b - MRC does not exist

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0_0100b - 4 0_1000b - 8 0_1100b - 12 1_0000b - 16 All other values are reserved.

18.8.3.8 Domain Error Location (DERRLOC0 - DERRLOC3)

Offset

Register	Offset
DERRLOC0	200h
DERRLOC1	204h
DERRLOC2	208h
DERRLOC3	20Ch

Function

Indicates the MRC or PAC instance in domain *d* where an access violation has occurred. Each bit corresponds to the like-numbered instance. For more information, see Domain error capture management.

Attempting to write to this register causes an error.

Access: Secure privileged read

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0												PACINST			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MRCINST															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20 —	Reserved
19-16 PACINST	PAC Instance Indicates the presence of a detected access violation for domain *d* in a PAC instance. Each bit corresponds to the instance index for the DERR_W*w*_*i* registers: bit 16 of the register corresponds to the DERR_W*w*_*16* registers, which show error information for PAC 0, and so on. Multiple bits can be 1 at any time, indicating access violations have been detected across multiple PACs. For each bit in this field: 0b - No access violation error or the PAC instance is not physically present 1b - Access violation detected
15-0 MRCINST	MRC Instance Indicates the presence of a detected access violation for domain *d* in an MRC instance. Each bit corresponds to the like-numbered MRC instance: bit 0 (bit 0 of the register) corresponds to MRC instance 0, and so on. Multiple bits can be 1 at any time, indicating access violations have been detected across multiple MRCs. For each bit in this field: 0b - No access violation error or the MRC instance is not physically present 1b - Access violation detected

18.8.3.9 Domain Error Word 0 (DERR_W0_0 - DERR_W0_19)

Offset

Register	Offset
DERR_W0_0	400h
DERR_W0_1	410h
DERR_W0_2	420h
DERR_W0_3	430h
DERR_W0_16	500h
DERR_W0_17	510h
DERR_W0_18	520h
DERR_W0_19	530h

Function

Indicates the address of an access violation detected by an MRC or a PAC, indexed by the MRC or PAC instance (*i*) that detected the violation, as indicated in DERRLOC*d*. This register is part of a 16-byte set:

- DERR_W0_*i*: Word 0, the first 4 bytes

- DERR_W1_*i*: Word 1, the second 4 bytes
- Word 2, 4 reserved bytes
- DERR_W3_*i*: Word 3, the fourth 4 bytes

The first 16 sets (*i* from 0 to 15) are associated with MRCs and the rest (starting with *i* = 16) are associated with PACs. For more information, see Domain error capture management.

The error capture registers in the memory region controller and peripheral access controller submodules contain physical registers for each domain, but are organized in the DERR_Wn registers to provide the information for the requesting domain only. The registers return the error information for the domain id that is used to read the registers. When no error occurred for this domain id, it returns 0 data.

When the error capture logic is rearmed by writing the required data pattern to DERR_W3_n, this register is cleared.

When XRDC detects an access violation, it captures the error information and disables subsequent updates to the error capture registers until you write to DERR_W3_*i*.

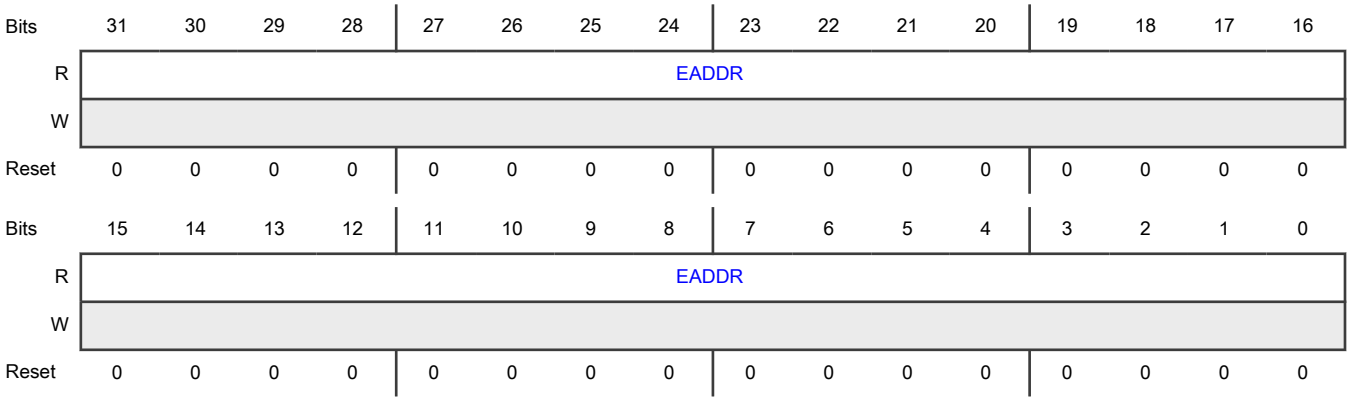
NOTE

If masters with the same DID cause simultaneous error accesses, the error capture registers record only the error of the lowest target index.

Attempting to write to this register causes an error. Attempting to read the error registers for a non-existent MRC or PAC instance causes an error.

Access: Secure privileged read

Diagram



Fields

Field	Function
31-0 EADDR	Error Address Indicates the target address of the first transaction that causes an access violation after reset or after rearming error capture.

18.8.3.10 Domain Error Word 1 (DERR_W1_0 - DERR_W1_19)

Offset

Register	Offset
DERR_W1_0	404h
DERR_W1_1	414h
DERR_W1_2	424h
DERR_W1_3	434h
DERR_W1_16	504h
DERR_W1_17	514h
DERR_W1_18	524h
DERR_W1_19	534h

Function

Indicates the attributes of an access violation detected by an MRC or a PAC, indexed by the MRC or PAC instance (*i*) that detected the access violation, as indicated in DERRLOC*d*. For more information, see DERR_W0_*i* and Domain error capture management.

The error capture registers in the memory region controller and peripheral access controller submodules contain physical registers for each domain, but are organized in the DERR_Wn registers to provide the information for the requesting domain only. The registers return the error information for the domain id that is used to read the registers. When no error occurred for this domain id, it returns 0 data.

When the error capture logic is rearmed by writing the required data pattern to DERR_W3_n, this register is cleared.

NOTE

If masters with the same DID cause simultaneous error accesses, the error capture registers record only the error of the lowest target index.

Attempting to write to this register causes an error. Attempting to read the error registers for a non-existent MRC or PAC instance causes an error.

Access: Secure privileged read

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EST		0		EPORT				0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				ERW	EATR			0				EDID			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 EST	Error State Indicates the state of access violations for this domain in this instance of the MRC or PAC. After the first access violation to occur after reset or rearming of error capture, XRDC records subsequent errors as an overrun condition without any data captured. 00b-01b - No access violations detected 10b - A single access violation has been detected 11b - Multiple access violations have been detected
29-27 —	Reserved
26-24 EPORT	Error Port Identifies the encoded port number of the MRC that detected the access violation. See the chip-specific configuration details for the MRC port connections. For access violations detected by a PAC, this field is zero.
23-12 —	Reserved
11 ERW	Error Read Or Write Indicates whether the captured access violation occurred on a read or write access. 0b - Read access 1b - Write access
10-8 EATR	Error Attributes Indicates attributes of the access violation. 000b - Secure user mode, instruction fetch access 001b - Secure user mode, data access 010b - Secure privileged mode, instruction fetch access 011b - Secure privileged mode, data access 100b - Nonsecure user mode, instruction fetch access 101b - Nonsecure user mode, data access 110b - Nonsecure privileged mode, instruction fetch access 111b - Nonsecure privileged mode, data access
7-4 —	Reserved
3-0 EDID	Error Domain Identifier Indicates the DID of the access violation.

18.8.3.11 Domain Error Word 3 (DERR_W3_0 - DERR_W3_19)

Offset

Register	Offset
DERR_W3_0	40Ch
DERR_W3_1	41Ch
DERR_W3_2	42Ch
DERR_W3_3	43Ch
DERR_W3_16	50Ch
DERR_W3_17	51Ch
DERR_W3_18	52Ch
DERR_W3_19	53Ch

Function

Rearms instance error capture, resets the error capture registers (DERR_W0_*d*, DERR_W1_*d*), and deasserts the instance bit in DERRLOC*d*. After reading the access violation error information, an error handler must write 1 to RECR.

Register write only rearms error capture registers for the domain id that is used to write this register.

This register returns 0000h when read. Attempted reads of an MRC or PAC instance that is not physically present cause an error.

For more information, see Domain error capture management.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		0													
W	RECR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30	Rearm Error Capture Registers
RECR	Resets and rearms the domain error capture registers for this instance, including deasserting the instance bit in DERRLOC*d*.

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Table continued from the previous page...

Field	Function
	00b,10b,11b - No effect 01b - Rearms error capture, resets error capture registers, and deasserts instance bit in DERRLOCd
29-0 —	Reserved

18.8.3.12 Process Identifier (PID0 - PID6)

Offset

Register	Offset
PID0	700h
PID3	70Ch
PID4	710h
PID6	718h

Function

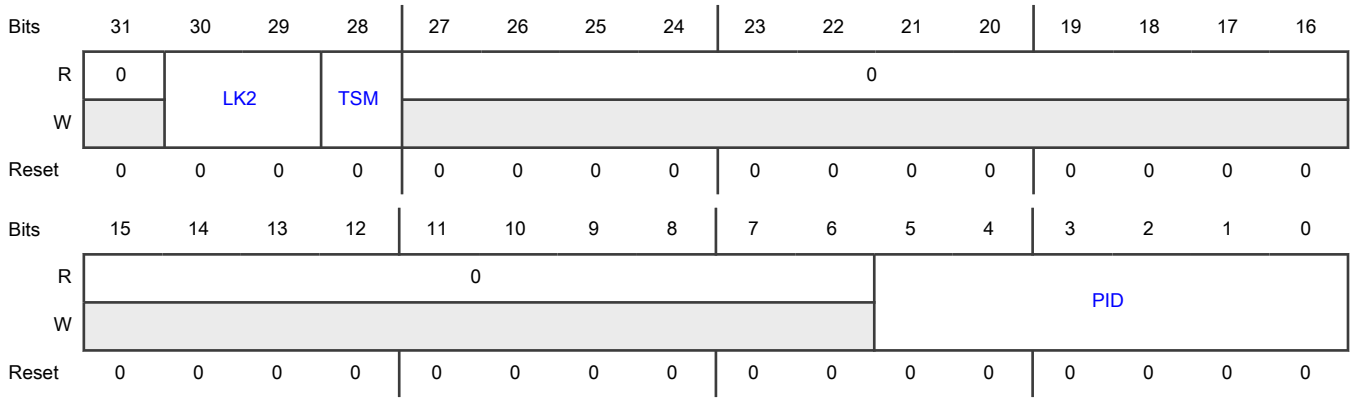
Specifies the PID for the associated core master *m*.

Some cores contain a built-in PID register. If the core has a built-in PID register, XRDC populates the PID field with the value from the core PID register. If the core does not have the built-in register, the XRDC PID register allows applications to mimic PID operation for that core by writing the desired PID to the associated register.

HWCFG2 provides a bitmap of the implemented PID*m* registers. Noncore masters do not have an associated PID register.

For information about PID-based operation, see PID-based domain assignment.

Diagram



Fields

Field	Function
31 —	Reserved
30-29 LK2	Lock Limits or prohibits writes to this register. When you assert a bit in this field, it remains asserted until the next module reset. If the core master has a built-in PID register, as indicated in HWCFG2, then a secure privileged read returns 0 for this field. 00b,01b - Any secure privileged write 10b - Secure privileged writes from master only 11b - Locks
28 TSM	Three-State Model Specifies that the core master supports only the three-state access control model. If you write 1 to this field, it remains asserted until the next reset. For cores that support only the three-state access control model, you must assert this field before loading any nonsecure value into the PID. See Generation of secure attribute.
27-6 —	Reserved
5-0 PID	Process Identifier Specifies the transaction PID for the corresponding core master. If the core has a built-in PID register, then a secure privileged read returns the core's PID register value. Bit 5 specifies the secure attribute (0 = secure, 1 = nonsecure) for the transaction.

18.8.3.13 Master Domain Assignment (MDA_W0_0_DFMT0 - MDA_W0_6_DFMT0)

Offset

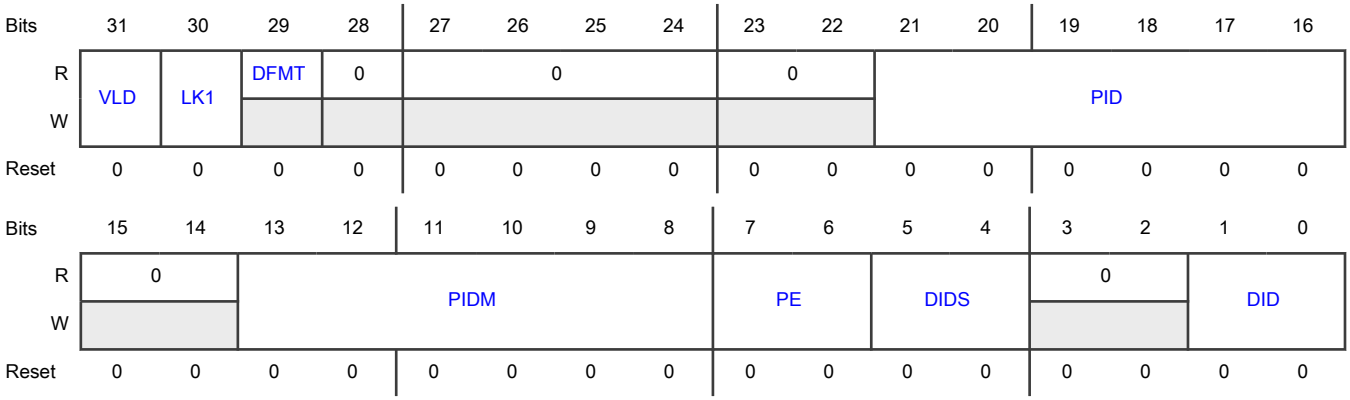
Register	Offset
MDA_W0_0_DFMT0	800h
MDA_W0_3_DFMT0	860h
MDA_W0_4_DFMT0	880h
MDA_W0_6_DFMT0	8C0h

Function

Specifies the information used by the MDAC to assign a core bus master to a specific domain (DID). For more information, see Master domain assignment controller (MDAC).

Access: Secure privileged read/write

Diagram



Fields

Field	Function
31 VLD	Valid Specifies whether this domain assignment is valid. In other words, if VLD and CR[GVLD] are both asserted, XRDC uses the configuration in this register in the domain assignment process. If CR[GVLD] is set to 1 and VLD is set to 0 then every transaction from this master will be assigned a DID of 0. This field has no effect unless XRDC is enabled (CR[GVLD] = 1). 0b - Invalid 1b - Valid
30 LK1	Lock Prohibits writes to this register. • If unlocked, this register accepts any secure privileged write. • If locked, you cannot write to this register and it remains read-only until after the next reset. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Unlocked 1b - Locks When writing 0b - No effect 1b - Locks

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Field	Function
29 DFMT	Domain Format Indicates the domain assignment format. 0b - Core bus master domain assignment (DFMT0)
28 —	Reserved
27-24 —	Reserved
23-22 —	Reserved
21-16 PID	Process Identifier Specifies the PID to be combined with the PIDM field and included in the domain assignment process. This field applies only if PID is enabled (PE = 1).
15-14 —	Reserved
13-8 PIDM	Process Identifier Mask Specifies a mask applied to the PID to support including multiple PIDs in the domain hit determination. For each bit asserted in PIDM, the corresponding bit of the PID is ignored in the comparison. This field applies only if PID is enabled (PE = 1).
7-6 PE	Process Identifier Enable Enables the optional inclusion of PID, qualified by PIDM, in the domain hit evaluation. This inclusion supports the definition of inclusive or exclusive sets of masked PID values. 00b-01b - No PID is included 10b - Partial domain hit = (PID & ~PIDM) == (PIDm[PID] & ~PIDM) 11b - Partial domain hit = ~((PID & ~PIDM) == (PIDm[PID] & ~PIDM))
5-4 DIDS	DID Select Selects the source of the DID. 00b - Use the DID field of this register 01b - Use the input DID 10b - Concatenate bits 3–2 of this register with the least significant 2 bits of the input DID (DID_in[1:0]) 11b - Reserved
3-2	Reserved

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Field	Function
—	
1-0 DID	Domain Identifier Specifies the DID. DIDS controls whether and how this value is used.

18.8.3.14 Master Domain Assignment (MDA_W0_1_DFMT1 - MDA_W0_8_DFMT1)

Offset

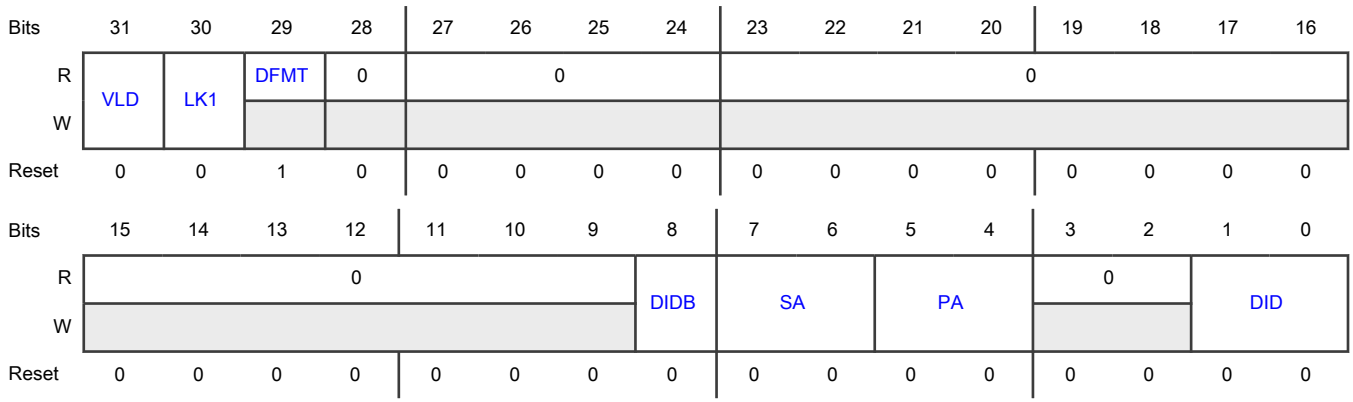
Register	Offset
MDA_W0_1_DFMT1	820h
MDA_W0_2_DFMT1	840h
MDA_W0_5_DFMT1	8A0h
MDA_W0_7_DFMT1	8E0h
MDA_W0_8_DFMT1	900h

Function

Specifies the information used by the MDAC to assign a bus master to a specific domain (DID). For more information, see Master domain assignment controller (MDAC).

Access: Secure privileged read/write

Diagram



Fields

Field	Function
31	Valid

Table continues on the next page...

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Field	Function
VLD	Specifies whether this domain assignment is valid. In other words, if VLD and CR[GVLD] are both asserted, XRDC uses the configuration in this register in the domain assignment process. If CR[GVLD] is set to 1 and VLD is set to 0 then every transaction from this master will be assigned a DID of 0. This field has no effect unless XRDC is enabled (CR[GVLD] = 1). 0b - Invalid 1b - Valid
30 LK1	Lock Prohibits writes to this register. • If unlocked, this register accepts any secure privileged write. • If locked, you cannot write to this register and it remains read-only until after the next reset. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Unlocked 1b - Locks When writing 0b - No effect 1b - Locks
29 DFMT	Domain Format Indicates the domain assignment format. 1b - Bus master domain assignment (DFMT1)
28 —	Reserved
27-24 —	Reserved
23-9 —	Reserved
8 DIDB	DID Bypass Enables bypassing of an input DID as the domain identifier for this master. This capability allows noncore masters (for example, a DMA) to appear as a core. After this field is set to 1, it remains at that value until the next reset. 0b - Bypass DID input. Use DID

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Field	Function
	1b - Use DID input
7-6 SA	Secure Attribute Specifies the secure attribute. **NOTE** If SA = 1X or VLD = 0, use the secure attribute input from the master. 00b - Force to secure 01b - Force to nonsecure 1xb - Use secure attribute from the master
5-4 PA	Privileged Attribute Specifies the privileged (supervisor/user) attribute. **NOTE** If PA = 1X or VLD = 0, use the privileged attribute input from the master. 00b - Force to user 01b - Force to privileged 1xb - Use privileged attribute from the master
3-2 —	Reserved
1-0 DID	Domain Identifier Specifies the DID.

18.8.3.15 Peripheral Domain Access Control Word 0 (PDAC_W0_3 - PDAC_W0_449)

Offset

Register	Offset
PDAC_W0_3	1018h
PDAC_W0_4	1020h
PDAC_W0_5	1028h
PDAC_W0_6	1030h
PDAC_W0_7	1038h
PDAC_W0_8	1040h
PDAC_W0_9	1048h

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Register	Offset
PDAC_W0_10	1050h
PDAC_W0_11	1058h
PDAC_W0_12	1060h
PDAC_W0_13	1068h
PDAC_W0_14	1070h
PDAC_W0_15	1078h
PDAC_W0_16	1080h
PDAC_W0_17	1088h
PDAC_W0_18	1090h
PDAC_W0_19	1098h
PDAC_W0_20	10A0h
PDAC_W0_32	1100h
PDAC_W0_33	1108h
PDAC_W0_34	1110h
PDAC_W0_38	1130h
PDAC_W0_39	1138h
PDAC_W0_40	1140h
PDAC_W0_41	1148h
PDAC_W0_42	1150h
PDAC_W0_43	1158h
PDAC_W0_44	1160h
PDAC_W0_45	1168h
PDAC_W0_46	1170h
PDAC_W0_47	1178h
PDAC_W0_48	1180h
PDAC_W0_49	1188h
PDAC_W0_128	1400h
PDAC_W0_129	1408h
PDAC_W0_130	1410h
PDAC_W0_131	1418h
PDAC_W0_132	1420h
PDAC_W0_133	1428h

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Register	Offset
PDAC_W0_134	1430h
PDAC_W0_135	1438h
PDAC_W0_136	1440h
PDAC_W0_137	1448h
PDAC_W0_138	1450h
PDAC_W0_139	1458h
PDAC_W0_140	1460h
PDAC_W0_141	1468h
PDAC_W0_142	1470h
PDAC_W0_143	1478h
PDAC_W0_144	1480h
PDAC_W0_145	1488h
PDAC_W0_146	1490h
PDAC_W0_147	1498h
PDAC_W0_148	14A0h
PDAC_W0_149	14A8h
PDAC_W0_151	14B8h
PDAC_W0_152	14C0h
PDAC_W0_153	14C8h
PDAC_W0_154	14D0h
PDAC_W0_155	14D8h
PDAC_W0_156	14E0h
PDAC_W0_157	14E8h
PDAC_W0_158	14F0h
PDAC_W0_159	14F8h
PDAC_W0_160	1500h
PDAC_W0_161	1508h
PDAC_W0_162	1510h
PDAC_W0_163	1518h
PDAC_W0_164	1520h
PDAC_W0_165	1528h
PDAC_W0_166	1530h

Table continues on the next page...

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Register	Offset
PDAC_W0_167	1538h
PDAC_W0_168	1540h
PDAC_W0_169	1548h
PDAC_W0_170	1550h
PDAC_W0_171	1558h
PDAC_W0_173	1568h
PDAC_W0_175	1578h
PDAC_W0_178	1590h
PDAC_W0_180	15A0h
PDAC_W0_181	15A8h
PDAC_W0_182	15B0h
PDAC_W0_183	15B8h
PDAC_W0_184	15C0h
PDAC_W0_186	15D0h
PDAC_W0_187	15D8h
PDAC_W0_188	15E0h
PDAC_W0_189	15E8h
PDAC_W0_190	15F0h
PDAC_W0_191	15F8h
PDAC_W0_193	1608h
PDAC_W0_194	1610h
PDAC_W0_195	1618h
PDAC_W0_196	1620h
PDAC_W0_197	1628h
PDAC_W0_198	1630h
PDAC_W0_201	1648h
PDAC_W0_202	1650h
PDAC_W0_203	1658h
PDAC_W0_204	1660h
PDAC_W0_205	1668h
PDAC_W0_212	16A0h
PDAC_W0_213	16A8h

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Register	Offset
PDAC_W0_214	16B0h
PDAC_W0_215	16B8h
PDAC_W0_216	16C0h
PDAC_W0_217	16C8h
PDAC_W0_220	16E0h
PDAC_W0_221	16E8h
PDAC_W0_223	16F8h
PDAC_W0_224	1700h
PDAC_W0_225	1708h
PDAC_W0_226	1710h
PDAC_W0_227	1718h
PDAC_W0_229	1728h
PDAC_W0_230	1730h
PDAC_W0_231	1738h
PDAC_W0_232	1740h
PDAC_W0_233	1748h
PDAC_W0_234	1750h
PDAC_W0_235	1758h
PDAC_W0_236	1760h
PDAC_W0_238	1770h
PDAC_W0_256	1800h
PDAC_W0_257	1808h
PDAC_W0_260	1820h
PDAC_W0_261	1828h
PDAC_W0_262	1830h
PDAC_W0_263	1838h
PDAC_W0_264	1840h
PDAC_W0_265	1848h
PDAC_W0_266	1850h
PDAC_W0_267	1858h
PDAC_W0_268	1860h
PDAC_W0_269	1868h

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Register	Offset
PDAC_W0_270	1870h
PDAC_W0_271	1878h
PDAC_W0_272	1880h
PDAC_W0_273	1888h
PDAC_W0_274	1890h
PDAC_W0_275	1898h
PDAC_W0_276	18A0h
PDAC_W0_277	18A8h
PDAC_W0_278	18B0h
PDAC_W0_279	18B8h
PDAC_W0_280	18C0h
PDAC_W0_281	18C8h
PDAC_W0_283	18D8h
PDAC_W0_284	18E0h
PDAC_W0_285	18E8h
PDAC_W0_286	18F0h
PDAC_W0_288	1900h
PDAC_W0_303	1978h
PDAC_W0_304	1980h
PDAC_W0_307	1998h
PDAC_W0_315	19D8h
PDAC_W0_316	19E0h
PDAC_W0_317	19E8h
PDAC_W0_321	1A08h
PDAC_W0_322	1A10h
PDAC_W0_323	1A18h
PDAC_W0_324	1A20h
PDAC_W0_325	1A28h
PDAC_W0_326	1A30h
PDAC_W0_327	1A38h
PDAC_W0_328	1A40h
PDAC_W0_329	1A48h

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Register	Offset
PDAC_W0_330	1A50h
PDAC_W0_331	1A58h
PDAC_W0_384	1C00h
PDAC_W0_385	1C08h
PDAC_W0_386	1C10h
PDAC_W0_387	1C18h
PDAC_W0_388	1C20h
PDAC_W0_389	1C28h
PDAC_W0_390	1C30h
PDAC_W0_391	1C38h
PDAC_W0_392	1C40h
PDAC_W0_393	1C48h
PDAC_W0_394	1C50h
PDAC_W0_395	1C58h
PDAC_W0_396	1C60h
PDAC_W0_397	1C68h
PDAC_W0_398	1C70h
PDAC_W0_399	1C78h
PDAC_W0_413	1CE8h
PDAC_W0_414	1CF0h
PDAC_W0_416	1D00h
PDAC_W0_418	1D10h
PDAC_W0_419	1D18h
PDAC_W0_420	1D20h
PDAC_W0_421	1D28h
PDAC_W0_424	1D40h
PDAC_W0_425	1D48h
PDAC_W0_428	1D60h
PDAC_W0_430	1D70h
PDAC_W0_431	1D78h
PDAC_W0_432	1D80h
PDAC_W0_433	1D88h

Table continues on the next page...

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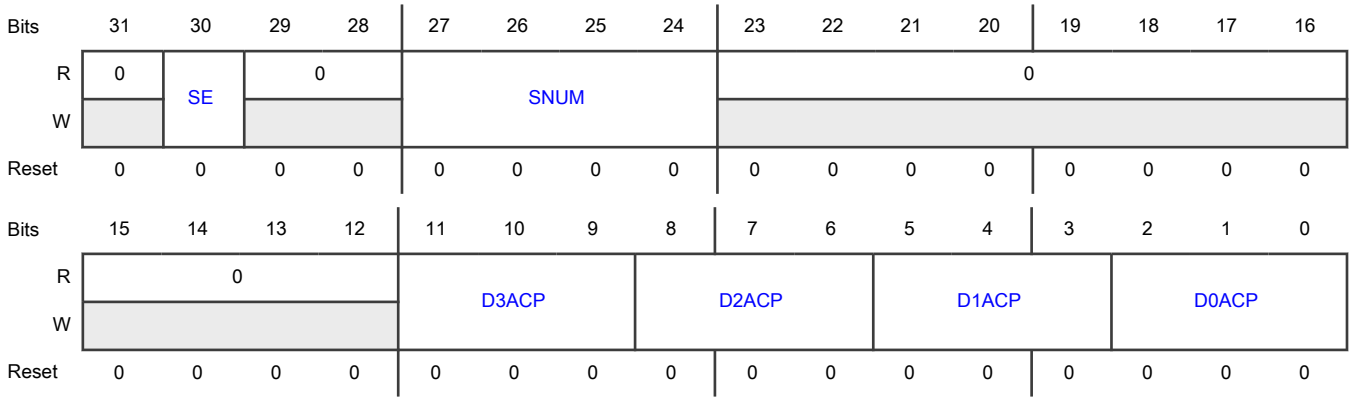
Register	Offset
PDAC_W0_434	1D90h
PDAC_W0_435	1D98h
PDAC_W0_436	1DA0h
PDAC_W0_437	1DA8h
PDAC_W0_438	1DB0h
PDAC_W0_439	1DB8h
PDAC_W0_440	1DC0h
PDAC_W0_441	1DC8h
PDAC_W0_442	1DD0h
PDAC_W0_443	1DD8h
PDAC_W0_445	1DE8h
PDAC_W0_446	1DF0h
PDAC_W0_447	1DF8h
PDAC_W0_448	1E00h
PDAC_W0_449	1E08h

Function

In conjunction with PDAC_W1_*s*, specifies the ACP configuration for peripheral slot *s*. The ACP controls access to the peripheral by all masters within the domain. For the available ACPs, see Domain ACP specification. For more information, see Peripheral access controller (PAC).

Access: Secure privileged read/write

Diagram



Fields

Field	Function
31 —	Reserved
30 SE	Semaphore Enable Enables the inclusion of the semaphore specified in SNUM in the D*d*ACP evaluation. 0b - Disables 1b - Enables
29-28 —	Reserved
27-24 SNUM	Semaphore Number Specifies the hardware semaphore to include in the D*d*ACP access evaluation. This field applies only if you enable semaphore (write 1 to SE).
23-12 —	Reserved
11-9: D3ACP 8-6: D2ACP 5-3: D1ACP 2-0: D0ACP	Domain Access Control Policy Specifies the ACP for the associated domain. This field applies only for a supported DID; if the DID is not implemented, the field is read-only zero (no access rights). For field values, see Domain ACP specification.

18.8.3.16 Peripheral Domain Access Control Word 1 (PDAC_W1_3 - PDAC_W1_449)

Offset

Register	Offset
PDAC_W1_3	101Ch
PDAC_W1_4	1024h
PDAC_W1_5	102Ch
PDAC_W1_6	1034h
PDAC_W1_7	103Ch
PDAC_W1_8	1044h
PDAC_W1_9	104Ch
PDAC_W1_10	1054h
PDAC_W1_11	105Ch

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Register	Offset
PDAC_W1_12	1064h
PDAC_W1_13	106Ch
PDAC_W1_14	1074h
PDAC_W1_15	107Ch
PDAC_W1_16	1084h
PDAC_W1_17	108Ch
PDAC_W1_18	1094h
PDAC_W1_19	109Ch
PDAC_W1_20	10A4h
PDAC_W1_32	1104h
PDAC_W1_33	110Ch
PDAC_W1_34	1114h
PDAC_W1_38	1134h
PDAC_W1_39	113Ch
PDAC_W1_40	1144h
PDAC_W1_41	114Ch
PDAC_W1_42	1154h
PDAC_W1_43	115Ch
PDAC_W1_44	1164h
PDAC_W1_45	116Ch
PDAC_W1_46	1174h
PDAC_W1_47	117Ch
PDAC_W1_48	1184h
PDAC_W1_49	118Ch
PDAC_W1_128	1404h
PDAC_W1_129	140Ch
PDAC_W1_130	1414h
PDAC_W1_131	141Ch
PDAC_W1_132	1424h
PDAC_W1_133	142Ch
PDAC_W1_134	1434h
PDAC_W1_135	143Ch

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Register	Offset
PDAC_W1_136	1444h
PDAC_W1_137	144Ch
PDAC_W1_138	1454h
PDAC_W1_139	145Ch
PDAC_W1_140	1464h
PDAC_W1_141	146Ch
PDAC_W1_142	1474h
PDAC_W1_143	147Ch
PDAC_W1_144	1484h
PDAC_W1_145	148Ch
PDAC_W1_146	1494h
PDAC_W1_147	149Ch
PDAC_W1_148	14A4h
PDAC_W1_149	14ACh
PDAC_W1_151	14BCh
PDAC_W1_152	14C4h
PDAC_W1_153	14CCh
PDAC_W1_154	14D4h
PDAC_W1_155	14DCh
PDAC_W1_156	14E4h
PDAC_W1_157	14ECh
PDAC_W1_158	14F4h
PDAC_W1_159	14FCh
PDAC_W1_160	1504h
PDAC_W1_161	150Ch
PDAC_W1_162	1514h
PDAC_W1_163	151Ch
PDAC_W1_164	1524h
PDAC_W1_165	152Ch
PDAC_W1_166	1534h
PDAC_W1_167	153Ch
PDAC_W1_168	1544h

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Register	Offset
PDAC_W1_169	154Ch
PDAC_W1_170	1554h
PDAC_W1_171	155Ch
PDAC_W1_173	156Ch
PDAC_W1_175	157Ch
PDAC_W1_178	1594h
PDAC_W1_180	15A4h
PDAC_W1_181	15ACh
PDAC_W1_182	15B4h
PDAC_W1_183	15BCh
PDAC_W1_184	15C4h
PDAC_W1_186	15D4h
PDAC_W1_187	15DCh
PDAC_W1_188	15E4h
PDAC_W1_189	15ECh
PDAC_W1_190	15F4h
PDAC_W1_191	15FCh
PDAC_W1_193	160Ch
PDAC_W1_194	1614h
PDAC_W1_195	161Ch
PDAC_W1_196	1624h
PDAC_W1_197	162Ch
PDAC_W1_198	1634h
PDAC_W1_201	164Ch
PDAC_W1_202	1654h
PDAC_W1_203	165Ch
PDAC_W1_204	1664h
PDAC_W1_205	166Ch
PDAC_W1_212	16A4h
PDAC_W1_213	16ACh
PDAC_W1_214	16B4h
PDAC_W1_215	16BCh

Table continues on the next page...

Table continued from the previous page...

Register	Offset
PDAC_W1_216	16C4h
PDAC_W1_217	16CCh
PDAC_W1_220	16E4h
PDAC_W1_221	16ECh
PDAC_W1_223	16FCh
PDAC_W1_224	1704h
PDAC_W1_225	170Ch
PDAC_W1_226	1714h
PDAC_W1_227	171Ch
PDAC_W1_229	172Ch
PDAC_W1_230	1734h
PDAC_W1_231	173Ch
PDAC_W1_232	1744h
PDAC_W1_233	174Ch
PDAC_W1_234	1754h
PDAC_W1_235	175Ch
PDAC_W1_236	1764h
PDAC_W1_238	1774h
PDAC_W1_256	1804h
PDAC_W1_257	180Ch
PDAC_W1_260	1824h
PDAC_W1_261	182Ch
PDAC_W1_262	1834h
PDAC_W1_263	183Ch
PDAC_W1_264	1844h
PDAC_W1_265	184Ch
PDAC_W1_266	1854h
PDAC_W1_267	185Ch
PDAC_W1_268	1864h
PDAC_W1_269	186Ch
PDAC_W1_270	1874h
PDAC_W1_271	187Ch

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Register	Offset
PDAC_W1_272	1884h
PDAC_W1_273	188Ch
PDAC_W1_274	1894h
PDAC_W1_275	189Ch
PDAC_W1_276	18A4h
PDAC_W1_277	18ACh
PDAC_W1_278	18B4h
PDAC_W1_279	18BCh
PDAC_W1_280	18C4h
PDAC_W1_281	18CCh
PDAC_W1_283	18DCh
PDAC_W1_284	18E4h
PDAC_W1_285	18ECh
PDAC_W1_286	18F4h
PDAC_W1_288	1904h
PDAC_W1_303	197Ch
PDAC_W1_304	1984h
PDAC_W1_307	199Ch
PDAC_W1_315	19DCh
PDAC_W1_316	19E4h
PDAC_W1_317	19ECh
PDAC_W1_321	1A0Ch
PDAC_W1_322	1A14h
PDAC_W1_323	1A1Ch
PDAC_W1_324	1A24h
PDAC_W1_325	1A2Ch
PDAC_W1_326	1A34h
PDAC_W1_327	1A3Ch
PDAC_W1_328	1A44h
PDAC_W1_329	1A4Ch
PDAC_W1_330	1A54h
PDAC_W1_331	1A5Ch

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Register	Offset
PDAC_W1_384	1C04h
PDAC_W1_385	1C0Ch
PDAC_W1_386	1C14h
PDAC_W1_387	1C1Ch
PDAC_W1_388	1C24h
PDAC_W1_389	1C2Ch
PDAC_W1_390	1C34h
PDAC_W1_391	1C3Ch
PDAC_W1_392	1C44h
PDAC_W1_393	1C4Ch
PDAC_W1_394	1C54h
PDAC_W1_395	1C5Ch
PDAC_W1_396	1C64h
PDAC_W1_397	1C6Ch
PDAC_W1_398	1C74h
PDAC_W1_399	1C7Ch
PDAC_W1_413	1CECh
PDAC_W1_414	1CF4h
PDAC_W1_416	1D04h
PDAC_W1_418	1D14h
PDAC_W1_419	1D1Ch
PDAC_W1_420	1D24h
PDAC_W1_421	1D2Ch
PDAC_W1_424	1D44h
PDAC_W1_425	1D4Ch
PDAC_W1_428	1D64h
PDAC_W1_430	1D74h
PDAC_W1_431	1D7Ch
PDAC_W1_432	1D84h
PDAC_W1_433	1D8Ch
PDAC_W1_434	1D94h
PDAC_W1_435	1D9Ch

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Table continued from the previous page...

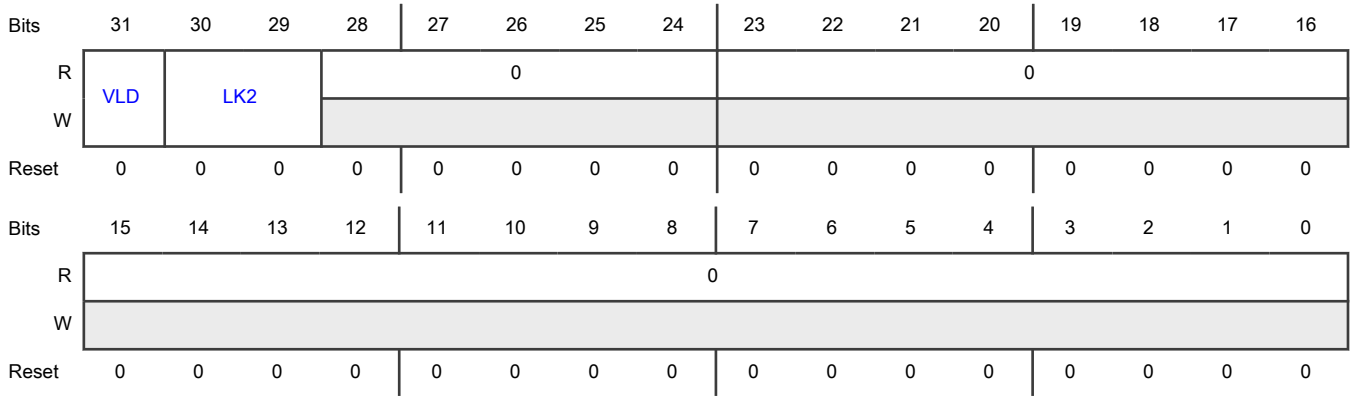
Register	Offset
PDAC_W1_436	1DA4h
PDAC_W1_437	1DACh
PDAC_W1_438	1DB4h
PDAC_W1_439	1DBCh
PDAC_W1_440	1DC4h
PDAC_W1_441	1DCCh
PDAC_W1_442	1DD4h
PDAC_W1_443	1DDCh
PDAC_W1_445	1DECh
PDAC_W1_446	1DF4h
PDAC_W1_447	1DFCh
PDAC_W1_448	1E04h
PDAC_W1_449	1E0Ch

Function

In conjunction with PDAC_W0_*s*, specifies the ACP configuration for peripheral slot *s*.

Access: Secure privileged read/write

Diagram



Fields

Field	Function
31 VLD	Valid Specifies whether this domain assignment is valid. In other words, if VLD and CR[GVLD] are both asserted, XRDC uses the configuration in this pair of registers. If either CR[GVLD] or this field is 0, all accesses to

Table continues on the next page...

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Field	Function
	the peripheral are allowed. To support a coherent register state, any write to PDAC_W0_*s* forces this field to zero. This field has no effect unless XRDC is enabled (CR[GVLD] = 1). 0b - Invalid 1b - Valid
30-29 LK2	Lock Limits or prohibits writes to the set of PDAC words (PDAC_W0_*s* and PDAC_W1_*s*) for this peripheral slot. When you assert a bit in this field, it remains asserted until the next module reset. 00b-01b - Both words can be written to 10b - Domain d can update only its associated DdACP field—all other fields are read-only 11b - Locks (both words are read-only)
28-24 —	Reserved
23-0 —	Reserved

18.8.3.17 Memory Region Descriptor Word 0 (MRGD_W0_0 - MRGD_W0_63)

Offset

Registers in this array exist only for the following combinations of index values.

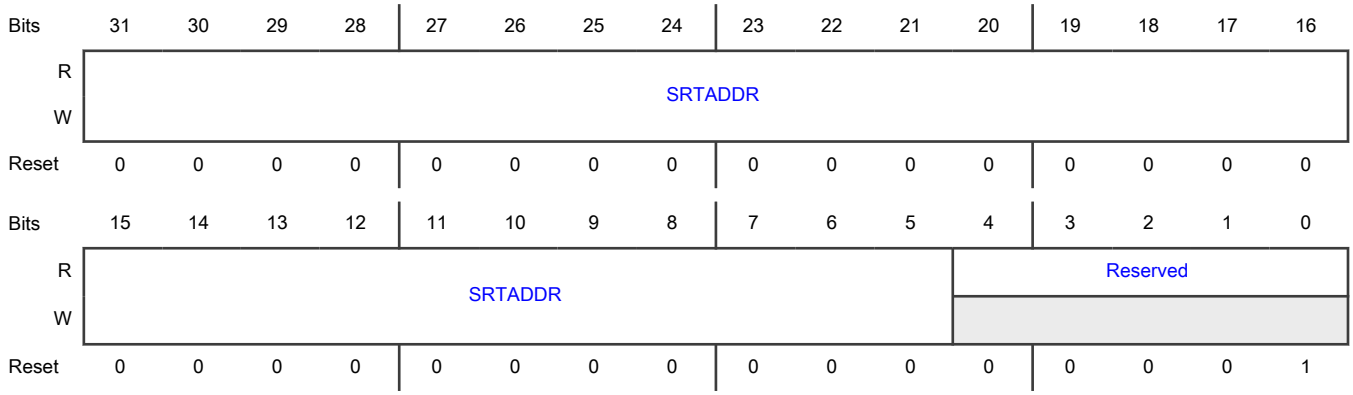
Index *n*	Index *m*
0–1, 3	0–15
2	0–3

Register	Offset
MRGD_W0_(n * 16 + m)	2000h + (n × 200h) + (m × 20h)

Function

Specifies the starting address of memory region *r*.

Diagram



Fields

Field	Function
31-5 SRTADDR	Start Address Specifies the most significant bits of the 0-modulo 32-byte start address of the memory region. The minimum region size is 32 bytes.
4-0 —	Reserved

18.8.3.18 Memory Region Descriptor Word 1 (MRGD_W1_0 - MRGD_W1_63)

Offset

Registers in this array exist only for the following combinations of index values.

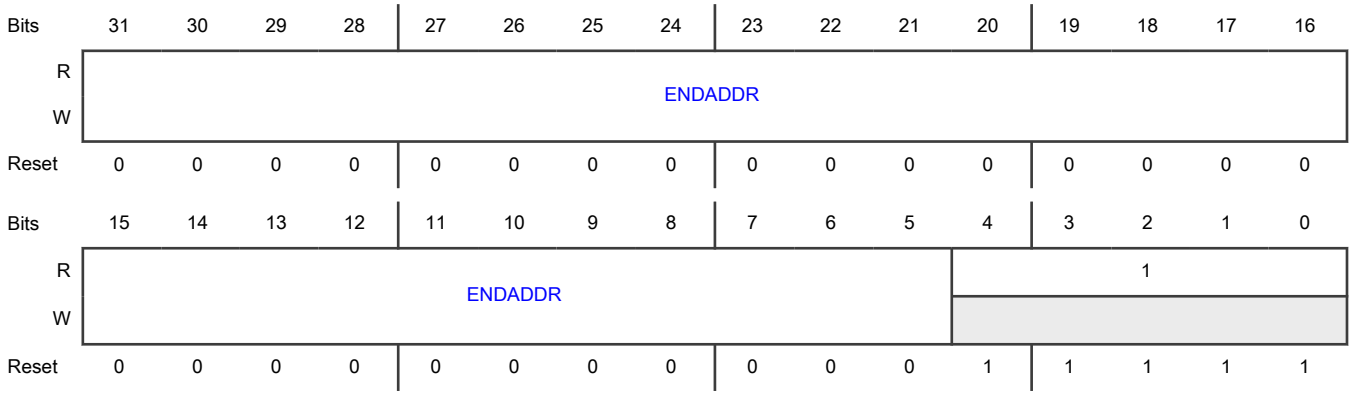
Index *n*	Index *m*
0–1, 3	0–15
2	0–3

Register	Offset
MRGD_W1_(n * 16 + m)	2004h + (n × 200h) + (m × 20h)

Function

Specifies the ending address of memory region *r*.

Diagram



Fields

Field	Function
31-5 ENDADDR	End Address Specifies the most significant bits of the 31-modulo 32-byte end address of memory region *r*.
4-0 —	Reserved

18.8.3.19 Memory Region Descriptor Word 2 (MRGD_W2_0 - MRGD_W2_63)

Offset

Registers in this array exist only for the following combinations of index values.

Index *n*	Index *m*
0–1, 3	0–15
2	0–3

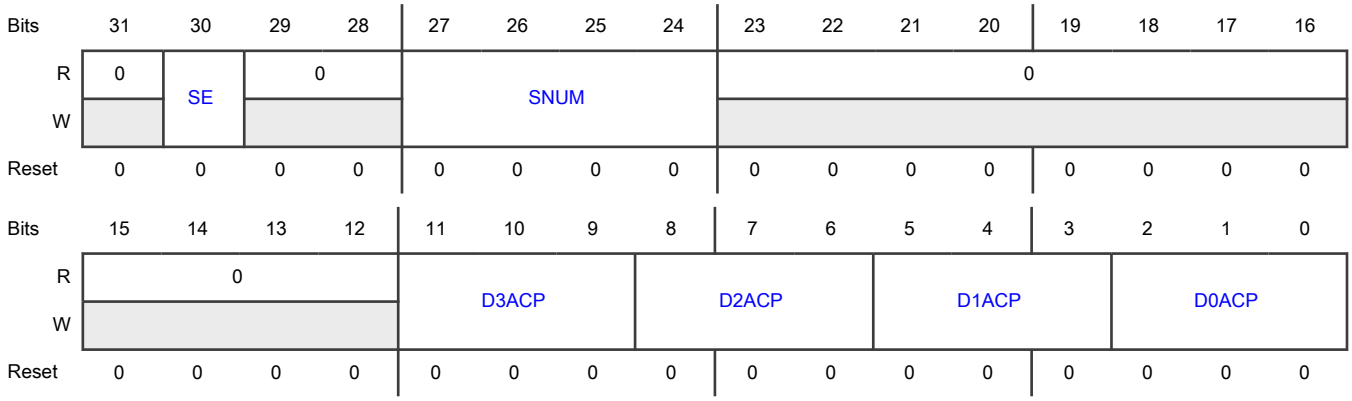
Register	Offset
MRGD_W2_(n * 16 + m)	2008h + (n × 200h) + (m × 20h)

Function

Specifies the ACP for the associated domain. The encodings specify read and write access capabilities based on the four operating states. This field applies only for a supported DID; if the DID is not implemented, the field is read-only zero (no access rights).

For field values, see Domain ACP specification.

Diagram



Fields

Field	Function
31 —	Reserved
30 SE	Semaphore Enable Enables the inclusion of the semaphore specified in SNUM in the D*d*ACP evaluation. 0b - Disables 1b - Enables
29-28 —	Reserved
27-24 SNUM	Semaphore Number Specifies the hardware semaphore to include in the D*d*ACP access evaluation. This field applies only if you enable semaphore (write 1 to SE).
23-12 —	Reserved
11-9: D3ACP 8-6: D2ACP 5-3: D1ACP 2-0: D0ACP	Domain Access Control Policy Specifies the ACP for the associated domain. This field applies only for a supported DID; if the DID is not implemented, the field is read-only zero (no access rights). For field values, see Domain ACP specification.

18.8.3.20 Memory Region Descriptor Word 3 (MRGD_W3_0 - MRGD_W3_63)

Offset

Registers in this array exist only for the following combinations of index values.

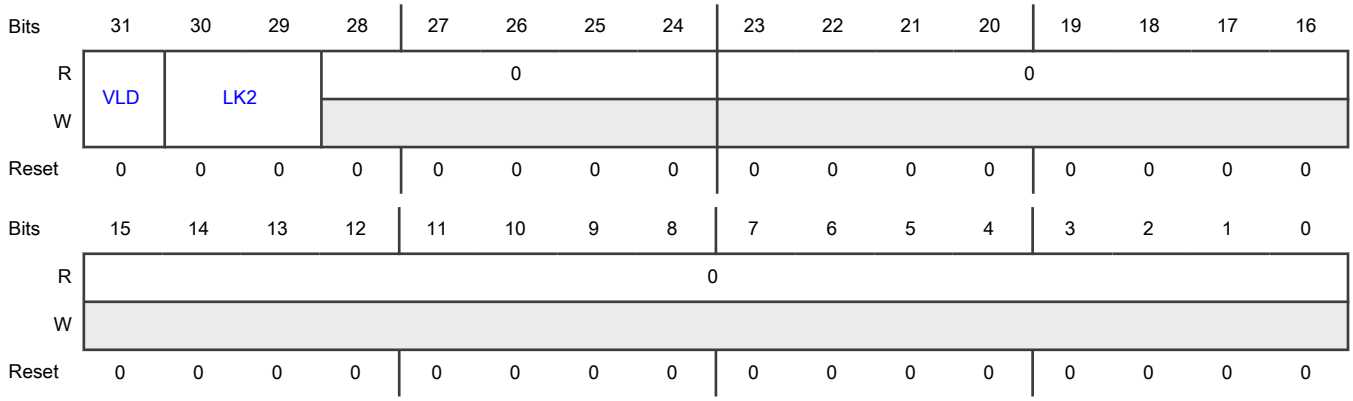
Index *n*	Index *m*
0–1, 3	0–15
2	0–3

Register	Offset
MRGD_W3_(n * 16 + m)	200Ch + (n × 200h) + (m × 20h)

Function

Specifies whether this memory region descriptor is enabled and limits or prohibits writes to it.

Diagram



Fields

Field	Function
31 VLD	Valid Specifies whether this domain assignment is valid. In other words, if VLD and CR[GVLD] are both asserted, XRDC uses the configuration in this set of registers. If CR[GVLD] is 0, all accesses to the memory are allowed. If CR[GVLD] is 1 and VLD is 0, all accesses are blocked. To support a coherent register state, a write to any of the MRGD W0–W2 registers forces this field to zero. This field has no effect unless XRDC is enabled (CR[GVLD] = 1). 0b - Invalid 1b - Valid
30-29 LK2	Lock Limits or prohibits writes to the set of MRGD words (MRGD_W*w_n*) for this memory region. When you assert a bit in this field, it remains asserted until the next module reset. 00b - All words in the set can be written to 01b - Reserved

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Field	Function
	10b - Domain d can update only its associated DdACP field; all other fields are read-only 11b - Locks (all words are read-only)
28-24 —	Reserved
23-0 —	Reserved

18.9 Glossary

ACP access control policy. The access limitations specified for memory and peripheral resources.

DID domain identifier. A numeric value that identifies a specific domain.

domain An access-controlled virtual group of on-chip masters (cores and noncore masters) and targets (memories and peripherals) that comprise an isolated computing environment. All masters in a domain have the same access to chip resources within that domain.

See Introduction to domains for more information.

LPID logical partition identifier. Also called an operating system ID or VMID, the LPID identifies a virtual master (either core or noncore) that runs on a hypervisor.

master A processor core or non-processor module, such as DMA or a communications channel, that can initiate transactions with memory and peripheral resources.

MDAC Master Domain Assignment Controller. Manages resource assignments and DIDs.

MGR Manager. Manages accesses through the XRDC programming model.

MRC Memory Region Controller. Controls access to memories based on memory region descriptors.

PAC Peripheral Access Controller (also sometimes called PDAC). Controls access to peripherals.

PDAC See PAC.

PID process identifier. A numeric value provided by some core processors to identify the currently active process.

SDAC Deprecated. See MRC.

target A peripheral or memory resource that one or more masters can access. This term replaces "slave."

transaction A read or write request made by a master to a target peripheral or memory.

VMID virtual machine identifier. See LPID.

Chapter 19
Memory and Memory Interfaces

19.1 Introduction

This chapter discusses the configuration of memories and memory interfaces, such as flash memory, flash memory controller, and SRAM.

19.2 Flash memory controller and flash memory modules

For information on these, see the following chapters:

- Flash Memory Controller (PFLASH)
- Embedded Flash Memory

19.3 Related information

Table 75. Related information

Related chapters	For additional information
Memory Map	See the memory map file attached to this document.
• Clocking • Clock Generation Module (MC_CGM)	—
Cortex-M7 Overview	—
Extended Resource Domain Controller (XRDC)	—
• Direct Memory Access Multiplexer (DMAMUX) • Enhanced Direct Memory Access (eDMA)	See the DMAMUX map file attached to this document.
Error Injection Module (EIM)	—
Error Reporting Module (ERM)	—

19.4 SRAM access

In case a master accesses an SRAM with multi-bit ECC errors, the chip may respond as follows:

- Map all such faults to FCCU. The recommended reaction for the fault is to generate the functional reset.
- Map such faults to ERM. If the ERM interrupt is enabled, ERM generates an interrupt.

19.5 Memory configuration

The following table provides information on the types of memories and their associated configurations in S32K396.

Table 76. Memory configuration

Memory	Size	Configuration	ECC or parity	ECC or parity width (bit)	Diagnostic information or error report
SYS_RAM0	128 KB	64 KB_CUT1_PD0 8192 x 72	ECC (SECDED)	8	ERM
SYS_RAM0	128 KB	64 KB_CUT2_PD1 8192 x 72	ECC (SECDED)	8	ERM
SYS_RAM0	128 KB	28 KB_CUT3_PD1 16384 x 72	ECC (SECDED)	8	ERM
SYS_RAM1	128 KB	128 KB_CUT2_PD1 16384 x 72	ECC (SECDED)	8	ERM
SYS_RAM1	128 KB	28 KB_CUT1_PD1 16384 x 72	ECC (SECDED)	8	ERM
Cortex-M7_2 I-cache data	16 KB	1024 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_2 I-cache data	16 KB	1024 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_2 I-cache tag	1280 bytes	256 x (20 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 I-cache tag	1280 bytes	256 x (20 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache tag	384 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM

Table continues on the next page...

Table 76. Memory configuration (continued)

Memory	Size	Configuration	ECC or parity	ECC or parity width (bit)	Diagnostic information or error report
Cortex-M7_2 D-cache tag	384 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache tag	384 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_2 D-cache tag	384 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 I-cache data	16 KB	1024 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_1 I-cache data	16 KB	1024 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_1 I-cache tag	1280 bytes	256 x (20 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 I-cache tag	1280 bytes	256 x (20 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_1 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM

Table continues on the next page...

Table 76. Memory configuration (continued)

Memory	Size	Configuration	ECC or parity	ECC or parity width (bit)	Diagnostic information or error report
Cortex-M7_0 I-cache data	16 KB	1024 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_0 I-cache data	16 KB	1024 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_0 I-cache tag	1280 bytes	256 x (20 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 I-cache tag	1280 bytes	256 x (20 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 +7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache data	16 KB	512 x (32 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
Cortex-M7_0 D-cache tag	1536 bytes	128 x (24 + 7)	ECC (SECDED)	7	ERM
DMA TCD	1024 bytes	128 x (64 + 8)	ECC (SECDED)	8	ERM
DMA TCD_1	1024 bytes	128 x (64 + 8)	ECC (SECDED)	8	ERM
FlexCAN_0	5120 bytes	640 x (64 + 40)	ECC (SECDED)	40	Module
FlexCAN_1	5120 bytes	640 x (64 + 40)	ECC (SECDED)	40	Module
FlexCAN_2	5120 bytes	640 x (64 + 40)	ECC (SECDED)	40	Module

Table continues on the next page...

Table 76. Memory configuration (continued)

Memory	Size	Configuration	ECC or parity	ECC or parity width (bit)	Diagnostic information or error report
FlexCAN_3	1920 bytes	240 x (64 + 40)	ECC (SECDED)	40	Module
FlexCAN_4	1920 bytes	240 x (64 + 40)	ECC (SECDED)	40	Module
FlexCAN_5	1920 bytes	240 x (64 + 40)	ECC (SECDED)	40	Module
QuadSPI RAM	1024 bytes	128 x 64	None	0	Module
QuadSPI TX	1152 bytes	256 x 36	None	0	Module
EMAC TX_0	4480 bytes	1024 x (35 + 7)	ECC (SECDED)	7	Module
EMAC RX_0	4480 bytes	1024 x (35 + 7)	ECC (SECDED)	7	Module
EMAC TX_1	4480 bytes	1024 x (35 + 7)	ECC (SECDED)	7	Module
EMAC RX_1	4480 bytes	1024 x (35 + 7)	ECC (SECDED)	7	Module
EMAC TSN	1664 bytes	512 x (26 + 7)	ECC (SECDED)	7	Module
EMAC RXPARSER	960 bytes	80 x (96 + 8)	ECC (SECDED)	8	Module
Cortex-M7 cluster ETF, ETMI	2048 bytes	256 x 64	None	0	N/A
Cortex-M7 cluster ETF ETMD	2048 bytes	128 x 128	None	0	N/A
HTM ETF	1024 bytes	128 x 64	None	0	N/A
Shared system ETF	4096 bytes	512 x 64	None	0	N/A
Boot ROM	160 KB	8192 x 32	None	0	Module
eTPU_ETF	1024 bytes	128 x 64	None	0	N/A
Cortex-M7_0_ITCM	32 KB	4096 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_0_D0TCM	32 KB	8192 x (32 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_0_D1TCM	32 KB	8192 x (32 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_1_ITCM	32 KB	4096 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_1_D0TCM	32 KB	8192 x (32 + 8)	ECC (SECDED)	8	ERM

Table continues on the next page...

Table 76. Memory configuration (continued)

Memory	Size	Configuration	ECC or parity	ECC or parity width (bit)	Diagnostic information or error report
Cortex-M7_1_D1TCM	32 KB	8192 x (32 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_2_ITCM	32 KB	4096 x (64 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_2_D0TCM	32 KB	8192 x (32 + 8)	ECC (SECDED)	8	ERM
Cortex-M7_2_D1TCM	32 KB	8192 x (32 + 8)	ECC (SECDED)	8	ERM
CoolFlux_PMEM	32 KB	8192 x (32 + 7)	ECC (SECDED)	7	Module
CoolFlux_XMEM_EVEN	24 KB	6144 x (16 + 6)	ECC (SECDED)	6	Module
CoolFlux_XMEM_ODD	24 KB	6144 x (16 + 6)	ECC (SECDED)	6	Module
eTPU_SCM	32 KB	8192 x (32 + 7)	ECC (SECDED)	7	Module
eTPU_SDM	8 KB	2048 x (32 + 20)	ECC (SECDED)	20	Module

19.6 Recommendations for Arm memories

As stated in the *ARM Cortex-M7 Safety Manual*, consider the following recommendations for proper operation of Arm memories:

- Before performing any read operation, you must properly initialize ITCM and DTCM using the correct ECC to avoid any code runaway, software malfunction, or core lockup.

  NOTE

  You must initialize ITCM with 64-bit writes, whereas you can initialize DTCM with 32-bit writes.

- To safely disable TCM:
  1. Write 0 to ITCMCR[EN] or DTCMCR[EN] as required. See Arm Cortex-M7 Devices Generic User Guide for details on ITCMCR and DTCMCR.
  2. Execute the DSB instruction.
  3. Execute the ISB instruction.

  NOTE

  Be careful when disabling ITCM while executing from it. Ensure that the switch-off code is stored in the L2 code memory region from where execution continues when ITCM is disabled.

- To safely disable the I-cache:
  1. Write 0 to CCR[IC]. See Arm Cortex-M7 Devices Generic User Guide for details on CCR.
  2. Execute the DSB instruction.
  3. Execute the ISB instruction.
- To safely disable the D-cache:
  1. Clean and invalidate non-WT locations in D-cache.

2. Write 0 to CCR[DC].
3. Execute the DSB instruction.

See Table 77 for details on memory ECC initialization.

19.7 Memory ECC initialization summary

Table 77. Memory ECC initialization summary

Memory	Write access size	Masters		
		Cortex-M7_*n*	Cortex-M7_*m*	eDMA
SRAM	64 bits only	System	System	System
Cortex-M7_*n* ITCM	64 bits only	Direct or backdoor	Backdoor	Not possible
Cortex-M7_*n* DTCM	32 bits or 64 bits	Direct or backdoor	Backdoor	Backdoor
Cortex-M7_*m* ITCM	64 bits only	Backdoor	Direct or backdoor	Not possible
Cortex-M7_*m* DTCM	32 bits or 64 bits	Backdoor	Direct or backdoor	Backdoor

19.8 Glossary

DTCM	Data tightly coupled memory
ECC	Error code correction
ETF	Embedded trace FIFO
ETMD	Embedded trace macrocell data
ETMI	Embedded trace macrocell instruction
ITCM	Instruction tightly coupled memory
MTB	Macrocell trace buffer
PKC	Public key cryptography
RXPARSER	Receive parser memory
SECDED	Single-error correction double-error detection
SRAM	Static random access memory
TSN	Time-sensitive network

Chapter 20
Embedded Flash Memory (c40asf)

20.1 Chip-specific c40asf flash memory information

20.1.1 Flash memory configuration and register settings

Table 78 shows flash memory blocks and their associated configuration.

Table 78. Flash block configuration

Block or address number	Block name	Start address (hex)	End address (hex)	Size
0	Code flash memory 0	0040_0000	005F_FFFF	2 MB
1	Code flash memory 1	0060_0000	007F_FFFF	2 MB
2[1]	Code flash memory 2	0080_0000	009F_FFFF	2 MB
3	Data flash memory	1000_0000	1001_FFFF	88 KB
0[2]	UTest NVM	1B00_0000	1B00_1FFF	8 KB

1. Code flash memory block 2 is not available for S32K394, S32K374, and S32K364.
2. The address region number is the same as block number for all the blocks except this one. Address region is called UTest NVM address region in this case.

No application cores except HSE_B can access the address regions shown in Table 79.

Table 79. Secure flash memory configuration

Description	Start address	End address	Size
Reserved for NXP internal usage	007F_FBF8h	007F_FBFFh	8 B
Reserved for NXP internal usage	009F_FBF8h	009F_FBFFh	8 B
Secure BAF code (SBAF_CODE)	009F_4000h	009F_FFFFh	48 KB

The flash memory can perform multiple reads in parallel (between different blocks), using the single-, dual-, or quad-read feature. The code flash memory allows four data paths to be accessed simultaneously. An internal UTest mode that can generate single- and double-bit ECC errors is also included.

The code flash memory lets you access four data paths simultaneously.

You can configure the flash memory sectors as erase- or write-protected by using the flash memory's sector and super-sector locking features.

Data flash and/or Code flash memory blocks can be altered by a code executing from different flash block or SRAM.

Data flash memory is the same as code flash memory—supporting program, erase, and read operations.

After the completion of the program or erase operations, the MCR and MCRS registers notify you as soon as the code flash memory code can be executed. At the end of reset recovery, MCRS[DONE] transitions from 0 to 1.

NOTE

MCRS[RWE] might become 1 during the program or erase operation because of speculative accesses by Cortex-M7 core(s). If there are memory regions where no speculative accesses must be initiated, Arm recommends to configure the on-core MPU to set those regions with these attributes:

- Device or strongly-ordered
- Execute never

NOTE

ADR[A5:A4] bits are reserved.

20.1.2 MCRE register reset value

The reset value of the MCRE register depends on the chip-specific flash memory configuration. This table provides the flash memory configuration of the chip and the associated register reset values.

Table 80. MCRE register reset value

MCRE fields	Reset value
n2M (bit position 31:29)	011b – Three 2 MB blocks (S32K396, S32K376, and S32K366) 011b – Two 2 MB blocks (S32K394, S32K374, and S32K364)
n1M (bit position 23:21)	000b – Zero 1 MB blocks
n512K (bit position 15:14)	00b – Zero 512 KB blocks
n256K (bit position 7:6)	01b – One 256 KB blocks
MCRE register reset value	6000_0040h

20.1.3 Debugger considerations while Flash Program/Erase

While performing flash programming via the debugger, special considerations should be taken.

20.2 Introduction

The primary function of the embedded flash memory serves as an electrically programmable and erasable non-volatile memory (NVM) that may be used for instruction or data storage.

20.2.1 Overview

The embedded flash memory is designed for use in embedded MCU and SoC applications. It supports a total memory size up to 8.5 MB of NVM in main space and 8 KB of UTest NVM space per module. Multiple flash modules may be instantiated within an SoC to achieve higher density. The embedded flash memory is addressable by page (256 bits) for read operation and double-word(s) and page and quad page for program operations. Flash memory reads always return 256 bits, although read page buffering may be performed by the PFC. The flash memory is able to do multiple reads in parallel (between different blocks), utilizing the quad read feature.

For details on the embedded flash memory architecture and features, see Functional description.

The following figure shows the top-level diagram and functional organization of the flash memory unit.

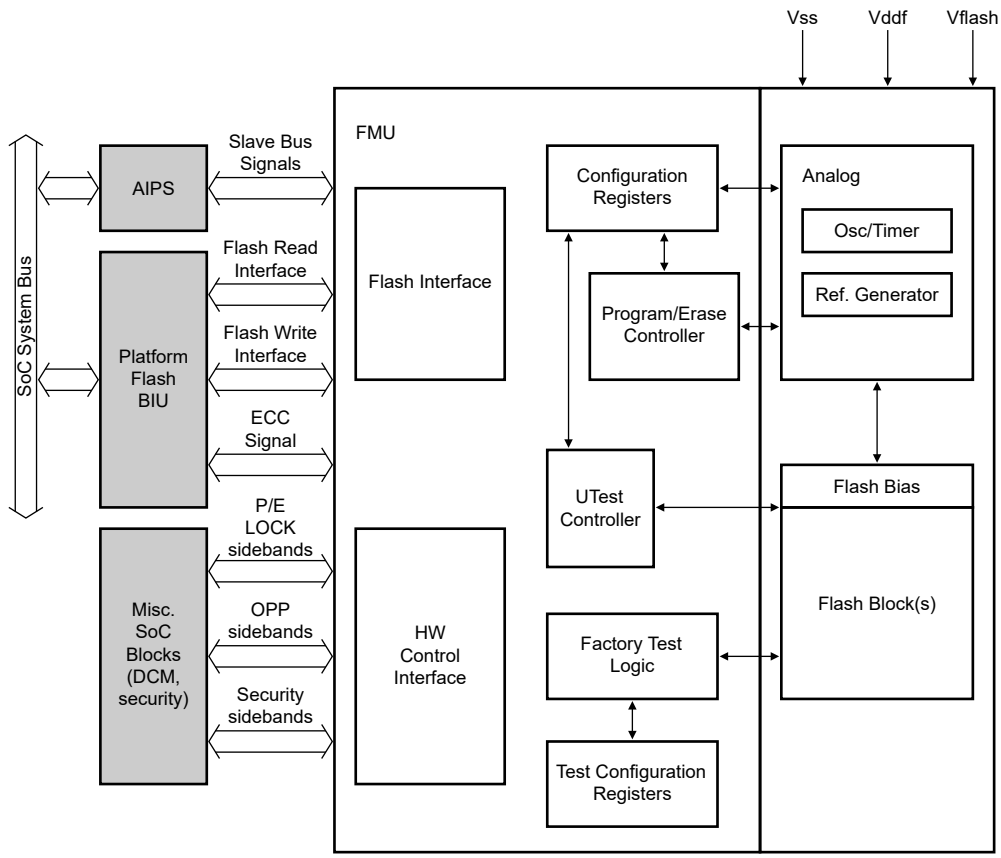

Figure 46. Block diagram

20.2.2 Features

The embedded flash memory includes these distinct features:

- Test information stored in a dedicated non-volatile sector (referred to as the UTest sector)
- OTP space made available in the UTest sector
- Read page size of 256 bits (8 words)
- ECC with single bit correction, double bit detection (all 1s valid) with 64-bit granularity
- Quad page programming (256-bit granularity)
- Hardware programmable sector and super sector program or erase restriction control
- Erasing of selected sector or block erase
- Independent programming of the UTest NVM sector
- Embedded hardware program and erase algorithms
- Support for reading while writing when the accesses are to different blocks
- UTest mode (user-accessible test modes) including array integrity and margin read
- Triple-voted flops for safety-critical flash memory functions (for example, internal trimming, redundancy, mode control, and others)

20.2.3 Modes of operation

Following is a brief description of the embedded flash memory operating modes.

- User mode is the default operating mode of the embedded flash memory. In this mode, it is possible to read and write registers (including register-based interlock writes), read the memory array, program the memory array, and erase the memory array. In this mode program and erase operations are initiated by doing register writes. Program and erase operations are controlled by an internal state machine.
- Low-Power mode turns off all DC current sources within the embedded flash memory and enables VFLASH and VDDF to be power gated. The embedded flash memory is not accessible for read, write, program, or erase when in Low-Power mode. This mode results in the lowest current draw that embedded flash memory can achieve.
- UTest mode is a tiered test mode strategy in which a portion of the factory test modes are made available. This mode is protected but accessible.

20.3 UTest NVM sector

The UTest NVM sector may be enabled by PEADR[PEASAD] during interlock writes. When the UTest NVM space is enabled, all program and erase operations are mapped to the UTest NVM sector. User-mode programming of the UTest NVM sector is enabled only when PEADR[PEASAD] is high.

The UTest NVM sector is an OTP sector (assuming Test mode disable seal is written) . Therefore, performing an erase operation is not permitted.

The UTest NVM sector supports RWW, and is grouped with the sectors in partition 0.

The UTest NVM sector may be locked against program by using hardware program and erase protection input to the flash module (MCRS[TSPELOCK]).

The UTest NVM sector contains specified data that is needed for embedded flash memory or SoC features.

Programming of the UTest NVM space has restrictions that are similar to those of the main space in terms of how ECC is calculated. Only one program operation is allowed per 64-bit ECC segment.

20.4 Test mode disable seal

The UTest NVM sector includes a mechanism to disable factory entry into Test mode selectable by block. Extreme care must be taken when using this feature, because blocks that are selected to be protected in this method will not have possible failures analyzed by factory failure analysts. Once sealed, the UTest sector becomes OTP (erase locked, and OPP enabled). The UTest sector is not accessible in Test Mode.

Protection of this sort prevents all high voltage operations to the flash memory executed by the internal state-machine, as well as reads through this state machine, and reads through the array integrity state machine when using Test mode interfaces.

UTest operations, margin read and array integrity, are also protected by preventing MISR updates on blocks selected for protection, although reads are still performed, and single bit corrections and double bit detections will be logged. Protection through other interfaces is provided by normal User mode protection mechanisms and is device-specific.

The method to disable factory entry into Test mode is to first program the Test mode disable seal location to be 5A4B_3C2Dh. After the next reset is asserted, Test mode is disabled.

It is possible to create a password to enable factory entry into Test mode. This can be programmed into the Test mode disable override passcode. The passcode may not be 0000_0000h, FFFF_FFFFh, or 5555_5555h. These are all invalid passcodes and will not be accepted to override. If it is desired, by the customer, that override never be possible, one of the three invalid passcodes must be put into the Test mode disable override passcode location. Passcode may be entered to authenticate entry, if enabled, by performing a 32-bit register write to register address 90h.

Even if the Test mode disable seal password is written, the UTest NVM sector is always protected and the UTest operations, margin read and array integrity, are always protected.

Only blocks selected in the Test mode disable block select field are controlled by the Test mode disable feature. Therefore, it is possible for customers to selectively pick blocks that have this type of protection and will not be eligible for factory failure

analysis. Bits programmed to 0 in the Test mode disable block select field(s) designate blocks that are controlled by the Test mode disable feature.

In order to let two opportunities to select blocks for the Test mode disable, two regions are available, Test mode disable bock select - 1 and Test mode disable block select - 2. If either Test mode disable block select - 1 or Test mode disable block select - 2 has a 0 programmed, that block will be protected. The bits of these two regions are logically ANDed to define the blocks that are effectively selected for the Test mode disable feature. The bock select field is organized as shown in the next table:

Table 81. Test mode disable block select

Block	Bits used to select blocks
Block 0 disable	Data[0]
Block 1 disable	Data[8]
Block 2 disable	Data[16]
Block 3 disable	Data[24]
Block 4 disable	Data[32]
Block 5 disable	Data[40]

20.5 Functional description

The embedded flash memory module consists of blocks with the following options:

- 2 MB blocks (0, 1, 2, 3 or 4 blocks allowed per module)
- 1 MB blocks (0, 1, 2, 3 or 4 blocks allowed per module)
- 512 KB blocks (0, 1, 2 or 4 blocks allowed per module)
- 256 KB blocks (0, 1, 2 or 4 blocks allowed per module)
- A total of six blocks are allowed per module

Read while Write is allowed within a module, and is determined based on block boundaries. Read while Write partitions are used to determine locations for valid read-while-write (RWW) operations. While the embedded flash memory performs a write (program or erase) to a given partition, it can simultaneously perform a read from any other partition. For program and erase operations, only the address specified by an interlock write determines the partition being written (sector or super sector locking does not determine the RWW partitions being written).

The main address space is also divided into sectors and super sectors to implement independent erase and program protection. The UTest NVM space also exists as a sector and has independent program protection. The UTest NVM sector is included to support systems that require non-volatile memory (NVM) for security or to store system initialization information.

A number of MCR bits are protected against write when another field, or set of fields, is in a specific state. These write locks are covered on a bit-by-bit basis in Module Configuration Register. The write locks do not consider the effects of trying to write two or more bits simultaneously. This module does not allow fields to be written simultaneously that put the device into an illegal state. This is implemented through a priority mechanism among the fields, and the next table shows this mechanism.

Table 82. MCR field set and clear priority levels

Priority level	MCR field(s)
1	ERS
2	PGM
3	EHV

If two or more MCR fields are written simultaneously, only the field with the lowest priority number is accepted for modification. For example, writing 1 to ERS and PGM simultaneously results in 1 being written only to ERS.

Each read of the embedded flash memory retrieves a page, or eight consecutive words (256 bits), of information. The address for each word retrieved within a page differs from the other addresses in the page only by address bits [4:2]. The flash memory page read architecture easily supports both cache and burst mode at the PFC BIU level for high-speed read applications.

The embedded flash memory supports fault tolerance through error correction code (ECC) and error detection. ECC implemented within the embedded flash memory corrects single bit failures and detects double bit failures.

Program and erase of the embedded flash memory requires multiple system clock cycles to complete. Program and erase may be aborted.

The embedded flash memory may operate in various modes as described in the following sections.

20.5.1 User mode

In User mode, the embedded flash memory may be read and written (register writes and interlock writes), programmed or erased. The following sub-sections define all actions that may be performed in User mode.

20.5.1.1 Read and write

The default state of the embedded flash memory is read. The main and UTest NVM address spaces can be read only in the read state. The flash registers are always available for read, except when the embedded flash memory is in Low-Power mode. The module enters the read state on reset, and remains in the read state under two sets of conditions:

- The read state is active when the embedded flash memory is enabled (User mode read).
- The read state is active when MCR[PGM] or MCR[ERS] are 1 and a high voltage operation is ongoing (RWW).

NOTE

Reads done to the partition(s) being operated on (either erased or programmed) result in MCRS[RWE] becoming 1.

In embedded flash memory, flash core reads return 256 bits (1 page). Register reads return 32 bits of data.

NOTE

Flash core reads are performed through the PFC BIU. In many cases, the BIU does read page buffering to allow sequential reads to be done with higher performance. This could provide a data coherency issue that must be handled with software. Data coherency may be an issue after a program or erase operation, as well as UTest NVM sector operations.

In user mode, registers may be written (including interlock writes using registers).

Register reads to unmapped register address space return all 0s.

Register writes to unmapped register address space have no effect.

Interlock writes that are attempted during a high voltage operation (MCR[EHV] = 1 or MCRS[DONE] =0) result in the interlock write being ignored, and address and data will not be updated.

20.5.1.2 Program

A flash memory program sequence operates on any page within the flash core. Within a page, up to eight words may be altered in a single program operation. Also, up to four pages can be altered in a single program operation. Whenever the array is programmed, the ECC bits also get programmed.

ECC is handled on a 64-bit boundary. Thus, if only one word in any given 64-bit ECC segment is programmed, the adjoining word in that segment should not be programmed, because ECC calculation is already complete for that 64-bit segment. Attempts to program the adjoining word may likely result in an operation failure. It is recommended that all programming operations ranger from 64 bits to 1024 bits, and be 64-bit aligned. The programming operation should completely fill selected ECC segments within the page. Only one program is allowed per 64-bit ECC segment between erases.

Caution

In rare cases, over-programming of a 64-bit ECC segment may be done (EEPROM emulation in data flash region). In this case, approved EEPROM emulation drivers must be used, and they must limit the number of over-program operations to three times (four total programs between erases).

Programming changes the value stored in an array bit from logic 1 to logic 0 only. Programming cannot change a stored logic 0 to a logic 1.

NOTE

If a logic 0 is attempted to be over-programmed by a logic 1, the resulting operation fails (MCRS[PEG] = 0), and the 0s that are interlocked are merged (ORed) with the 0s that are already present in the 64-bit ECC segment, unless the block is designated as an over-orogram protected block.

Addresses in locked sectors cannot be programmed. Values may be programmed in any or all of eight words, within a page, with a single program sequence. Up to four pages can be programmed at once on a quad-page boundary. The program operation consists of the following sequence of events:

1. Write the address to be programmed using logical address registers located in the PFC. The result of this write will also be reflected physically in the PEADR register.

   NOTE

   PEADR writes are initiated by writes that first occur in the PFC. Please see the platform flash memory controller chapter for more information. PEADR reads are allowed, and represent the flash memory physical address.

   NOTE

   Ensure the sector that contains the address to be programmed is unlocked. Sector and super sector lock status is latched at this step and does not change until the next program or erase sequence is started.

2. Data to be programmed must be written in the appropriate DATAX register (where X is 0 to 31). All unwritten data words default to FFFF_FFFFh.
3. Change the value in MCR[PGM] from a 0 to a 1.
4. Write a 1 to MCR[EHV] to start the internal program sequence or skip to step 8 to terminate.
5. Wait until MCRS[DONE] becomes 1.

   NOTE

   Since MCRS[DONE] clears with MCR[EHV] being set, it may not be possible for software to read MCRS[DONE] as 0 between step 4 and step 5, depending on the operation selected.

6. Confirm MCRS[PEG] = 1.
7. Write 0 to MCR[EHV].
8. Write 0 to MCR[PGM] to terminate the program sequence.

Program may be initiated with the writing of the PEADR register (enabled with a write done in the PFC block). The PEADR write to initiate the program sequence determines the quad-page address to be programmed. Data must also be written to the DATA register(s). This first write is referred to as an interlock write. Unwritten locations default to a data value of FFFF_FFFFh.

An interlock write must be performed before writing 1 to MCR[PGM], and MCR[PGM] must be set before writing 1 to MCR[EHV] during a program sequence. A program sequence may be terminated by writing 0 to MCR[PGM] prior to writing 1 to MCR[EHV].

While MCR[EHV] is 1 and MCRS[DONE] is 0, MCR[EHV] may be cleared, resulting in a program abort. A program abort forces the embedded flash memory to step 8 of the program sequence. An aborted program results in PEG becoming 0, indicating a failed operation. The data space being operated on before the abort contains indeterminate data.

Caution

Aborting a program operation leaves the FC addresses being programmed in an indeterminate data state. This may be recovered by executing an erase on the affected block.

20.5.1.2.1 Program hardware locking

Hardware locking which affects the program and erase operations is available for UTest sector and all array blocks.

20.5.1.2.2 Over-program protection enable

One-time programming can be enabled. If over-program protection is enabled, any double word that has already been programmed cannot be programmed again. The over-program protection enable does not affect the erase operation. Attempts to over-program result in MCRS[PEG] becoming 0. If any double word within a quad-page has an over-program protection violation, MCRS[PEG] becomes 0, and no double words are programmed.

One-time programming can be enabled for the UTest NVM sector.

20.5.1.3 Erase

An erase changes the value stored in all bits of the selected sector or block to logic 1, and operates on a sector or a block in the main address space. The erase sequence is fully automated within the flash memory. Locked sectors cannot be erased. The erase sequence consists of the following events:

1. Write to the sector or block address to be erased using logical address registers located in the PFC. The result of this write is reflected physically in the PEADR register. One, and only one, DATA register must also be written. This is referred to as an erase interlock write.

   NOTE

   PEADR writes are initiated by writes that first occur in the PFC. Please see the platform memory flash controller chapter for more information. PEADR reads are allowed, and represent the flash memory physical address.

   NOTE

   The selected block or sector must be unlocked prior to initiating an erase with the appropriate sector or super sector lock registers. Sector and super sector lock status is latched at this step and does not change until the next program or erase sequence starts. If a block is selected for erase, all the sectors and super sectors must be unlocked within that block.

2. Change the value in MCR[ERS] from a 0 to a 1, and at the same time select the size of erase using MCR[ESS].
3. Write a 1 to MCR[EHV] to start the internal erase sequence or skip to step 6 to terminate.
4. Wait until MCRS[DONE] becomes 1.

   NOTE

   Since MCRS[DONE] clears with MCR[EHV] being set, it may not be possible for software to read MCRS[DONE] as 0 between step 3 and step 4, depending on the operation selected.

5. Confirm MCRS[PEG] = 1.
6. Write 0 to MCR[EHV].
7. Write 0 to MCR[ERS] to terminate the erase, and if set MCR[ESS] should also be cleared (else the field auto clears).

Erase may be initiated with the writing of the PEADR register (enabled with a write done in the Platform Flash Controller block). The PEADR write to initiate the erase sequence determines the sector or block to be erased. One write must also occur to a DATA register. Data word written during an erase sequence interlock write is ignored. This write is referred to as an erase interlock write.

An erase interlock write must occur before writing 1 to MCR[ERS] (and optionally MCR[ESS]), and MCR[ERS] must be set before writing 1 to MCR[EHV] during an erase sequence. The erase sequence may be terminated by writing 0 to MCR[ERS] prior to writing 1 to MCR[EHV].

While MCR[EHV] is 1 and MCRS[DONE] is 0, MCR[EHV] may be cleared, resulting in an erase abort. An erase abort forces the embedded flash memory to step 7 of the erase sequence. An aborted erase results in PEG becoming 0, indicating a failed operation. The sector or block being operated on before the abort contain indeterminate data.

20.5.1.3.1 Erase hardware locking

Hardware locking which affects the erase and program operations is available for UTest sector and all array blocks. For details, see Program hardware locking.

20.5.1.4 Express program

A mechanism is made available to provide an express method to program up to 1024 bits of flash memory. When activated, all ongoing program and erase operations through the register interface are automatically aborted (MCR[EHV] becomes 0 automatically) and the express interface is given priority. When using the express interface, sequence requirements are ignored, although a XPEADR write is required to start the express program sequence.

The flash express program mechanism provides a quicker way to get information programmed into a block of flash memory when an application needs an immediate diary access, or a crash log access.

Addresses in locked sectors cannot be express programmed.

The express program operation consists of the following sequence of events:

1. Write the address to be programmed using the logical address register located in the PFC. The result of this write will also be reflected physically in the XPEADR register.

   NOTE

   XPEADR writes are initiated by writes that first occur to the PFC. Please see the platform flash controller chapter for more information. XPEADR reads are allowed, and represent the flash memory physical address.

   NOTE

   Ensure the sector that contains the address to be programmed is unlocked. Sector and super sector lock status is latched at this step and does not change until the next program, erase or express program is started.

   NOTE

   If XMCR[XPGM] interrupts a program or erase setup after MCR[EHV] is written to 1, the MCR and MCRS registers indicate if the operation was automatically aborted (MCR[EHV] = 0, MCRS[PEG] = 0, MCR[PGM] =1 or MCR[ERS] = 1), or if the operation was successful (MCR[EHV] = 1, MCRS[PEG] = 1, MCR[PGM] =1 or MCR[ERS] = 1). If express program interrupts a program or erase setup prior to MCR[EHV] being written to a 1, the MCR and PEADR registers will be preserved to show the state of the setup upon interruption. If fields MCR[PGM] = 1 or MCR[ERS] = 1 at interruption, the user must terminate the event by writing 0 to these fields. However, if MCR[PGM] or MCR[ERS] were not 1 at interruption, PEADR is preserved and does not need to be rewritten, but the PDATA registers are required to be rewritten for the interrupted operation. After the PDATA write(s) are repeated to finish the interlock write, the remainder of the program and erase sequence can be done to restart the interrupted operation (including doing a terminate after PGM or ERS are written to 1, if desired).

   NOTE

   Before starting the express program, ensure that UTest operations (array integrity or user margin read) are not ongoing (or about to be started). UT0[UTE] must be low before requesting the express program, and remain low during express program operations. Hardware locks are in place to ensure this occurs.

2. Wait until XMCR[XDOK] goes high.
3. Write the DATA registers with the data desired to be programmed. Up to 1024b (128B) may be programmed with express program. Only DATA registers that are written will receive program pulses.
4. Change the value in XMCR[XPGM] from a 0 to a 1.
5. Write a 1 to XMCR[XEHV] to start the internal express program sequence.

6. Wait until XMCR[XDONE] becomes 1.
7. Confirm XMCR[XPEG] = 1.
8. Write 0 to XMCR[XEHV].
9. Write 0 to XMCR[XPGM] to terminate the express program sequence.

20.5.2 Low-Power mode

In Low-Power mode, the embedded flash memory is put into a state where VDDF power gating and VFLASH power gating is allowed. It is the lowest current mode for the flash memory. No reads from or writes to the embedded flash memory are possible when in this mode. Most power dissipation is due to leakage in this mode.

Prior to entering Low-Power mode, it is required that all program, erase, and UTest operations be stopped.

When in Low-Power mode, register access is prevented. Flash core accesses are also prevented until power mode is exited. Flash core reads and writes may occur after power mode is exited.

The embedded flash memory returns to a post-reset state in all cases.

20.5.3 Program and erase watchdog timer

The embedded flash memory contains an internal watchdog timer that is used to prevent denial of service issues and events.

The watchdog timer is active during two periods of a program and erase event: program/erase setup and program/erase cleanup. If it is desired that program and erase operations also be checked with a watchdog timer, a system resource may be used for this purpose.

Program/erase setup always starts at the time of the PEADR write. An express program setup starts with a write to XPEADR and XMCR[XDOK] = 1. In the event of an Express program interrupt of main or alternate interface setup, the timer starts at the time when the express program operation completes (write of XMCR[XPGM] = 0). The watchdog stops when either MCR[EHV] is set to start the operation, or when the operation is terminated. Termination can occur when MCR[PGM] or MCR[ERS] are written to 0 (prior to MCR[EHV] being written to 1), or MCRS[PES] written to 0. If the express program interrupts the program/erase setup, this also stops the timer on that interface, and express program maintains priority. The above statements also apply to the alternate interface.

NOTE

If PEADR writes occur while UT0[UTE] is 1, the watchdog feature does not activate for setup. Watchdog timer is not active during UTest operations.

Program/erase cleanup always starts at the time of MCRS[DONE] = 1 on completion or an abort. In the event of an express program auto-abort of main or alternate interface, the cleanup starts at the time of MCRS[DONE] becoming 1 and the express program operation completed (XMCR[XPGM] written to 0). The watchdog stops when MCR[PGM] or MCR[ERS] are written to 0 at the end of the operation. If express program interrupts the program/erase cleanup, the timer on that interface also stops. The above statements also apply to the alternate interface.

Watchdog timers exist for each interface (main, alternate and express).

If a watchdog timeout occurs, the watchdog interrupt will be reflected in MCRS[WDI], AMCRS[AWDI] or XMCR[XWDI]. Interrupts can be enabled on the main and alternate interfaces using MCR[WDIE] or AMCR[AWDIE]. When a watchdog timeout occurs and an interrupt register asserts, the PEID restrictions on that interface are released. At that point, any master can complete the operation, and PEID locking is no longer enforced. If the watchdog timeout occurs, the EHV bit on that interface (MCR[EHV], AMCR[AEHV], and XMCR[XEHV]) are locked for writing to a 1. In this instance, any master can take the interface to a program and erase terminate. This enables accepted MCRS[WDI], AMCRS[AWDI] or XMCR[XWDI] to become 0, and the operation may restart with a new interlock write.

NOTE

If the watchdog timeout occurs before PGM becomes 1 (on any interface), or ERS becomes 1 (on any interface), the sequence must be taken to the point that the PGM or ERS bit for that interface is written and then the field for that interface can be cleared to create the terminate event and to clear the watchdog interrupt.

By default, the watchdog is enabled. Through the alternate MCR, the watchdog may be disabled (AMCR[WDD]), and the watchdog timeouts maybe adjusted (AMCR[WDT]) for all timeouts and all interfaces.

20.5.4 UTest mode

UTest mode enables customers to do specific tests that check the integrity of the embedded flash memory.

NOTE

When entering UTest mode, a best practice is to ensure all error flags and address error reporting in ADR are cleared to their reset value to ensure robust software and procedure execution.

NOTE

UTest mode diagnostic features ECC Logic Check, EDC after ECC Logic Check, Address Encode Logic Check, and Read Reference and Voltage Check, require serialization of flash reads starting with mode setup and ending with mode exit. This may be accomplished by executing diagnostic code from system RAM (with single reads to flash tagged address) as well as ensuring any flash reads outside of this diagnostic code are idle (single core).

20.5.4.1 Array integrity self check

Array integrity is checked using a predefined address sequence (based on UT0[AIS]), and this operation is executed on selected blocks.

The data to be read is customer-specific user code programmed into the flash memory and the correct MISR signature is calculated based on that code.

Any random or nonrandom code is valid. After the operation completes, the results of the reads can be checked by reading the MISR value, to determine if an incorrect read or ECC detection was noted. Array integrity MISR value is calculated after ECC detection and correction. Array integrity requires that the read wait states control registers in the CTL register be set to match the system frequency being used.

The array integrity self check consists of the following steps:

1. Enable UTest mode.
2. Select the block to receive the array integrity check by performing an interlock write to that block. Write logical address register in the PFC (which will be reflected in the PEADR register) and 1 DATA register (PDATA is ignored). The block selected for array integrity check does not need to be unlocked.

   NOTE

   Blocks protected with the Test mode disable seal are still read as part of the array integrity sequence. The resulting read on sealed blocks is not captured in the MISR, but single bit correction, double bit detection and breakpoints are still honored.

   NOTE

   It is not possible to perform array integrity operations on the UTest NVM sector.

3. If desired, write 1 to UT0[AIS] for sequential addressing only.

   NOTE

   For normal integrity checks of the flash memory, sequential addressing is recommended. If it is required to more thoroughly check the read path (in a diagnostic mode), AIS shall remain 0 to examine more read transitions. This sequence takes more time.

4. Seed the MISR registers (UM0 - UM9) with desired values.
5. If breakpoints are desired, write 1 to UT0[AIBPE], and ensure that MCRS[EER] and MCRS[SBC] are 0. If it is desired to break on a single bit correction, ensure that UT0[SBCE] = 1.
6. Write 1 to UT0[AIE].

a. If desired, the array integrity operation may be aborted before UT0[AID] goes high. This may be done by writing 0 to UT0[AIE] and then continuing to the next step. Note that in the event of an aborted array integrity check, MISRs contain a signature for the portion of the operation that was completed prior to the abort and are not deterministic. Before performing another array integrity operation, the UM0, UM1, UM2, UM3, UM4, UM5, UM6, UM7, UM8, and UM9 registers may need to be initialized to the desired seed value by doing register writes.

b. If desired, the array integrity operation may be suspended before UT0[AID] goes high. This may be done by writing 1 to UT0[AISUS] to request an array integrity suspend. After UT0[AISUS] becomes 1, the user should wait for UT0[AID] to become 1, which indicates that the flash memory has entered the suspend state, and normal reads to the flash memory may be done. After UT0[AID] becomes 1, UT0[AISUS] may be written to 0 to resume the array integrity sequence.

NOTE

User mode array reads requested during the array integrity test are ignored to ensure that the array integrity operation is not corrupted. The memory array does not respond to array read requests during this time. User mode array reads may be executed if suspended or at a breakpoint.

7. Wait until UT0[AID] becomes 1.
8. If breakpoints are enabled, check if UT0[NAIBP] = 1. If the value of this field is 1, MCRS[EER], MCRS[SBC], and ADDR may be checked to determine the cause of the break and the address of the break. Prior to resuming the operation, write 1 to clear MCRS[SBC] or MCRS[EER]. Then, the operation may be resumed by writing 0 to UT0[NAIBP]. Continue to wait until UT0[AID] becomes 1. If breakpoints are not enabled, or if UT0[NAIBP] = 0 when UT0[AID] becomes 1, the operation is complete. Continue to the next step.
9. Read values in MISRs (UM0 - UM9) to ensure correct signature.

NOTE

Array integrity reads may be done to unselected (or non-present) locations. Reads done to these locations do not update the MISRs, MCRS[EER] and MCRS[SBC].

10. Write 0 to UT0[AIE].

20.5.4.2 User margin read

User margin read may be done using the array integrity interface, and has all the associated features of the array integrity interface (MISR and breakpoints).

User margin reads are done at a read margin level, checking for erased bits or programmed bits encroaching on the nominal read level.

User margin read requires that the Read Wait States control registers in the CTL register be written to match the system frequency being used. Margin ECC corrections and detections are noted during the user margin read test. Margin read MISR value is calculated after ECC detection and correction.

The data to be read is customer-specific user code programmed into the flash memory.

Any random or non-random code is valid. After the operation completes, the margin read results can be checked by reading MCRS[EER] and the MCRS[SBC] to determine if zero, one, or two bits are being detected by the margin read, as well as checking the MISR signature.

The use model for margin read is in the event of a user-detected single bit correction (through user reads), a margin read may be done to check for a possible second bit falling within the selected margin levels.

The user margin read consists of the following steps:

1. Enable UTest mode.
2. Select the block to receive the array integrity check by performing an interlock write to that block. Write logical address register in the PFC (which will be reflected in the PEADR register) and 1 DATA register (PDATA is ignored). The block selected for user margin read check does not need to be unlocked.

NOTE

Blocks protected with the Test mode disable seal are still read as part of the margin read sequence. The resulting read on sealed blocks is not captured in the MISR, but single bit correction, double bit detection and breakpoints are still honored.

NOTE

It is not possible to perform margin read operations on the UTest NVM sector.

3. Write 1 to UT0[AIS] for sequential addressing only.

NOTE

For margin read checks of the flash memory, sequential addressing is recommended. Writing 0 to UT0[AIS] is possible for margin reads, but using the sequence takes more time, and is not recommended.

4. Seed the MISR registers (UM0 - UM9) with desired values.
5. Ensure that MCRS[EER] and MCRS[SBC] are 0.
6. To enable single bit correction reporting during margin read, write UT0[SBCE] = 1.
7. Write 1 to UT0[MRE].
8. Write UT0[MRV] to the desired value depending on if it is desired to do one's margin or zero's margin.
9. Write 1 to UT0[AIE].

NOTE

User mode array reads requested during the margin read test are ignored to ensure that the margin read operation is not corrupted. The memory array does not respond to array read requests during this time. User mode array reads may be executed if suspended or at a breakpoint.

NOTE

During margin read operations, with UT0[AID] = 0, it is not recommended to attempt write operations to MCRS[SBC] and MCRS[EER]. It is recommended that these fields only be written during suspend, breakpoints or at the completion of the margin read operation.

10. Wait until UT0[AID] becomes 1.
11. If breakpoints are enabled or a suspend was requested during margin read, the operation may be at a breakpoint or a suspend state. See Array integrity self check for more information.
12. Read values in the MISRs (UM0 - UM9) to ensure correct signature.

NOTE

Margin reads may be done to unselected (or non-present) locations. Reads done to these locations do not update the MISRs, MCRS[EER] and MCRS[SBC].

13. Write 0 to UT0[AIE].

20.5.4.3 ECC logic check

ECC logic can be checked by providing data to be read in UD0[EDATA], UD1[EDATA] and/or UD2[EDATAC]. Array reads can then be performed, ensuring expected results.

The ECC logic check consists of the following steps:

1. Enable UTest mode.
2. Write 1 to UT0[EIE].
3. Write to UD0[EDATA], UD1[EDATA] and/or UD2[EDATAC] to provide data and check bit values to be read. Single bit corrections or double bit detections can be simulated by properly selecting data and check bit combinations.

4. Write the page address to receive data provided in step 3 into ADR.
5. Write to UD2[ED3], UD2[ED2], UD2[ED1] and/or UD2[ED0] to select the double words on the page to receive the check.
6. Reads can now be done through the BIU using an array read request. In the event of a BIU read requested from an address that matches the address in ADR, expected data and corrections or detections are observed based on data written into UD0[EDATA], UD1[EDATA] and/or UD2[EDATAC]. MCRS[EER] and MCRS[SBC] can be checked to evaluate the status of reads done.

NOTE

In the event of an ECC error or single bit correction, during the ECC logic check (UT0[EIE] = 1), ADR is not loaded, and the address tagged to receive the ECC logic check values is preserved.

7. Once completed, write UT0[EIE] to 0.

20.5.4.4 EDC after ECC logic check

EDC after ECC logic can be checked by providing data to be read in UD3[EDDATA], UD4[EDDATA] and/or UD5[EDDATAC]. Array reads can then be performed, ensuring expected results.

The EDC after ECC logic check consists of the following steps:

1. Enable UTest mode.
2. Write 1 to UT0[EDIE].
3. Write to UD3[EDDATA], UD4[EDDATA] and/or UD5[EDDATAC] to provide data and check bit values to be read.
4. Write the page address to receive data provided in step 3 into ADR.
5. Write to UD5[EDD3], UD5[EDD2], UD5[EDD1] and/or UD5[EDD0] to select the double words on the page to receive the check.
6. Reads can now be done through the BIU using an array read request. In the event of a BIU read requested from an address that matches the address in ADR, expected EDC after ECC errors are observed based on data written into UD3[EDDATA], UD4[EDDATA] and/or UD5[EDDATAC]. MCRS[EEE] can be checked to evaluate the status of reads done.
7. Once completed, write UT0[EDIE] to 0.

20.5.4.5 Address encode logic check

Address encode logic can be checked by inverting the address encode information from the memory array in UA0[AEI] and UA1[AEI]. Array reads can then be performed, ensuring expected results.

The Address encode check consists of the following steps:

1. Enable UTest mode.
2. Write 1 to UT0[AEIE].
3. Write to UA0[AEI] and/or UA1[AEI] to provide address bit(s) to be inverted.
4. Write the page address to receive inverted addresses provided in step 3 into ADR.
5. Reads can now be done through the BIU using an array read request. In the event of a BIU read requested from an address that matches the address in ADR, expected address encode errors are observed based on address invert values written into UA0[AEI] and/or UA1[AEI]. MCRS[AEE] can be checked to evaluate the status of reads done.
6. Once completed, write UT0[AEIE] to 0.

20.5.4.6 Read reference and voltage check

Read reference and voltage detection logic can be checked by writing 1 to UT0[RRIE]. Array reads can be then be performed, ensuring expected results.

The read reference and voltage check consists of the following steps:

1. Enable UTest mode.
2. Write 1 to UT0[RRIE].
3. Write the page address to receive a read reference error MCRS[RRE] and a read voltage error MCRS[RVE] into ADR.
4. Reads can now be done through the BIU using an array read request. In the event of a BIU read requested from an address that matches the address in ADR, expected read reference and read voltage errors are observed based on ADR registers. MCRS[RRE] and MCRS[RVE] can be checked to evaluate the status of reads done.
5. Once completed, write UT0[RRIE] to 0.

20.5.5 Data flash memory requirements for EEPROM emulation

The embedded flash memory may be used to emulate an EEPROM utilizing software drivers, strategic over-programming of double words in the flash memory and following the below requirement and best practices in EEPROM software drivers.

It is required that the EEPROM emulation driver must build in fault tolerance allowing for the ability to “skip” records. In the case of an unsuccessful program, the ability to retry programming in the next available record location is required (record retirement). In the case of an unsuccessful sector erase, the ability to retire a sector is required (sector retirement).

In addition, following are best practices for the EEPROM emulation software driver to be considered:

- Choose a record scheme which allows for grouping of EEPROM data contents that are updated at one time such that unchanged data is not needlessly copied while minimizing record qualifier and status overhead. A variable length record scheme may be used to allow for grouping of data that is written together and limiting total record overhead.
- Copy only the valid records during a sector change and re-constitution of EEPROM data set to avoid needless copying of data within flash memory. This avoids rebuilding the entire data set.
- Only redundantly storing critical data which cannot be recovered in two sectors if attempting to protect against record or sector failures.
- Load level total program/erase cycles applied to flash memory locations allocated for EEPROM emulation by using a round-robin sector scheme.

When combining round-robin with sector retirement requirement, three or more sectors must be allocated for EEPROM emulation inclusive of extra spare sector(s).

For details, see NXP application notes published on this topic.

20.6 Initialization information

A reset is the highest priority operation for the embedded flash memory and terminates all other operations.

The embedded flash memory uses reset to initialize register and status fields to their default reset values. If the embedded flash memory is executing a program or erase operation (MCR[PGM] = 1 or MCR[ERS] = 1) and a reset is issued, the operation aborts and the embedded flash memory disables the high voltage logic without causing any damage to the high voltage circuits. Reset aborts all operations and forces the embedded flash memory into User mode, ready to receive accesses.

After reset is requested, MCRS[DONE] becomes 0, and remains low during reset and reset recovery.

At the end of reset recovery, MCRS[DONE] transitions from 0 to 1.

After a reset completes, register reads may be performed.

NOTE

Registers that require updating from UTest NVM information, or other inputs, may not read updated values until MCRS[DONE] becomes 1.

During reset recovery, register writes are not allowed until MCRS[DONE] becomes 1 to indicate reset recovery is complete.

Caution

Resetting during a program or erase operation leaves the FC blocks being programmed or erased in an indeterminate data state. This may be recovered by executing an erase on the affected blocks.

20.7 Memory map and register description

20.7.1 c40asf flash memory register descriptions

The embedded flash memory map consists of a flash memory array (which includes main array space and UTest NVM space) and a region of registers associated with the programming model that enable flash memory array operation and modification.

The address space consists of up to 6 blocks (with restrictions), and blocks can be 2 MB, 1 MB, 512 KB or 256KB in size.

20.7.1.1 c40asf_flash memory map

FLASH base address: 402E_C000h

FLASH_ALT base address: 402F_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration (MCR)	32	RW	00FF_0000h
4h	Module Configuration Status (MCRS)	32	RW	0000_C100h
8h	Extended Module Configuration (MCRE)	32	R	0000_0000h
Ch	Module Control (CTL)	32	RW	0000_0600h
10h	Address (ADR)	32	RW	0000_0000h
14h	Program and Erase Address (PEADR)	32	R	0000_0000h
50h	Sector Program and Erase Hardware Lock (SPELOCK)	32	R	FFFF_FFFFh
54h	Super Sector Program and Erase Hardware Lock (SSPELOCK)	32	R	0FFF_FFFFh
70h	Express Sector Program and Erase Hardware Lock (XSPELOCK)	32	R	FFFF_FFFFh
74h	Express Super Sector Program and Erase Hardware Lock (XSSPELOCK)	32	R	0FFF_FFFFh
90h	Test Mode Disable Password Check (TMD)	32	RW	0000_0000h
94h	UTest 0 (UT0)	32	RW	0000_0001h
98h - B8h	UMISRn (UM0 - UM8)	32	RW	0000_0000h
BCh	UMISR9 (UM9)	32	RW	0000_0000h
D0h	UTest Data 0 (UD0)	32	RW	0000_0000h
D4h	UTest Data 1 (UD1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
D8h	UTest Data 2 (UD2)	32	RW	0000_0000h
DCh	UTest Data 3 (UD3)	32	RW	0000_0000h
E0h	UTest Data 4 (UD4)	32	RW	0000_0000h
E4h	UTest Data 5 (UD5)	32	RW	0000_0000h
E8h	UTest Address 0 (UA0)	32	RW	0000_0000h
ECh	UTest Address 1 (UA1)	32	RW	0000_0000h
F0h	Express Module Configuration (XMCR)	32	RW	00FF_C000h
F4h	Express Program Address (XPEADR)	32	R	0000_0000h
100h - 17Ch	Program Data (DATA0 - DATA31)	32	RW	FFFF_FFFFh

20.7.1.2 Module Configuration (MCR)

Offset

Register	Offset
MCR	0h

Function

NOTE

- A number of Module Configuration Register (MCR) bits are locked against write by other bits. These locks are discussed in relationship to each bit in this section. Simultaneously writing bits which lock each other out is also discussed in Functional description.
- See Functional description for information about simultaneous MCR writes, and priority levels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								PEID							
W																
Reset	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PECIE	0		WDIE	0			PGM	0		ESS	ERS	0			EHV
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-16 PEID	Program and Erase Master/Domain ID This field shows the ID of the master that has started the Program or Erase sequence (as well as Array Integrity and User Margin Reads). The ID is latched when the sequence has started (writing of the PEADR register). Upon completion of an operation (Program (MCR[PGM] written to 0 and MCRS[PES] equals 0), Erase (MCR[ERS] written to 0 and MCRS[PES] equals 0), Array Integrity (UT0[AIE] written to 0), User Margin Read(UT0[AIE] written to 0)), or Program and Erase Sequence clear (MCRS[PES] cleared to 0) the PEID field will return to an all ones state. See the chip-specific information for a list of Master IDs.
15 PECIE	Program/Erase Complete Interrupt Enable PECIE provides a mechanism to trigger an interrupt request upon the assertion of the DONE status due to a high voltage event (program or erase) finishing (normal, abort). If PECIE is written while not in a high voltage event, the interrupt will not immediately trigger, but will trigger after the next high voltage event is completed. Writing (and reading) of this bit will be restricted to the master that updated the PEADR register as captured in the PEID register at the start of the Program or Erase sequence. **NOTE** See the chip-specific information for interrupt details 0b - Interrupt request not generated when MCRS[DONE] is 1 1b - Interrupt request generated when MCRS[DONE] is 1
14-13 —	Reserved
12 WDIE	Watch Dog Interrupt Enable WDIE provides a mechanism to trigger an interrupt request upon the assertion of the WDI bit on the main interface. If WDIE is asserted, when WDI asserts, an interrupt from the flash will trigger to the system. The interrupt from the flash will mirror exactly the WDI bit. WDIE does not affect the register bit WDI. Writing (and reading) of this bit will be restricted to the master that updated the PEADR register as captured in the PEID register at the start of the Program or Erase sequence. **NOTE** See the chip-specific information for interrupt details 0b - Watchdog interrupt not enabled 1b - Watchdog interrupt enabled
11-9 —	Reserved
8 PGM	Program

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Field	Function
	PGM is used as part of the setup for a program operation. A 0 to 1 transition of PGM after program interlock write(s) is part of the program sequence. A 1 to 0 transition of PGM ends the program sequence. PGM can be set while in user mode read (ERS is low and UTE is low), and after the interlock write is completed. PES must also be low to enable PGM to be set. PGM can be cleared only when EHV is low and DONE is high. PGM is cleared on reset. Writing (and reading) of this bit will be restricted to the master that updated the PEADR register as captured in the PEID register at the start of the Program or Erase sequence. 0b - Flash memory not executing a program sequence 1b - Flash memory executing a program sequence
7-6 —	Reserved
5 ESS	Erase Size Select ESS is used to qualify the embedded flash memory erase operation for either sector erase or block erase. If ESS is selected for block erase, only the main array of that block will be erased. **NOTE** Block erase is for Factory use only, under controlled conditions. See Appendix A (Electrical Specifications) for more information on environmental condition requirements, and cycle limit. **NOTE** If interlock write occurs to UTest sector, ESS will be locked from setting to a 1. Block Erase of UTest sector is not supported, only sector erase is allowed. Erase of UTest space is not allowed if sealed, although ERS can be set and a PEG error will occur in response to the HV request. ESS can only be written to a 1 at the same time that ERS is written to a 1. If ESS is set, ESS will auto clear with ERS clearing (independent of the value written to ESS). ESS can not be cleared by writing a zero. ESS is cleared on reset. Writing (and reading) of this bit will be restricted to the master that updated the PEADR register as captured in the PEID register at the start of the Program or Erase sequence. 0b - Flash memory erase is on a sector 1b - Flash memory erase is on a block
4 ERS	Erase ERS is used as part of the setup for an erase operation. A 0 to 1 transition of ERS after an erase interlock write is part of the erase sequence. A 1 to 0 transition of ERS ends the erase sequence. ERS can only be set in user mode read (PGM is low and UTE is low), and after the interlock write is completed. PES must also be low to enable ERS to be set. ERS can be cleared only when EHV is low and DONE is high. ERS is cleared on reset. Writing (and reading) of this bit will be restricted to the master that updated the PEADR register as captured in the PEID register at the start of the Program or Erase sequence. 0b - Flash memory not executing an erase sequence

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Field	Function
	1b - Flash memory executing an erase sequence
3-1 —	Reserved
0 EHV	Enable High Voltage The EHV bit enables the embedded flash memory for a high voltage program/erase operation. EHV is cleared on reset. EHV must be set after the PGM or ERS bit is set in a program or erase sequence. Writing (and reading) of this bit will be restricted to the master that updated the PEADR register as captured in the PEID register at the start of the Program or Erase sequence. EHV may be set, initiating a program/erase under one of the following conditions: • Erase (ERS = 1, PEP = 0, PES = 0, WDI = 0) • Program (PGM = 1, PEP = 0, PES = 0, WDI = 0) Clearing EHV while DONE is low will abort the current program/erase high voltage operation. An abort causes the value of PEG to be cleared, indicating a failed program/erase; address locations being operated on by the aborted operation contain indeterminate data after an abort. EHV may not be written to a 1 after an abort is requested (EHV being cleared) and before DONE transitions high. EHV may not be written to a 1 after it is cleared as part of a program or erase cleanup, until after the next PEADR write. **NOTE** Aborting a high voltage operation leaves addresses in an indeterminate data state. This may be recovered by executing an erase on the affected sectors. 0b - Flash memory is not enabled to perform a high voltage operation. 1b - Flash memory is enabled to perform a high voltage operation.

20.7.1.3 Module Configuration Status (MCRS)

Offset

Register	Offset
MCRS	4h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EER	SBC	AEE	EEE	0		RVE	RRE	0			RWE	0		PEP	PES
W	W1C	W1C	W1C	W1C			W1C	W1C				W1C			W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DONE	PEG	0	WDI	0		EPEG	TSPELOCK	0							RE
W																
Reset	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EER	ECC Event Error This bit provides information on previous reads (either user initiated reads or internally initiated reset reads).If a double bit detection occurred, the EER bit is set to a '1'. This bit must then be cleared, or a reset must occur before it returns to a 0 state. This bit may not be set by software. In the event of a single bit detection and correction, this bit is not set. If EER is not set, or remains 0, this indicates that all previous reads (from the last reset, or clearing of EER) are correct. Since this bit is an error flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Reads occurring normally 1b - ECC error occurred during a previous read
30 SBC	Single Bit Correction SBC provides information on previous reads, if the SBCE is set. If a single bit correction occurred, the SBC bit is set to a 1. This bit must then be cleared, or a reset must occur before this bit returns to a 0 state. If SBC is not set, or remains 0, this indicates that all previous reads (from the last reset, or clearing of SBC) did not require a correction. Since this bit is a status flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Reads occurring without corrections 1b - Single bit correction occurred during a previous read
29 AEE	Address Encode Error AEE provides information on previous reads monitoring the address encode feature. On every read request to the flash, the incoming address is compared to an encoded address (row, column, and block) coming back from the memory array using the read data sense amplifier timing. If these two values do not match (zero selected, multiple selected, wrong selected), or the timing is incorrect, an address encode error will be recorded. If an address encode mismatch is detected, this bit is set to indicate that previous reads requested may have been corrupted. Since this bit is a status flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Reads are occurring without address encode mismatches 1b - Previous read may be corrupted based on address encode mismatch

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Field	Function
28 EEE	EDC after ECC Error EEE provides information on previous reads monitoring the EDC after ECC feature. On every read request to the flash, ECC is recalculated serially, and if there is a mismatch between the ECC calculations (taking into account corrections or detections) a late error will be reported. If an EDC after ECC mismatch is detected, this bit is set to indicate that previous reads requested may have been corrupted. Since this bit is a status flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Reads are occurring without EDC after ECC mismatches 1b - Previous read may be corrupted based on ECC calculation errors
27-26 —	Reserved
25 RVE	Read Voltage Error RVE provides information on previous reads monitoring the read voltage. If the read voltage is detected to be out of range, this bit is set to indicate that previous reads requested may have been corrupted. Since this bit is a status flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Reads are occurring without voltage issues 1b - A previous read may have been corrupted due to read voltage being out of range
24 RRE	Read Reference Error RRE provides information on previous reads monitoring the read reference. If the read reference is detected to be out of range, this bit is set to indicate that previous reads requested may have been corrupted. Since this bit is a status flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Reads occur without reference issues 1b - Previous read may be corrupted because of read reference being out of range
23-21 —	Reserved
20 RWE	Read-While-Write Event Error This bit provides information on previous read-while-write (RWW) reads. If an RWW error occurs, this bit is set to 1. The bit must then be cleared, or a reset must occur before it returns to a 0 state. If RWE is not set, or remains 0, this indicates that all previous RWW reads (from the last reset, or clearing of RWE) are correct. Since this bit is an error flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Reads occur normally 1b - RWW error occurred during a previous read
19-18 —	Reserved
17	Program and Erase Protection Error

Table continues on the next page...

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Field	Function
PEP	PEP provides information about program and erase operations with respect to protection errors. A protection error occurs if a program is attempted to a locked sector or super sector, or if an erase is selected to a locked sector or super sector. This is evaluated prior to the operation beginning, and if an error is detected, high voltage operations (either a Program or Erase) will not be attempted for this request. **NOTE** If a location has both OTP and Lock protection, the response from the NVM will be PEP=1 only. If PEP is asserted, it must be cleared prior to attempting another high voltage operation. Since this bit is a status flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Program and erase protection errors do not exist 1b - Previous program or erase protection error encountered
16 PES	Program and Erase Sequence Error PES provides information about program and erase operations with respect to sequence errors. A sequence error occurs when the program or erase sequence is not followed exactly. If an “out-of-order” event is detected, PES will assert, and the remainder of the sequence will not be accepted. PES monitoring begins when the PEADR register is written and ends when EHV is set to start the operation. PES monitoring only applies to Program and Erase (Sector and Block). It does not apply to Express Program, or UTest operations. Following is a complete list of sequence error conditions: • Any specific DATA register written twice. • More than one DATA register write for ERS operations. • Attempts to write PGM or ERS register out of sequence. • Attempts to write PGM after ERS, or ERS after PGM. • Attempts to write DATA registers after PGM or ERS are written. • Attempts to write EHV out of sequence. Writes to the MCR that are protected by the MCR Priority Levels (i.e. simultaneous PGM, ERS and EHV writes) will not result in a PES condition. Attempts to write MCR or DATA registers by a master that does not match the PEID, will not result in a PES condition. Those reads and writes will be blocked, and the master in control of the interface may continue with its' sequence. Clearing of PES (due to a sequence error) has the same effect as the clearing of PGM or ERS after a program or erase operation. PEADR and DATA registers are cleared, PEID is cleared, and the operation must be re-started from the beginning. If PGM or ERS are already set, they must be cleared before PES is cleared. PES can only be cleared once the PGM or ERS bit for the sequence in progress is cleared. Since this bit is a status flag, it must be cleared to a 0 by writing a 1 to the register location. A write of 0 has no effect. 0b - Program and erase sequence errors do not exist 1b - Previous program or erase sequence encountered an error
15 DONE	State Machine Status

Table continues on the next page...

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Field	Function
	DONE indicates whether the embedded flash memory is performing a high voltage operation. DONE is set to a 1 on termination of the embedded flash memory reset. DONE is read only. DONE is set to a 1 at the end of program and erase high voltage sequences. **NOTE** This field transitions from a 0 to 1 during reset and remains at 1 after reset. 0b - Performing a high voltage operation 1b - Not executing a high voltage operation
14 PEG	Program/Erase Good The value of PEG is updated automatically during the program and erase high voltage operations. Aborting a program/erase high voltage operation causes PEG to be cleared, indicating the sequence failed. PEG is set to a 1 when the embedded flash memory is reset. PEG is read only. The value of PEG is valid only when PGM = 1 or ERS = 1 and after DONE transitions from 0 to 1 due to an abort or the completion of a program/erase operation. PEG is valid until PGM/ERS makes a 1 to 0 transition or EHV makes a 0 to 1 transition. **NOTE** 1. If program or erase operations are attempted on sector(s) that are locked, the response from embedded flash memory is PEG = 1, indicating that the operation was successful, and the contents of the sector(s) are properly protected from the program or erase operation. PEG = 1 is also true if an abort occurs during an HV request to a locked sector. 2. If a program or erase operation is attempted to a location marked as OTP, the response from the embedded flash memory is PEG = 0, indicating that the operation was not allowed. The value interlocked is not programmed, since desired double word was already programmed with a previous program operation. Erase is prevented on OTP locations. 0b - Program or erase operation failed 1b - Program or erase operation successful
13 —	Reserved
12 WDI	Watch Dog Interrupt WDI is a status register to indicate that the Watchdog Timer for Program or Erase had expired. WDI is status only, and will be automatically cleared once the operation that caused the watchdog timeout is terminated or clean up from the operation is completed (clearing of PGM (with PES low), ERS (with PES low) or PES bit). 0b - Normal Operation, Watchdog Timer has not expired. 1b - Program Watchdog Timer has expired.
11-10 —	Reserved

Table continues on the next page...

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Field	Function
9 EPEG	ECC Enabled Program/Erase Good EPEG is a qualifier to PEG to indicate if a passing program or erase required ECC Enabled verifies to pass. In the event of a failed operation (PEG=0), EPEG will always remain 0. The value of EPEG is updated automatically during the program and erase high voltage operations. EPEG is set to a 0 when the embedded flash memory is reset. EPEG is read only. The value of EPEG is valid only when PGM = 1 or ERS = 1 and after DONE transitions from 0 to 1 due to an abort or the completion of a program/erase operation. EPEG is valid until PGM/ERS makes a 1 to 0 transition or EHV makes a 0 to 1 transition. 0b - Program or erase operation did not require ECC Enabled verifies. 1b - Program or erase operation required ECC Enabled verifies to pass.
8 TSPELOCK	UTest NVM Program and Erase Lock TSPELOCK reflects the status of the hardware program and erase protection input to the flash module. The TSPELOCK register is latched on the PEADR[PEASAD] write (UTest Sector Interlock), is not writable, and is status only. During high voltage events, the status is locked. When not interlocked this bit will read 1. The default value of the TSPELOCK bits is program and erase protected. 0b - Corresponding sector not locked, and may be programmed or erased 1b - Corresponding sector protected from the program and erase sequences
7-1 —	Reserved
0 RE	Reset Error This bit provides information on previous resets. Checks are done within the flash and if a coherency issue or ECC error is detected during the reset reads used for trimming on the flash, this status flag will assert. This bit is status only, and is not writable. 0b - Reset occurred without errors 1b - Reset error encountered

20.7.1.4 Extended Module Configuration (MCRE)

Offset

Register	Offset
MCRE	8h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	n2M				0				n1M				0			
W																
Reset [1]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	n512K		0						n256K		0					
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1. The reset value of this register is set at the factory and varies among chips. See the chip-specific c40asf information for details.

Fields

Field	Function
31-29 n2M	Number of 2 MB Blocks 000b - Zero 2 MB blocks 001b - One 2 MB block 010b - Two 2 MB blocks 011b - Three 2 MB blocks 100b - Four 2 MB blocks 101b - Reserved 110b - Reserved 111b - Reserved
28-24 —	Reserved
23-21 n1M	Number of 1 MB Blocks 000b - Zero 1 MB blocks 001b - One 1 MB block 010b - Two 1 MB blocks 011b - Three 1 MB blocks 100b - Four 1 MB blocks 101b - Reserved 110b - Reserved 111b - Reserved

Table continues on the next page...

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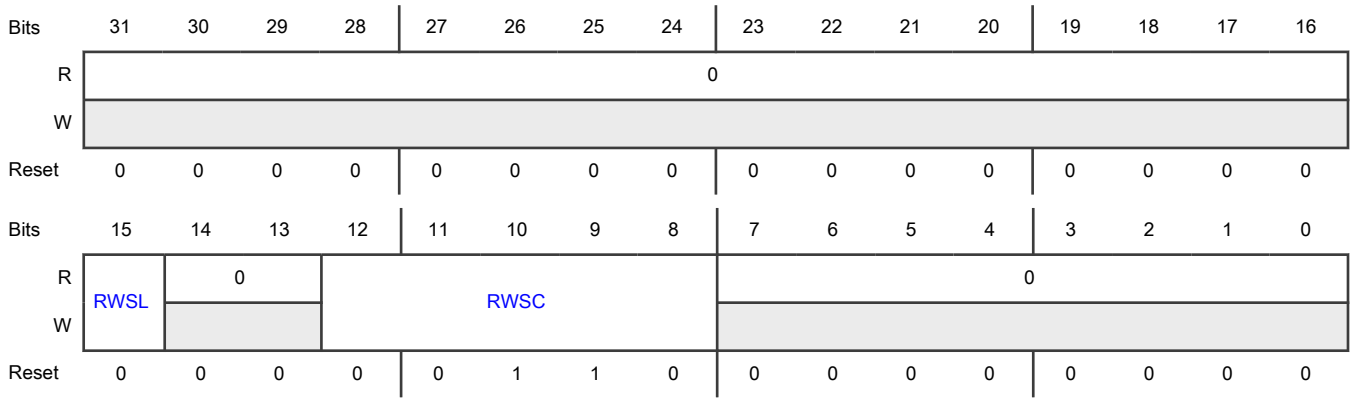
Field	Function
20-16 —	Reserved
15-14 n512K	Number of 512 KB Blocks 00b - Zero 512 KB blocks 01b - One 512 KB block 10b - Two 512 KB blocks 11b - Four 512 KB blocks
13-8 —	Reserved
7-6 n256K	Number of 256 KB Blocks 00b - Zero 256 KB blocks 01b - One 256 KB block 10b - Two 256 KB blocks 11b - Four 256 KB blocks
5-0 —	Reserved

20.7.1.5 Module Control (CTL)

Offset

Register	Offset
CTL	Ch

Diagram



Fields

Field	Function
31-16 —	Reserved
15 RWSL	Read Wait State Lock Read Wait State Lock. The RWSL bit locks the read wait state control register (RWSC). If RWSL is set, then the RWSC field can not be written. RWSL is not clearable by a register write, it is only cleared upon reset. Once RWSL is written to a 1, it will remain a 1 until the next reset and RWSC will be locked from writing. RWSC and RWSL are allowed to be written simultaneously. RWSL does not affect readability of RWSC. 0b - RWSC not locked and available for writing 1b - RWSC locked and unavailable for writing
14-13 —	Reserved
12-8 RWSC	Wait State Control This field controls the number of wait states to be added to the best-case flash array access time for reads. RWSC is only writable when RWSL is a 0. The best case flash array access time for reads is one cycle. This field must be set to a value corresponding to the operation frequency of the Flash and the actual read access time of the Flash to the flash boundary. Total read latency will be SoC dependant based on the how the cores are coupled within the platform. The frequency information, and total latency details are documented in the SoC specification. Higher operating frequencies require non-zero settings for this field for proper flash operation. **NOTE** • Updates to this configuration field that control reads must take place only when the flash memory is idle. Changing configuration settings while flash memory access is in progress can lead to non-deterministic behavior. • Values of RWSC[4:0] not listed here are reserved. **NOTE** 0_0000b - Reserved 0_0001b - One additional wait state is added. 0_0010b - Two additional wait states are added. 0_0011b - Three additional wait states are added. 0_0100b - Four additional wait states are added. 0_0101b - Five additional wait states are added. 0_0110b - Six additional wait states are added. 0_0111b - Seven additional wait states are added. 0_1000b - Eight additional wait states are added.

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Field	Function
	0_1001b - Reserved 1_1111b - Reserved
7-0 —	Reserved

20.7.1.6 Address (ADR)

Offset

Register	Offset
ADR	10h

Function

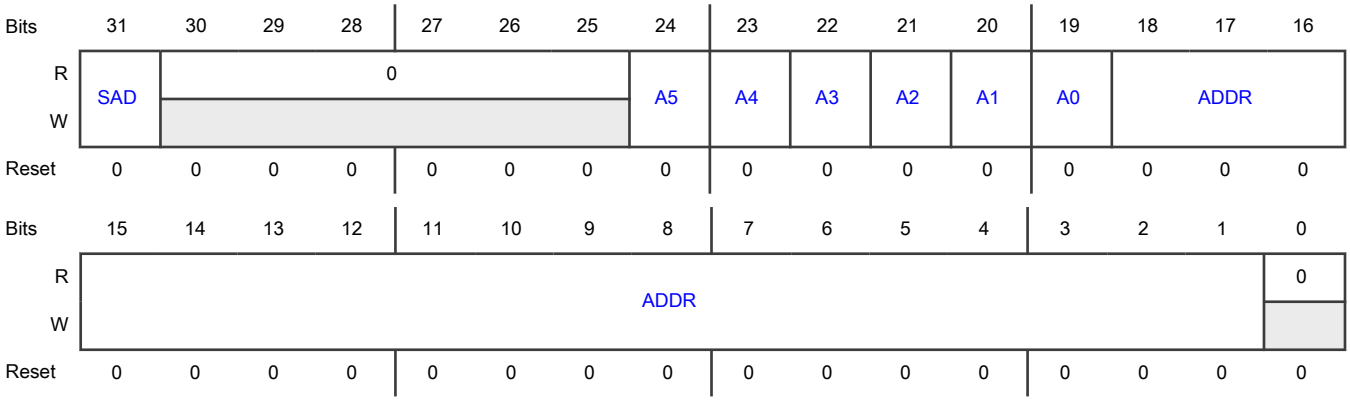
The Address register (ADR) provides the first failing address in the event of a failure (ECC or PGM/Erase state machine), as well as single bit correction information. The address register is also writable for UTest Mode operations. The address is identified using a combination of bits that identify the memory region and offset address.

NOTE

- The address given is an offset from the base address of the address space.
- The block numbering scheme that corresponds to the offset address is based on the flash memory's *internal* addressing scheme, which may be different than the chip's system addressing scheme.

Understanding the mapping between the flash address, which is specified relative to the flash module's internal addressing scheme, and the location within the chip's system memory map requires a clear understanding of the flash memory layout. See the chip-specific information for a detailed explanation of the chip's flash memory layout and how to map system addresses to the flash module's internal addressing.

Diagram



Fields

Field	Function
31 SAD	UTest NVM Address Qualifies the address captured during an ECC event error, single bit correction, or state machine operation. See the description of the ADDR field for more information. This field is not writeable if UTE = 1, and is ignored if it's in UTest mode. 0b - Address captured or to be accessed is from the main array space 1b - Address captured or to be accessed is from the UTest NVM array space
30-25 —	Reserved Reserved; reset to 0
24 A5	Address Region 5 Qualifies the address field (ADDR) to region 5 If the value of this field is 1, the ADDR field maps to region 5. See the description of the ADDR field for more information. If the region is not present, this field is locked to 0. 0b - Address captured or to be accessed is not from region 5 1b - Address captured or to be accessed is from region 5
23 A4	Address Region 4 Qualifies the address field (ADDR) to region 4 If the value of this field is 1, the ADDR field maps to region 4. See the description of the ADDR field for more information. If the region is not present, this field is locked to 0. 0b - Address captured or to be accessed is not from region 4 1b - Address captured or to be accessed is from region 4
22 A3	Address Region 3 Qualifies the address field (ADDR) to region 3 If the value of this field is 1, the ADDR field maps to region 3. See the description for the ADDR field for more information. If the region is not present, this field is locked to 0. 0b - Address captured or to be accessed is not from region 3 1b - Address captured or to be accessed is from region 3
21 A2	Address Region 2 Qualifies the address field (ADDR) to region 2 If the value of this field is 1, the ADDR field maps to region 2. See the description of the ADDR field for more information. If the region is not present, this field is locked to 0. 0b - Address captured or to be accessed is not from region 2 1b - Address captured or to be accessed is from region 2
20	Address Region 1

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Field	Function
A1	Qualifies the address field (ADDR) to the region If the value of this field is 1, the ADDR field maps to region 1. See the description for the ADDR field for more information. If the region is not present, this field is locked to 0. 0b - Address captured or to be accessed is not from region 1 1b - Address captured or to be accessed is from region 1
19 A0	Address Region 0 Qualifies the ADDR field to region 0. If A0 = 1, then the ADDR field maps to that region. If the region is not present, this field is locked to 0. For details, see the field description for ADDR. 0b - Address captured or to be accessed is not from region 0 1b - Address captured or to be accessed is from region 0
18-1 ADDR	Address The ADR register provides the first failing address in the event of ECC event error (EER set), single bit correction (SBC set), as well as providing the address of a failure that may have occurred in a state machine operation (PEG cleared). ECC event errors take priority over single bit corrections, which take priority over state machine errors. This is especially valuable in the event of an RWW operation, where the read senses an ECC error or single bit correction, and the state machine fails simultaneously. The failing address for ECC event error is held until EER is cleared. The failing address for single bit correction is held until an ECC event error, or until SBC is cleared. State machine address is held until an ECC event error or single bit correction event occurs, or until the next state machine event (PEG cleared) occurs. This address is always a double word address that selects 64 bits. The ADR register is writable, and can be used in the UTest ECC Logic Test, UTest EDC after ECC Logic Test, and UTest Address Encode Logic Test. If any of these tests are enabled (UT0[EIE] = 1, UT0[EDIE] = 1, or UT0[AEIE] = 1) then the ADR register will not update for ECC event error, single bit correction or state machine errors. If MCRS[EER] or MCRS[SBC] are set, the ADR register is locked from writing. MCRS[PEG] does not affect the writeability of the ADR register. ADDR[18:1] is an offset from a base address of 0h for each block region. The A0, A1, A2, A3, A4, and A5 bits qualify the block size region the ADDR field.
0 —	Reserved Reserved; reset to 0

20.7.1.7 Program and Erase Address (PEADR)

Offset

Register	Offset
PEADR	14h

Function

The Program and Erase Address register (PEADR) is used to provide the address to be programmed or the location of the sector or block to be erased. The program and erase address register is read only in user mode (user mode writes occur with writes done to the Platform Flash Controller). The address is identified using a combination of bits that identify the memory region and offset address.

NOTE

- The address provided is an offset from the base address of the address space.
- The block numbering scheme that corresponds to the offset address is based on the flash memory's *internal* addressing scheme, which may be different from the chip's system addressing scheme.

Understanding the mapping between the flash address, which is specified relative to the flash module's internal addressing scheme, and the location within the chip's system memory map requires a clear understanding of the flash memory layout. See the chip-specific information for a detailed explanation of the chip's flash memory layout and how to map system addresses to the flash module's internal addressing.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PEASAD	0						PEA5	PEA4	PEA3	PEA2	PEA1	PEA0	PEADDR		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PEADDR												0			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 PEASAD	UTest NVM Program and Erase Address Qualifies the address field (PEADDR) to the region. If PESAD = 1, the PEADDR field maps to that region. See the description of the PEADDR field for more information. This field is not writeable if UTE = 1 and is ignored if it becomes 1 while in UTest mode. 0b - Address accessed is from the main array space 1b - Address accessed is from the UTest NVM array space
30-25 —	Reserved Reserved; reset to 0
24 PEA5	Program and Erase Address Region 5 Qualifies the address field (PEADDR) to region 5.

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Field	Function
	If PEA5 = 1, the PEADDR field maps to region 5. See the description of the PEADDR field for more information. If region 5 is not present, this field is locked to 0. 0b - Address accessed is not from region 5 1b - Address accessed is from region 5
23 PEA4	Program and Erase Address Region 4 Qualifies the address field (PEADDR) to region 4. If PEA4 = 1, the PEADDR field maps to region 4. See the description of the PEADDR field for more information. If region 4 is not present, this field is locked to 0. 0b - Address accessed is not from region 4 1b - Adrress accessed is from region 4
22 PEA3	Program and Erase Address Region 3 Qualifies the address field (PEADDR) to region 3. If PEA3 = 1, the PEADDR field maps to region 3. See the description for PEADDR for more information. If region 3 is not present, this field is locked to 0. 0b - Address accessed is not from region 3 1b - Address accessed is from region 3
21 PEA2	Program and Erase Address Region 2 Qualifies the address field (PEADDR) to the region. If PEA2 = 1, the PEADDR field maps to region 2. See the description of the PEADDR field for more information. If region 2 is not present, this field is locked to 0. 0b - Address accessed is not from region 2 1b - Address accessed is from region 2
20 PEA1	Program and Erase Address Region 1 Qualifies the address field (PEADDR) to the region. If PEA1 = 1, the PEADDR field maps to region 1. See the description of the PEADDR field for more information. If region 1 is not present, this field is locked to 0. 0b - Address accessed is not from region 1 1b - Address accessed is from region 1
19 PEA0	Program and Erase Address Region 0 Qualifies the address field (PEADDR) to the region. If PEA0 = 1, the PEADDR field maps to region 0. See the description of the PEADDR field for more information. If region 0 is not present, this field is locked to 0. 0b - Address accessed is not from region 0 1b - Address accessed is from region 0

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Field	Function
18-5 PEADDR	Program and Erase Address The PEADDR register provides offset address location to be programmed or the sector to be erased in the case of sector erase. This address is always a quad page address that selects 1024 bits. The PEADDR register is read only in user mode and represents the flash physical address status. PEADDR may be updated once (and only once) per Program or Erase event. PEADDR writes initiate a Program, Erase, Array Integrity or User Margin Read request. Once PEADDR is updated, it will be locked for the full program and erase operation, until MCR[PGM] or MCR[ERS] is cleared at the end of the operation (as long as MCRS[PES] is zero). If MCRS[PES] is set, PEADR is locked until this bit is also cleared. **NOTE** If Express Program has been initiated (XPEADR written), the PEADR is locked from writing until Express Program is completed (XPGM written to 0). Upon completion of an operation (Program (MCR[PGM] written to 0 and MCRS[PES] equals 0), Erase (MCR[ERS] written to 0 and MCRS[PES] equals 0), Array Integrity (UT0[AIE] written to 0), User Margin Read(UT0[AIE] written to 0)), or Program and Erase Sequence clear (MCRS[PES] written to 0) the PEADR registers will return to an all zeros state. When MCR[EHV] or UT0[AIE] are set, PEADDR bits will not be writeable. Once PEADDR is updated, it will have read restrictions based on the PEID master that did the original write in the Platform Flash Controller. PEADDR[18:5] is an offset from a base address of 0h for each block region. The PEA0, PEA1, PEA2, PEA3, PEA4 and PEA5 qualify the block size region the PEADDR field.
4-0 —	Reserved Reserved; reset to 0

20.7.1.8 Sector Program and Erase Hardware Lock (SPELOCK)

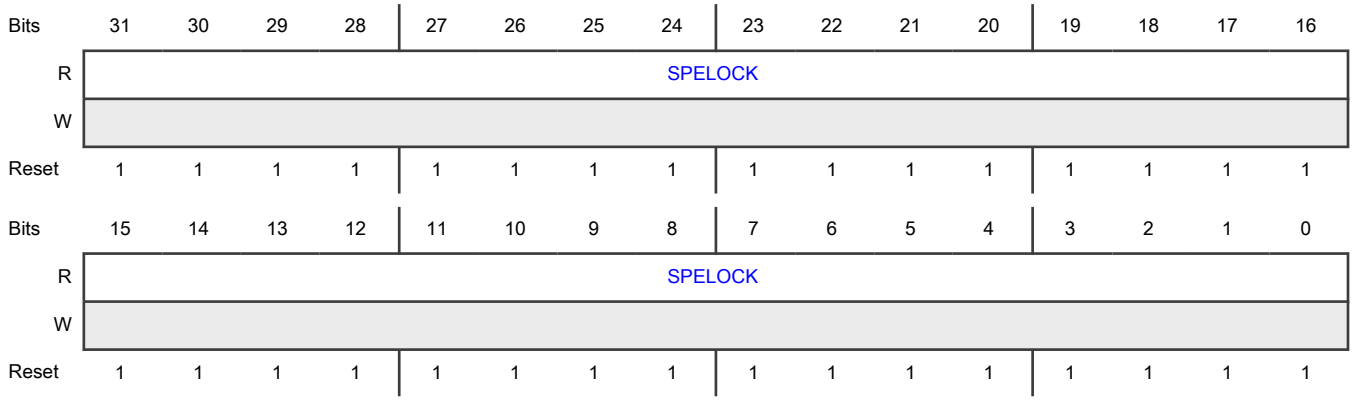
Offset

Register	Offset
SPELOCK	50h

Function

The Sector Program and Erase Lock register provides a means to protect sectors from being programed and erased on the main interface. The last 256 KB of all blocks have sector lock protection capability. The rest of the block (if applicable) is protected with super sector protection capability. This register shows the status of the pelock hardware input for the block that is interlocked. For more information on hardware program and erase protection see Program hardware locking and Erase hardware locking .

Diagram



Fields

Field	Function
31-0 SPELOCK	Sector Program and Erase Lock [31:0] SPELOCK reflects the status of the hardware program and erase protection input to the flash module for the block interlocked on the main interface. The SPELOCK register is latched on the PEADR write, is not writable, and is status only. SPELOCK will return back to all ones at the same time that PEADR is cleared. When not interlocked this register will read all ones. During high voltage events, the status is locked. The default value of the SPELOCK bits is program and erase protected. In the event that sectors are not present (due to configuration or total memory size), the SPELOCK bits default to locked, and will remain 1. 0 - The corresponding sector is not locked, and may be programed or erased. 1 - The corresponding sector is protected from program or erase.

20.7.1.9 Super Sector Program and Erase Hardware Lock (SSPELOCK)

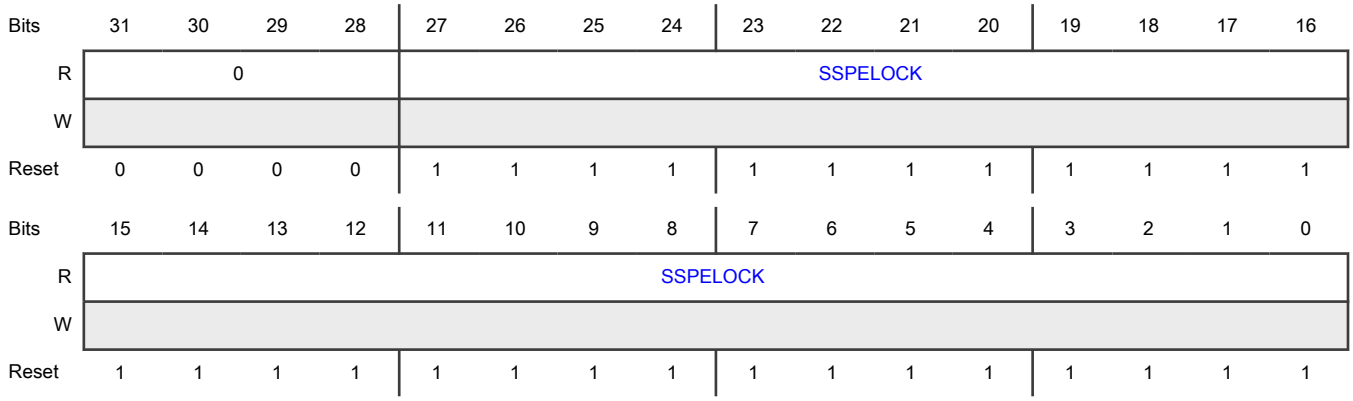
Offset

Register	Offset
SSPELOCK	54h

Function

The Program and Erase Lock register provides a means to protect super sectors from being programed and erased on the main interface. Super Sector protection is available on block space greater than 256 KB. For 256 KB blocks, this register is not applicable. For 512 KB blocks, the first half of the block is protected with super sector granularity. For 1 MB blocks, the first 768 KB is protected with super sector granularity. For 2 MB blocks, the first 1792 KB is protected with super sector granularity. This register shows the status of the pelock hardware input for the block interlocked. For more information on hardware program and erase protection see Program hardware locking and Erase hardware locking .

Diagram



Fields

Field	Function
31-28 —	Reserved Reserved; reset to 0
27-0 SSPELOCK	Super Sector Program and Erase Lock [27:0] SSPELOCK reflects the status of the hardware program and erase protection input to the flash module for the block interlocked on the main interface. The SSPELOCK register is latched on the PEADR write, is not writable, and is status only. SSPELOCK will return back to all ones at the same time that PEADR is cleared. When not interlocked this register will read all ones. During high voltage events, the status is locked. The default value of the SSPELOCK bits is program and erase protected. In the event that super sectors are not present (due to configuration or total memory size), or super sectors not present due to block size, the SSPELOCK bits default locked, and will remain 1. 0 - The corresponding super sector is not locked, and may be programmed or erased. 1 - The corresponding super sector is protected from program or erase.

20.7.1.10 Express Sector Program and Erase Hardware Lock (XSPELOCK)

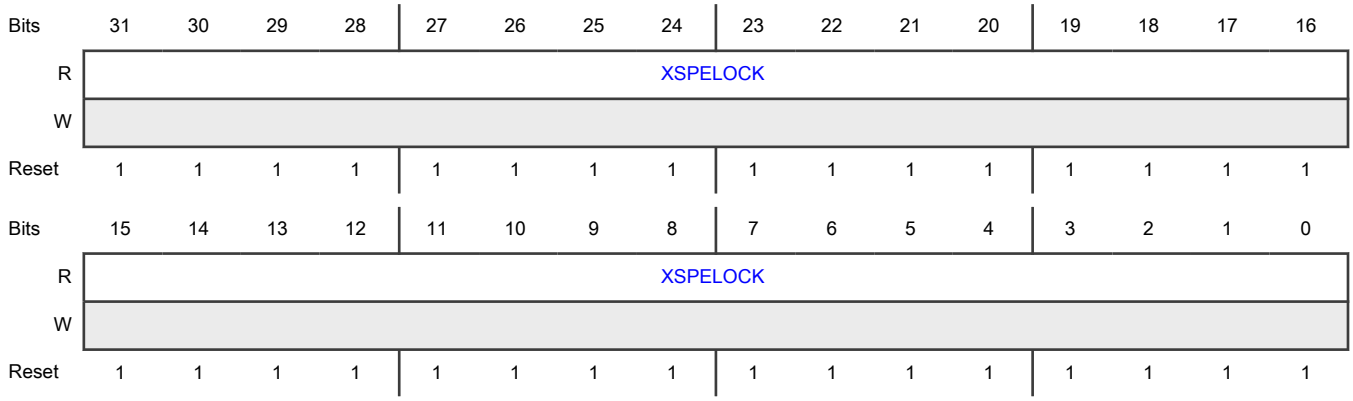
Offset

Register	Offset
XSPELOCK	70h

Function

The Express Program and Erase Lock register provides a means to protect sectors from being programed and erased on the express program interface. The last 256 KB of all blocks have sector lock protection capability. The rest of the block (if applicable) is protected with super sector protection capability. This register shows the status of the pelock hardware input for the block that is interlocked. For more information on hardware program and erase protection see Program hardware locking and Erase hardware locking .

Diagram



Fields

Field	Function
31-0 XSPELOCK	Express Sector Program and Erase Lock [31:0] XSPELOCK reflects the status of the hardware program and erase protection input to the flash module for the block interlocked on the express program interface. The XSPELOCK register is latched on the XPEADR write, is not writable, and is status only. XSPELOCK will return back to all ones at the same time that XPEADR is cleared. When not interlocked this register will read all ones. During high voltage events, the status is locked. The default value of the XSPELOCK bits is program and erase protected. In the event that sectors are not present (due to configuration or total memory size), the XSPELOCK bits default to locked, and will remain 1. 0 - The corresponding sector is not locked, and may be programmed or erased. 1 - The corresponding sector is protected from program or erase.

20.7.1.11 Express Super Sector Program and Erase Hardware Lock (XSSPELOCK)

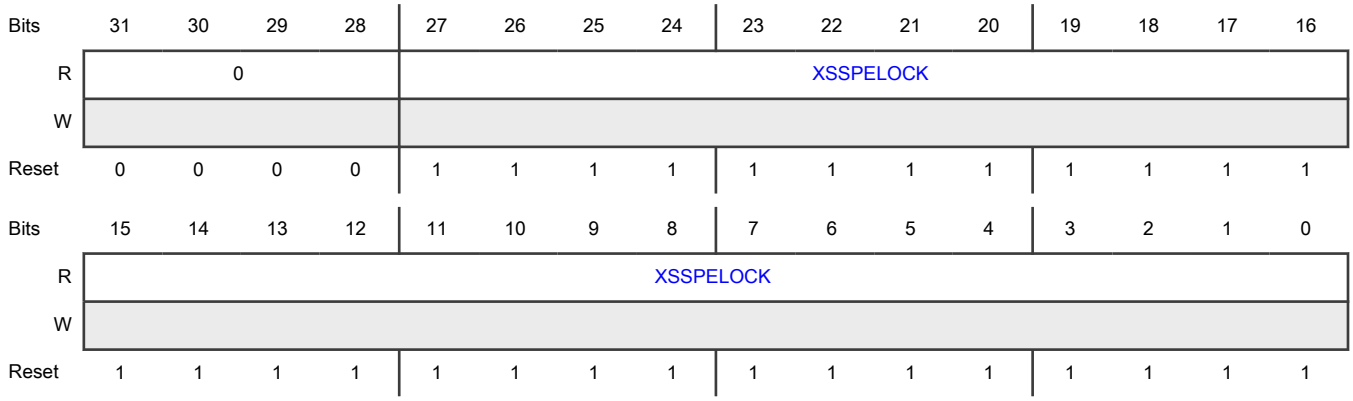
Offset

Register	Offset
XSSPELOCK	74h

Function

The Express Program and Erase Lock register provides a means to protect super sectors from being programed and erased on the express program interface. Super Sector protection is available on block space greater than 256 KB. For 256 KB blocks, this register is not applicable. For 512 KB blocks, the first half of the block is protected with super sector granularity. For 1 MB blocks, the first 768 KB is protected with super sector granularity. For 2 MB blocks, the first 1792 KB is protected with super sector granularity. This register shows the status of the pelock hardware input for the block interlocked. For more information on hardware program and erase protection see Program hardware locking and Erase hardware locking .

Diagram



Fields

Field	Function
31-28 —	Reserved Reserved; reset to 0
27-0 XSSPELOCK	Express Super Sector Program and Erase Lock [27:0] XSSPELOCK reflects the status of the hardware program and erase protection input to the flash module for the block interlocked on the express program interface. The XSSPELOCK register is latched on the XPEADR write, is not writable, and is status only. XSSPELOCK will return back to all ones at the same time that XPEADR is cleared. When not interlocked this register will read all ones. During high voltage events, the status is locked. The default value of the XSSPELOCK bits is program and erase protected. In the event that super sectors are not present (due to configuration or total memory size), or super sectors not present due to block size, the XSSPELOCK bits default to locked, and will remain 1. 0 - The corresponding super sector is not locked, and may be programmed or erased. 1 - The corresponding super sector is protected from program or erase.

20.7.1.12 Test Mode Disable Password Check (TMD)

Offset

Register	Offset
TMD	90h

Function

Provides a means to supply a challenge password to disable the Test mode disable seal block select.

Writes to the register have no effect except for a password challenge. Reads to this register always return 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PWD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PWD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PWD	Password Challenge

20.7.1.13 UTest 0 (UT0)

Offset

Register	Offset
UT0	94h

Function

Provides a means to control UTest.

UTest mode provides the ability to perform test features on the flash memory. This register is only writeable when the flash memory is put into UTest mode by writing a passcode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	UTE	SBCE	0													
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RRIE	AEIE	EDIE	EIE	0		NAIBP	AIBPE	0	AISUS	MRE	MRV	0	AIS	AIE	AID
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31 UTE	UTest Enable This status bit indicates when U-Test is enabled. All bits in UT0, UM0, UM1, UM2, UM3, UM4, UM5, UM6, UM7, UM8, UM9, UD0, UD1, UD2, UD3, UD4, UD5, UA0 and UA1 registers are locked when this bit is 0. This bit is not writeable to a 1, but may be cleared. The reset value is 0. The method to set this bit is to provide a password, and if the password matches, the UTE bit is set to reflect a status of enabled, and is enabled until it is cleared by a register write. The UTE password (set UTE=1) and UTE clearing to 0 will only be accepted if Program or Erase are not in progress (PEADR write through clearing of PGM/ERS/PES), Alternate Program or Erase are not in progress (APEADR write through clearing of APGM/AERS/APES), AI/MR Operation are not in progress (PEADR write through clearing of AIE), and an Express Program operation is not in progress (XPEADR write through the clearing of XPGM). UTE can only be cleared if AID = 1, MRE, AIE, EIE, EDIE, AEIE, and RRIE are all equal to 0. While successfully clearing UTE, writes to set AIE, MRE, EIE, EDIE, AEIE or RRIE will be ignored. For UTE, the password F9F9_9999h must be written to the UT0 register, and this must be a 32bit write. 0b - U-Test mode is not enabled. 1b - U-Test mode is enabled.
30 SBCE	Single Bit Correction Enable SBCE enables single bit correction results to be observed in SBC. ECC corrections that occur when SBCE is cleared will not be logged. 0b - Disabled 1b - Enabled
29-16 —	Reserved Reserved; reset to 0
15 RRIE	Read Reference Input Enable RRIE enables the force of an error on the read reference detection circuit. This is useful in the Read Reference Error check. If this bit is set, the read reference error register MCRS[RRE] will set when an address match is achieved to the ADR register. RRIE is not simultaneously writable to a 1 as UTE is being successfully cleared to a 0. 0b - Read reference input disabled 1b - Read reference input enabled
14 AEIE	Address Encode Invert Enable AEIE enables the input register AEI to invert the address encode value received from the array, and force a mismatch in the address encode comparison. This is useful in the Address Encode logic check. If this bit is set, address encode information from the memory array will be inverted based on values in the AEI register when an address match is achieved to the ADR register. AEIE is not simultaneously writable to a 1 as UTE is being successfully cleared to a 0. 0b - Address encode invert is disabled 1b - Address encode values are inverted based on UA0[AEI]
13	EDC after ECC Data Input Enable

Table continues on the next page...

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Field	Function
EDIE	EDIE enables the input registers EDDATA and EDDATAC to be the source of data to the EDC after ECC comparator or EDC after ECC encoder. This is useful in the EDC after ECC logic check. If this bit is set, data read via a BIU read request will be from the EDDATA and EDDATAC registers when an address match is achieved to the ADR register. EDIE is not simultaneously writable to a 1 as UTE is being successfully cleared to a 0. 0b - EDC after ECC data input is disabled 1b - Data read is from UD3[EDDATA] and UD5[EDDATAC]
12 EIE	ECC Data Input Enable EIE enables the input registers EDATA and EDATAC to be the source of data to the ECC logic (instead of from the memory array). This is useful in the ECC logic check. If this bit is set, data read via a BIU read request will be from the EDATA and EDATAC registers when an address match is achieved to the ADR register. EIE is not simultaneously writable to a 1 as UTE is being successfully cleared to a 0. 0b - ECC data input is disabled 1b - Data read is from UD0[EDATA] and UD2[EDATAC]
11-10 —	Reserved
9 NAIBP	Next Array Integrity Break Point If AIBPE is set, NAIBP will be set once a single bit correction (if enabled) or double bit detection is noted during the Array Integrity test. NAIBP is not writable to 1, but may be cleared to 0. Clearing NAIBP to 0, will enable the Array Integrity operation to be re-started after a breakpoint is encountered. NAIPB may only be cleared to 0 if both EER = 0 and SBC = 0. If the Array Integrity operation completes without encountering another correction or detection, AID will be set with NAIBP remaining 0. 0b - Array integrity state machine is not currently at a breakpoint 1b - Array integrity state machine is at a breakpoint
8 AIBPE	Array Integrity Break Point Enable To enable breakpoints during an array integrity test, AIBPE may be set. See NAIBP description for more information about array integrity breakpoints. 0b - Array integrity breakpoints disabled 1b - Array integrity breakpoints enabled during array integrity checks
7 —	Reserved Reserved; reset to 0
6 AISUS	Array Integrity Suspend AISUS enables a suspend of an Array Integrity Operation. Array Integrity may be suspend by setting AISUS, and resumed by clearing AISUS. AISUS is writeable to a 1 only when AID is low. AISUS is clearable to a 0 only when AID is high. Attempting to write AISUS and AIE on the same clock cycle will result in only AIE getting written.

Table continues on the next page...

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Field	Function
	0b - Array integrity sequence not suspended. 1b - Array integrity sequence is suspended.
5 MRE	Margin Read Enable MRE combined with MRV enables user margin reads to be done. Normal user reads are not affected by MRE, although user reads while the margin read operation is ongoing are not supported. MRE is not writable if AID is low, or if AISUS is high, or if NAIBP is high. MRE is not simultaneously writable to a 1 as UTE is being successfully cleared to a 0. 0b - Margin reads are not enabled. 1b - Margin reads are enabled.
4 MRV	Margin Read Value MRV selects the margin level that is being checked. Margin can be checked to an erased level (MRV=1) or to a programmed level (MRV=0). In order for this value to be valid, MRE must also be set. MRV is not writable if AID is low, or if AISUS is high, or if NAIBP is high. 0b - Zero's margin reads are requested. 1b - One's margin reads are requested.
3 —	Reserved
2 AIS	Array Integrity Sequence AIS determines the address sequence to be used during array integrity checks. The default sequence (AIS = 0) is meant to replicate sequences that normal user code follows, and thoroughly checks the read propagation paths. This sequence is proprietary. The alternative sequence (AIS = 1) is logically sequential. It should be noted that the time to run a sequential sequence is shorter than the time to run the proprietary sequence. AIS is not writeable if AIE is high. 0b - Array integrity sequence is proprietary sequence 1b - Array integrity sequence is sequential
1 AIE	Array Integrity Enable AIE set to one starts the array integrity check done on all selected blocks. The address sequence is determined by AIS, and the MISR (UM0 through UM9) can be checked after the operation is complete, to determine if a correct signature has been obtained. Once an array integrity operation is requested (AIE=1), it may be terminated by clearing AIE if the operation has finished (AID = 1) or aborted by clearing AIE if the operation is ongoing (AID = 0). AIE is locked from writing unless an interlock write occurred (PEADR write and DATA write). AIE is not simultaneously writable to a 1 as UTE is being successfully cleared to a 0. 0b - Array integrity checks not enabled 1b - Array integrity checks enabled
0	Array Integrity Done

Table continues on the next page...

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Field	Function
AID	AID is cleared upon an array integrity check being enabled (to signify the operation is ongoing). Once completed, AID is set to indicate that the array integrity check is complete. At this time the MISR (UMR registers) can be checked. AID may also assert if breakpoints are enabled (AIBPE is set), an abort is requested or a suspend is requested. AID cannot be written, and is status only. 0b - Array integrity check ongoing 1b - Array integrity check complete

20.7.1.14 UMISRn (UM0 - UM8)

Offset

For a = 0 to 8:

Register	Offset
UMa	98h + (a × 4h)

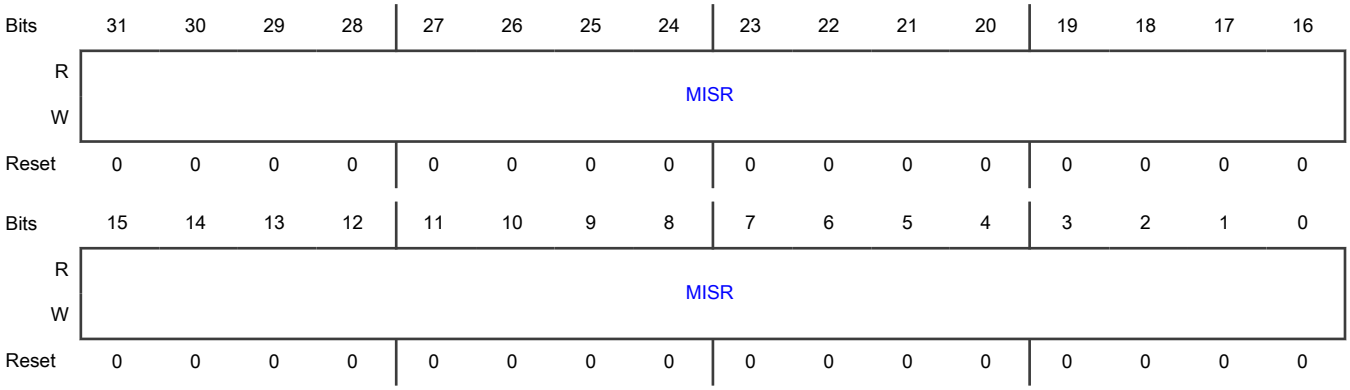
Function

Provides a means to evaluate array integrity. UM9 to UM0 are a set of multiple-input signature registers (MISRs) that hold the 289-bit MISR value as shown in the next table.

Table 83. MISR mapping

UM register	MISR bits
UM0	MISR[31:0]
UM1	MISR[63:32]
UM2	MISR[95:64]
UM3	MISR[127:96]
UM4	MISR[159:128]
UM5	MISR[191:160]
UM6	MISR[223:192]
UM7	MISR[255:224]
UM8	MISR[287:256]
UM9	MISR[288]

Diagram



Fields

Field	Function
31-0 MISR	MISR[31:0] The MISR registers accumulate a signature from an array integrity event. The MISR captures all data fields, as well as ECC fields, and the ECC error signal. Data (read and ECC) captured in the MISR is after the ECC logic, and represents corrected data (if required). The MISR can be seeded to any value by writing the MISR registers. **NOTE** Writing the MISR register during an array integrity operation (including suspend or breakpoint) although possible, is not recommended. A write of the MISR registers at this point may alter the final signature in an unpredictable way. Writing the MISR registers prior to an Array Integrity operation (to seed the MISR) is allowed. The MISR register provides a means to calculate a MISR during array integrity operations. The MISR can be represented by the following polynomial: $x^{289} + x^{7} + x^{6} + x^{5} + x^{4} + x^{2} + 1$ The MISR is calculated by taking the previous MISR value and then "exclusive ORing" the new data. In addition the most significant bit (in this case it is MISR[288]), is then "exclusive ORed" into input of MISR[7], MISR[6], MISR[5], MISR[4], MISR[2] and MISR[0]. The result of the "exclusive OR" is shifted left on each read. The MISR register is used in array integrity operations. If during address sequencing, reads extend into an invalid address location (in other words, greater than the maximum address for a given array size) then reads are still executed to the array, but the results from the array read are not deterministic. In this instance, the MISR registers are not recalculated, and the previous value is retained. Once the AIE register is cleared, the MISR register will return to an all 0's state.

20.7.1.15 UMISR9 (UM9)

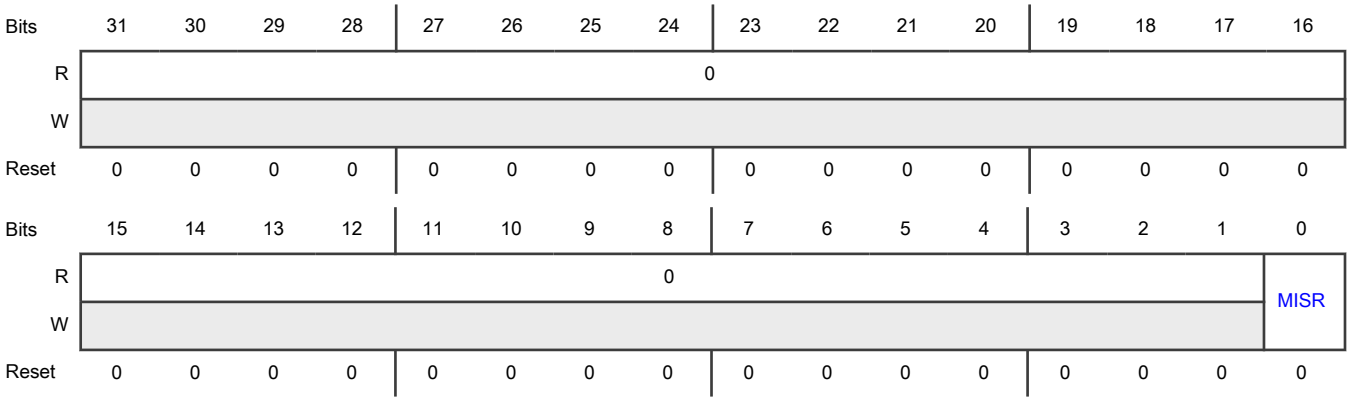
Offset

Register	Offset
UM9	BCh

Function

Provides a means to evaluate array integrity.

Diagram



Fields

Field	Function
31-1 —	Reserved Reserved; reset to 0
0 MISR	MISR[288] The MISR registers accumulate a signature from an array integrity event. The MISR captures all data fields, as well as ECC fields, and the ECC error signal. Data (read and ECC) captured in the MISR is after the ECC logic, and represents corrected data (if required). The MISR can be seeded to any value by writing the MISR registers. **NOTE** Writing the MISR register during an array integrity operation (including suspend or breakpoint) although possible, is not recommended. A write of the MISR registers at this point may alter the final signature in an unpredictable way. Writing the MISR registers prior to an Array Integrity operation (to seed the MISR) is allowed. The MISR register provides a means to calculate a MISR during array integrity operations. The MISR can be represented by the following polynomial: $x^{289} + x^{7} + x^{6} + x^{5} + x^{4} + x^{2} + 1$

Table continues on the next page...

Table continued from the previous page...

Field	Function
	The MISR is calculated by taking the previous MISR value and then "exclusive ORing" the new data. In addition the most significant bit (in this case it is MISR[288]), is then "exclusive ORed" into input of MISR[7], MISR[6], MISR[5], MISR[4], MISR[2] and MISR[0]. The result of the "exclusive OR" is shifted left on each read. The MISR register is used in array integrity operations. If during address sequencing, reads extend into an invalid address location (in other words, greater than the maximum address for a given array size) then reads are still executed to the array, but the results from the array read are not deterministic. In this instance, the MISR registers are not recalculated, and the previous value is retained. Once the AIE register is cleared, the MISR register will return to an all 0's state.

20.7.1.16 UTest Data 0 (UD0)

Offset

Register	Offset
UD0	D0h

Function

Provides a means to enable data to be substituted during UTest procedures.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	EDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	EDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 EDATA	ECC Data [31:0] Enables checks of ECC logic by allowing data bits to be input into the ECC logic and then read out by doing array reads or array integrity checks. EDATA corresponds to the 32 array bits representing word 0 of all double words in the page selected in ADR.

20.7.1.17 UTest Data 1 (UD1)

Offset

Register	Offset
UD1	D4h

Function

Provides a means to enable data to be substituted during UTest procedures.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	EDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	EDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 EDATA	ECC Data [63:32] Enables checks of ECC logic by allowing data bits to be input into the ECC logic and then read out by doing array reads or array integrity checks. UD0[EDATA] corresponds to the 32 array bits representing word 1 of all double words in the page selected in ADR.

20.7.1.18 UTest Data 2 (UD2)

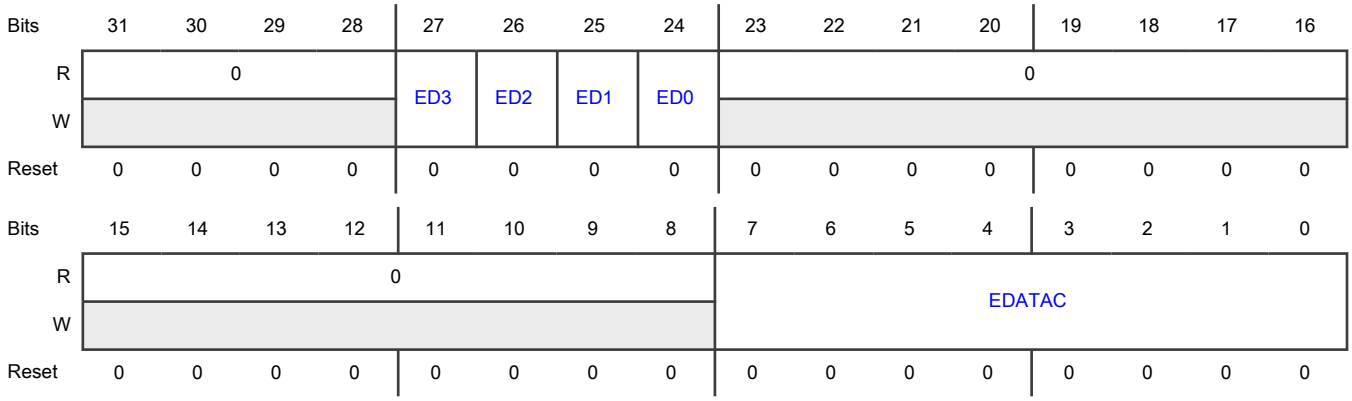
Offset

Register	Offset
UD2	D8h

Function

Provides a means to enable data to be substituted during UTest procedures.

Diagram



Fields

Field	Function
31-28 —	Reserved
27 ED3	ECC Logic Check Double Word 3 Enables checks of ECC logic by allowing data bits to be input into the ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW3 on the page selected in ADR.
26 ED2	ECC Logic Check Double Word 2 Enables checks of ECC logic by allowing data bits to be input into the ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW2 on the page selected in ADR.
25 ED1	ECC Logic Check Double Word 1 Enables checks of ECC logic by allowing data bits to be input into the ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW1 on the page selected in ADR.
24 ED0	ECC Logic Check Double Word 0 Enables checks of ECC logic by allowing data bits to be input into the ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW0 on the page selected in ADR.
23-8 —	Reserved
7-0 EDATAC	ECC Data Check Bits [7:0] Enables checks of ECC logic by allowing data bits to be input into the ECC logic and then read out by doing array reads or array integrity checks.

Table continues on the next page...

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Field	Function
	This field corresponds to the eight array bits representing the check bits of all double words in the page selected in ADR.

20.7.1.19 UTest Data 3 (UD3)

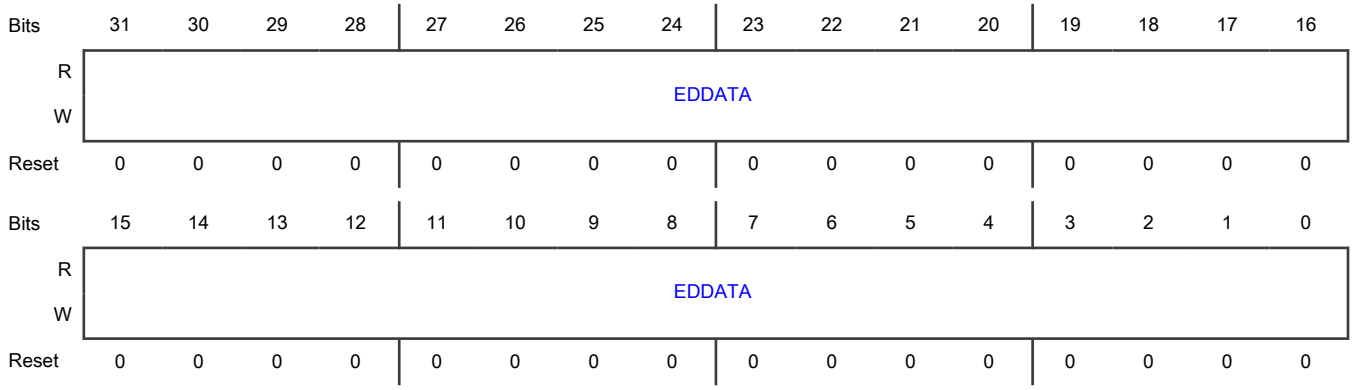
Offset

Register	Offset
UD3	DCh

Function

Provides a means to enable data to be substituted during UTest procedures.

Diagram



Fields

Field	Function
31-0 EDDATA	EDC After ECC Data [31:0] Enables checks of EDC after ECC logic by allowing data bits to be input into the EDC after ECC logic and then read out by doing array reads or array integrity checks. This field corresponds to the 32 array bits representing word 0 of all double words in the page selected in ADR.

20.7.1.20 UTest Data 4 (UD4)

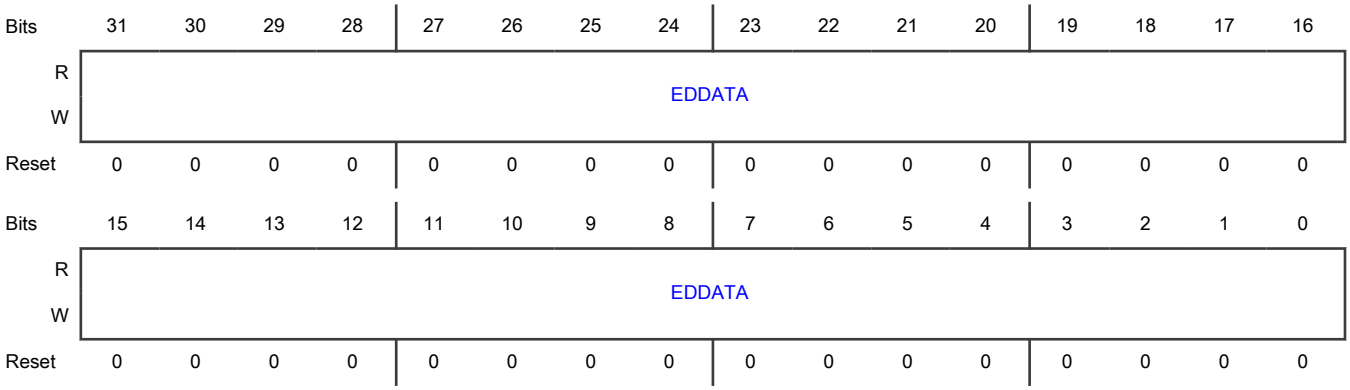
Offset

Register	Offset
UD4	E0h

Function

Provides a means to enable data to be substituted during UTest procedures.

Diagram



Fields

Field	Function
31-0 EDDATA	EDC After ECC Data [63:31] Enables checks of EDC after ECC logic by allowing data bits to be input into the EDC after ECC logic and then read out by doing array reads or array integrity checks. This field corresponds to the 32 array bits representing word 1 of all double words in the page selected in ADR.

20.7.1.21 UTest Data 5 (UD5)

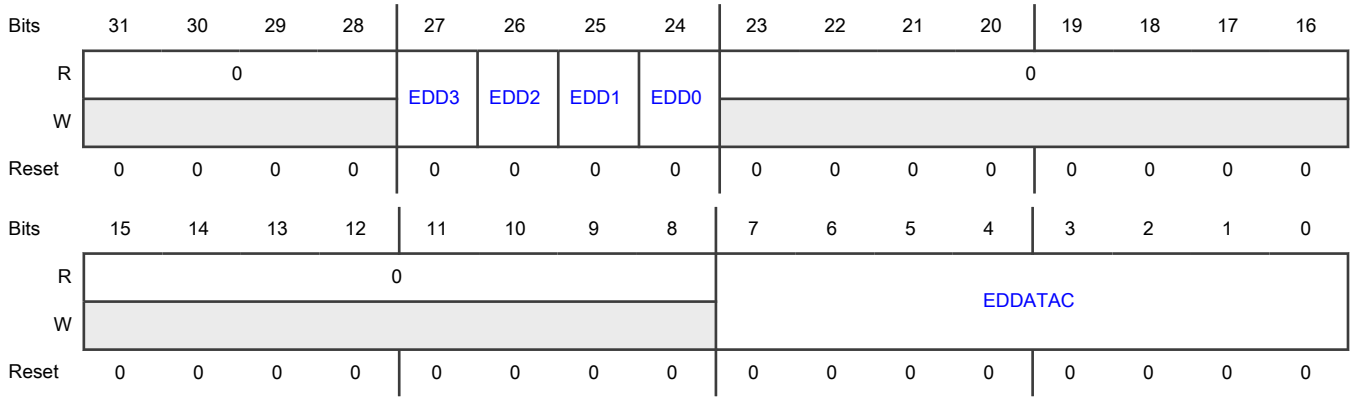
Offset

Register	Offset
UD5	E4h

Function

Provides a means to enable data to be substituted during UTest procedures.

Diagram



Fields

Field	Function
31-28 —	Reserved
27 EDD3	EDC After ECC Logic Check Double Word 3 Enables checks of EDC after ECC logic by allowing data bits to be input into the EDC after ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW3 on the page selected in ADR.
26 EDD2	EDC after ECC Logic Check Double Word 2 Enables checks of EDC after ECC logic by allowing data bits to be input into the EDC after ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW2 on the page selected in ADR.
25 EDD1	EDC After ECC Logic Check Double Word 1 Enables checks of EDC after ECC logic by allowing data bits to be input into the EDC after ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW1 on the page selected in ADR.
24 EDD0	EDC After ECC Logic Check Double Word 0 Enables checks of EDC after ECC logic by allowing data bits to be input into the EDC after ECC logic and then read out by doing array reads or array integrity checks. If this field's value becomes 1, the data replacement occurs on DW0 on the page selected in ADR.
23-8 —	Reserved
7-0 EDDATAC	EDC After ECC Data Check Bits [7:0] Enables checks of EDC after ECC logic by allowing data bits to be input into the EDC after ECC logic and then read out by doing array reads or array integrity checks.

Table continues on the next page...

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Field	Function
	This field corresponds to the eight array bits representing the check bits of all double words in the page selected in ADR.

20.7.1.22 UTest Address 0 (UA0)

Offset

Register	Offset
UA0	E8h

Function

Provides a means to enable address to be inverted during UTest procedures.

NOTE

- UTest Address 0 (UA0) and UTest Address 1 (UA1) combine to represent a 52-bit wide field, which matches the width of the address internally to the flash memory that is used for the address encode comparison.
- Writing 1 to any one of the fields in UA0 or UA1 leads to flagging an AEE error when causing the error injection.
- When the value of a field within the range of bits 18:3 is 1, the corresponding address signal to the flash memory controller or BIU is inverted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	AEI															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	AEI															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 AEI	Address Encode Invert [31:0] Enables checks of address encode logic by allowing address bits to be inverted into the address encode compare logic, forcing a miscompare. Performing array reads on the page selected in ADR allows the address encode invert(s) to be active.

Table continues on the next page...

Field	Function
	Additionally, in the event of an address encode error during normal user mode operation, the page address provided to the PFC is inverted when an address encode error is encountered. AEI[18:3], which reflects the page address, can be used with the Address Encode Logic Check to control this inversion feature (aligning with ADR). Any bit in AEI[18:3] written to a 1 also enables the inversion of the corresponding signal of that address, allowing checks to be performed on the comparison logic that exists in the PFC. **NOTE** Multiple bits in AEI[18:3] may be written to a 1, which causes these bits to miscompare on the address encode comparison logic, as well as causing multiple bits to have their inversion enabled as part of the address provided to the BIU.

20.7.1.23 UTest Address 1 (UA1)

Offset

Register	Offset
UA1	ECh

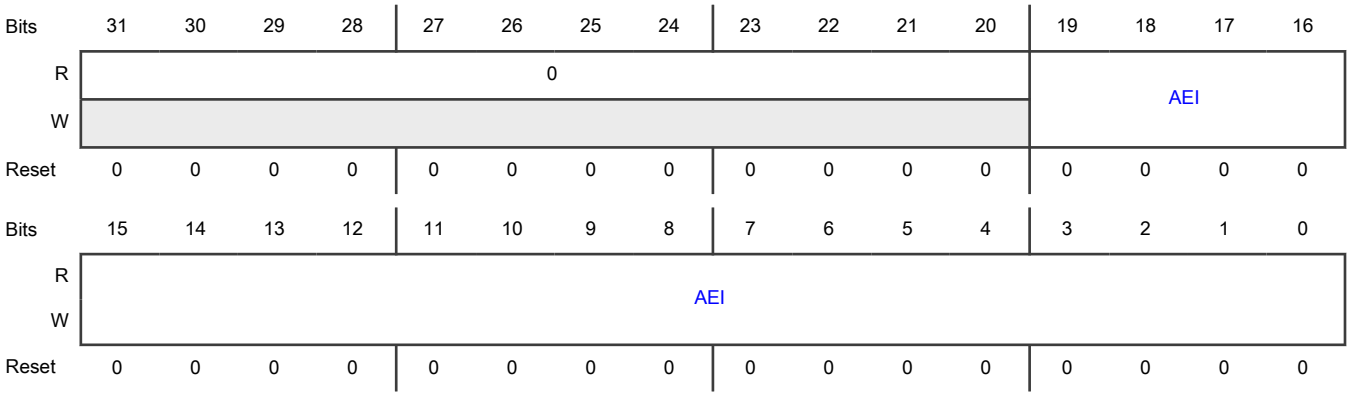
Function

Provides a means to enable address to be inverted during UTest procedures.

NOTE

- UTest Address 0 (UA0) and UTest Address 1 (UA1) combine to represent a 52-bit wide field, which matches the width of the address internally to the flash that is used for the address encode comparison.
- Writing 1 to any one of the fields in UA0 or UA1 leads to flagging an AEE error when causing the error injection.

Diagram



Fields

Field	Function
31-20 —	Reserved
19-0 AEI	Address Encode Invert [51:32] Enables checks of address encode logic by allowing address bits to be inverted into the address encode compare logic, forcing a miscompare. Performing array reads on the page selected in ADR allows the address encode invert(s) to be active.

20.7.1.24 Express Module Configuration (XMCR)

Offset

Register	Offset
XMCR	F0h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								XPEID							
W																
Reset	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	XDONE	XPEG	XDOK	XWDI	XWDIE	0	XEPEG	XPGM	0							XEHV
W																
Reset	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-16 XPEID	Express Program Master/Domain ID This field shows the ID of the master that has started the express program sequence. The ID is latched when the sequence has started (writing of the XPEADR register). It is set back to the reset value (set to all '1') when the operation is completed. See the chip-specific information for a list of Master IDs.
15	Express State Machine Status

Table continues on the next page...

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Field	Function
XDONE	XDONE indicates whether the embedded flash memory is performing an express program operation. XDONE is set to a 1 on completion of the express program operation. 0b - Executing an express program operation 1b - Not executing an express program operation
14 XPEG	Express Program Good The XPEG field indicates the completion status of the last flash memory express program operation. The value of XPEG is updated automatically after the program operations. XPEG will be 0 if the program operation failed. See MCRS[PEG] for more information, as the features of that bit apply to XPEG as well. 0b - Program operation failed 1b - Program operation successful
13 XDOK	Express Data OK This field is a status signal from the flash to indicate that it is OK to load Data into the DATA registers. It will assert in response to a XPEADR load (once ongoing operations are aborted, if required). XDOK will clear once the Express Program operation is complete (XPGM written to 0). 0b - Flash memory not ready to accept writes to the DATA registers 1b - Writes to DATA registers allowed
12 XWDI	Express Watch Dog Interrupt XWDI is a status register to indicate that the Watchdog Timer for Express Program had expired. XWDI is status only, and will be automatically cleared once the operation that caused the watchdog timeout is terminated or clean up from the operation is completed (clearing of XPGM bit). 0b - Normal Operation, Watchdog Timer has not expired. 1b - Express Program Watchdog Timer has expired.
11 XWDIE	Express Watch Dog Interrupt Enable XWDIE provides a mechanism to trigger an interrupt request upon the assertion of the XWDI bit on the express interface. If XWDIE is asserted, when XWDI asserts an interrupt from the flash will trigger to the system. The interrupt from the flash will mirror exactly the XWDI bit. XWDIE does not affect the register bit XWDI. Writing (and reading) of this bit will be restricted to the master that updated the XPEADR register as captured in the XPEID register at the start of the Express Program sequence. 0b - Express watchdog interrupt disabled 1b - Express watchdog interrupt enabled
10 —	Reserved
9 XEPEG	Express ECC Enabled Program Good XEPEG is a qualifier to XPEG to indicate if a passing program required ECC Enabled verifies to pass. In the event of a failed operation (XPEG=0), XEPEG will always remain 0. The value of XEPEG is updated

Table continues on the next page...

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Field	Function
	automatically after the program operations. See MCRS[EPEG] for more information, as the features of that bit apply to XEPEG as well. 0b - Program operation did not require ECC-enabled verifies 1b - Program operation required ECC-enabled verifies to pass
8 XPGM	Express Program XPGM is used as part of the setup for an express program operation. A 0 to 1 transition of XPGM after program interlock write(s) is part of the setup for an express program sequence. A 1 to 0 transition of XPGM ends the express program sequence. XPGM can be set at any time if UT0[UTE] is low, and after the interlock write is completed (XPEADR written, XDOK asserted, and DATAn register(s) written). XPGM may be cleared when XEHV is low. Writing (and reading) of this bit will be restricted to the master that updated the XPEADR register as captured in the XPEID register at the start of the Program sequence. 0b - Flash memory not executing an express program sequence 1b - Flash memory executing an express program sequence
7-1 —	Reserved
0 XEHV	Express Enable High Voltage The XEHV field enables the embedded flash memory for a high voltage program/erase operation. XEHV is cleared on reset. XEHV must be set after DATA writes to start an express program operation and XPGM is set. This field may be set when XPGM = 1, XDOK = 1, and XWDI = 0. XEHV may not be written to a 1 after it is cleared as part of an express program cleanup, until after the next XPEADR write. Express Program operations may not be aborted. XEHV may only be cleared once XDONE is set to 1. Writing (and reading) of this bit will be restricted to the master that updated the XPEADR register as captured in the XPEID register at the start of the Program sequence. 0b - Flash memory is not enabled to perform an express high voltage operation. 1b - Flash memory is enabled to perform an express high voltage operation.

20.7.1.25 Express Program Address (XPEADR)

Offset

Register	Offset
XPEADR	F4h

Function

The Express Program Address register (XPEADR) is used to provide the address to be programmed. The express program address register is read only in user mode (user mode writes occur with writes done to the Platform Flash Controller). The address is identified using a combination of bits that identify the memory region and offset address.

NOTE

- The address given is an offset from the base address of the address space.
- The block numbering scheme that corresponds to the offset address is based on the flash memory's *internal* addressing scheme, which may be different than the chip's system addressing scheme.

Understanding the mapping between the flash address, which is specified relative to the flash module's internal addressing scheme, and the location within the chip's system memory map requires a clear understanding of the flash memory layout. See the chip-specific information for a detailed explanation of the chip's flash memory layout and how to map system addresses to the flash module's internal addressing.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0							XPEA5	XPEA4	XPEA3	XPEA2	XPEA1	XPEA0	XPEADDR		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	XPEADDR												0			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-25 —	Reserved Reserved; reset to 0
24 XPEA5	Express Program Address Region 5 Qualifies the address field (XPEADDR) to the region. If XPEA5 = 1, the XPEADDR field maps to that region. See the description of the XPEADDR field for more information. If this region is not present, the field is locked to 0. 0b - Address accessed is not from region 5 1b - Address accessed is from region 5
23 XPEA4	Express Program Address Region 4 Qualifies the address field (XPEADDR) to the region. If XPEA4 = 1, the XPEADDR field maps to that region. See the description of the XPEADDR field for more information. If this region is not present, the field is locked to 0. 0b - Address accessed is not from region 4 1b - Address accessed is from region 4
22 XPEA3	Express Program Address Region 3 Qualifies the address field (XPEADDR) to the region.

Table continues on the next page...

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Field	Function
	If XPEA3 = 1, the XPEADDR field maps to that region. See the description of the XPEADDR field for more information. If this region is not present, the field is locked to 0. 0b - Address accessed is not from region 3 1b - Address accessed is from region 3
21 XPEA2	Express Program Address Region 2 Qualifies the address field (XPEADDR) to the region. If XPEA2 = 1, the XPEADDR field maps to that region. See the description of the XPEADDR field for more information. If this region is not present, the field is locked to 0. 0b - Address accessed is not from region 2 1b - Address accessed is from region 2
20 XPEA1	Express Program Address Region 1 Qualifies the address field (XPEADDR) to the region. If XPEA1 = 1, the XPEADDR field maps to that region. See the description of the XPEADDR field for more information. If this region is not present, the field is locked to 0. 0b - Address accessed is not from region 1 1b - Address accessed is from region 1
19 XPEA0	Express Program Address Region 0 Qualifies the address field (XPEADDR) to the region. If XPEA0 = 1, the PEADDR field maps to that region. See the description of the XPEADDR field for more information. If this region is not present, the field is locked to 0. 0b - Address accessed is not from region 0 1b - Address accessed is from region 0
18-5 XPEADDR	Express Program Address The XPEADDR register provides offset address location to be programmed. This address is always a quad page address that selects 1024 bits. The XPEADDR register is read only in user mode and represents the flash physical address status. XPEADDR may be updated once (and only once) per Express Program event. XPEADDR writes initiate an Express Program request. XPEADDR may be updated four times between reset events. Upon completing the fourth Express Program request (clearing of XPGM register), the XPEADDR register will return to all zeros, and remain locked from future XPEADDR updates and thus future Express Program requests will be ignored until the next reset. Once XPEADDR is updated, it will be locked for the full express program operation, until XMCR[XPGM] is cleared at the end of the operation. Writing of XPEADDR has the effect of blocking other registers used for program and erase to be written (PEADR/MCR registers as well as APEADR/APDATA/AMCR registers) until the express program operation is completed.

Table continues on the next page...

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Field	Function
	Upon completion of an Express Program operation (XMCR[XPGM] written to 0) the XPEADR registers will return to an all zeros state. When UT0[UTE] is set or XMCR[XEHV] is set, XPEADDR bits will not be writeable. Once XPEADDR is updated, it will have read restrictions based on the PEID master that did the original write in the Platform Flash Controller. XPEADDR[18:5] is an offset from a base address of 0h for each block region. The XPEA0, XPEA1, XPEA2, XPEA3, XPEA4 and XPEA5 qualify the block size region the XPEADDR field.
4-0 —	Reserved Reserved; reset to 0

20.7.1.26 Program Data (DATA0 - DATA31)

Offset

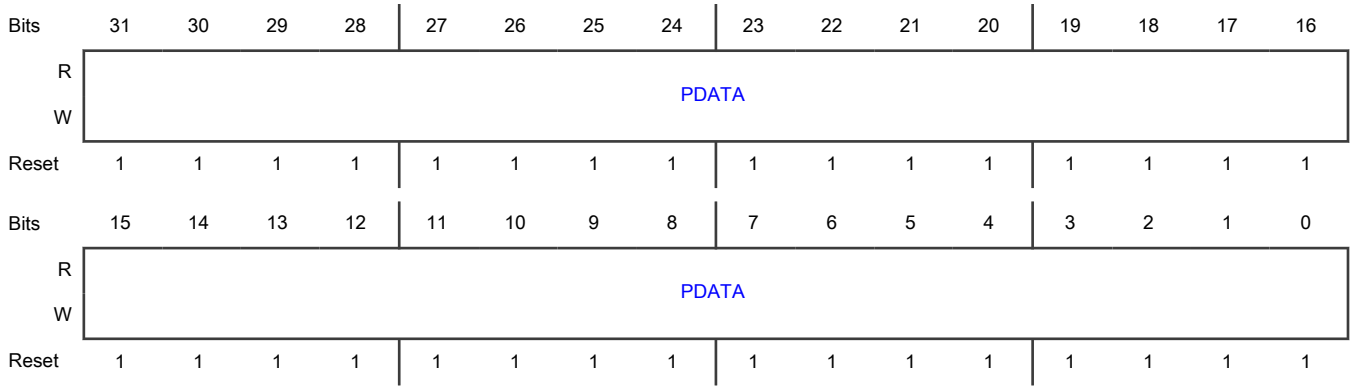
For a = 0 to 31:

Register	Offset
DATAa	100h + (a × 4h)

Function

Enables data to be provided for program (or express program). This set of 32 data registers enables 1024 bits of data to be programmed.

Diagram



Fields

Field	Function
31-0	Program Data

Table continues on the next page...

Field	Function
PDATA	PDATA registers will reset to all ones. PDATA is not writable before PEADR is written or updated to start a program, express program, erase or UTest operation, and will read a value of all ones. Once PEADR is written, all PDATA registers will be made available for writing. Writing (and reading) of the PDATA registers will be restricted to the master that updated the PEADR register as captured in the PEID register. **NOTE** PDATA restrictions related to PEID will be disabled if UT0[UTE] is set. **NOTE** For Express Program a similar behavior exists on the PDATA registers. Once XPEADR is written, and XDOK comes back as a 1, all PDATA registers will switch to all 1's (program safe state) and be made available for writing (and reading) to the master's ID that matches XPEID captured during the XPEADR update. In the event of an interrupted operation, XPEID permissions will override PEID permissions until the express program operation is completed (XPGM written to a 0). Upon completion of an operation (Program (MCR[PGM] written to 0 and MCRS[PES] equals 0), Erase (MCR[ERS] written to 0 and MCRS[PES] equals 0), Express Program (XMCR[XPGM] written to 0), Array Integrity (UT0[AIE] written to 0), User Margin Read(UT0[AIE] written to 0)) or Program and Erase Sequence clear (MCRS[PES] written to 0) the PDATA registers will return to an all ones state. When UT0[AIE] is set, PDATA bits will not be writeable. When MCRS[PES] is set, PDATA bits will not be writeable except when an express program request occurs and XMCR[XDOK] is set. Also, when MCR[PGM] or MCR[ERS] are set, PDATA bits will not be writeable except when an express program request occurs and XMCR[XDOK] is set. When an express program operation is in process, PDATA bits will not be writeable once XMCR[XEHV] is set until XMCR[XPGM] is cleared. Only PDATA Bits that are written will receive program or express program pulses.

20.8 Glossary

Abort Premature end of a mode, sequence, state or operation. An abort may leave the embedded flash memory in a state in which it contains indeterminate or corrupted data.

BIU Bus interface unit(Contains all system-level customization required to make the embedded flash memory part of an SoC)

Block Subdivision of the Flash Module containing NVM memory bits. Block sizes range from 256KB to 2MB. Each block is made up of 8KB sectors.

Double word Two words, or 64 bits.

ECC Error correction code(Internally used to correct single bit errors, or detect double errors within a 64-bit double word.)

ECC segment 64 bit double word, representing the size of data used to calculate ECC information.

EDC Error detection code

FC Flash memory core

FMU	Flash Management Unit - Logic that enables program, erase, read, and other flash functions.
Interlock Write	A write to the PEADR register followed by a write to any DATA register performed while initiating a program, erase, array integrity, or user margin read sequence. Interlock in cleared once the operation is finished by clearing the appropriate control bit, causing PEADR register to clear.
MCU	Microcontroller unit
Module	Flash memory instance that contains flash block(s), FMU, and required analog support structures.
NVM	Nonvolatile memory
OTP	One time programmable
PFC	Platform flash memory controller(Contains all system-level customization required to make the embedded flash memory part of an SoC)
Page	8 words of data (256 bits). When doing reads to the embedded flash memory, this is the width of data read. Up to 4 pages can be programmed at a time.
Partition	Subdivision of the Flash Module. Used for read-while-write operation, where addresses in the partition being written may not be read. Partitions is always equal to 1 block, and contains multiple sectors.
RWW	Read-while-write (operation)
Sector	Subdivision of the Flash Block that is independently erasable. Sector Size is always 8 KB.
Super sector	Subdivision of the flash block that includes a group of sectors. Super Sector Size is always 64 KB, and consists of 8 sectors.
SoC	System-on-chip
UTest NVM sector	8 KB sector outside the main address space
Word	32 bits

Chapter 21
Flash Memory Controller (PFLASH)

21.1 Chip-specific PFLASH information

21.1.1 Flash memory architecture

The flash memory on the chip consists of a flash memory controller and a flash memory array module. The flash memory controller provides flash–memory configuration and control functions and manages the interface between the flash memory array and the chip's crossbar switch.

This chip implements three 64-bit AHB buses.

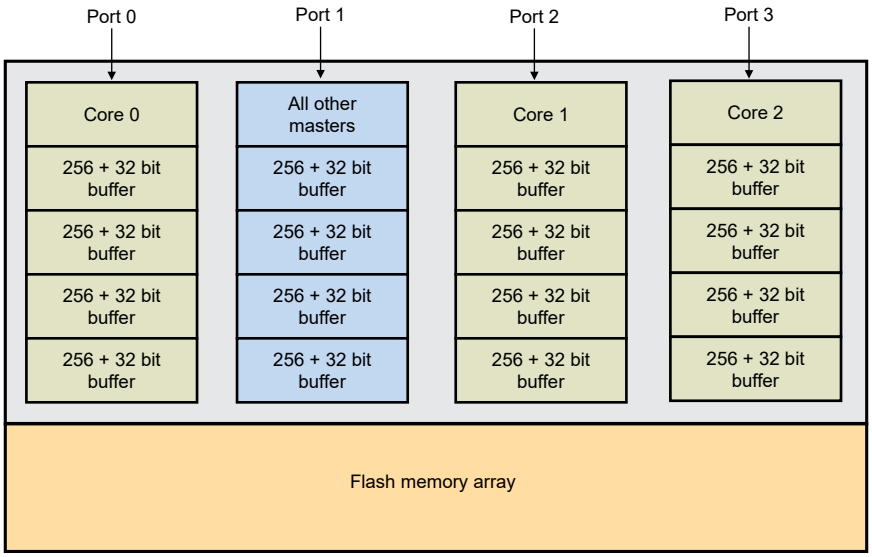


Figure 47. Flash memory architecture

21.1.2 Flash memory controller

The flash memory controller:

- Acts as an interface between the system bus and flash memory array.
- Four port controller with a dedicated line buffering per port and per master ID. This enables you to use the line buffers more efficiently because various masters have dedicated buffers that are not compromised when other masters perform read operations.

Also, by having separate ports, you can have separate connections for each CPU instruction bus and a single port for all data accesses as shown in Figure 47.

In general, the flash memory controller registers affect the global flash memory behavior (for example, read buffering and access control).

21.1.3 Platform flash configuration registers (PFCR*n*)

The table below defines the PFCR*n* fields that the chip uses.

Table 84. Platform flash configuration registers (PFCR*n*)

Master	Buffer enable field	Prefetch enable field
Cortex–M7_0	P0_CBFEN, P0_DBFEN	P0_CPFEN, P0_DPFEN
eDMA + HSE_B + EMAC+eDMA1+Zipwire	P1_CBFEN, P1_DBFEN	P1_CPFEN, P1_DPFEN
Cortex–M7_1	P2_CBFEN, P2_DBFEN	P2_CPFEN, P2_DPFEN
Cortex–M7_2	P3_CBFEN, P3_DBFEN	P3_CPFEN, P3_DPFEN

21.1.4 Platform flash access protection register (PFAPR)

This table defines the PFAPR[M*n*AP] fields that the chip uses. This chip does not use the other master access protection fields, but those fields are readable and writable.

Table 85. Platform flash access protection register (PFAPR)

Master ID	Master name	Access protection field
0x00	Cortex-M7_0	M0AP
0x01	Cortex-M7_1	M1AP
0x02	eDMA	M2AP
0x03	HSE	M3AP
0x04	EMAC	M4AP
0x05	Zipwire	M5AP
0x06	eDMA1	M6AP
0x07	Cortex-M7_2	M7AP
0x08	Reserved	
0x09		
0x0a		
0x0b		

21.2 Overview

PFLASH acts as an interface between the system bus (AHB-Lite 2.v6) and flash memory array.

PFLASH supports three 64-bit AHB buses and a 256-bit read data interface from each flash memory array. The slave port assignments and buffer organization are organized to offer maximum performance of code execution in a multicore architecture. The buffer mechanism serves to deliver flash memory read data with zero-wait state response on lines that reside in cache. AHB requests that miss the prefetch cache generate the needed flash memory array access and are forwarded to the AHB upon completion. Each cache entry is 256 bits, matching the flash memory array page size and providing 512 bytes of high-speed local storage.

21.2.1 Block diagrams

The following figure provides a block diagram showing PFLASH and the attached flash memory array.

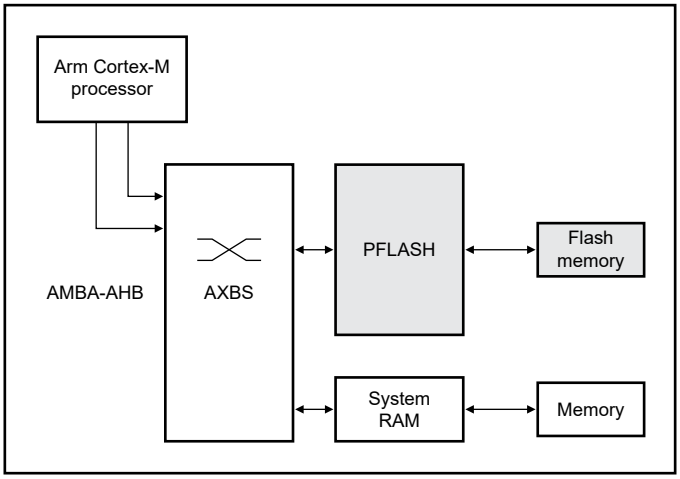


Figure 48. Platform-centric simple block diagram with PFLASH

21.2.2 Features

- Four 64-bit AHB interface ports (p0, p1, p2, p3) allowing simultaneous access to dedicated prefetch mini-cache per slave port
- 256-bit read data bus and 64-bit write data bus
- Configurable read buffering and line prefetching support via a mini-cache, plus a prefetch controller for each AHB port to provide single-cycle buffer hit read response
- Configurable access control based on read/write and AHB master ID attributes
- Support for reporting single-bit and multi-bit flash memory ECC events on a 64-bit doubleword boundary

21.3 Functional description

As shown in Figure 48, PFLASH interfaces between:

- The AHB system bus port
- The flash memory array

For accesses targeting flash memory, the PFLASH generates as inputs to the flash memory array:

- Read and write enables
- Block selects
- Array address
- Write size
- Write data

PFLASH captures read data from the flash memory array and drives it onto the AHB system bus. Up to four pages of data (256-bit page size) may be buffered in each prefetch buffer for AHB Port0, Port1, and Port2. and Port 3. Lines may be prefetched in advance of being requested, allowing single-cycle (zero AHB wait-states) read data responses on buffer hits.

Access protections may be applied on a per-master basis for both reads and writes to support security and privilege mechanisms.

21.3.1 Read transactions

On an incoming AHB read request, a mini-cache lookup and access privilege evaluation are performed during the AHB address phase. If a buffer hit occurs, the requested data is retrieved from the previously loaded prefetch buffer entry and returned on the system bus with a zero wait-state response. If a buffer miss occurs, a flash memory access is initiated.

Read accesses are terminated under control of the appropriate wait state settings. Access timing can be varied to account for the operating conditions of the chip (for example, frequency, voltage, temperature, and so on) by appropriately setting the read wait state field in flash memory.

21.3.2 Write transactions

An interlock write on a program or erase sequence is initiated by first writing to Platform Flash Memory Program Erase Address Logical (PFCPGM_PEADR_L), Platform Flash Memory Express Program Erase Address Logical (PFCPGM_XPEADR_L)(see the Flash Memory chapter for write sequence details).

21.3.3 Access protections

21.3.3.1 PFAPR

PFLASH provides programmable, configurable access protections for read cycles on a per-master basis in PFAPR[M*n*AP]. This field restricts read access on a per-master basis. This functionality is described in Platform Flash Memory Access Protection (PFAPR). Detection of a protection violation based on PFAPR settings results in an error response from PFLASH on the AHB transfer.

21.3.4 Error termination

PFLASH can invoke a system bus error termination in the following scenarios:

- Access privilege violation (see Access protections for details)
- Attempted access by an AHB master to a reserved region in the flash memory map
- Multi-bit ECC error detection on AHB read, and PFCR4[DMEEE] = 0 (for data flash memory, it is further qualified by PFCR4[DERR_SUP] = 0)

21.3.5 Line read buffers and prefetch operation

The PFLASH AHB ports of the a mini-cache. PFLASH uses the buffers for both prefetch and normal demand fetches. Also, the buffers are shared for code and data fetches, and can be controlled independently for code and data from control registers.

Prefetch triggering is controllable on a per-port basis. A PFLASH read access may trigger a prefetch to the next sequential line of array data on the cycle following the request. The access address is incremented by 32 bytes, and a subsequent flash memory access is initiated. A flash memory array prefetch is initiated if the data is not already resident in a line read buffer. Prefetched data is always loaded into the least-recently-used buffer.

For Port0, Port1, and Port2 there are four line buffer entries in their respective prefetch mini-caches that follow a fully associative, least-recently-used replacement policy. Port 3 configuration is the same as other ports.

For prefetching to occur, you must set the following configuration fields, where *n* corresponds to the port number and *m* corresponds to *C* (code) or *D* (data):

PFCRn[Pn_mBFEN] = 1 and PFCRn[Pn_mPFEN] = 1

21.3.6 Array integrity considerations

During an array integrity sequence, the flash memory array ignores any incoming read requests. When a flash memory array integrity check is in progress, PFLASH terminates all flash memory access requests with an error. More specifically, it aborts the incoming flash memory access requests and terminates the system bus transfer with an error.

21.3.7 Safety considerations

21.3.7.1 Flash memory address generation check

Functional safety coverage of the address path and control within PFLASH rely on a feedback path between PFLASH and flash memory. Remember that on a requested access to flash memory, PFLASH must decode the system AHB bus signals to generate the corresponding flash memory interface signals to invoke a flash memory lookup. In addition to providing the requested read data, the flash memory also provides output sidebands reflecting the encoded address and block selects used to perform the actual row lookup.

PFLASH uses this sideband information to verify the expected transaction. If a mismatch is detected, indicating a failure in the address generation or control logic within PFLASH or the transmission path between PFLASH and the flash memory array, then the event is forwarded to the chip fault collection module and the corresponding buffer is invalidated.

21.3.8 ECC error handling on data flash block

When PFCR4[DERR_SUP] is enabled, ECC errors on data flash blocks are handled specially.

If there is a noncorrectable error detection, a fixed, illegal opcode value is returned to the requesting master along with the associated ECC checkbits as determined by the requesting address.

For noncorrectable error detection, PFLASH returns a value of 1555_1555h to the requesting master.

This is mainly used for EEPROM emulation applications.

21.3.9 Read cycles—buffer miss

On an incoming AHB read request, a mini-cache lookup and access privilege evaluation are performed during the AHB address phase. If a buffer miss occurs, a flash memory access is initiated.

If the flash memory access was the direct result of an AHB transaction, the corresponding page buffer is loaded and marked as the most-recently-used. If the flash memory access was the result of a speculative prefetch to the next sequential line, it is loaded into the least-recently-used buffer. The status of this buffer is not changed to most-recently-used until a subsequent buffer hit occurs as a result of an AHB read request.

21.3.10 Read cycles—buffer hit

PFLASH allows single-cycle read responses to the AHB when the requested read access was previously loaded into one of the page buffers. In these cases of a buffer hit, read data is returned on the system bus with a zero wait-state response.

21.3.11 Flash memory error response operation

The flash memory array may signal an error response to terminate a requested access because of improper sequencing during program/erase operations and improper sequencing during array integrity testing. When an error response is received, PFLASH does not update or validate a page read buffer. An error response may be signaled on a read or interlock write operation. For more information on the specifics related to signaling of flash memory errors, including flash memory ECC events, array integrity testing, and read-while-write events, see the flash memory chapter.

21.3.12 Clocking

This module has no clocking considerations.

21.3.13 Interrupts

This module has no interrupts.

21.4 External signals

This module has no external signals.

21.5 PFLASH register descriptions

PFLASH provides an IPS programming model mapped to a standard 16 KB on-platform peripheral slot. The programming model consists of flash memory access configuration.

You can reference the programming model only by using a 32-bit (word) access. References that are attempted using different access sizes, or to undefined (reserved) addresses, or in User mode generate an IPS error termination. PFLASH allows access to the programming model by all system bus masters.

Write to read only registers don't generate error termination.

You can only access the programming model in Supervisor mode, except *PEADR* registers which can be accessed in Supervisor or User mode.

Attempted updates to the programming model when PFLASH is in the middle of an operation results in non-deterministic behavior. You must architect software to avoid this scenario. The recommended flow for multicore devices is:

1. Start only one core.
2. Execute initialization code until it is complete.
3. Start the remaining cores.

If you need to reconfigure the flash memory, code execution must be temporarily moved to system RAM.

21.5.1 PFLASH memory map

PFLASH base address: 4026_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Platform Flash Memory Configuration 0 (PFCR0)	32	RW	0000_0003h
4h	Platform Flash Memory Configuration 1 (PFCR1)	32	RW	0000_0003h
8h	Platform Flash Memory Configuration 2 (PFCR2)	32	RW	0000_0003h
Ch	Platform Flash Memory Configuration 3 (PFCR3)	32	RW	0000_0003h
10h	Platform Flash Memory Configuration 4 (PFCR4)	32	RW	0000_0000h
14h	Platform Flash Memory Access Protection (PFAPR)	32	RW	FFFF_FFFFh
300h	Platform Flash Memory Program Erase Address Logical (PFCPGM_PEADR_L)	32	RW	0000_0000h
304h	Platform Flash Memory Program Erase Address Physical (PFCPGM_PEADR_P)	32	R	0000_0000h
308h	Platform Flash Memory Express Program Erase Address Logical (PFCPGM_XPEADR_L)	32	RW	0000_0000h
30Ch	Platform Flash Memory Express Program Erase Address Physical (PFCPGM_XPEADR_P)	32	R	0000_0000h
340h - 34Ch	Block n Sector Program Erase Lock (PFCBLK0_SPELOCK - PFCBLK3_SPELOCK)	32	RW	FFFF_FFFFh
358h	Block UTEST Sector Program Erase Lock (PFCBLKU_SPELOCK)	32	RW	0000_0001h
35Ch - 364h	Block n Super Sector Program Erase Lock (PFCBLK0_SSPELOCK - PFCBLK2_SSPELOCK)	32	RW	0FFF_FFFFh

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Offset	Register	Width (In bits)	Access	Reset value
380h - 38Ch	Block n Set Sector Lock (PFCBLK0_SETSLOCK - PFCBLK3_SETSLOCK)	32	RW	0000_0000h
398h	Block UTEST Set Sector Lock (PFCBLKU_SETSLOCK)	32	RW	0000_0000h
39Ch - 3A4h	Block n Set Super Sector Lock (PFCBLK0_SSETSLOCK - PFCBLK2_SSETSLOCK)	32	RW	0000_0000h
3C0h - 43Ch	Block a Lock Master Sector b (PFCBLK0_LOCKMASTER_S0 - PFCBLK3_LOCKMASTER_S7)	32	R	FFFF_FFFFh
480h	Block UTEST Lock Master Sector (PFCBLKU_LOCKMASTER_S)	32	R	0000_00FFh
484h - 4D4h	Block m Lock Master Super Sector n (PFCBLK0_LOCKMASTER_SS0 - PFCBLK2_LOCKMASTER_SS6)	32	R	FFFF_FFFFh

21.5.2 Platform Flash Memory Configuration 0 (PFCR0)

Offset

Register	Offset
PFCR0	0h

Function

Specifies the operation of PFLASH Port0.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0										P0_DP FEN	P0_CP FEN	0		P0_DB FEN	P0_CB FEN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-6 —	Reserved
5 P0_DPFEN	Port0 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port0. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P0_CPFEN	Port0 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port0. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P0_DBFEN	Port0 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable
0 P0_CBFEN	Port0 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.5.3 Platform Flash Memory Configuration 1 (PFCR1)

Offset

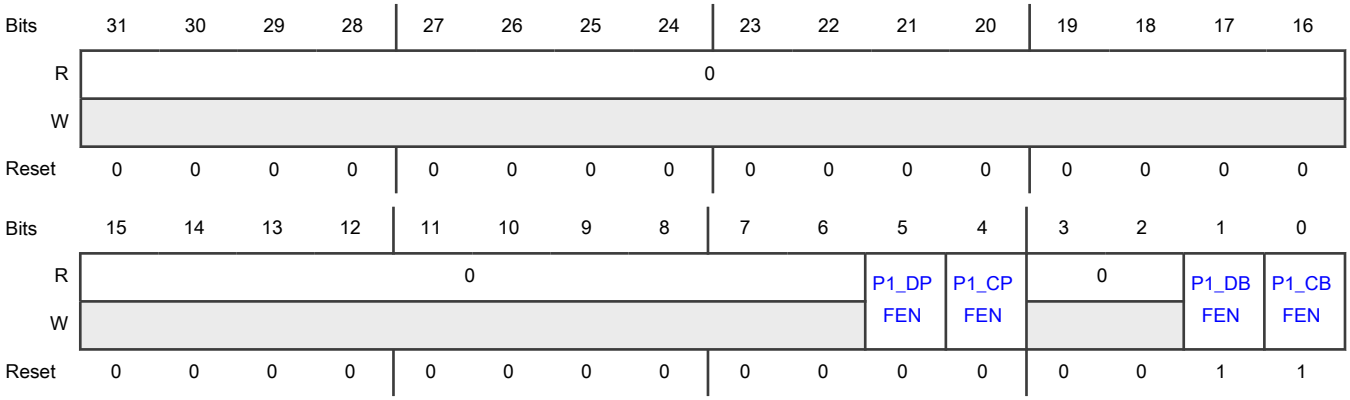
Register	Offset
PFCR1	4h

Function

Specifies the operation of PFLASH Port1.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 P1_DPFEN	Port1 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port1. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P1_CPFEN	Port1 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port1. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P1_DBFEN	Port1 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled.

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Field	Function
	0b - Disable 1b - Enable
0 P1_CBFEN	Port1 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.5.4 Platform Flash Memory Configuration 2 (PFCR2)

Offset

Register	Offset
PFCR2	8h

Function

Specifies the operation of PFLASH Port2.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0										P2_DP FEN	P2_CP FEN	0		P2_DB FEN	P2_CB FEN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-6	Reserved

Table continues on the next page...

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Field	Function
—	
5 P2_DPFEN	Port2 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port2. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P2_CPFEN	Port2 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port2. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P2_DBFEN	Port2 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable
0 P2_CBFEN	Port2 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.5.5 Platform Flash Memory Configuration 3 (PFCR3)

Offset

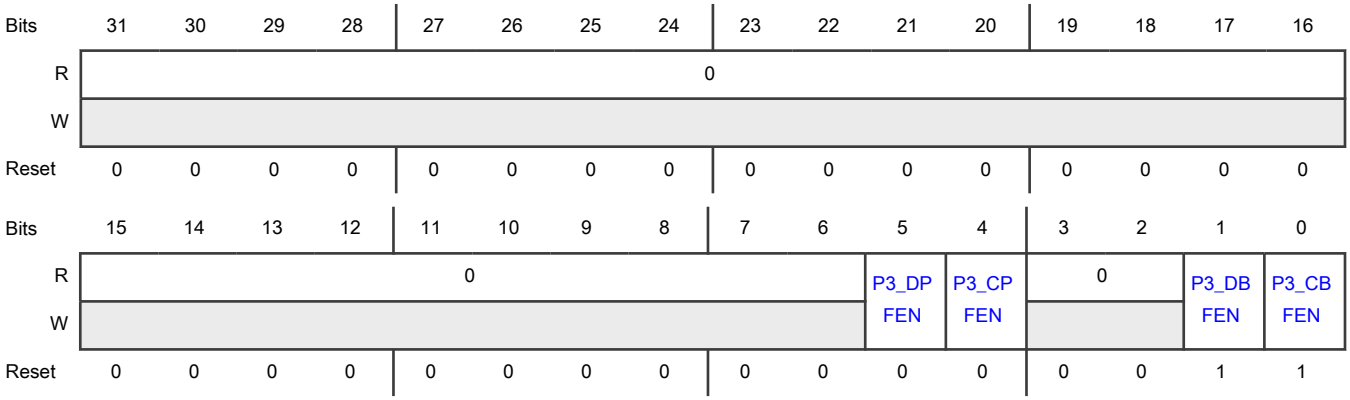
Register	Offset
PFCR3	Ch

Function

Specifies the operation of PFLASH Port3.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 P3_DPFEN	Port3 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port3. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P3_CPFEN	Port3 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port3. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P3_DBFEN	Port3 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled.

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Field	Function
	0b - Disable 1b - Enable
0 P3_CBFEN	Port3 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.5.6 Platform Flash Memory Configuration 4 (PFCR4)

Offset

Register	Offset
PFCR4	10h

Function

Specifies operation of the flash memory controller buffer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								DMEEE	0			BLK4_PS			DERR_SUP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved

Table continues on the next page...

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Field	Function
7 DMEEE	Disable Multi-Bit ECC Error Exception Enables or disables system bus error response on multi-bit ECC error. Hardware reset returns this field to 0. 0b - Error response sent on system bus for multi-bit ECC error 1b - Error response not sent on system bus for multi-bit ECC error
6-4 —	Reserved
3-1 BLK4_PS	Block 4 Pipe Select Selects the active pipe for flash memory block 4 access. PFLASH has four independent command pipes to issue four parallel read commands to different flash memory blocks. Reads from flash memory block 0–3 are always done through command pipe 0–3, respectively. However, the access to block 4 is not fixed and can be through any of the command pipes. You must only change this field when there is no ongoing block 4 access. A special round-robin arbitration scheme snoops the availability of a command pipe during block 4 access. If any of the command pipes are idle during the first read request to block 4, the ownership of that command pipe gets shared between block 4 and the respective block. If none of the command pipes are idle during a block 4 read request, block 4 gets associated with each of the command pipes in round-robin fashion. When a command pipe acquires ownership of block 4, it keeps that ownership until all the commands to block 4 from all the masters are served. 000b - Block 4 access is always through pipe0 001b - Block 4 access is always through pipe1 010b - Block 4 access is always through pipe2 011b - Block 4 access is always through pipe3 1xxb - Block 4 access can be through any of the command pipes, based on which command pipe is available for block 4 access
0 DERR_SUP	Data Error Suppression See the Embedded Flash Memory configuration information or system memory map for which flash memory blocks are affected by this field. 0b - Reports ECC events on data flash memory accesses 1b - Single-bit and multi-bit ECC events on data flash memory accesses are suppressed

21.5.7 Platform Flash Memory Access Protection (PFAPR)

Offset

Register	Offset
PFAPR	14h

Function

Controls read accesses to the flash memory array.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	M0AP		M1AP		M2AP		M3AP		M4AP		M5AP		M6AP		M7AP	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	M8AP		M9AP		M10AP		M11AP		M12AP		M13AP		M14AP		M15AP	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-30: M0AP 29-28: M1AP 27-26: M2AP 25-24: M3AP 23-22: M4AP 21-20: M5AP 19-18: M6AP 17-16: M7AP 15-14: M8AP 13-12: M9AP 11-10: M10AP 9-8: M11AP 7-6: M12AP 5-4: M13AP 3-2: M14AP 1-0: M15AP	Master n Access Protection Controls whether read accesses to the flash memory are allowed based on the master ID of a requesting master. These fields are initialized by hardware reset. The field M4'd3AP is reserved. x0b - This master cannot perform any read accesses x1b - This master can perform read accesses

21.5.8 Platform Flash Memory Program Erase Address Logical (PFCPGM_PEADR_L)

Offset

Register	Offset
PFCPGM_PEADR_L	300h

Function

Provides the flash memory address to be programmed, or the location of the sector or block to be erased through main flash memory (pgm/erase) queue. Write access to this register is domain-ID aware.

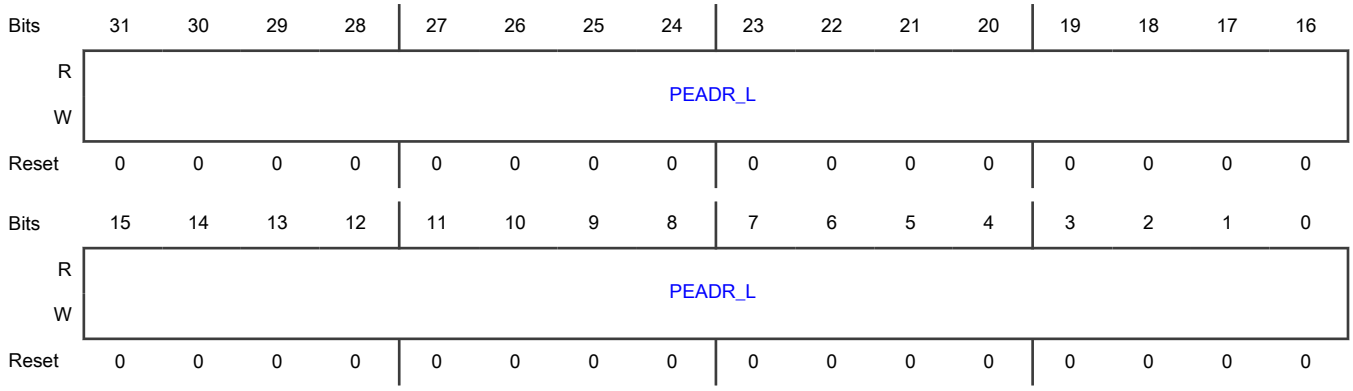
The respective bus master must have program/erase permission to the flash memory address written to this register. Otherwise a transfer error results. For further information on flash memory address restrictions see the XRDC chapter.

A write to this register is managed via three-cycle access. Before updating the register, you must ensure that no ongoing high-voltage operation is executing through the flash memory main queue.

Unauthorized flash memory address writes result in a transfer error.

Writes to this register during an ongoing high-voltage operation (initiated through the flash memory main queue) or during express program operation are ignored.

Diagram



Fields

Field	Function
31-0 PEADR_L	Program Erase Address Logical Contains the system logical address for flash memory program/erase.

21.5.9 Platform Flash Memory Program Erase Address Physical (PFCPGM_PEADR_P)

Offset

Register	Offset
PFCPGM_PEADR_P	304h

Function

Reflects the flash memory block number and offset address corresponding to Platform Flash Memory Program Erase Address Logical (PFCPGM_PEADR_L). This register has the same format as the PEADR register in the Flash Memory chapter—see it for details.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PEADR_P	Program Erase Address Physical Contains the flash block select and offset address for flash memory program/erase.

21.5.10 Platform Flash Memory Express Program Erase Address Logical (PFCPGM_XPEADR_L)

Offset

Register	Offset
PFCPGM_XPEADR_L	308h

Function

Provides the flash memory address to be programmed using the flash memory express program feature. Write access to this register is domain-ID aware.

The respective bus master must have program/erase permission to the flash memory address written to this register. Otherwise a transfer error results. See the XRDC chapter for further information on flash memory address restrictions.

A write to this register is managed via three-cycle access. Before updating the register, you must ensure that no ongoing high-voltage operation is executing through the flash memory main queue.

Unauthorized flash memory address writes result in a transfer error.

Writes to this register during an ongoing express program operation are ignored.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	XPEADR_L															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	XPEADR_L															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 XPEADR_L	Express Program Erase Address Logical Contains the system logical address for express flash program/erase.

21.5.11 Platform Flash Memory Express Program Erase Address Physical (PFCPGM_XPEADR_P)

Offset

Register	Offset
PFCPGM_XPEADR_P	30Ch

Function

Reflects the flash memory block number and offset address corresponding to PFCPGM_XPEADR_L. This register has the same format as the XPEADR register in the Flash Memory chapter—see it for details.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	XPEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	XPEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 XPEADR_P	Express Program Erase Address Physical Contains the flash memory block select and offset address for flash memory express program/erase.

21.5.12 Block n Sector Program Erase Lock (PFCBLK0_SPELOCK - PFCBLK3_SPELOCK)

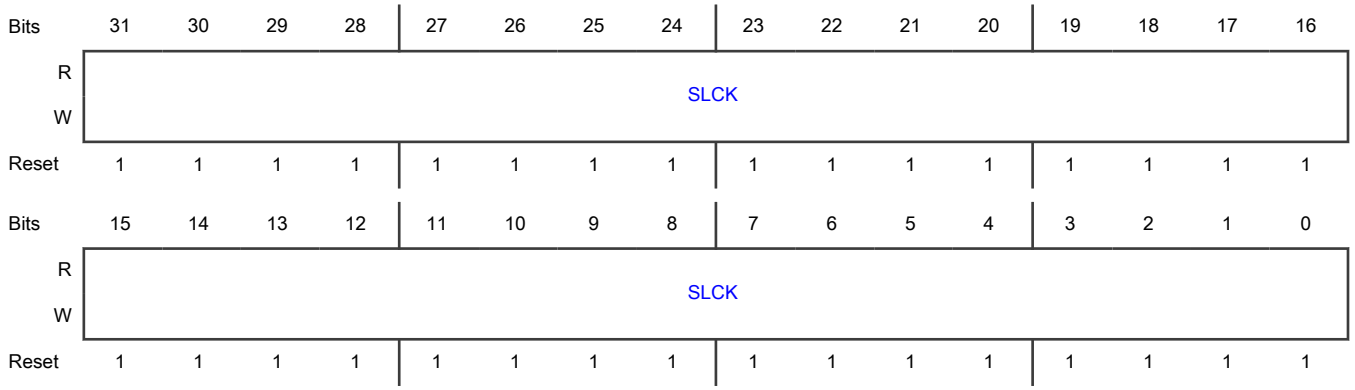
Offset

Register	Offset
PFCBLK0_SPELOCK	340h
PFCBLK1_SPELOCK	344h
PFCBLK2_SPELOCK	348h
PFCBLK3_SPELOCK	34Ch

Function

Provides a way to protect sectors from being modified. Sector protection is available on the last 256 KB of every block (for 256 KB blocks, all sectors are available for protection). Each lock bit can be associated with a particular domain ID by writing 1 to the appropriate bit in PFCBLKn_SETSLOCK[SETSLCK]. After the lock is acquired, only a master having the same domain ID can modify the corresponding lock bit. If the corresponding PFCBLKn_SETSLOCK[SETSLCK] bit is not equal to 1, any master can modify the appropriate SLCK bit. If a lock bit is already acquired by a particular domain ID, any effort to modify (1 to 0, or 0 to 1) the lock bit by a master with a different domain ID results in a transfer error.

Diagram



Fields

Field	Function
31-0 SLCK	Sector Lock Locks selected sector. If vector bit value = 0, the sector is available for program and erase operations. If vector bit value = 1, the sector is locked and not available for program and erase operations.

21.5.13 Block UTEST Sector Program Erase Lock (PFCBLKU_SPELOCK)

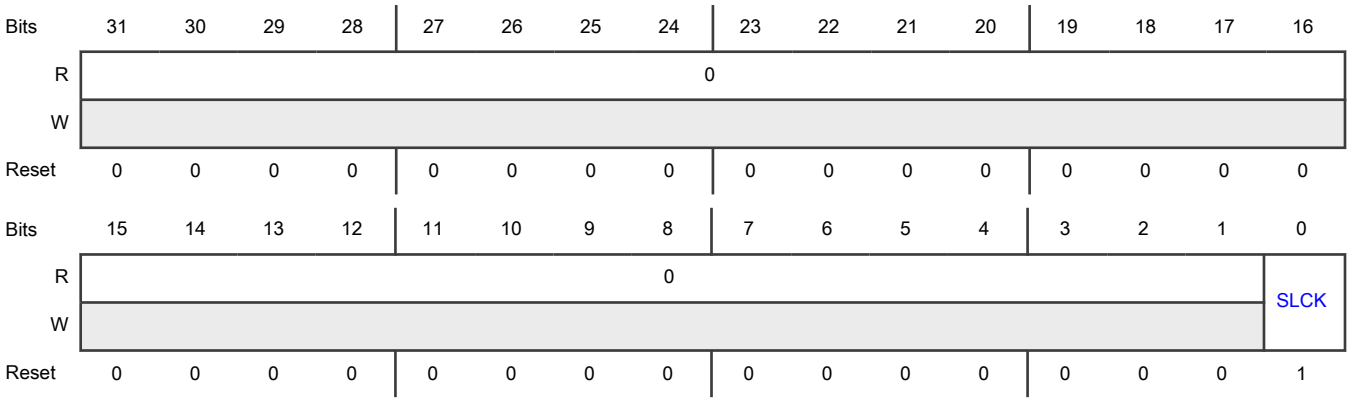
Offset

Register	Offset
PFCBLKU_SPELOCK	358h

Function

Provides a way to protect sectors from being modified. Sector protection is available on the last 256 KB of every block (for 256 KB blocks, all sectors are available for protection). Each lock bit can be associated with a particular domain ID by writing 1 to PFCBLKU_SETSLOCK[SETSLCK]. After the lock is acquired, only a master having the same domain ID can modify the corresponding lock bit. If the corresponding PFCBLKU_SETSLOCK[SETSLCK] bit is not equal to 1, any master can modify the SLCK bit. If a lock bit is already acquired by a particular domain ID, any effort to modify (1 to 0, or 0 to 1) the lock bit by a master with a different domain ID results in a transfer error.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 SLCK	Sector Lock Locks selected sector. If vector bit value = 0, the sector is available for program and erase operations. If vector bit value = 1, the sector is locked and not available for program and erase operations.

21.5.14 Block n Super Sector Program Erase Lock (PFCBLK0_SSPELOCK - PFCBLK2_SSPELOCK)

Offset

Register	Offset
PFCBLK0_SSPELOCK	35Ch

Table continues on the next page...

Table continued from the previous page...

Register	Offset
PFCBLK1_SSPELOCK	360h
PFCBLK2_SSPELOCK	364h

Function

Provides a way to protect super sectors from being modified. Super sector protection is available on block space larger than 256 KB. For 256 KB blocks, this register is not applicable. For 512 KB blocks, the first half of the block is protected with super sector granularity. For 1 MB blocks, the first 768 KB is protected with super sector granularity. Each lock bit can be associated with a particular domain ID by writing 1 to the appropriate bit in PFCBLKn_SSETSLOCK[SSETSLCK]. After the lock is acquired, only a master having the same domain ID can modify the corresponding lock bit. If the corresponding PFCBLKn_SSETSLOCK[SSETSLCK] bit is not equal to 1, any master can modify the SSLCK bit. If a lock bit is already acquired by a particular domain ID, any effort to modify (1 to 0, or 0 to 1) the lock bit by a master with a different domain ID results in a transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SSLCK											
W																
Reset	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SSLCK															
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-28 —	Reserved
27-0 SSLCK	Super Sector Lock Locks selected super sector. If vector bit value = 0, the super sector is available for program and erase operations. If vector bit value = 1, the super sector is locked and not available for program and erase operations.

21.5.15 Block n Set Sector Lock (PFCBLK0_SETSLOCK - PFCBLK3_SETSLOCK)

Offset

Register	Offset
PFCBLK0_SETSLOCK	380h
PFCBLK1_SETSLOCK	384h
PFCBLK2_SETSLOCK	388h
PFCBLK3_SETSLOCK	38Ch

Function

Provides a mechanism for the masters to gain the ownership of the corresponding PFCBLKn_SPELOCK lock bit based on domain id . After it is equal to 1, the bit is returned to 0 at next reset. If any SETSLOCK bit is not equal to 1, the corresponding LOCK bit can be modified by any master. If a bit is already acquired by a particular domain ID, any effort to modify the lock bit by a master with a different domain ID is ignored without transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SETSLCK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SETSLCK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SETSLCK	If the vector bit value = 0, the corresponding lock bit is not owned by any master. If the vector bit value = 1, the lock bit is owned by the masters having the domain ID stored in PFCBLKn_LOCKMASTER_Sm.

21.5.16 Block UTEST Set Sector Lock (PFCBLKU_SETSLOCK)

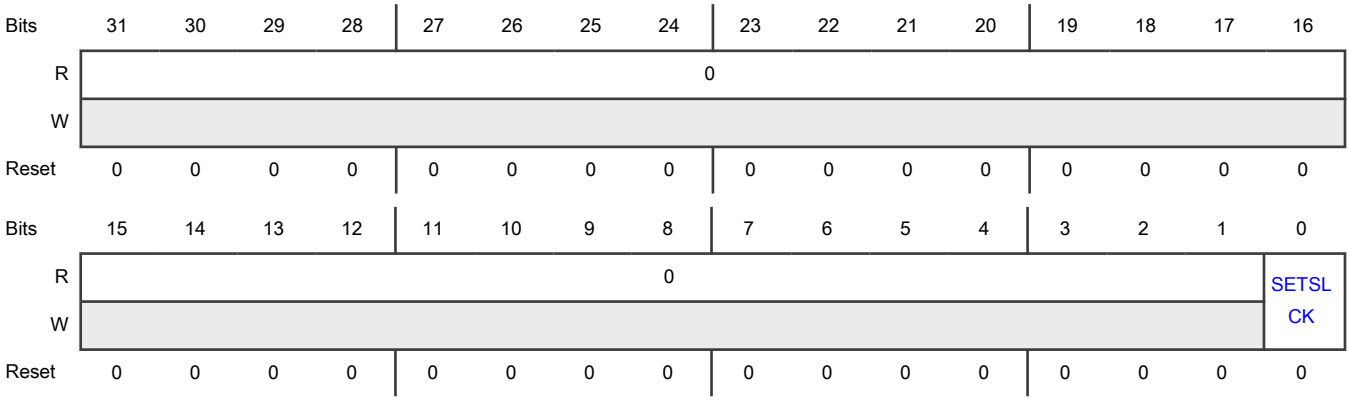
Offset

Register	Offset
PFCBLKU_SETSLOCK	398h

Function

Provides a mechanism for the masters to gain ownership of the corresponding PFCBLKU_SPELOCK lock bit based on domain id. After it is equal to 1, the bit is returned to 0 at next reset. If any SETSLOCK bit is not equal to 1, the corresponding LOCK bit can be modified by any master. If a bit is already acquired by a particular domain ID, any effort to modify the lock bit by a master with a different domain ID is ignored without transfer error.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 SETSLCK	Set Sector Lock Locks selected sector. If vector bit value = 0, the corresponding lock bit is not owned by any master. If vector bit value = 1, the lock bit is owned by the masters having the domain ID stored in PFCBLKn_LOCKMASTER_SSm.

21.5.17 Block n Set Super Sector Lock (PFCBLK0_SSETSLOCK - PFCBLK2_SSETSLOCK)

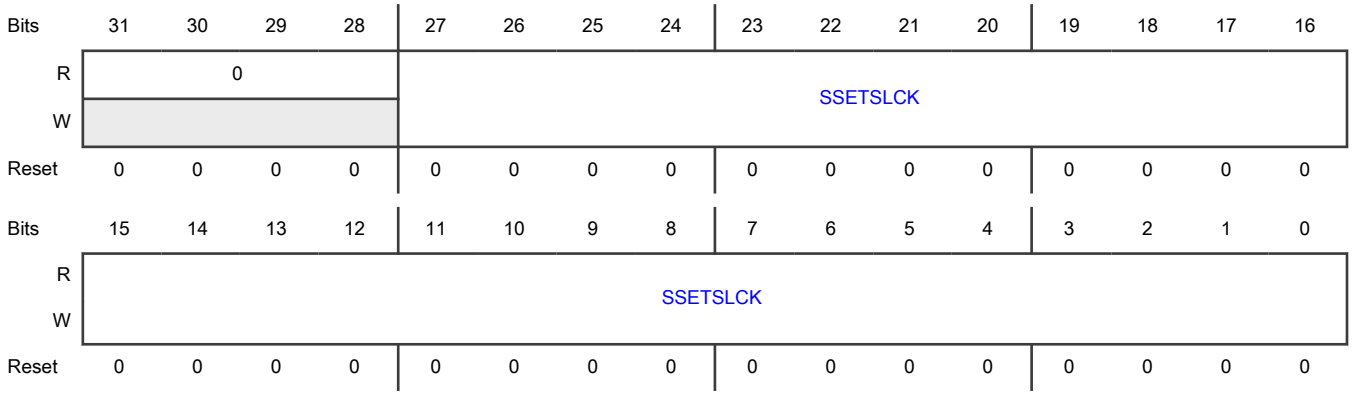
Offset

Register	Offset
PFCBLK0_SSETSLOCK	39Ch
PFCBLK1_SSETSLOCK	3A0h
PFCBLK2_SSETSLOCK	3A4h

Function

Provides a mechanism for the masters to gain ownership of the corresponding PFCBLKn_SPELOCK lock bit based on domain id. After it is equal to 1, the bit is returned to 0 at next reset. If any SSETSLOCK bit is not equal to 1, the corresponding LOCK bit can be modified by any master. If a bit is already acquired by a particular domain ID, any effort to modify the lock bit by a master with a different domain ID is ignored without transfer error.

Diagram



Fields

Field	Function
31-28 —	Reserved
27-0 SSETSLCK	Set Super Sector Lock Locks selected super sector. If vector bit value = 0, the corresponding lock bit is not owned by any master. If vector bit value = 1, the lock bit is owned by the masters having the domain ID stored in Block a Lock Master Sector b (PFCBLK0_LOCKMASTER_S0 - PFCBLK3_LOCKMASTER_S7).

21.5.18 Block a Lock Master Sector b (PFCBLK0_LOCKMASTER_S0 - PFCBLK3_LOCKMASTER_S7)

Offset

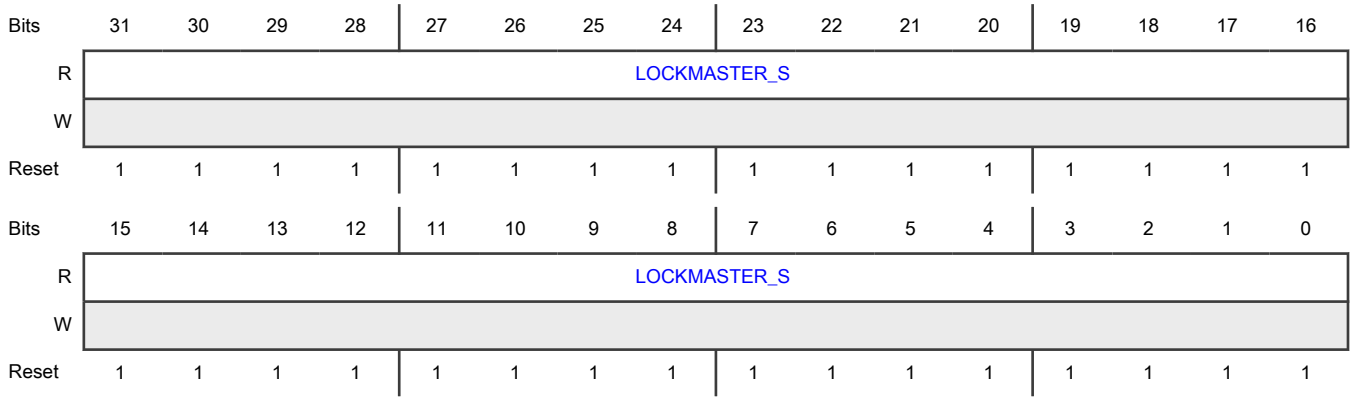
For a = 0 to 3; b = 0 to 7:

Register	Offset
PFCBLKa_LOCKMASTER_Sb	3C0h + (a × 20h) + (b × 4h)

Function

Provides the domain ID information of the master currently acquiring the lock bit. The domain ID is represented by an 8-bit field. This is a read-only register.

Diagram



Fields

Field	Function
31-0 LOCKMASTER_S	Block a Lock Master Sector b Contains domain ID of the master currently acquiring the lock bit. PFCBLK0_LOCKMASTER_S0[LOCKMASTER_S[7:0]] holds the domain ID information of PFCBLK0_SPELOCK[0]. PFCBLK0_LOCKMASTER_S0[LOCKMASTER_S[15:8]] holds the domain ID information of PFCBLK0_SPELOCK[1], and so on in incremental order.

21.5.19 Block UTEST Lock Master Sector (PFCBLKU_LOCKMASTER_S)

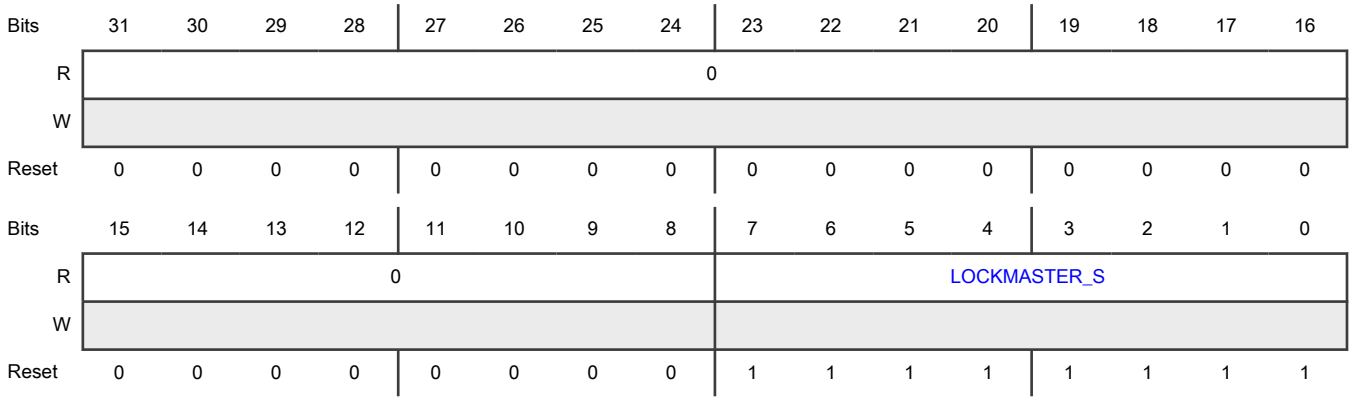
Offset

Register	Offset
PFCBLKU_LOCKMASTER_S	480h

Function

Provides the domain ID information of the master currently acquiring the lock bit. The domain ID is represented by an 8-bit field. This is a read-only register.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 LOCKMASTER_S	Lock Master Sector Contains domain ID of the master currently acquiring the lock bit. PFCBLKU_LOCKMASTER_S[LOCKMASTER_S[7:0]] holds the domain ID information of PFCBLKU_SPELOCK[0].

21.5.20 Block m Lock Master Super Sector n (PFCBLK0_LOCKMASTER_SS0 - PFCBLK2_LOCKMASTER_SS6)

Offset

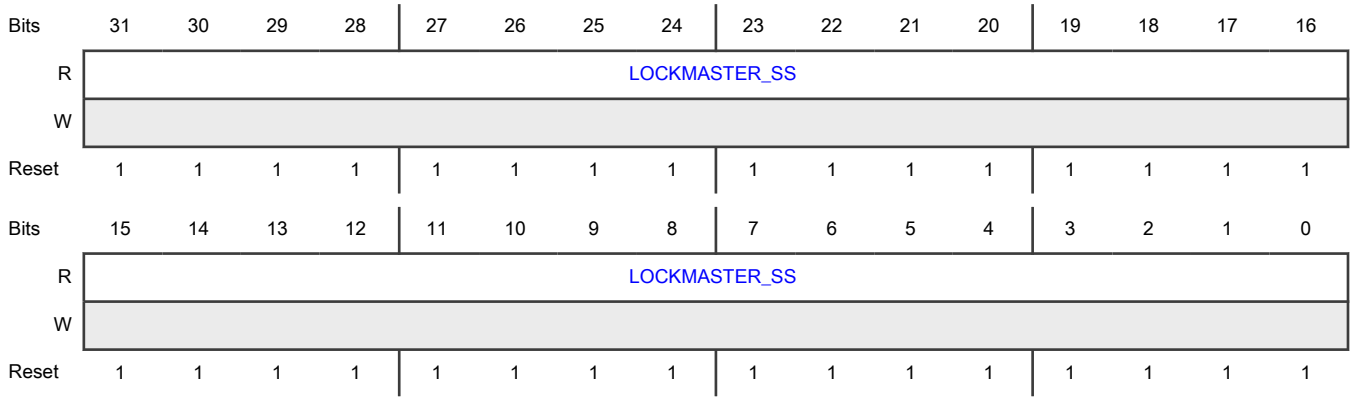
For a = 0 to 2; b = 0 to 6:

Register	Offset
PFCBLKa_LOCKMASTER_SSb	484h + (a × 1Ch) + (b × 4h)

Function

Provides the domain ID information of the master currently acquiring the lock bit. The domain ID is represented by an 8-bit field. This is a read-only register.

Diagram



Fields

Field	Function
31-0 LOCKMASTER_SS	Block a Lock Master Super Sector b Contains domain ID of the master currently acquiring the lock bit. PFCBLK0_LOCKMASTER_SS0[LOCKMASTER_SS[7:0]] holds the domain ID information of PFCBLK0_SSPELOCK[0]. PFCBLK0_LOCKMASTER_SS0[LOCKMASTER_SS[15:8]] holds the domain ID information of PFCBLK0_SSPELOCK[1], and so on in incremental order.

21.6 PFLASH register descriptions

PFLASH provides an IPS programming model mapped to a standard 16 KB on-platform peripheral slot. The programming model consists of flash memory access configuration.

You can reference the programming model only by using a 32-bit (word) access. References that are attempted using different access sizes, or to undefined (reserved) addresses, or in User mode generate an IPS error termination. PFLASH allows access to the programming model by all system bus masters.

Write to read only registers don't generate error termination.

You can only access the programming model in Supervisor mode, except *PEADR* registers which can be accessed in Supervisor or User mode.

Attempted updates to the programming model when PFLASH is in the middle of an operation results in non-deterministic behavior. You must architect software to avoid this scenario. The recommended flow for multicore devices is:

1. Start only one core.
2. Execute initialization code until it is complete.
3. Start the remaining cores.

If you need to reconfigure the flash memory, code execution must be temporarily moved to system RAM.

21.6.1 PFLASH memory map

PFLASH_ALT base address: 4026_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Platform Flash Memory Configuration 0 (PFCR0)	32	RW	0000_0003h
4h	Platform Flash Memory Configuration 1 (PFCR1)	32	RW	0000_0003h
8h	Platform Flash Memory Configuration 2 (PFCR2)	32	RW	0000_0003h
Ch	Platform Flash Memory Configuration 3 (PFCR3)	32	RW	0000_0003h
10h	Platform Flash Memory Configuration 4 (PFCR4)	32	RW	0000_0000h
14h	Platform Flash Memory Access Protection (PFAPR)	32	RW	FFFF_FFFFh
300h	Platform Flash Memory Program Erase Address Logical (PFCPGM_PEADR_L)	32	RW	0000_0000h
304h	Platform Flash Memory Program Erase Address Physical (PFCPGM_PEADR_P)	32	R	0000_0000h
308h	Platform Flash Memory Express Program Erase Address Logical (PFCPGM_XPEADR_L)	32	RW	0000_0000h
30Ch	Platform Flash Memory Express Program Erase Address Physical (PFCPGM_XPEADR_P)	32	R	0000_0000h
340h - 34Ch	Block n Sector Program Erase Lock (PFCBLK0_SPELOCK - PFCBLK3_SPELOCK)	32	RW	FFFF_FFFFh
358h	Block UTEST Sector Program Erase Lock (PFCBLKU_SPELOCK)	32	RW	0000_0001h
35Ch - 364h	Block n Super Sector Program Erase Lock (PFCBLK0_SSPELOCK - PFCBLK2_SSPELOCK)	32	RW	0FFF_FFFFh
380h - 38Ch	Block n Set Sector Lock (PFCBLK0_SETSLOCK - PFCBLK3_SETSLOCK)	32	RW	0000_0000h
398h	Block UTEST Set Sector Lock (PFCBLKU_SETSLOCK)	32	RW	0000_0000h
39Ch - 3A4h	Block n Set Super Sector Lock (PFCBLK0_SSETSLOCK - PFCBLK2_SSETSLOCK)	32	RW	0000_0000h
3C0h - 43Ch	Block a Lock Master Sector b (PFCBLK0_LOCKMASTER_S0 - PFCBLK3_LOCKMASTER_S7)	32	R	FFFF_FFFFh
480h	Block UTEST Lock Master Sector (PFCBLKU_LOCKMASTER_S)	32	R	0000_00FFh
484h - 4D4h	Block m Lock Master Super Sector n (PFCBLK0_LOCKMASTER_SS0 - PFCBLK2_LOCKMASTER_SS6)	32	R	FFFF_FFFFh

21.6.2 Platform Flash Memory Configuration 0 (PFCR0)

Offset

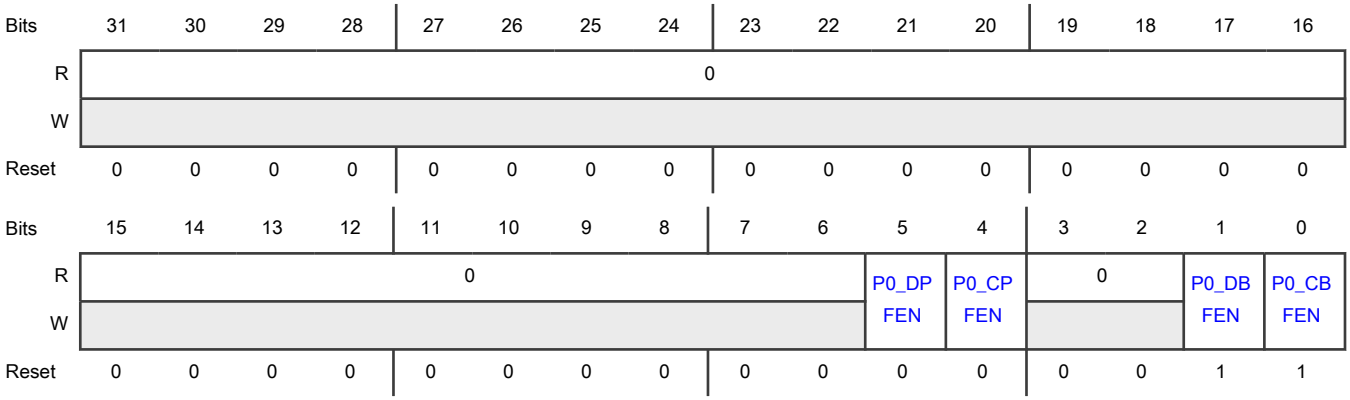
Register	Offset
PFCR0	0h

Function

Specifies the operation of PFLASH Port0.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 P0_DPFEN	Port0 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port0. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P0_CPFEN	Port0 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port0. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P0_DBFEN	Port0 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
0 P0_CBFEN	Port0 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.6.3 Platform Flash Memory Configuration 1 (PFCR1)

Offset

Register	Offset
PFCR1	4h

Function

Specifies the operation of PFLASH Port1.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0										P1_DPFEN	P1_CPFEN	0		P1_DBFEN	P1_CBFEN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-6	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
5 P1_DPFEN	Port1 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port1. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P1_CPFEN	Port1 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port1. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P1_DBFEN	Port1 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable
0 P1_CBFEN	Port1 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.6.4 Platform Flash Memory Configuration 2 (PFCR2)

Offset

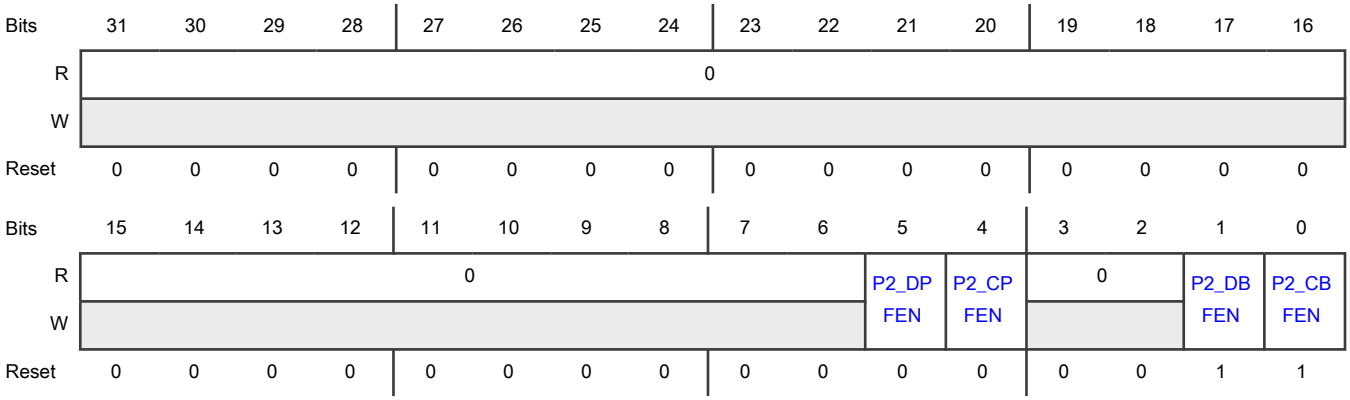
Register	Offset
PFCR2	8h

Function

Specifies the operation of PFLASH Port2.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 P2_DPFEN	Port2 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port2. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P2_CPFEN	Port2 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port2. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P2_DBFEN	Port2 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
0 P2_CBFEN	Port2 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.6.5 Platform Flash Memory Configuration 3 (PFCR3)

Offset

Register	Offset
PFCR3	Ch

Function

Specifies the operation of PFLASH Port3.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0										P3_DPFEN	P3_CPFEN	0		P3_DBFEN	P3_CBFEN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-6	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
5 P3_DPFEN	Port3 Data Prefetch Enable Enables or disables data prefetching initiated by a read access on Port3. Prefetching can only be enabled if the buffers are enabled by writing 1 to DBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
4 P3_CPFEN	Port3 Code Prefetch Enable Enables or disables code prefetching initiated by a read access on Port3. Prefetching can only be enabled if the buffers are enabled by writing 1 to CBFEN. Hardware reset returns this field to 0. 0b - Disable 1b - Enable
3-2 —	Reserved
1 P3_DBFEN	Port3 PFLASH Line Read Data Buffers Enable Enables or disables line read data buffer hits. It is also used to invalidate the buffers. If this field is 0, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If this field is enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable
0 P3_CBFEN	Port3 PFLASH Line Read Code Buffers Enable Enables or disables line read code buffer hits. It is also used to invalidate the buffers. If disabled, the line read buffers are disabled from satisfying read requests, and all buffer valid bits are set to 0. If enabled, the line read buffers are enabled to satisfy read requests on hits. Buffer valid bits may be set when the buffers are successfully filled. 0b - Disable 1b - Enable

21.6.6 Platform Flash Memory Configuration 4 (PFCR4)

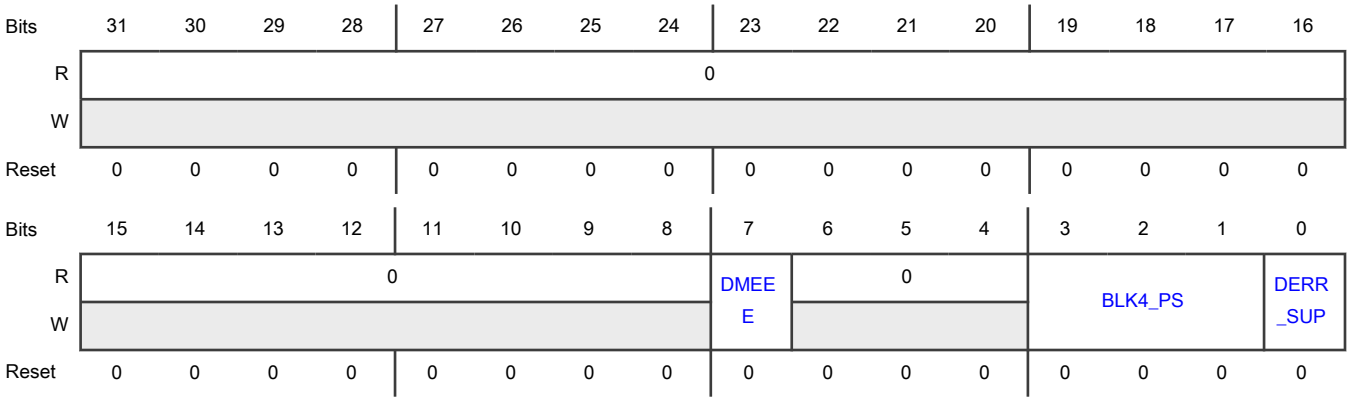
Offset

Register	Offset
PFCR4	10h

Function

Specifies operation of the flash memory controller buffer.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 DMEEE	Disable Multi-Bit ECC Error Exception Enables or disables system bus error response on multi-bit ECC error. Hardware reset returns this field to 0. 0b - Error response sent on system bus for multi-bit ECC error 1b - Error response not sent on system bus for multi-bit ECC error
6-4 —	Reserved
3-1 BLK4_PS	Block 4 Pipe Select Selects the active pipe for flash memory block 4 access. PFLASH has four independent command pipes to issue four parallel read commands to different flash memory blocks. Reads from flash memory block 0–3 are always done through command pipe 0–3, respectively. However, the access to block 4 is not fixed and can be through any of the command pipes. You must only change this field when there is no ongoing block 4 access. A special round-robin arbitration scheme snoops the availability of a command pipe during block 4 access. If any of the command pipes are idle during the first read request to block 4, the ownership of that command pipe gets shared between block 4 and the respective block. If none of the command pipes are idle during a block 4 read request, block 4 gets associated with each of the command pipes in round-robin fashion. When a command pipe acquires ownership of block 4, it keeps that ownership until all the commands to block 4 from all the masters are served. 000b - Block 4 access is always through pipe0 001b - Block 4 access is always through pipe1

Table continues on the next page...

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Field	Function
	010b - Block 4 access is always through pipe2 011b - Block 4 access is always through pipe3 1xxb - Block 4 access can be through any of the command pipes, based on which command pipe is available for block 4 access
0 DERR_SUP	Data Error Suppression See the Embedded Flash Memory configuration information or system memory map for which flash memory blocks are affected by this field. 0b - Reports ECC events on data flash memory accesses 1b - Single-bit and multi-bit ECC events on data flash memory accesses are suppressed

21.6.7 Platform Flash Memory Access Protection (PFAPR)

Offset

Register	Offset
PFAPR	14h

Function

Controls read accesses to the flash memory array.

See the chip-specific PFLASH information for details about the actual masters available on the chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	M0AP		M1AP		M2AP		M3AP		M4AP		M5AP		M6AP		M7AP	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	M8AP		M9AP		M10AP		M11AP		M12AP		M13AP		M14AP		M15AP	
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-30: M0AP	Master n Access Protection

Table continues on the next page...

Field	Function
29-28: M1AP 27-26: M2AP 25-24: M3AP 23-22: M4AP 21-20: M5AP 19-18: M6AP 17-16: M7AP 15-14: M8AP 13-12: M9AP 11-10: M10AP 9-8: M11AP 7-6: M12AP 5-4: M13AP 3-2: M14AP 1-0: M15AP	Controls whether read accesses to the flash memory are allowed based on the master ID of a requesting master. These fields are initialized by hardware reset. The field M4'd3AP is reserved. x0b - This master cannot perform any read accesses x1b - This master can perform read accesses

21.6.8 Platform Flash Memory Program Erase Address Logical (PFCPGM_PEADR_L)

Offset

Register	Offset
PFCPGM_PEADR_L	300h

Function

Provides the flash memory address to be programmed, or the location of the sector or block to be erased through main flash memory (pgm/erase) queue. Write access to this register is domain-ID aware.

The respective bus master must have program/erase permission to the flash memory address written to this register. Otherwise a transfer error results. For further information on flash memory address restrictions see the XRDC chapter.

A write to this register is managed via three-cycle access. Before updating the register, you must ensure that no ongoing high-voltage operation is executing through the flash memory main queue.

Unauthorized flash memory address writes result in a transfer error.

Writes to this register during an ongoing high-voltage operation (initiated through the flash memory main queue) or during express program operation are ignored.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PEADR_L															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PEADR_L															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PEADR_L	Program Erase Address Logical Contains the system logical address for flash memory program/erase.

21.6.9 Platform Flash Memory Program Erase Address Physical (PFCPGM_PEADR_P)

Offset

Register	Offset
PFCPGM_PEADR_P	304h

Function

Reflects the flash memory block number and offset address corresponding to Platform Flash Memory Program Erase Address Logical (PFCPGM_PEADR_L). This register has the same format as the PEADR register in the Flash Memory chapter—see it for details.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PEADR_P	Program Erase Address Physical Contains the flash block select and offset address for flash memory program/erase.

21.6.10 Platform Flash Memory Express Program Erase Address Logical (PFCPGM_XPEADR_L)

Offset

Register	Offset
PFCPGM_XPEADR_L	308h

Function

Provides the flash memory address to be programmed using the flash memory express program feature. Write access to this register is domain-ID aware.

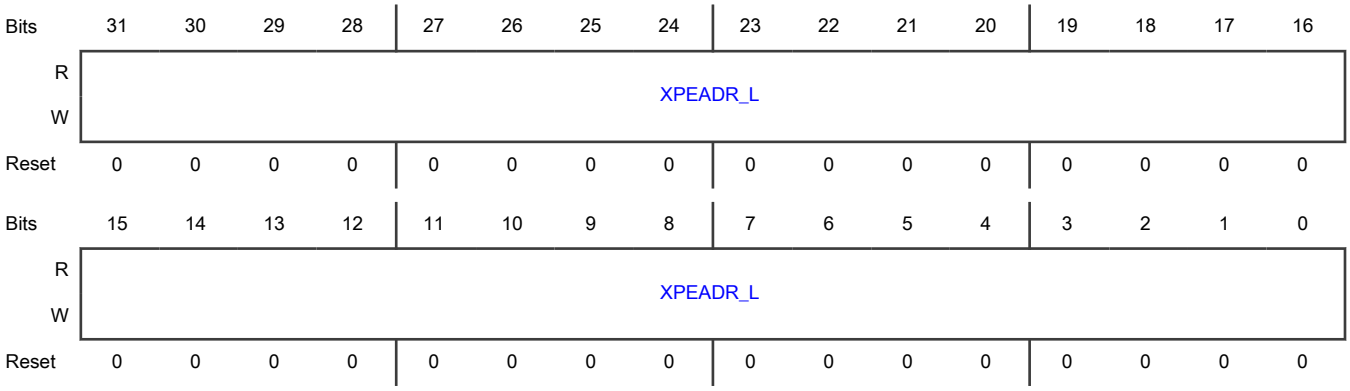
The respective bus master must have program/erase permission to the flash memory address written to this register. Otherwise a transfer error results. See the XRDC chapter for further information on flash memory address restrictions.

A write to this register is managed via three-cycle access. Before updating the register, you must ensure that no ongoing high-voltage operation is executing through the flash memory main queue.

Unauthorized flash memory address writes result in a transfer error.

Writes to this register during an ongoing express program operation are ignored.

Diagram



Fields

Field	Function
31-0 XPEADR_L	Express Program Erase Address Logical Contains the system logical address for express flash program/erase.

21.6.11 Platform Flash Memory Express Program Erase Address Physical (PFCPGM_XPEADR_P)

Offset

Register	Offset
PFCPGM_XPEADR_P	30Ch

Function

Reflects the flash memory block number and offset address corresponding to PFCPGM_XPEADR_L. This register has the same format as the XPEADR register in the Flash Memory chapter—see it for details.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	XPEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	XPEADR_P															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 XPEADR_P	Express Program Erase Address Physical Contains the flash memory block select and offset address for flash memory express program/erase.

21.6.12 Block n Sector Program Erase Lock (PFCBLK0_SPELOCK - PFCBLK3_SPELOCK)

Offset

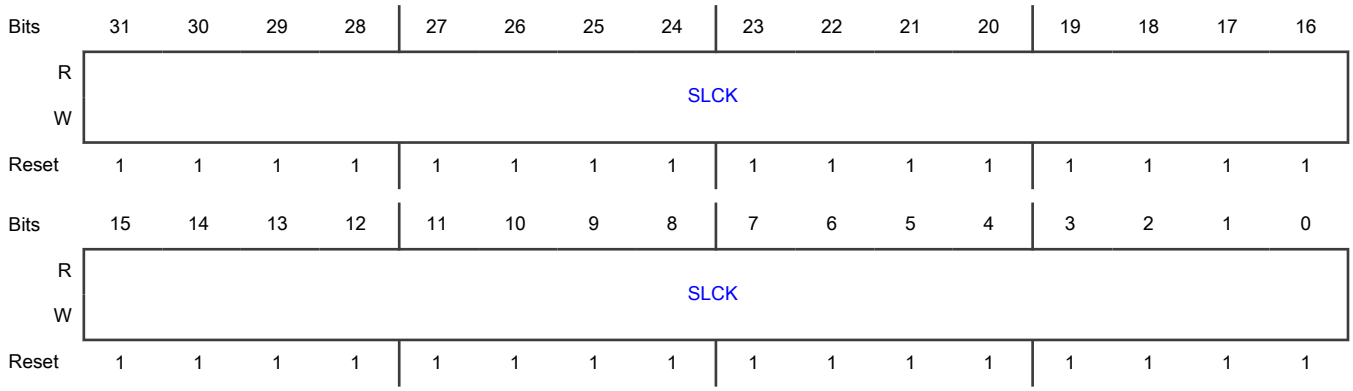
Register	Offset
PFCBLK0_SPELOCK	340h
PFCBLK1_SPELOCK	344h
PFCBLK2_SPELOCK	348h
PFCBLK3_SPELOCK	34Ch

Function

Provides a way to protect sectors from being modified. Sector protection is available on the last 256 KB of every block (for 256 KB blocks, all sectors are available for protection). Each lock bit can be associated with a particular domain ID by writing 1 to

the appropriate bit in PFCBLKn_SETSLOCK[SETSLCK]. After the lock is acquired, only a master having the same domain ID can modify the corresponding lock bit. If the corresponding PFCBLKn_SETSLOCK[SETSLCK] bit is not equal to 1, any master can modify the appropriate SLCK bit. If a lock bit is already acquired by a particular domain ID, any effort to modify (1 to 0, or 0 to 1) the lock bit by a master with a different domain ID results in a transfer error.

Diagram



Fields

Field	Function
31-0 SLCK	Sector Lock Locks selected sector. If vector bit value = 0, the sector is available for program and erase operations. If vector bit value = 1, the sector is locked and not available for program and erase operations.

21.6.13 Block UTEST Sector Program Erase Lock (PFCBLKU_SPELOCK)

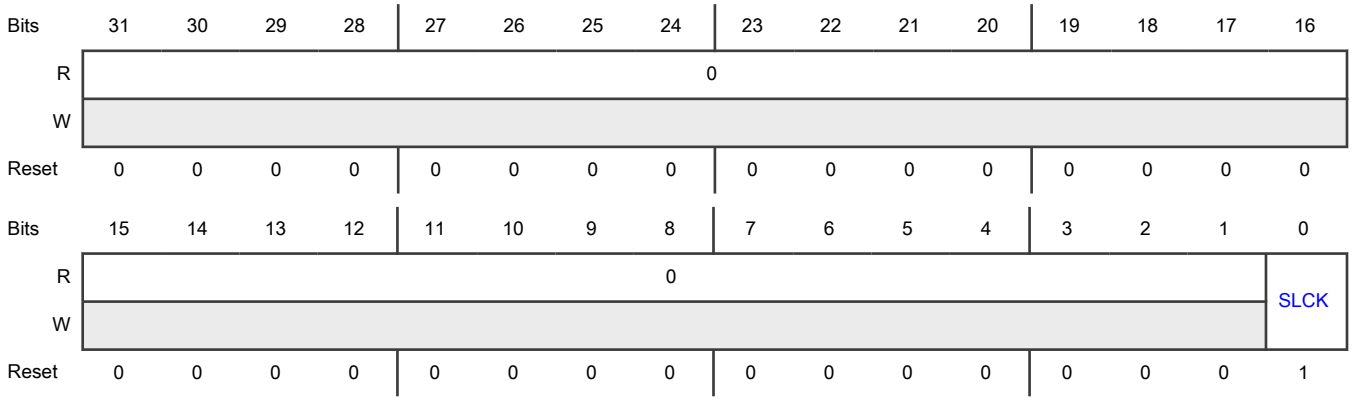
Offset

Register	Offset
PFCBLKU_SPELOCK	358h

Function

Provides a way to protect sectors from being modified. Sector protection is available on the last 256 KB of every block (for 256 KB blocks, all sectors are available for protection). Each lock bit can be associated with a particular domain ID by writing 1 to PFCBLKU_SETSLOCK[SETSLCK]. After the lock is acquired, only a master having the same domain ID can modify the corresponding lock bit. If the corresponding PFCBLKU_SETSLOCK[SETSLCK] bit is not equal to 1, any master can modify the SLCK bit. If a lock bit is already acquired by a particular domain ID, any effort to modify (1 to 0, or 0 to 1) the lock bit by a master with a different domain ID results in a transfer error.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 SLCK	Sector Lock Locks selected sector. If vector bit value = 0, the sector is available for program and erase operations. If vector bit value = 1, the sector is locked and not available for program and erase operations.

21.6.14 Block n Super Sector Program Erase Lock (PFCBLK0_SSPELOCK - PFCBLK2_SSPELOCK)

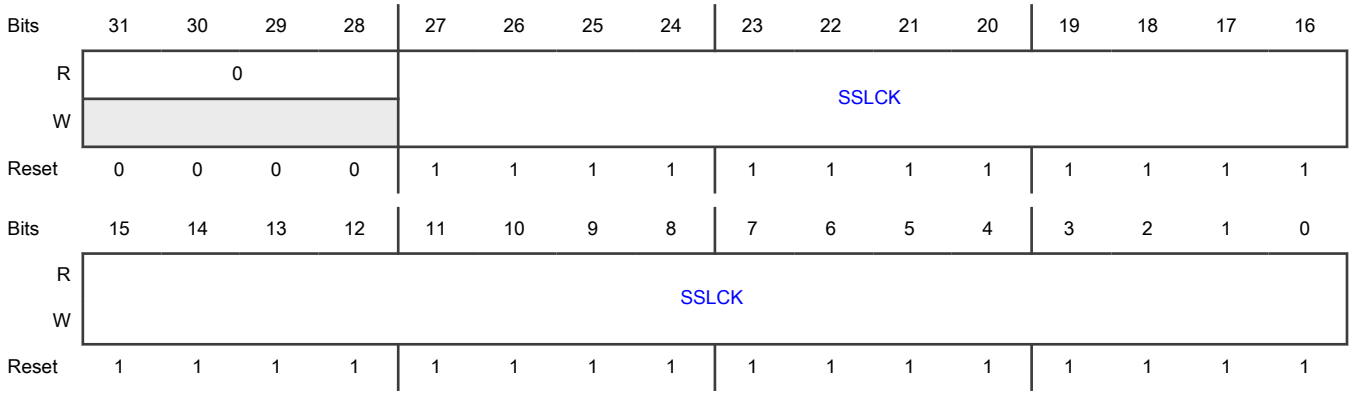
Offset

Register	Offset
PFCBLK0_SSPELOCK	35Ch
PFCBLK1_SSPELOCK	360h
PFCBLK2_SSPELOCK	364h

Function

Provides a way to protect super sectors from being modified. Super sector protection is available on block space larger than 256 KB. For 256 KB blocks, this register is not applicable. For 512 KB blocks, the first half of the block is protected with super sector granularity. For 1 MB blocks, the first 768 KB is protected with super sector granularity. Each lock bit can be associated with a particular domain ID by writing 1 to the appropriate bit in PFCBLKn_SSETSLOCK[SSETSLCK]. After the lock is acquired, only a master having the same domain ID can modify the corresponding lock bit. If the corresponding PFCBLKn_SSETSLOCK[SSETSLCK] bit is not equal to 1, any master can modify the SSLCK bit. If a lock bit is already acquired by a particular domain ID, any effort to modify (1 to 0, or 0 to 1) the lock bit by a master with a different domain ID results in a transfer error.

Diagram



Fields

Field	Function
31-28 —	Reserved
27-0 SSLCK	Super Sector Lock Locks selected super sector. If vector bit value = 0, the super sector is available for program and erase operations. If vector bit value = 1, the super sector is locked and not available for program and erase operations.

21.6.15 Block n Set Sector Lock (PFCBLK0_SETSLOCK - PFCBLK3_SETSLOCK)

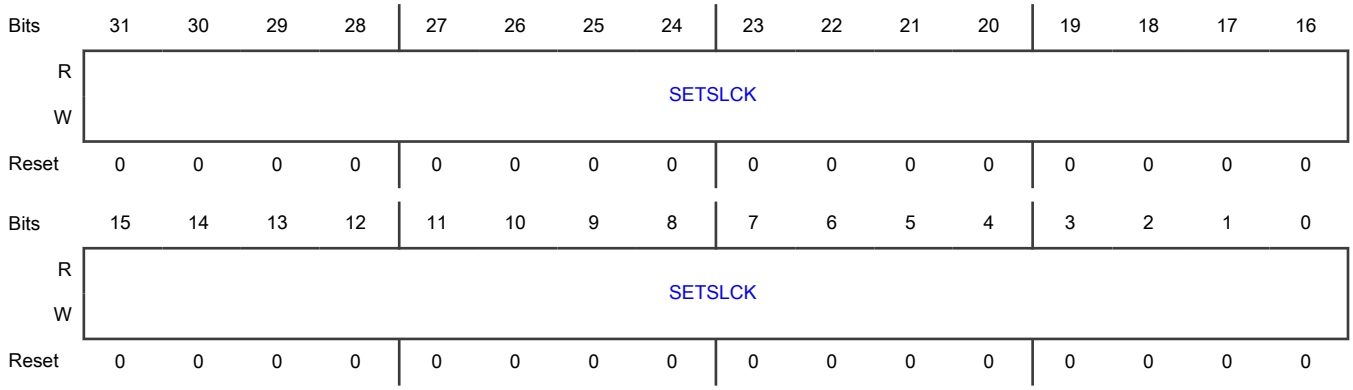
Offset

Register	Offset
PFCBLK0_SETSLOCK	380h
PFCBLK1_SETSLOCK	384h
PFCBLK2_SETSLOCK	388h
PFCBLK3_SETSLOCK	38Ch

Function

Provides a mechanism for the masters to gain the ownership of the corresponding PFCBLKn_SPELOCK lock bit based on domain id . After it is equal to 1, the bit is returned to 0 at next reset. If any SETSLOCK bit is not equal to 1, the corresponding LOCK bit can be modified by any master. If a bit is already acquired by a particular domain ID, any effort to modify the lock bit by a master with a different domain ID is ignored without transfer error.

Diagram



Fields

Field	Function
31-0 SETSLCK	If the vector bit value = 0, the corresponding lock bit is not owned by any master. If the vector bit value = 1, the lock bit is owned by the masters having the domain ID stored in PFCBLKn_LOCKMASTER_Sm.

21.6.16 Block UTEST Set Sector Lock (PFCBLKU_SETSLOCK)

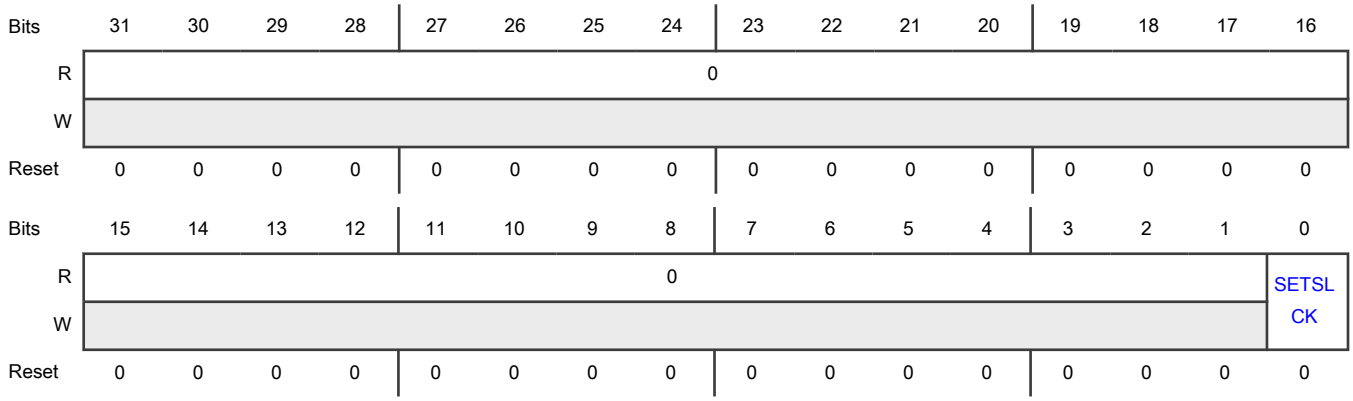
Offset

Register	Offset
PFCBLKU_SETSLOCK	398h

Function

Provides a mechanism for the masters to gain ownership of the corresponding PFCBLKU_SPELOCK lock bit based on domain id. After it is equal to 1, the bit is returned to 0 at next reset. If any SETSLOCK bit is not equal to 1, the corresponding LOCK bit can be modified by any master. If a bit is already acquired by a particular domain ID, any effort to modify the lock bit by a master with a different domain ID is ignored without transfer error.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 SETSLCK	Set Sector Lock Locks selected sector. If vector bit value = 0, the corresponding lock bit is not owned by any master. If vector bit value = 1, the lock bit is owned by the masters having the domain ID stored in PFCBLKn_LOCKMASTER_SSm.

21.6.17 Block n Set Super Sector Lock (PFCBLK0_SSETSLOCK - PFCBLK2_SSETSLOCK)

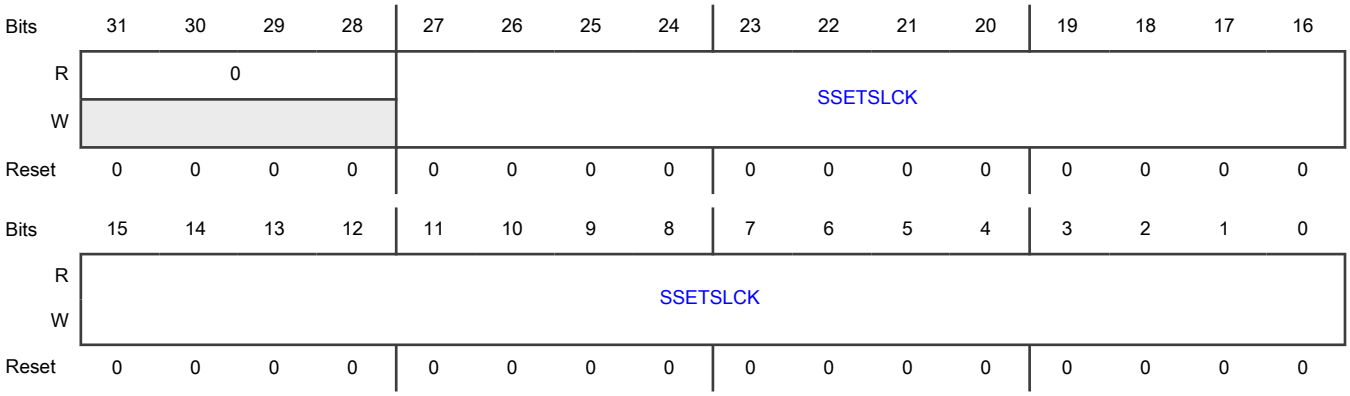
Offset

Register	Offset
PFCBLK0_SSETSLOCK	39Ch
PFCBLK1_SSETSLOCK	3A0h
PFCBLK2_SSETSLOCK	3A4h

Function

Provides a mechanism for the masters to gain ownership of the corresponding PFCBLKn_SPELOCK lock bit based on domain id. After it is equal to 1, the bit is returned to 0 at next reset. If any SSETSLOCK bit is not equal to 1, the corresponding LOCK bit can be modified by any master. If a bit is already acquired by a particular domain ID, any effort to modify the lock bit by a master with a different domain ID is ignored without transfer error.

Diagram



Fields

Field	Function
31-28	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
27-0 SSETSLCK	Set Super Sector Lock Locks selected super sector. If vector bit value = 0, the corresponding lock bit is not owned by any master. If vector bit value = 1, the lock bit is owned by the masters having the domain ID stored in Block a Lock Master Sector b (PFCBLK0_LOCKMASTER_S0 - PFCBLK3_LOCKMASTER_S7).

21.6.18 Block a Lock Master Sector b (PFCBLK0_LOCKMASTER_S0 - PFCBLK3_LOCKMASTER_S7)

Offset

For a = 0 to 3; b = 0 to 7:

Register	Offset
PFCBLKa_LOCKMASTER_Sb	3C0h + (a × 20h) + (b × 4h)

Function

Provides the domain ID information of the master currently acquiring the lock bit. The domain ID is represented by an 8-bit field. This is a read-only register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LOCKMASTER_S															
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LOCKMASTER_S															
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-0 LOCKMASTER_S	Block a Lock Master Sector b Contains domain ID of the master currently acquiring the lock bit.

Table continues on the next page...

Field	Function
	PFCBLK0_LOCKMASTER_S0[LOCKMASTER_S[7:0]] holds the domain ID information of PFCBLK0_SPELOCK[0]. PFCBLK0_LOCKMASTER_S0[LOCKMASTER_S[15:8]] holds the domain ID information of PFCBLK0_SPELOCK[1], and so on in incremental order.

21.6.19 Block UTEST Lock Master Sector (PFCBLKU_LOCKMASTER_S)

Offset

Register	Offset
PFCBLKU_LOCKMASTER_S	480h

Function

Provides the domain ID information of the master currently acquiring the lock bit. The domain ID is represented by an 8-bit field. This is a read-only register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								LOCKMASTER_S							
W																
Reset	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Fields

Field	Function
31-8 —	Reserved
7-0 LOCKMASTER_S	Lock Master Sector Contains domain ID of the master currently acquiring the lock bit. PFCBLKU_LOCKMASTER_S[LOCKMASTER_S[7:0]] holds the domain ID information of PFCBLKU_SPELOCK[0].

21.6.20 Block m Lock Master Super Sector n (PFCBLK0_LOCKMASTER_SS0 - PFCBLK2_LOCKMASTER_SS6)

Offset

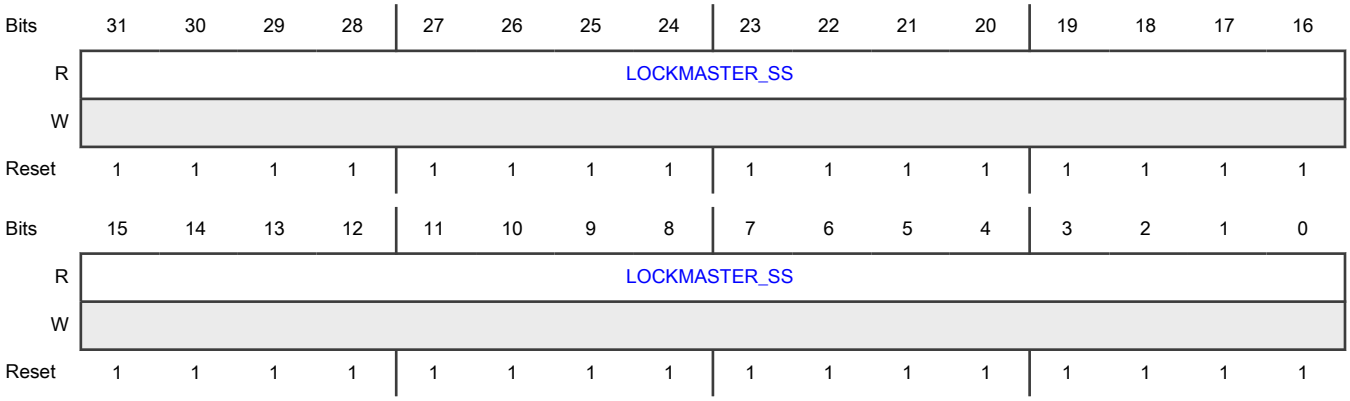
For a = 0 to 2; b = 0 to 6:

Register	Offset
PFCBLKa_LOCKMASTER_SSb	484h + (a × 1Ch) + (b × 4h)

Function

Provides the domain ID information of the master currently acquiring the lock bit. The domain ID is represented by an 8-bit field. This is a read-only register.

Diagram



Fields

Field	Function
31-0 LOCKMASTER_SS	Block a Lock Master Super Sector b Contains domain ID of the master currently acquiring the lock bit. PFCBLK0_LOCKMASTER_SS0[LOCKMASTER_SS[7:0]] holds the domain ID information of PFCBLK0_SSPELOCK[0]. PFCBLK0_LOCKMASTER_SS0[LOCKMASTER_SS[15:8]] holds the domain ID information of PFCBLK0_SSPELOCK[1], and so on in incremental order.

21.7 Glossary

AHB	Advanced high-performance bus
ECC	Error correcting code
HSE	Hardware security engine
IPS	Internal peripheral system
ID	Identification

Chapter 22
RAM Controller (PRAMC)

22.1 Chip-specific PRAMC information

22.1.1 PRAMC instances and configuration

Table 86. PRAMC instances and configuration

Instance	SRAM array	Size (KB)
PRAMC_0	SRAM 0	256
PRAMC_1	SRAM 1	256

22.1.2 RAM initialization

After chip power-on reset, you must initialize RAM to a known value using a 64-bit master before 32-bit masters can read or write to RAM. If you do not initialize RAM this way, any attempt to execute a 32-bit read or write access terminates with an uncorrectable ECC error event on this chip.

22.1.3 SRAM0 behavior while XRDC is configured to block access to SRAM0

While XRDC is configured to restrict access to SRAM0, the below behaviors should be considered:

1. In case if XRDC is configured to restrict access to SRAM0 and a read transaction to SRAM0 is performed: To ensure faster SRAM0 accesses, the access is routed to SRAM0 and blocked by PRAMC if XRDC is configured to block access. In such a case, if an error is present on the SRAM0 data, (that is error on data or error injected by EIM), the same is latched by ERM as well. This data is not used by application core since PRAMC gives a bus error in this case.
2. In case if XRDC is configured to restrict access to SRAM0 and a 32-bit write access is performed: Since SRAM is 64-bit wide, so a 32-bit write transaction is performed as a read-modify-write. In the read cycle, again as described in previous scenario, the PRAMC will initiate an error response. In this case also, if there is any error on SRAM0 data bus (i.e., error or error injected via EIM), the same is captured in ERM as well.n

NOTE

For any read/write accesses initiated by HSE-B security subsystem to system RAM, the platform must cancel the error injection request on SRAM controller.

22.2 Overview

The RAM controller is an interface between the system bus (AHB-Lite 2.v6) and the integrated system RAM. It converts the protocols between the system bus and the dedicated RAM array interface.

The RAM controller supports one 64-bit AHB interface and a 64-bit RAM array interface. The AHB port provides a connection to the platform crossbar for direct RAM access from the various crossbar masters.

22.2.1 Block diagram

Shown below in Figure 49 is a simplified block diagram depicting the position of the RAM controller within a typical platform architecture.

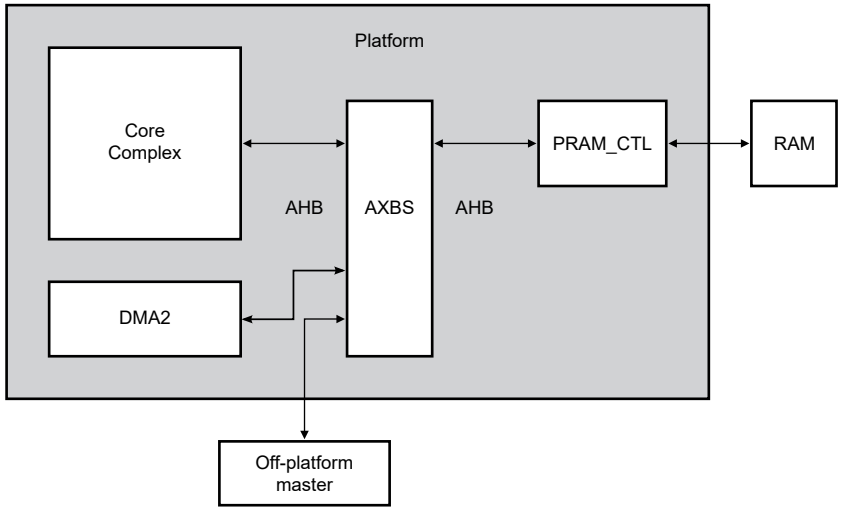


Figure 49. Simplified platform block diagram

22.2.2 Features

The following list summarizes the key features of the RAM controller:

- System bus supports 64-bit data
- Array interface supports a 64-bit data + 8-bit ECC interface
- Late-write support via 64-bit data + 8-bit ECC storage buffer supports single-cycle write accesses
- Configurable read access timing (zero or one wait state programmable) allowing use in large range of frequency targets
- Read-modify-write operation supports array write size smaller than a double-word
- Hardware EDC after ECC feature to check the ECC logic. Detected errors are connected to the FCCU with configurable error reaction.

22.3 Functional description

This section describes the functions of the RAM controller.

22.3.1 Read and write operations

The RAM controller processes read and write requests to on-chip RAM and provides a register interface for access to performance tuning functions.

NOTE

The RAM controller register interface is accessible only in supervisor mode. Accesses in user mode return a transfer error.

22.3.1.1 Reads

Read transfers, of any size, can be configured to complete with a zero or one additional wait state response on the system bus.

22.3.1.2 Optional read wait state

The RAM controller can be optionally programmed to register RAM read data prior to returning it on the system bus. Setting the PRCRx[FT_DIS] field inserts a register in the read data path for use when operating the controller at high frequencies. The state of PRCRx[FT_DIS] field has no effect on writes.

A random, initial access takes two clock cycles (2T) to complete if PRCRx[FT_DIS]=0, and a WRAP4 burst will have an access time of 2-2-2-2. A random, initial access takes three clock cycles (3T) to complete if PRCRx[FT_DIS]=1, and a WRAP4 burst has an access time of 3-2-2-2.

NOTE

The number of cycles taken for a RAM access can vary ±1 clock cycle depending on the RAM speed relative to the PRAMC controller clock frequency. If system RAM is running at the same frequency as the PRAMC controller, a random initial access takes two clock cycles. If system RAM is running at a slower frequency, a random initial access may take 3 clock cycles. Subsequent burst beats take either one or two cycles depending on RAM speed relative to the PRAMC controller clock frequency.

22.3.2 Writes

This section discusses various write operations of the RAM controller.

22.3.2.1 64-bit writes

Aligned 64-bit writes execute in a single AHB data phase cycle, resulting in zero wait states on back-to-back writes of these sizes. If, during the data phase of a write, a read is requested on the AHB, the write is registered in the late-write buffer, enabling the read to take place without a wait state. The valid buffered or late-write data is stored on the next available array address phase.

Back-to-back 64-bit writes execute slightly differently. The first write bypasses the late-write buffer—the write data is stored directly to the array in the same cycle in which it is valid on the AHB.

22.3.2.2 Less than 64-bit writes

Writes of size less than 64 bits incur a read-modify-write action as a consequence of the ECC coding scheme's 64-bit granularity. In the case of a read-modify-write action, the RAM controller performs SEC/DED on the read data. The write data is merged into the appropriate byte lanes along with the potentially corrected read data. A new codeword is generated based on the newly formed double-word. This double-word and its associated check-bits are subsequently written to RAM. Figure 50 provides details on the read-modify-write data path.

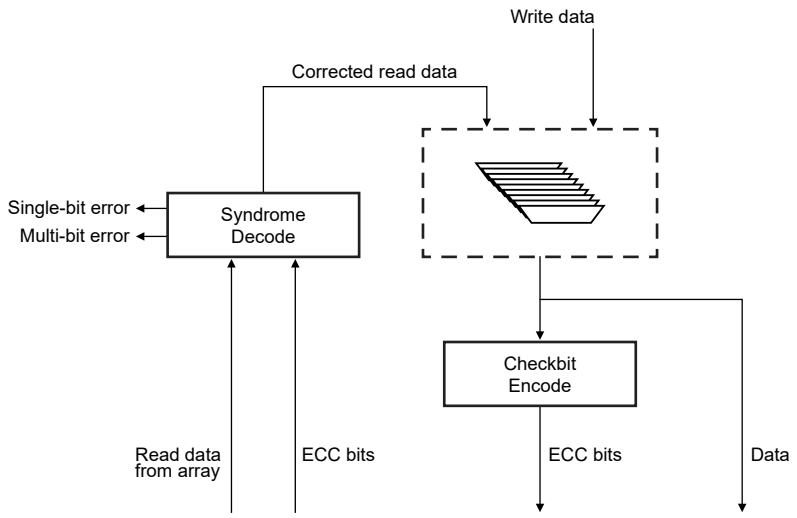


Figure 50. Read-modify-write data path

On a read-modify-write operation, the array read data is registered after it is decoded and before it is merged with the AHB write data. Therefore, writes of size less than 64 bits require the insertion of one wait state before the data phase can be completed.

22.3.2.3 Unaligned writes

The RAM controller is compliant with the AMBA-AHB2.v6 Extensions specification with regard to byte strobes. The size of the transfer is sufficient to cover all bytes being written, and covers more bytes in the case of an unaligned transfer. The address of the transfer is rounded down to the nearest boundary of the size of the transaction.

NOTE

Unaligned writes always generate read-modify-write operations in the RAM controller in order to preserve the validity of the ECC codeword.

22.3.3 Clocking

The following table describes clocks used in this module.

Table 87. Clock sources

Clock name	Description
System clock	This is the system clock used for accessing the PRAM controller over the system bus interconnect.

22.3.4 Reset

Table 88. Reset types

Reset	Description
System reset	This is the asynchronous system reset used for resetting the PRAM controller.

22.3.5 Interrupts

This module has no interrupts.

22.4 External signals

There are no external signals for this module.

22.5 Initialization/application information

Each memory address must be written to a known value before it is read, to initialize the ECC. This includes reads generated from the read-modify-write operation that occurs when a write transfer of less than 64 bits or an unaligned write is requested. Without first writing an address to a known value, a read from the address will most likely generate an uncorrectable ECC event.

22.6 PRAMC register descriptions

The RAM controller module provides an IPS programming model mapped to a standard on-platform peripheral slot.

NOTE

1. The programming model can only be referenced using a 32-bit (word) access. Attempted references using different access sizes or to undefined (reserved) addresses generate an IPS error termination.
2. Attempted updates to the PRAMC programming model while a PRAMC operation is in progress will result in non-deterministic behavior. Software architect must be such as to avoid this scenario by ensuring that PRAMC configuration changes are made only during system boot or when only one master is enabled. In multi-core devices, update the PRAMC configuration only when one core is active and no other masters, for example, DMA or communications modules, are enabled. Move any instruction execution or memory references outside the system RAM while updating the PRAMC configuration, for example, to the core local memory space.

22.6.1 PRAMC memory map

PRAMC_0 base address: 4026_4000h

PRAMC_1 base address: 4046_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Platform RAM Configuration register 1 (PRCR1)	32	RW	0000_0100h

22.6.2 Platform RAM Configuration register 1 (PRCR1)

Offset

Register	Offset
PRCR1	0h

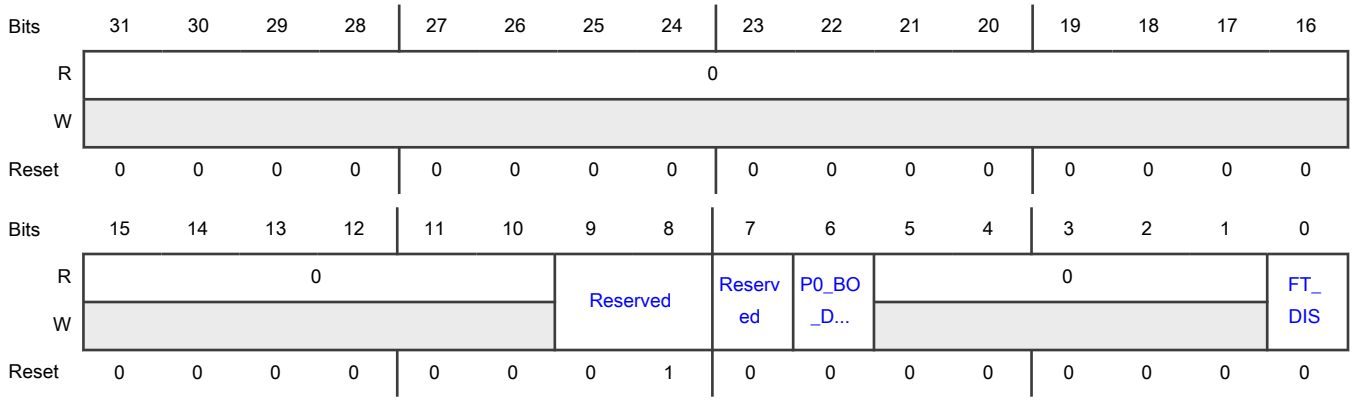
Function

The Platform RAM Configuration register 1 (PRCR1) is used to specify operation of the RAM controller.

NOTE

This register is accessible only in supervisor mode. Accesses in user mode return a transfer error.

Diagram



Fields

Field	Function
31-10 —	Reserved
9-8 —	Reserved
7 —	Reserved
6 P0_BO_DIS	Port p0 read burst optimization disable. **NOTE** The number of cycles taken for a RAM access can vary ± 1 clock cycle depending on the RAM speed relative to the PRAMC controller clock frequency. If system RAM is running at the same frequency as the PRAMC controller, a random initial access takes 2 clock cycles. If system RAM is running at a slower frequency, a random initial access may take 3 clock cycles. Subsequent burst beats take either 1 or 2 cycles depending on RAM speed relative to the PRAMC controller clock frequency. 0b - 64-bit WRP4 read bursts are optimized such that the controller returns a 2-1-1-1 response when PRCR1[FT_DIS]=1 1b - 64-bit WRP4 read bursts are not optimized; the controller returns a 2-2-2-2 response when PRCR1[FT_DIS]=1
5-1 —	Reserved
0 FT_DIS	Flow-through disabled This field defines the AHB response on reads. The state of this field has no impact on the response latency on writes. This bit is cleared by hardware reset. **NOTE** Do not change the FT_DIS bit value while accessing system RAM. Relocate code programming the FT_DIS bit to another memory area, for example, local core memory. 0b - RAM read data is passed directly to the system bus, incurring no additional latency 1b - RAM read data is registered prior to returning on the system bus, incurring one extra cycle of latency

22.7 Glossary

AHB	Arm advanced high-performance bus
DED	Double error detection
DMA	Direct memory access
MUX	Multiplexer

SEC	Single error correction

Chapter 23
Clocking

23.1 Introduction

This chapter describes the clocking architecture and includes the following information:

- System clock specifics
- Clock sources
- Clock architecture
- Clock control registers
- Clock monitoring
- Clock gating
- Module clocking

This chapter discusses the clocks generated on the chip. Peripheral-specific protocol clocks are described in the corresponding peripheral chapters.

23.2 Features

- Multiple clock sources supported for clock generation:
  - Fast internal RC oscillator (FIRC)
  - Slow internal RC oscillator (SIRC)
  - Fast external crystal oscillator (FXOSC)
  - Phase-locked loop (PLL)
- Frequency-modulated PLL output clock to reduce electromagnetic emissions
- Precise clocks for timers and communication functions
- Glitchless clock switching Clock Generation module (MC_CGM) clock selectors
- System clock progressive clock frequency switching (PCFS)
- Clock monitoring units (CMU_FC, CMU_FM) to check clock integrity
- Core and peripheral clock gating using the Mode Entry module's (MC_ME) partition process configuration registers

23.3 Clocking overview

The S32K396 clocking architecture consists of multiple:

- Clock sources
- Monitors
- Multiplexers
- Dividers

The blocks in the above bullet list provide the required clocking domains for the different functional blocks.

The sections in the following list show the clocking configuration of the chip:

- Clock source generation: PLL, FXOSC, FIRC and SIRC
- MC_CGM mux 0 clocks: MC_CGM mux 0 generated clocks (not including EMAC clock signals)

- Clockout overview: CLKOUT_STANDBY and CLKOUT_RUN
- Other clocks
- EMAC clocking: Ethernet utilized clocking

23.3.1 Clock source generation

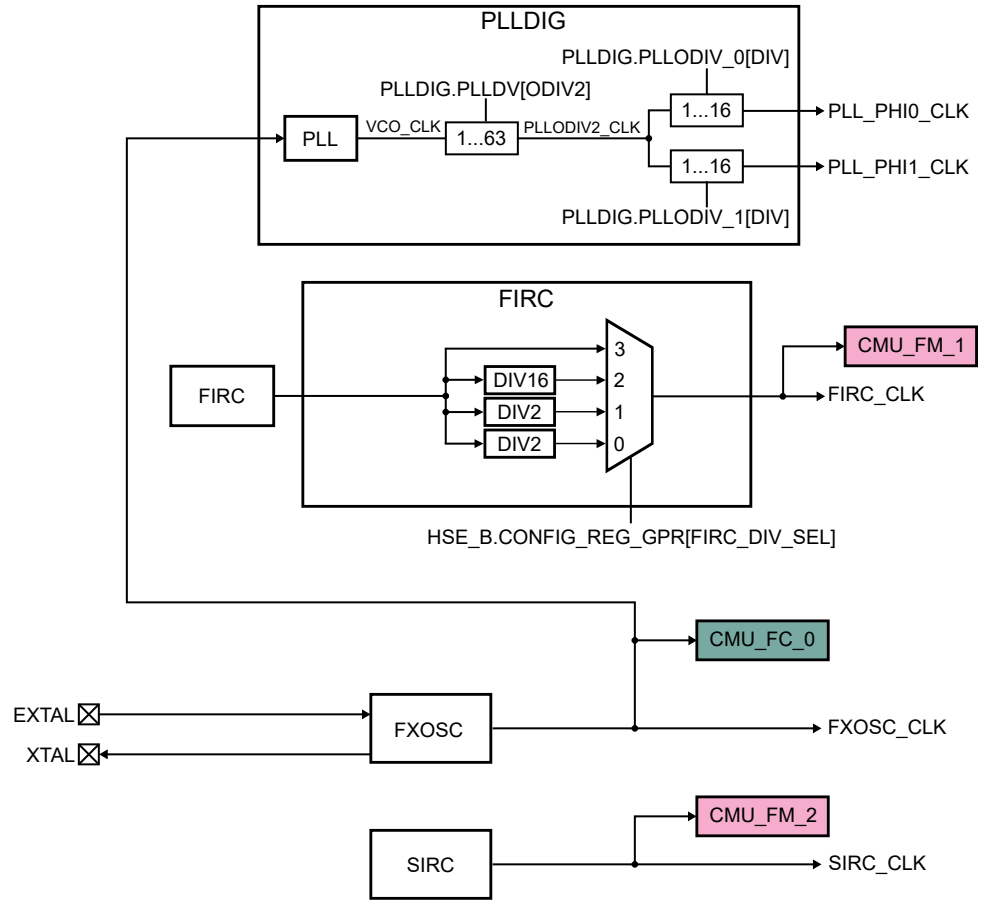


Figure 51. Clock source generation

23.3.2 MC_CGM mux 0 clocks

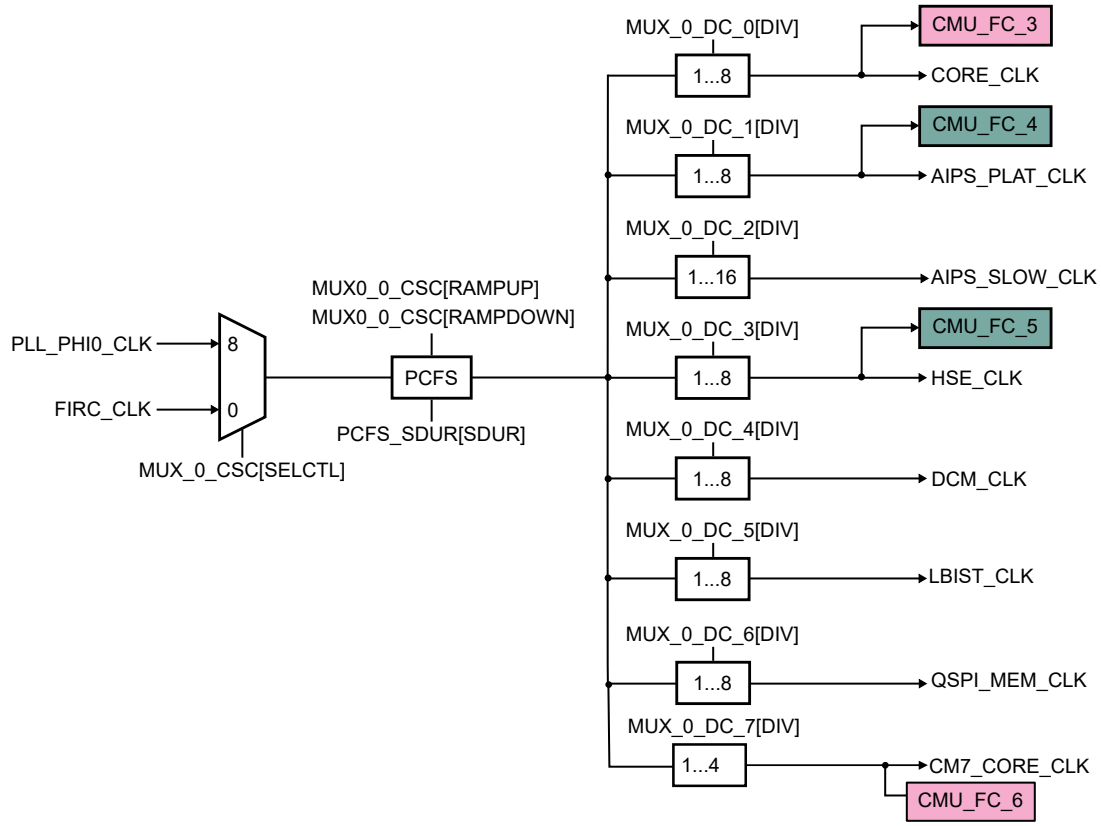


Figure 52. MC_CGM mux 0 clocks

NOTE

The clock frequency relationship between TCK and HSE_CLK clocks for HSE_B must be a minimum ratio of 1:1.5. For example, if HSE_CLK equals 80 MHz, then TCK must be less than or equal to 53 MHz (80 MHz ÷ 1.5).

23.3.3 Clockout overview

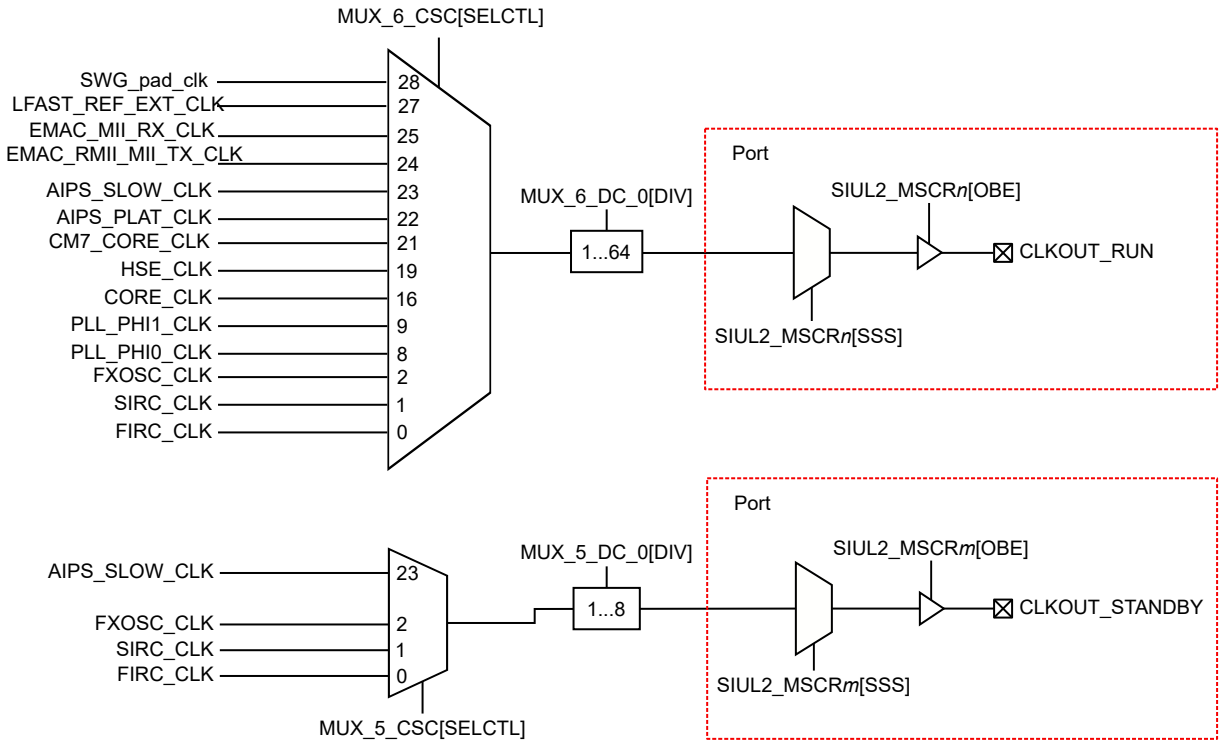


Figure 53. Clockout overview

NOTE

CLKOUT_RUN is not available during Standby mode.

23.3.3.1 SIUL2 options for CLKOUT_RUN

Table 89. SIUL2 options for CLKOUT_RUN

Source	Destination	Port	MSCR*n*	MSCR fields		
				OBE	IBE	SSS
MUX_6_DC_0 divider output	CLKOUT_RUN	PTB5	37	1	0	0101b
		PTD10	106	1	0	0110b
		PTD14	110	1	0	0111b

23.3.3.2 SIUL2 options for CLKOUT_STANDBY

Table 90. SIUL2 options for CLKOUT_STANDBY

Source	Destination	Port	MSCR*m*	MSCR fields		
				OBE	IBE	SSS
MUX_5_DC_0 divider output	CLKOUT_STANDBY	PTA22	22	1	0	1001b
		PTE10	138	1	0	0101b

23.3.4 Other clocks

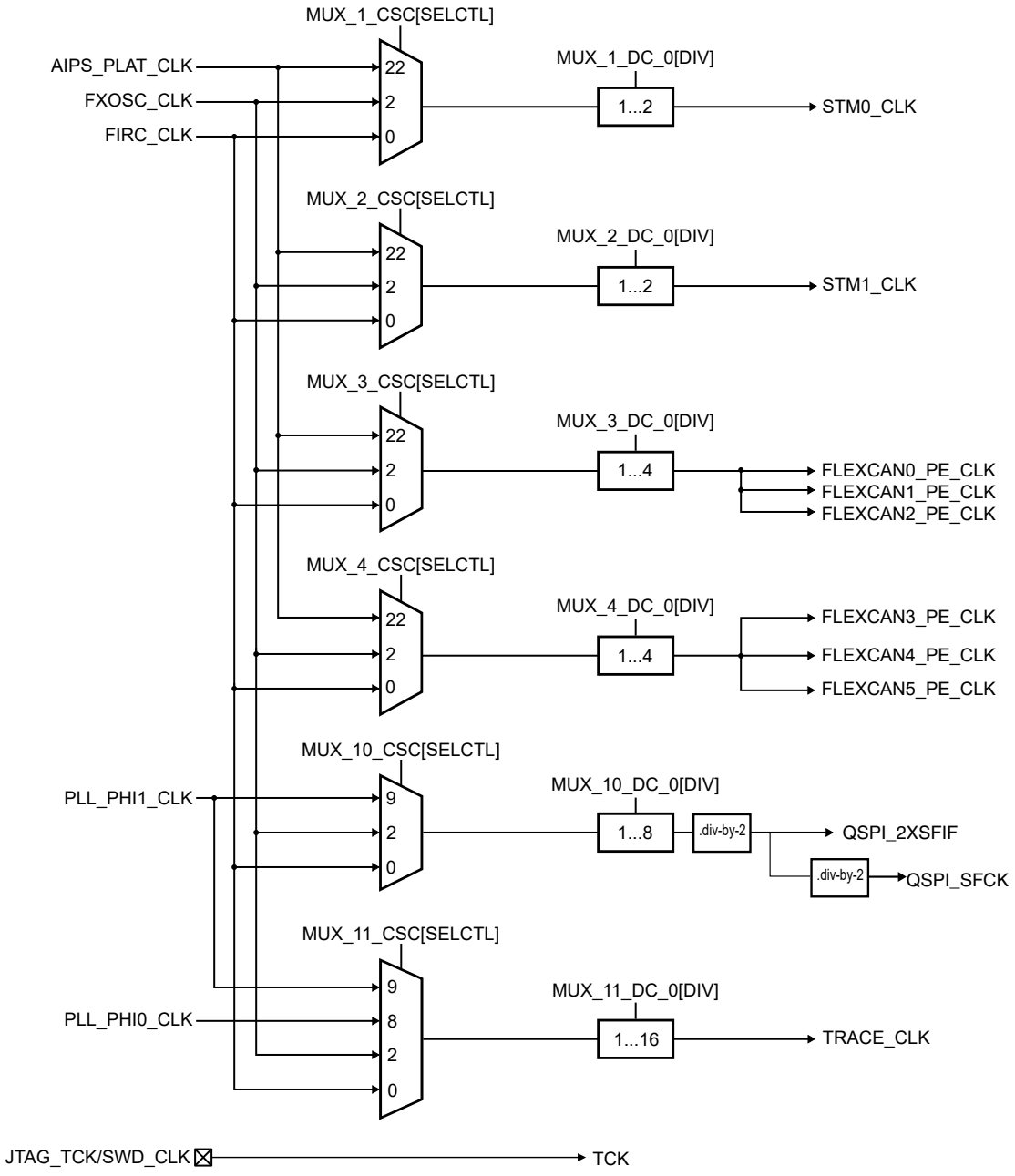


Figure 54. Other clocks

23.3.5 S32K396 Clock system diagram

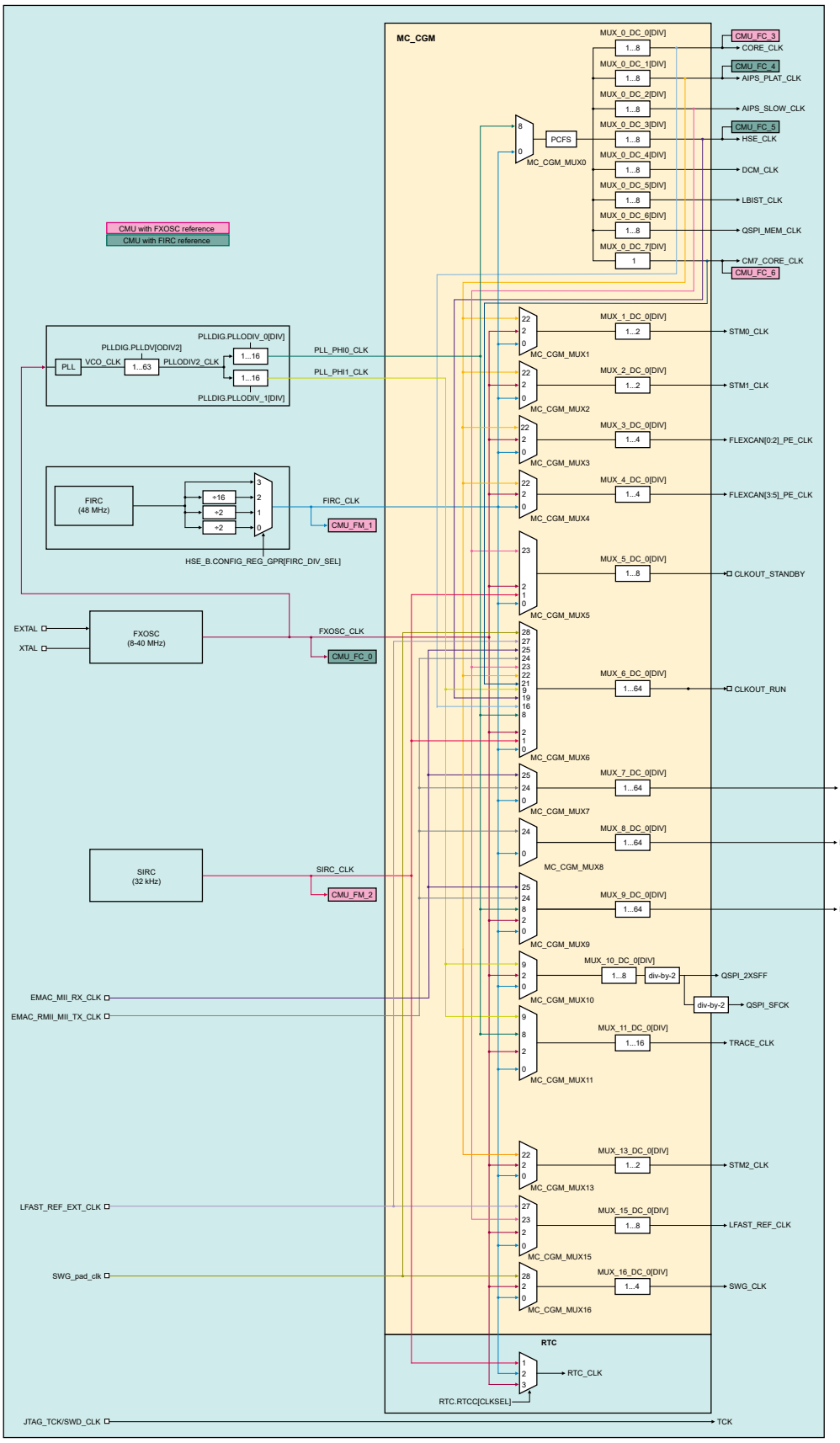


Figure 55. S32K396 clock system diagram

23.4 Clock sources

23.4.1 Introduction

The chip contains the following clock sourcing modules:

- FIRC
  - FIRC_CLK is the default system clock source.
- SIRC
- PLL
- LFAST_PLL
- FXOSC

The following list shows some of the clock system features:

- All clock sources support software configurability for enabling or disabling[3].
- All clock sources, are initialized to their default state on functional reset.

Only SIRC_CLK and FIRC_CLK are enabled out of reset and are enabled on any functional reset. The other clock sources are disabled on reset.

23.4.1.1 Chip clock sources

Table 91. Chip clock sources

Clock source	Divider	Default state	Reset	Uses
FIRC_CLK (48 MHz)	1, 2, 16	On	POR (enabled on functional and destructive reset) POR assertion - FIRC_CLK disabled asynchronously POR deassertion - FIRC_CLK enabled	• Boot clock • Default system clock source • Safe clock for safety modules FCCU and FOSU • SIUL2 filter clock • MC_RGM clock source
PLL_PHI*n*_CLK (640-1280 MHz)	1...16	Off	Functional (disabled on functional reset)	• Optional system clock source • Communication modules (FlexCAN, EMAC, QuadSPI, and so on)
FXOSC_CLK (8-40 MHz)	—	Off	Functional (disabled on functional reset)	• Reference clock source for PLL • Communication modules (FlexCAN, EMAC, QuadSPI, and so on)
SIRC_CLK (32 KHz)	—	On	POR (enabled on functional reset)	• Safe clock along with FIRC_CLK • SWT clock source • POR_WDG source clock

[3] FIRC_CLK and SIRC_CLK cannot be disabled during Run mode.

23.4.2 Chip input clocks

Table 92. Chip input clocks

Pin	Description
XTAL	FXOSC crystal pins
EXTAL	
EMAC_MII_RMII_TX_CLK	EMAC transmitter clock/EMAC RMII clock
EMAC_MII_RX_CLK	EMAC receiver clock
JTAG_TCLK/SWD_CLK	JTAG/SWD clock
LPSPI*n*_SCK	LPSPI*n* serial clock in slave mode
LPI2C*n*_SCL	LPI2C_*n* clock
LPI2C*n*_SCLS	LPI2C_*n* secondary clock
LFAST_REF_EXT_CLK	LFAST reference clock
SWG_PAD_CLK	SWG pad clock

23.4.3 Chip output clocks

Table 93. Chip output clocks

Pin	Description
CLKOUT_RUN	Available during Run mode, unavailable during Standby mode
CLKOUT_STANDBY	Available during both Run and Standby modes
LPSPI*n*_SCK	LPSPI*n* serial clock in master mode
LPI2C*n*_SCL	LPI2C_*n* clock
LPI2C*n*_SCLS	LPI2C_*n* secondary clock
EMAC_MII_RMII_MDC	EMAC clock for control data transfer to PHY
EMAC_MII_RMII_TX_CLK	EMAC transmit clock
TRACE_ETM_CLKOUT	ETM trace clock
QuadSPI_SCKFA	QuadSPI serial clock for serial flash device A (fast)
LFAST_REF_EXT_CLK	LFAST reference clock
EXT_REF_CLK	External Reference clock from LFAST to Zipwire.

23.4.4 Fast internal RC oscillator (FIRC)

The chip has an FIRC with the following features:

- Acts as the system clock source on power-up and after any reset event.
  - Important to detect FIRC_CLK failure and recovery
- Acts as the chip's safe clock for safety-relevant applications.
- Is always enabled in Run mode and can be optionally enabled in Standby mode.
- Used as clock source for the following:

- MC_RGM
- FCCU and FOSU
- SIUL2 filters

23.4.4.1 FIRC failure detection

The FIRC_CLK is the safe clock source used as the FCCU and FOSU clock source. The chip supports FIRC_CLK failure detection and recovery by the mechanisms described in the following cases:

- Case 1 - FIRC_CLK not used as system clock and goes out of range:
  - CMU_FM_1 continuously measures the FIRC_CLK clock frequency using FXOSC_CLK as the reference. On each metering window completion, CMU_FM_1 asserts an interrupt (if configured, CMU_FM_1.IER[FMCIE] is 1). You store a configured reference clock count CMU_FM_1.RCCR[REF_CNT] (for example, number of FXOSC_CLK cycles in metering window). Your software checks the FIRC_CLK clock counts by reading CMU_FM_1.SR[MET_CNT].
  - In the event FIRC_CLK goes out of range, the software detects the frequency variation after the subsequent metering window by checking CMU_FM_1.SR[MET_CNT] and takes necessary action by either of the recommended options:
    - SBC-driven power cycle: The SBC receives indication from the chip (through GPIO toggle, QuadSPI communication, and so on). The SBC initiates a power cycle sequence.
    - Software-driven functional reset: The chip executes a functional reset as configured by your software.
- Case 2 - FIRC_CLK not used as system clock and fails (becomes stuck):
  - CMU_FM_1 continuously measures the FIRC_CLK frequency with FXOSC_CLK as the reference. Application software must check FIRC_CLK after a defined time limit by reading CMU_FM_1.SR[MET_CNT] and CMU_FM_1.SR[FMTO].
  - If there is an FIRC_CLK failure, the CMU_FM_1 writes a 1 to the timeout status flag CMU_FM_1.SR[FMTO].
  - When CMU_FM_1.SR[FMTO] is 1, application software takes necessary action by an SBC-driven power cycle wherein the chip provides an indication to the SBC (through GPIO toggle, QuadSPI communication, and so on). The SBC then initiates a power cycle sequence.
- Case 3 - FIRC_CLK used as system clock and goes out of range or fails (becomes stuck):
  - CMU_FC_3, CMU_FC_4, CMU_FC_5, and CMU_FC_6 continuously monitor the system clock nodes with FXOSC_CLK as reference for FLL or FHH events.
  - In the event of FIRC_CLK failure (when FIRC_CLK acts as the system clock source), these CMUs report the FLL event, acting as a destructive reset source.
  - The system then undergoes the reset sequence, during which the FIRC_CLK is reinitialized.
  - The MC_RGM.DES fields indicate the source of the reset event.
  - In addition, CMU_FM_1 monitors FIRC_CLK. If the software is not able to service the CMU_FM_1 interrupt before POR_WDG timeout, POR_WDG treats this as a critical FIRC_CLK failure and initiates a POR_WDG recovery. Therefore, you must ensure that, if enabled, the CMU_FM_1 interrupt must be serviced within the POR_WDG timeout duration.

23.4.4.2 FIRC_CLK behavior in Standby mode

FIRC_CLK can be optionally enabled in Standby mode by configuring FIRC.STDBY_ENABLE[STDBY_EN].

When the PMC acknowledges the Standby mode entry, the FIRC_CLK switches from the On state to the Standby mode configuration selected by the FIRC.STDBY_ENABLE[STDBY_EN] configuration. On wakeup from Standby mode, the FIRC_CLK configuration switches from the Standby mode configured state to the On state.

NOTE

When the trims are being applied, the FIRC will appear as momentarily disabled as shown in Reset timing diagram in the Reset overview chapter.

23.4.5 SIRC

The chip has a SIRC having the following features:

- Is always enabled in Run mode and can be optionally enabled in Standby mode. Having the SIRC always enabled improves system robustness by ensuring that a clock is always available for various SWTs when reducing the chip power consumption in Standby mode.
- Used as clock source for the following:
  - SWT
  - POR_WDG

23.4.5.1 SIRC failure detection

Like the FIRC_CLK, the SIRC_CLK is a safe clock for the design. The SIRC_CLK is used as clock source for SWTs and POR_WDG and therefore it is important to detect SIRC failure and ensure its recovery. The chip supports SIRC_CLK failure detection and recovery by the mechanism described below.

- Case 1 - SIRC_CLK goes out of range:
  - CMU_FM_2 continuously measures the SIRC_CLK clock frequency with FXOSC_CLK as reference. On each metering window completion, the CMU_FM_2 raises an interrupt. The software checks the SIRC clock counts by CMU_FM_2.SR[MET_CNT] with respect to the reference clock counts CMU_FM_2.RCCR[REF_CNT].
  - In the event of clock going out of range, the software detects the frequency variation after the subsequent metering window by checking CMU_FM_2.SR[MET_CNT] and takes necessary action by either of the recommended options:
    1. SBC-driven power cycle. The chip gives an indication to the SBC (through GPIO toggle, QuadSPI communication, and so on.). The SBC then initiates a power cycle sequence.
    2. SW-driven functional reset. The chip executes a functional reset by software.
- Case 2 - SIRC_CLK fails (becomes stuck):
  - CMU_FM_2 continuously measures the SIRC clock frequency with FXOSC_CLK as reference. Software needs to check this reference after a predefined time by checking CMU_FM_2.SR[MET_CNT] and CMU_FM_2.SR[FMTO].
  - In the event of SIRC_CLK clock failure, the CMU_FM_2 writes 1 to the timeout status flag field in its status register, namely, CMU_FM_2.SR[FMTO].
  - When CMU_FM_2.SR[FMTO] is 1, the software takes necessary action by either of the recommended options:
    1. SBC-driven power cycle: The chip gives an indication to the SBC (through GPIO toggle, QuadSPI communication, and so on). The SBC then initiates a power cycle sequence.
    2. Software-driven functional reset: User software executes a functional reset.

23.4.5.2 SIRC behavior in Standby mode

SIRC can optionally be enabled in Standby mode by configuring SIRC.MISCELLANEOUS_IN[STANDBY_ENABLE].

When PMC acknowledges the Standby mode entry, the SIRC switches from the On state to the standby configuration selected by SIRC.MISCELLANEOUS_IN[STANDBY_ENABLE] configuration. On wake-up from Standby mode, the SIRC configuration switches back from the standby-configured state to the On state.

NOTE

When the trims are being applied, the SIRC will appear as momentarily disabled similar to FIRC, as shown in section Reset timing diagram.

23.4.6 FXOSC

The chip supports an 8–40 MHz fast crystal oscillator which has following features:

- Acts as the reference for PLL.
- Supports crystal input mode and bypass mode if using an external oscillator.
- Acts as a clock source for communication modules:
  - FlexCAN
  - QuadSPI
  - EMAC (EMAC_CLK_TS)

23.4.7 PLL

The chip contains a PLL providing a precision clock source with the following features:

- Optional system clock source (in high performance applications)
- System clock source in safety applications
- Can be used as clock source for communication modules, when configured as system clock source:
  - FlexCAN (in SYNC mode operation)
  - EMAC
  - QuadSPI
  - LPSPI
  - LPI2C
  - FlexIO
  - LPUART
  - MSC
- Supports frequency modulation
- Contains lock status monitoring logic which supports loss-of-lock indication

NOTE

See PLL Digital Interface (PLLDIG) for PLL configuration details. See the *Data Sheet* for PLL limitations.

23.4.7.1 PLL configurations

The PLL output predivider frequency depends on the PLLDIG.PLLDV[RDIV] and PLLDIG.PLLDV[MFI] configurations. The PLL VCO clock can be divided further by configuring PLLDIG.PLLODIV_0[DIV] for PLL_PHI0_CLK and PLLDIG_PLLODIV_1[DIV] for PLL_PHI1_CLK (see the PLL Digital Interface (PLLDIG) chapter for configuration details).

23.4.7.1.1 PLL configuration sequence

Before enabling the PLL, you must enable FXOSC_CLK and wait until it is stable. FXOSC.STAT[OSC_STAT] must be monitored to determine the FXOSC_CLK status.

To disable the PLL, the software must disable PLL first and only then disable FXOSC (if required).

23.4.8 Chip clock outputs

The chip supports two CLKOUT_*x* pins for allowing viewing of some internal clocks as follows:

- CLKOUT_STANDBY
  - Used for showing clocks available in Run and Standby modes.
- CLKOUT_RUN
  - Used for showing only Run mode clocks.

See the Clockout overview section and the Clock Generation Module (MC_CGM) chapter for details on available clocks and configuration.

NOTE

The CLKOUT_STANDBY registers are latched when the chip enters Standby mode and are reset in Standby mode sequence. Therefore, the CLKOUT_STANDBY signal needs to be reconfigured on Standby mode exit.

NOTE

CLKOUT_STANDBY is available on two pads GPIO[22] and GPIO[138] but CLKOUT across functional reset and standby is supported only on GPIO[22] and OBE(output buffer enable) is controlled by DCM GPR bit. Please refer to DCMRWP1[3] bit for detail.

23.5 MC_CGM

The MC_CGM controls the clock functionality of the chip. See the Clock Generation Module (MC_CGM) chapter for details on MC_CGM clocking controls.

23.5.1 MC_CGM clock multiplexer types

In this chip, CLKOUT_RUN, CLKOUT_STANDBY, and TRACE_CLK multiplexers are software-controlled multiplexers. The rest are hardware-controlled multiplexers (see the Clock Generation Module (MC_CGM) chapter for details on software and hardware multiplexers).

23.5.2 MC_CGM clock multiplexers

Table 94. MC_CGM clock multiplexers

Clock mux	Register description	Source inputs [1]	Register	Selector output	Divider output
Clock mux 0	Select Control	FIRC_CLK PLL_PHI0_CLK	MUX_0_CSC	—	—
	Select Status		MUX_0_CSS		
	Divider 0 Control	—	MUX_0_DC_0		CORE_CLK
	Divider 1 Control		MUX_0_DC_1		AIPS_PLAT_CLK
	Divider 2 Control		MUX_0_DC_2		AIPS_SLOW_CLK
	Divider 3 Control		MUX_0_DC_3		HSE_CLK
	Divider 4 Control		MUX_0_DC_4		DCM_CLK
	Divider 5 Control		MUX_0_DC_5		LBIST_CLK
	Divider 6 Control		MUX_0_DC_6		QSPI_MEM_CLK
	Divider 7 Control		MUX_0_DC_7		CM7_CORE_CLK
Clock mux 1	Select Control	FIRC_CLK FXOSC_CLK AIPS_PLAT_CLK	MUX_1_CSC	—	—
	Select Status		MUX_1_CSS		
	Divider 0 Control	—	MUX_1_DC_0		STM0_CLK

Table continues on the next page...

Table 94. MC_CGM clock multiplexers (continued)

Clock mux	Register description	Source inputs [1]	Register	Selector output	Divider output
Clock mux 2	Select Control	FIRC_CLK FXOSC_CLK AIPS_PLAT_CLK	MUX_2_CSC	—	—
	Select Status		MUX_2_CSS		
	Divider 0 Control	—	MUX_2_DC_0		STM1_CLK
Clock mux 3	Select Control	FIRC_CLK FXOSC_CLK AIPS_PLAT_CLK	MUX_3_CSC	—	—
	Select Status		MUX_3_CSS		
	Divider 0 Control	—	MUX_3_DC_0		FLEXCAN0_PE_CLK FLEXCAN1_PE_CLK FLEXCAN2_PE_CLK
Clock mux 4	Select Control	FIRC_CLK FXOSC_CLK AIPS_PLAT_CLK	MUX_4_CSC	—	—
	Select Status		MUX_4_CSS		
	Divider 0 Control	—	MUX_4_DC_0		FLEXCAN3_PE_CLK FLEXCAN4_PE_CLK FLEXCAN5_PE_CLK
Clock mux 5	Select Control	FIRC_CLK SIRC_CLK FXOSC_CLK AIPS_SLOW_CLK	MUX_5_CSC	—	—
	Select Status		MUX_5_CSS		
	Divider 0 Control	—	MUX_5_DC_0		CLKOUT_STANDBY
Clock mux 6	Select Control	LFAST_REF_EXT_CLK SWG_pad_clk FIRC_CLK SIRC_CLK FXOSC_CLK PLL_PHI0_CLK PLL_PHI1_CLK CORE_CLK HSE_CLK CM7_CORE_CLK AIPS_PLAT_CLK AIPS_SLOW_CLK EMAC_RMII_MII_TX_CLK EMAC_MII_RX_CLK	MUX_6_CSC	—	—
	Select Status		MUX_6_CSS		
	Divider 0 Control	—	MUX_6_DC_0		CLKOUT_RUN

Table continues on the next page...

Table 94. MC_CGM clock multiplexers (continued)

Clock mux	Register description	Source inputs [1]	Register	Selector output	Divider output
Clock mux 7	Select Control	FIRC_CLK EMAC_RMII_MII_TX_CLK (pin) EMAC_MII_RX_CLK (pin)	MUX_7_CSC	—	—
	Select Status		MUX_7_CSS		
	Divider 0 Control	—	MUX_7_DC_0		EMAC_RX_CLK
Clock mux 8	Select Control	FIRC_CLK EMAC_RMII_MII_TX_CLK (pin)	MUX_8_CSC	—	—
	Select Status		MUX_8_CSS		
	Divider 0 Control	—	MUX_8_DC_0		EMAC_TX_CLK
Clock mux 9	Select Control	EMAC_MII_RX_CLK (pin) EMAC_RMII_MII_TX_CLK (pin) PLL_PHI0_CLK FXOSC_CLK FIRC_CLK	MUX_9_CSC	—	—
	Select Status		MUX_9_CSS		
	Divider 0 Control	—	MUX_9_DC_0		EMAC_TS_CLK
Clock mux 10	Select Control	PLL_PHI1_CLK FXOSC_CLK FIRC_CLK	MUX_10_CSC	—	—
	Select Status		MUX_10_CSS		
	Divider 0 Control	—	MUX_10_DC_0		QSPI_2xSFIF
Clock mux 11	Select Control	FIRC_CLK FXOSC_CLK PLL_PHI0_CLK PLL_PHI1_CLK	MUX_11_CSC	—	—
	Select Status		MUX_11_CSS		
	Divider 0 Control	—	MUX_11_DC_0		TRACE_CLK
Clock mux 12	Select Control	FIRC_CLK FXOSC_CLK PLL_PHI0_CLK	MUX_12_CSC	—	—
	Select Status		MUX_12_CSS		
	Divider 0 Control	—	MUX_12_DC_0		EMAC_CLK_TX_RMII
Clock mux 13	Select Control	FIRC_CLK FXOSC_CLK AIPS_PLAT_CLK	MUX_13_CSC	—	—
	Select Status		MUX_13_CSS		
	Divider 0 Control	—	MUX_13_DC_0		STM2_CLK
Clock mux 14 [Reserved]	Select Control	Reserved	Reserved	—	—
	Select Status		Reserved		
	Divider 0 Control	—	Reserved		Reserved

Table continues on the next page...

Table 94. MC_CGM clock multiplexers (continued)

Clock mux	Register description	Source inputs [1]	Register	Selector output	Divider output
Clock mux 15	Select Control	LFAST_REF_EXT_CLK AIPS_SLOW_CLK FXOSC_CLK FIRC_CLK	MUX_15_CSC	—	—
	Select Status		MUX_15_CSS		
	Divider 0 Control	—	MUX_15_DC_0		LFAST_REF_CLK
Clock mux 16	Select Control	SWG_pad_clk FXOSC_CLK FIRC_CLK	MUX_16_CSC	—	—
	Select Status		MUX_16_CSS		
	Divider 0 Control	—	MUX_16_DC_0		SWG_CLK

1. The default clock selected for all clock mux selectors is FIRC_CLK (out of reset).

23.5.3 MC_CGM clock sources mapping

Table 95. MC_CGM clock sources mapping

Clock selector index [1]	MC_CGM clock source	Clock source
0	clk_src_0	FIRC_CLK
1	clk_src_1	SIRC_CLK
2	clk_src_2	FXOSC_CLK
3	Reserved	Reserved
5–7	Reserved	Reserved
8	clk_src_8	PLL_PHI0_CLK
9	clk_src_9	PLL_PHI1_CLK
10–15	Reserved	Reserved
16	clk_src_16	CORE_CLK
17–18	Reserved	Reserved
19	clk_src_19	HSE_CLK
20	Reserved	Reserved
21	clk_src_21	CM7_CORE_CLK
22	clk_src_22	AIPS_PLAT_CLK
23	clk_src_23	AIPS_SLOW_CLK
24	clk_src_24	EMAC_RMII_MII_TX_CLK
25	clk_src_25	EMAC_MII_RX_CLK
26	Reserved	Reserved
27	clk_src_27	LFAST_REF_EXT_CLK

Table continues on the next page...

Table 95. MC_CGM clock sources mapping (continued)

Clock selector index [1]	MC_CGM clock source	Clock source
28	clk_src_28	SWG_pad_clk
29–49	Reserved	Reserved
50	clk_src_50	CLKOUT_RUN

1. All clock selector indexes not shown are reserved.

23.6 Peripheral clocking

The module clocking diagrams for the peripherals are shown in the following subsections (see Peripheral clock gating for peripheral clock gating possibilities).

23.6.1 Module clocking

The following sections show how the chip modules use MODULE_CLK and REG_INTF_CLK to control their functionality.

23.6.1.1 Communication modules

Figure 56 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 96 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

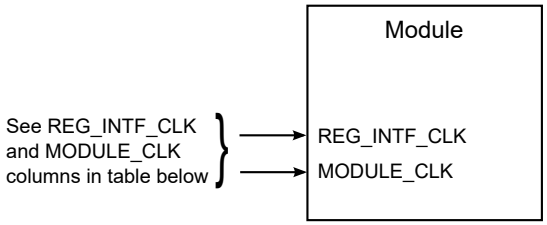


Figure 56. Communication module clocks

Table 96. Communication module clocking

Module	MODULE_CLK	REG_INTF_CLK
LPSPI	See LPSPI*n* clocking.	
LPI^{2}C	See LPI2C_*n* clocking.	
FlexIO	See FlexIO clocking.	
FlexCAN	See FlexCAN_*n* clocking.	
EMAC	See EMAC clocking.	
QuadSPI	See QuadSPI clocking.	
DSPI	See DSPI clocking	
LFAST	See LFAST clocking	
LFAST PLL	See LFAST PLL clocking	
SIPI	See SIPI clocking	

23.6.1.1.1 FlexCAN_*n* clocking

The figure below shows the FlexCAN_*n* clocking.

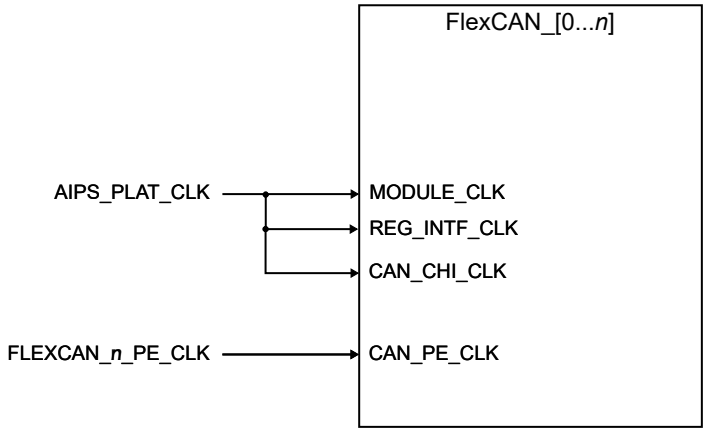


Figure 57. FlexCAN_*n* clocking

FlexCAN has the following unique clocks:

- CAN_CHI_CLK—FlexCAN controller host interface clock
- CAN_PE_CLK—FlexCAN protocol engine clock

FlexCAN supports up to an 8 Mbps data rate using a 40 MHz CAN_PE_CLK. With a 16 MHz crystal source, 3.2 Mbps is achievable for baud rate calculations (see the section Protocol timing in the "CAN (FlexCAN)" chapter for details).

NOTE

See Feature comparison for details on this module's availability on your chip variant.

23.6.1.1.1.1 FlexCAN timestamp implementation

The following figure shows the FlexCAN timestamping implementation. The related table shows the timestamp sources and corresponding clock nodes.

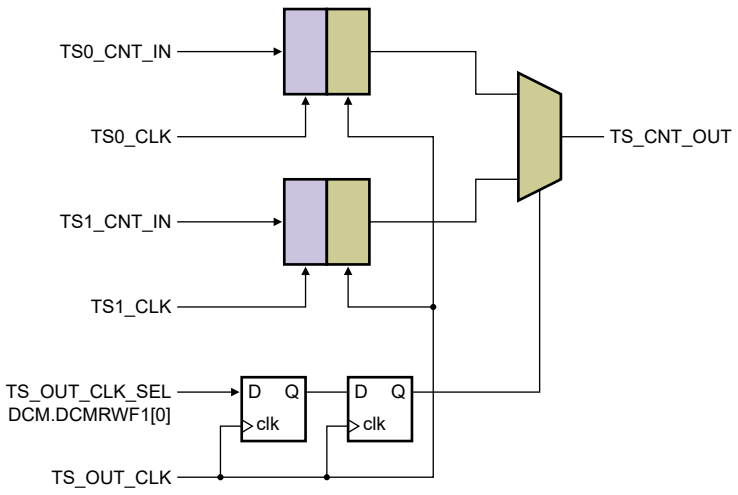


Figure 58. FlexCAN timestamping

Table 97. Timestamp sources and clock nodes

Timestamp	Module	TS clock domain
TS0_CLK	EMAC	TS0_CLK—EMAC_TS_CLK
TS1_CLK	STM0	TS1_CLK—AIPS_PLAT_CLK
TS_OUT_CLK	FlexCAN_*n*	TS_OUT_CLK—EMAC_TS_CLK

NOTE

The timestamp clock (TS_OUT_CLK, EMAC_TS_CLK) must be greater than or equal to FLEXCAN_*n*_PE_CLK. When using STM0 as the timestamp source, the FlexCAN timestamp clock (TS_OUT_CLK, EMAC_TS_CLK) must be greater than or equal to STM0_CLK.

23.6.1.1.2 LPI2C_*n* clocking

The following figure shows LPI2C_*n* clocking, and the related table shows the LPI2C SIUL2 configuration.

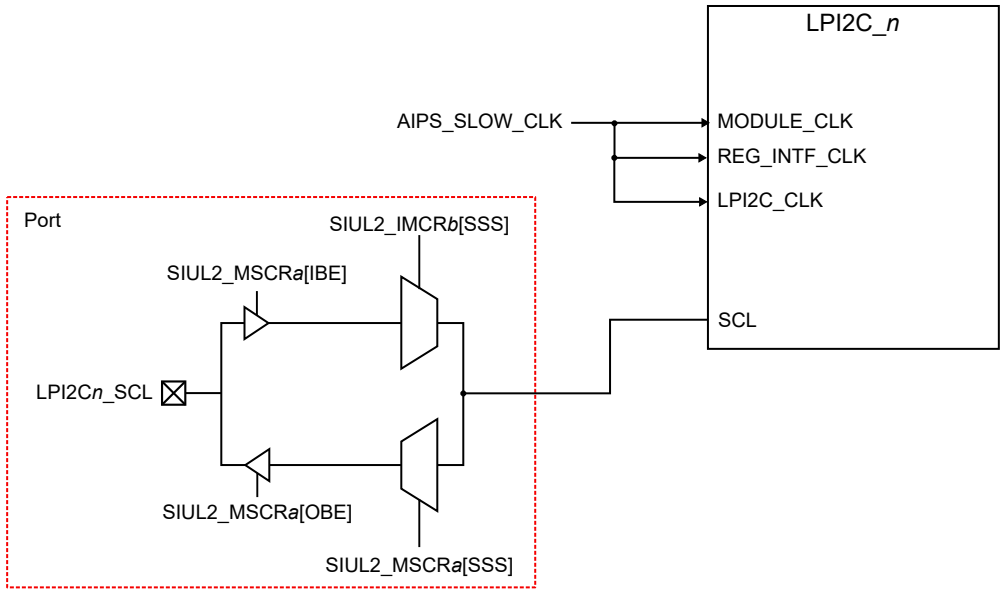


Figure 59. LPI2C clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

Table 98. SIUL2 options for LPI2C*n*_SCL clock

I²C_*n* signal	I²C mode	I/O signal	Port	MSCR*a*	MSCR fields			IMCR*b*	IMCR[SSS]
					OBE	IBE	SSS		
I2C_0_SCL	Slave	LPI2C0_SCL	PTC8	72	0	1	X	212	0001b
	Master				1	0	0001b		X
	Slave		PTD14	110	0	1	X		0010b
	Master				1	0	0100b		X

Table continues on the next page...

Table 98. SIUL2 options for LPI2C*n*_SCL clock (continued)

I^2C_*n* signal	I^2C mode	I/O signal	Port	MSCR*a*	MSCR fields			IMCR*b*	IMCR[SSS]
					OBE	IBE	SSS		
	Slave		PTF20	180	0	1	X		0011b
	Master				1	0	0100b		X
I2C_0_SCLS	Slave	LPI2C0_SCLS	PTB1	33	0	1	X	213	0001b
	Master				1	0	0001b		X
	Slave		PTA23	23	0	1	X		0010b
	Master				1	0	1001b		X
I2C_1_SCL	Slave	LPI2C1_SCL	PTC7	71	0	1	X	217	0001b
	Slave		PTC15	79	0	1	X		0110b
	Master				1	0	0111b		X
	Slave		PTC28	92	0	1	X		0100b
	Master				1	0	101b		X
	Slave		PTD9	105	0	1	X		0010b
	Master				1	0	010b		X
	Slave		PTF7	167	0	1	X		0101b
	Master				1	0	011b		X
	Salve		PTF29	89	0	1	X		0111b
	Master				1	0	1010b		X
I2C_1_SCLS	Slave	LPI2C1_SCLS	PTC17	81	0	1	X	218	0010b
	Master				1	0	0100b		X

23.6.1.1.3 EMAC clocking

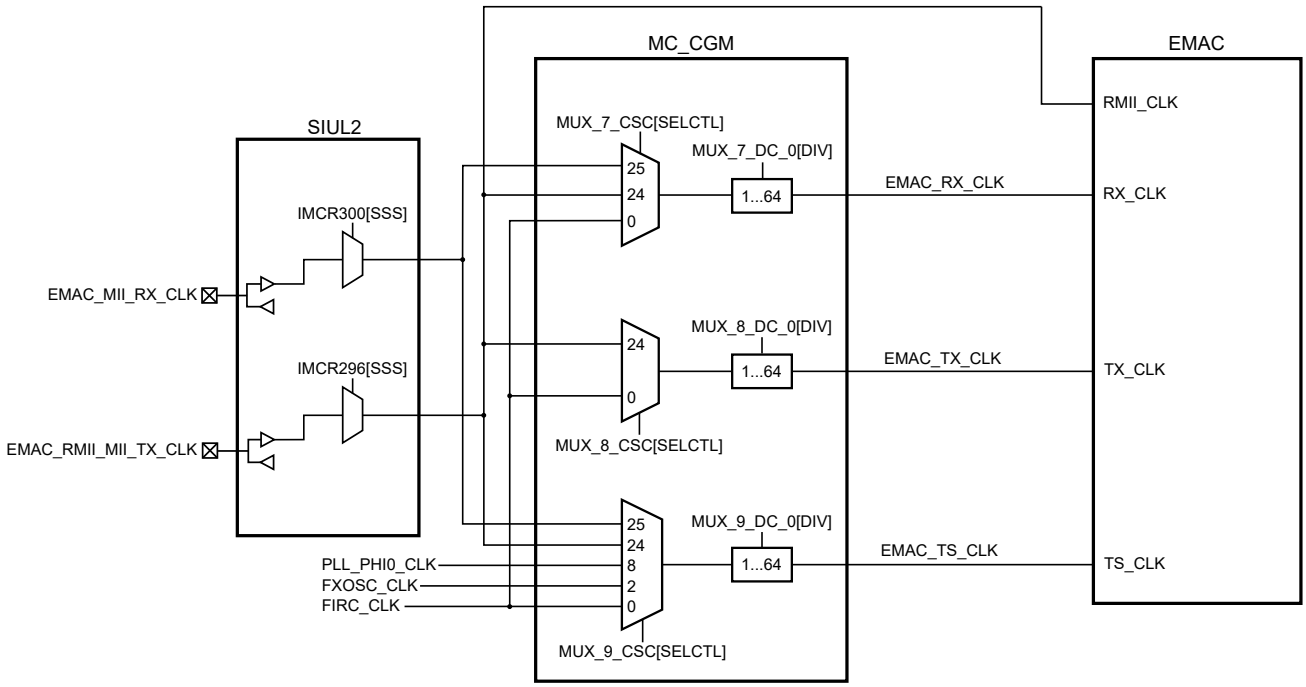


Figure 60. EMAC clocking

NOTE

EMAC operates only in Clock options A and B, since the module clock becomes lower than the protocol clock (RMII/MII clocks) in other modes.

NOTE

See Feature comparison for details on this module's availability on your chip variant.

23.6.1.1.3.1 EMAC RMII clocking

The following table shows the EMAC RMII clocking, and the related table shows the SIUL2 clock signal configuration for RMII.

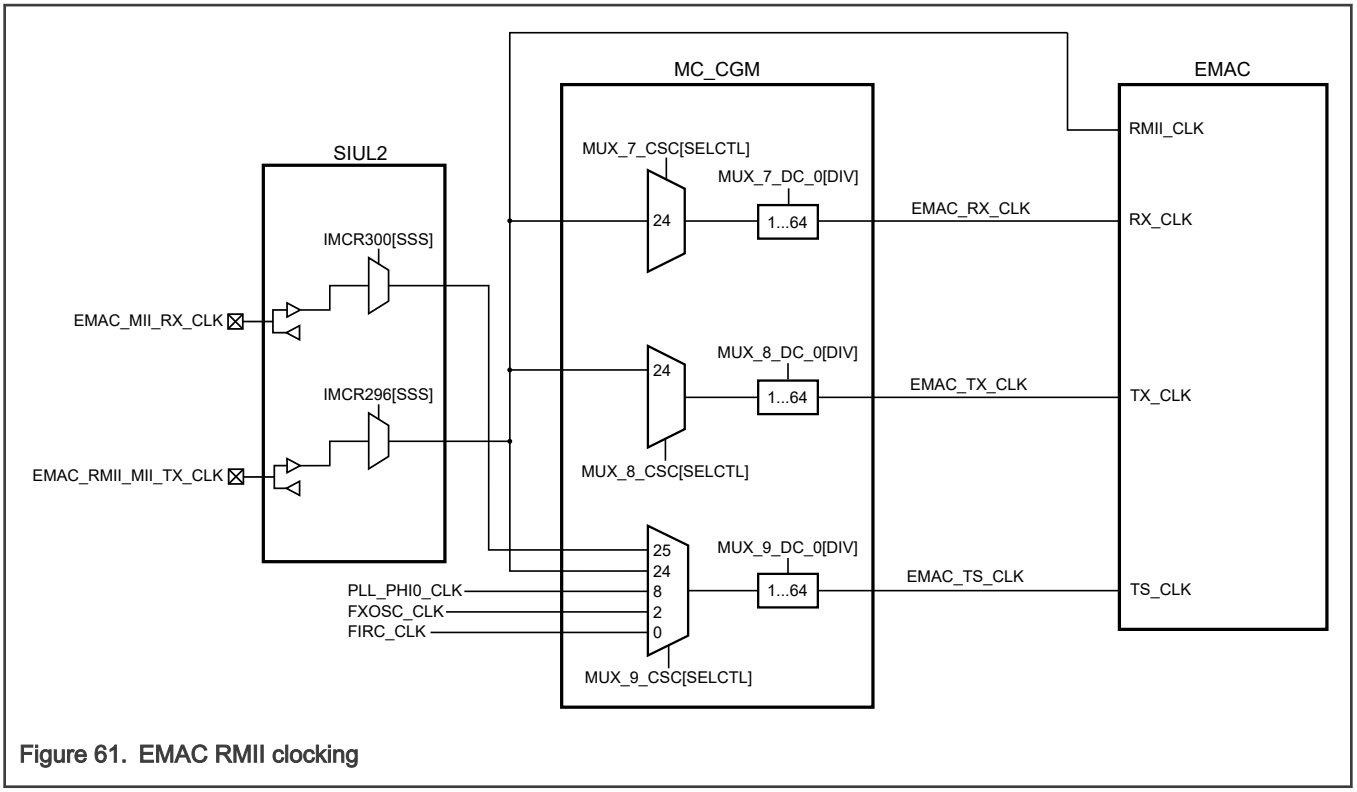


Figure 61. EMAC RMII clocking

Table 99. EMAC RMII clock configuration

Source clock	Destination clock	Port	SIUL2					
			MSCR *a*	MSCR fields			IMCR*b*	IMCR[SSS]
				OBE	IBE	SSS		
EMAC_RMII_MII_TX_CLK	EMAC_RX_CLK	PTB3	35	0	1	X	296	0101b
	EMAC_TX_CLK							
	EMAC_RX_CLK	PTC0	64	0	1	X		0100b
	EMAC_TX_CLK							
	EMAC_RX_CLK	PTC19	83	0	1	X		0110b
	EMAC_TX_CLK							
	EMAC_RX_CLK	PTD6	102	0	1	X		0010b
	EMAC_TX_CLK							
	EMAC_RX_CLK	PTD11	107	0	1	X		0001b
	EMAC_TX_CLK							
	EMAC_RX_CLK	PTD12	108	0	1	X		0011b
	EMAC_TX_CLK							

Table continues on the next page...

Table 99. EMAC RMII clock configuration (continued)

Source clock	Destination clock	Port	SIUL2					
			MSCR *a*	MSCR fields			IMCR*b*	IMCR[SSS]
				OBE	IBE	SSS		
EMAC_RMII_MII_TX_CLK (MC_CGM.MUX_9_CSC[SELCTL] = 18h)	EMAC_TS_CLK	PTB3	35	0	1	X	296	0101b
		PTC0	64	0	1	X		0100b
		PTC19	83	0	1	X		0110b
		PTD6	102	0	1	X		0010b
		PTD11	107	0	1	X		0001b
		PTD12	108	0	1	X		0011b
EMAC_MII_RX_CLK (MC_CGM.MUX_9_CSC[SELCTL] = 19h)	EMAC_TS_CLK	PTB26	58	0	1	X	300	0101b
		PTC0	64	0	1	X		0100b
		PTC1	65	0	1	X		0011b
		PTC16	80	0	1	X		0110b
		PTD5	101	0	1	X		0010b
		PTD10	106	0	1	X		0001b

NOTE

The EMAC time-stamp clock (EMAC_TS_CLK) can use either of the source clocks show in the table above, but can also select other clocks as selected in MC_CGM.MUX_9_CSC[SELCTL].

23.6.1.1.3.2 EMAC MII clocking

The following figure shows the EMAC MII clocking, and the related table shows the SIUL2 clock signal configuration for MII.

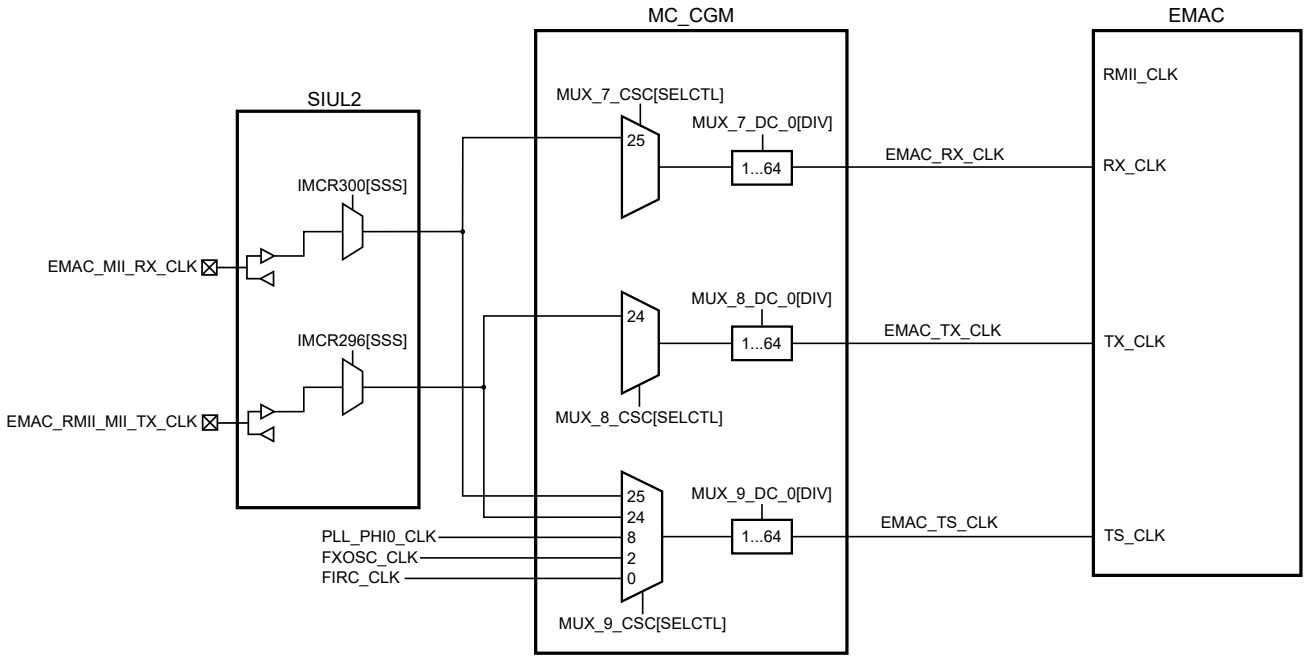


Figure 62. EMAC MII clocking

Table 100. SIUL2 EMAC MII clock configuration

Source clock	Destination	Port	SIUL2					
			MSCR*a*	MSCR fields			IMCR*b*	IMCR[SSS]
				OBE	IBE	SSS		
EMAC_RMII_MII_TX_CLK	EMAC_TX_CLK	PTB3	35	0	1	X	296	0101b
		PTC0	64	0	1	X		0100b
		PTC19	83	0	1	X		0110b
		PTD6	102	0	1	X		0010b
		PTD11	107	0	1	X		0001b
		PTD12	108	0	1	X		0011b
EMAC_MII_RX_CLK	EMAC_RX_CLK	PTB26	58	0	1	X	300	0101b
		PTC0	64	0	1	X		0100b
		PTC1	65	0	1	X		0011b
		PTC16	80	0	1	X		0110b
		PTD5	101	0	1	X		0010b
		PTD10	106	0	1	X		0001b

Table continues on the next page...

Table 100. SIUL2 EMAC MII clock configuration (continued)

Source clock	Destination	Port	SIUL2					
			MSCR*a*	MSCR fields			IMCR*b*	IMCR[SSS]
				OBE	IBE	SSS		
EMAC_RMII_MII_TX_CLK (MC_CGM.MUX_9_CSC[SELCTL] = 18h)	EMAC_TS_CLK	PTB3	35	0	1	X	296	0101b
		PTC0	64	0	1	X		0100b
		PTC19	83	0	1	X		0110b
		PTD6	102	0	1	X		0010b
		PTD11	107	0	1	X		0001b
		PTD12	108	0	1	X		0011b
EMAC_MII_RX_CLK (MC_CGM.MUX_9_CSC[SELCTL] = 19h)	EMAC_TS_CLK	PTB26	58	0	1	X	300	0101b
		PTC0	64	0	1	X		0100b
		PTC1	65	0	1	X		0011b
		PTC16	80	0	1	X		0110b
		PTD5	101	0	1	X		0010b
		PTD10	106	0	1	X		0001b

NOTE

The EMAC time-stamp clock (EMAC_TS_CLK) can use any of the signals shown in the figure above which includes either EMAC_RX_CLK or EMAC_RMII_MII_TX_CLK source clocks. MC_CGM.MUX_9_CSC[SELCTL] selects the specific source clock for EMAC_TS_CLK.

23.6.1.1.4 LPSPI*n* clocking

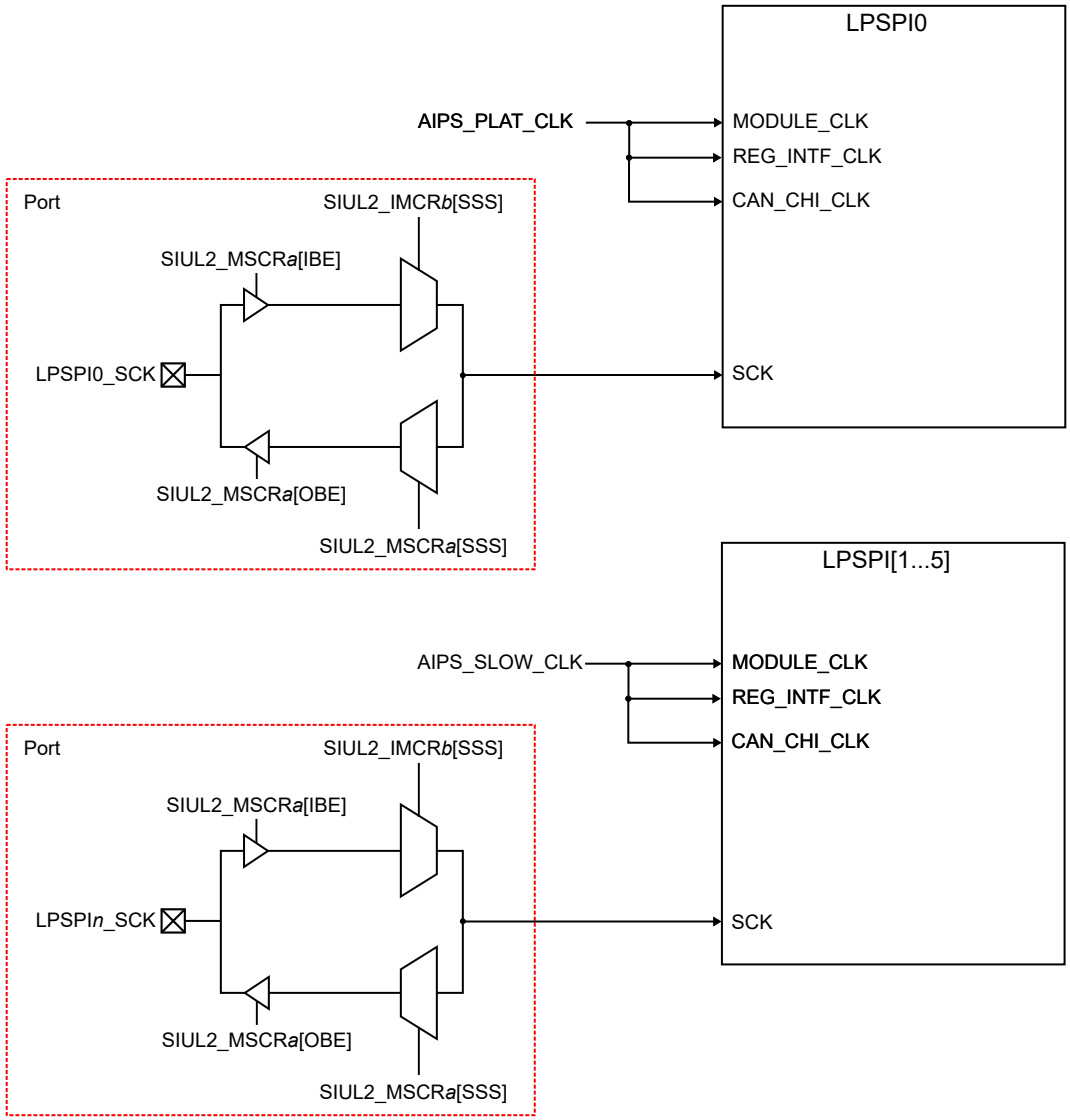


Figure 63. LPSPI*n* clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

Table 101. SIUL2 options for LPSPI*n* SCK

Source	Destination	SPI mode	Port	MSCR *a*	MSCR fields			IMCR *b*	IMCR[SSS]
					OBE	IBE	SSS		
LPSPI0_SCK	LPSPI0 SCK	Slave	PTC8	72	0	1	X	229	0001b
		Master			1	0	0110b		X
		Slave	PTD11	107	0	1	X		0101b

Table continues on the next page...

Table 101. SIUL2 options for LPSPI*n* SCK (continued)

Source	Destination	SPI mode	Port	MSCR *a*	MSCR fields			IMCR *b*	IMCR[SSS]
					OBE	IBE	SSS		
		Master			1	0	0110b		X
		Slave	PTD15	111	0	1	X		0011b
		Master			1	0	0100b		X
		Slave	PTE1	129	0	1	X		0010b
		Master			1	0	0010b		X
LPSPI1_SCK	LPSPI1 SCK	Slave	PTA3	3	0	1	X	238	0001b
		Master			1	0	0011b		X
		Slave	PTA19	19	0	1	X		0011b
		Master			1	0	0100b		X
		Slave	PTA28	28	0	1	X		0100b
		Master			1	0	0011b		X
		Slave	PTB14	46	0	1	X		0010b
		Master			1	0	0011b		X
LPSPI2_SCK	LPSPI2 SCK	Slave	PTB29	61	0	1	X	245	0011b
		Master			1	0	0101b		X
		Slave	PTC15	79	0	1	X		0010b
		Master			1	0	0011b		X
		Slave	PTE15	143	0	1	X		0001b
		Master			1	0	0011b		X
		Slave	PTF0	160	0	1	X		0100b
		Master			1	0	0011b		X
LPSPI3_SCK	LPSPI3 SCK	Slave	PTC17	81	0	1	X	252	0011b
		Master			1	0	0001b		X
		Slave	PTD1	97	0	1	X		0001b
		Master			1	0	0011b		X
		Slave	PTE7	135	0	1	X		0010b
		Master			1	0	0110b		X
		Slave	PTF13	173	0	1	X		0100b
		Master			1	0	0100b		X
LPSPI4_SCK	LPSPI4 SCK	Slave	PTB10	42	0	1	X	259	0010b

Table continues on the next page...

Table 101. SIUL2 options for LPSPI*n* SCK (continued)

Source	Destination	SPI mode	Port	MSCR *a*	MSCR fields			IMCR *b*	IMCR[SSS]
					OBE	IBE	SSS		
		Master			1	0	0001b		X
		Slave	PTC27	91	0	1	X		0001b
		Master			1	0	0111b		X
LPSPI5_SCK	LPSPI5 SCK	Slave	PTA3	3	0	1	X	266	0010b
		Master			1	0	0111b		X
		Slave	PTD14	110	0	1	X		0001b
		Master			1	0	0001b		X
		Slave	PTD26	122	0	1	X		0011b

23.6.1.1.5 LPUART clocking

The following figure shows the LPUART clocking configuration, and the related table shows LPUART use case baud rates.

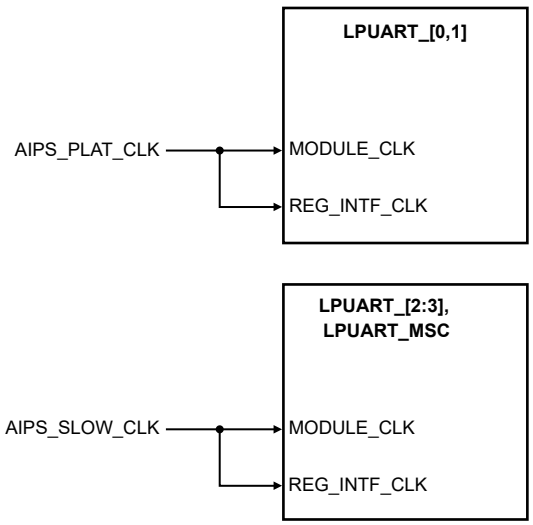


Figure 64. LPUART clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

Table 102. LPUART baud rate calculation

Required baud rate (bps)	LPUART_CLK (MHz)	OSR	SBR[12:0]	Calculated baud rate (bps) [1]
8192	40	4	976	8196
8192	80	15	610	8196

Table continues on the next page...

Table 102. LPUART baud rate calculation (continued)

Required baud rate (bps)	LPUART_CLK (MHz)	OSR	SBR[12:0]	Calculated baud rate (bps) [1]
8192	48	15	366	8196
115200	48	15	26	115384
115200	40	7	43	116279
19200	80	4	833	19207
19200	40	7	260	19230
38400	40	7	130	38461

1. MODULE_CLK ÷ (LPUART.BAUD[SBR] × (LPUART.BAUD[OSR] + 1))

23.6.1.1.6 FlexIO clocking

The following figure shows the FlexIO clocking interface. The related two tables show the FlexIO baud rate use cases.

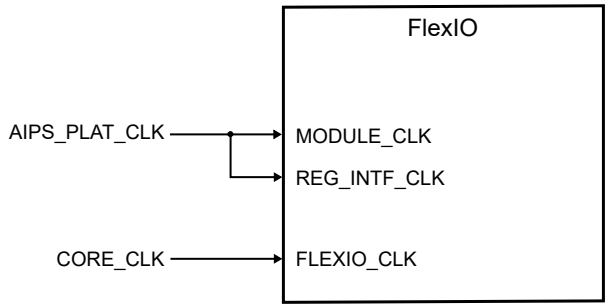


Figure 65. FlexIO clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

Table 103. FlexIO baud rate calculation (FlexIO.TIMCFG*n*[TIMDEC] = 101b)

FLEXIO_CLK (CORE_CLK)	Required baud rate	TIMCMP*n*[CMP]		Theoretical baud rate [1]	Bit duration	Observed baud rate
		Hex	Decimal			
88 MHz	9600	0010h	16	10110.29	101.33 µs	9868
88 MHz	19200	0007h	7	21484.37	47.44 µs	21079
88 MHz	57600	0001h	1	85937.50	11.66 µs	85763
88 MHz	115200	0000h	0	171875.00	5.88 µs	170068

1. Theoretical baud rate = Frequency ÷ (256 × 2 × (TIMCMP*n*[CMP] + 1))

Table 104. FlexIO baud rate calculation (FlexIO.TIMCFG*n*[TIMDEC] = 100b)

FLEXIO_CLK (CORE_CLK)	Required baud rate	TIMCMP*n*[CMP]		Theoretical baud rate [1]	Bit duration	Observed baud rate
		Hex	Decimal			
88 MHz	9600	—	—	—	—	—
88 MHz	19200	8Eh	142	19230.77	51.88 µs	19275
88 MHz	57600	2Eh	46	58510.64	16.89 µs	59206
88 MHz	115200	16h	22	119565.21	8.44 µs	118483

23.6.1.1.7 QuadSPI clocking

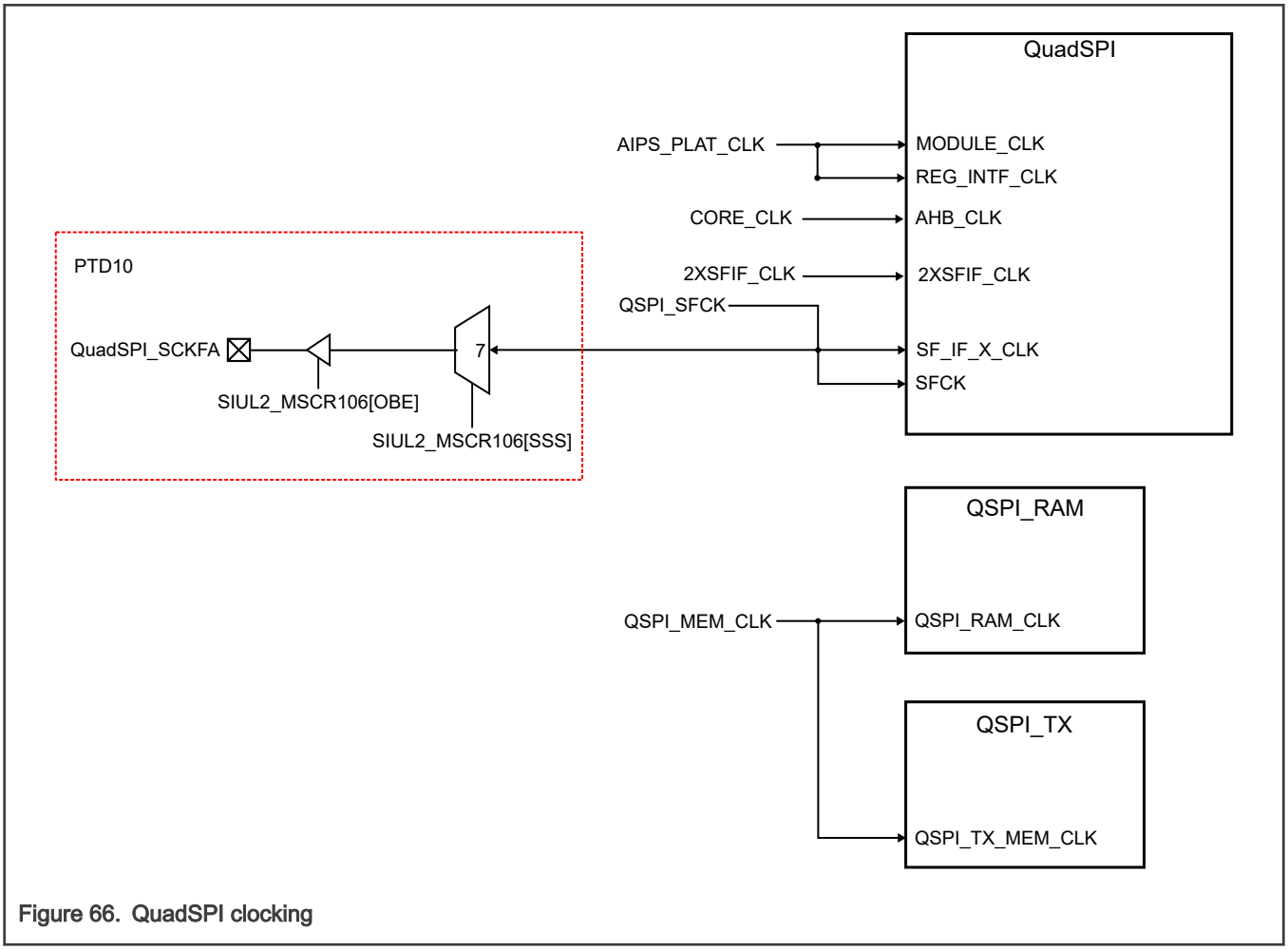


Figure 66. QuadSPI clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

The QSPI shall support DDR (for HyperRAM) of up to 120MHz

Table 105. QuadSPI clocking

Clock option	AIPS_PLAT_CLK	QSPI_SFCK	QSPI_MEM_CLK
See Option A+ - High Performance mode (CM7_CORE_CLK @ 320 MHz)	80 MHz	120 MHz	320 MHz
See Option B - Reduced Speed mode (CM7_CORE_CLK @ 240 MHz)	60 MHz	120 MHz or 80 MHz	240 MHz

23.6.1.1.8 DSPI clocking

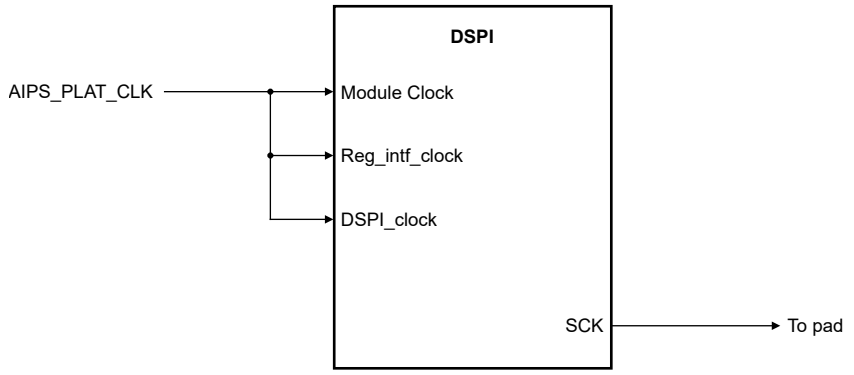


Figure 67. DSPI clocking

The DSPI is clocked at 80MHz.

Maximum frequency of DSPI in differential mode is 40 MHZ

23.6.1.1.9 LFAST clocking

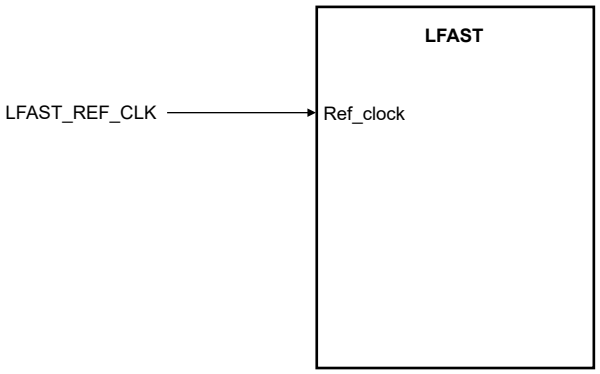


Figure 68. LFAST clocking

Table 106. SIUL2 options for LFAST_ref_clk

LFAST signal	LFAST mode	I/O signal	Port	MSCR*a*	MSCR fields			IMCR*b*	IMCR[SSS]
					OBE	IBE	SSS		
LFAST_ext_ref_clk	External	LFAST_ext_ref_clk	PTA29	29	0	1	X	953	0001b

Table continues on the next page...

Table 106. SIUL2 options for LFAST_ref_clk (continued)

LFAST signal	LFAST mode	I/O signal	Port	MSCR*a*	MSCR fields			IMCR*b*	IMCR[SSS]
					OBE	IBE	SSS		
	Internal generated				1	0	1000b		X

23.6.1.1.10 LFAST PLL clocking

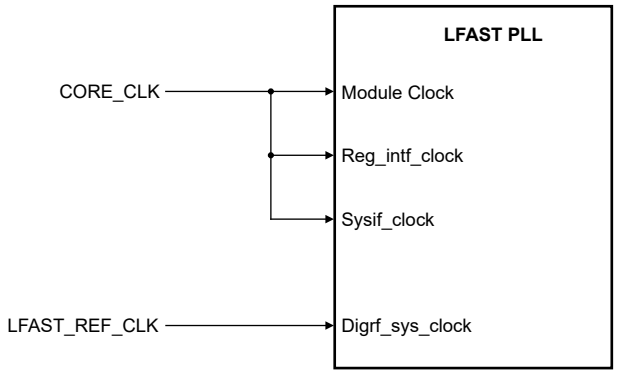


Figure 69. LFAST PLL clocking

Zipwire requires 2 clocks: The LFAST PLL and the IPS clock

LFAST_PLL is driven by LFAST_CLK. The PLL supports a startup frequency of 20MHz and then provides 320MHz or 480MHz operating frequency

23.6.1.1.11 SIPI clocking

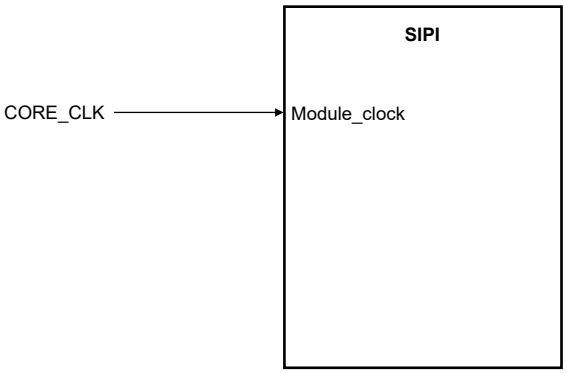


Figure 70. SIPI clocking

23.6.1.2 System modules

Figure 71 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 107 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

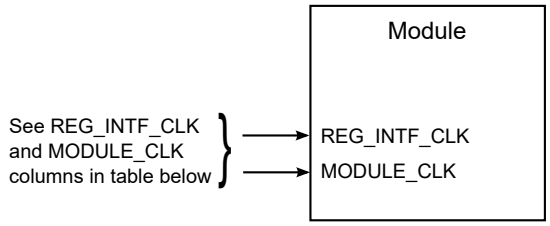


Figure 71. System module clocks

Table 107. System module clocking

Module	MODULE_CLK	REG_INTF_CLK
MSCM	AIPS_PLAT_CLK	AIPS_PLAT_CLK
MCM	AIPS_SLOW_CLK	AIPS_SLOW_CLK
SIUL2	See SIUL2 clocking.	
VIRT_WRAPPER	AIPS_SLOW_CLK	AIPS_SLOW_CLK
AXBS	CORE_CLK	AIPS_PLAT_CLK
DMAMUX	CORE_CLK	CORE_CLK
eDMA	CORE_CLK	AIPS_PLAT_CLK
INTM	AIPS_PLAT_CLK	AIPS_PLAT_CLK
SEMA42	AIPS_PLAT_CLK	AIPS_PLAT_CLK
XBIC	CORE_CLK	AIPS_PLAT_CLK
XRDC	CORE_CLK	AIPS_PLAT_CLK

23.6.1.2.1 SIUL2 clocking

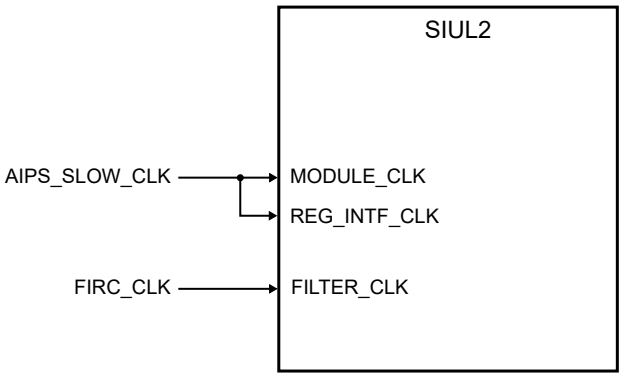


Figure 72. SIUL2 clocking

23.6.1.3 Clocking modules

Figure 73 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 108 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

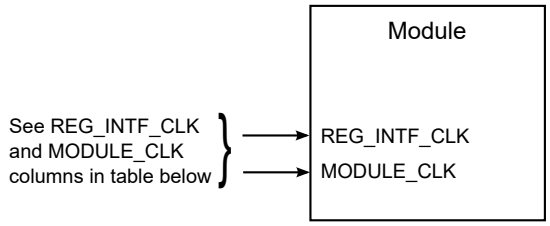


Figure 73. Clocking module clocks

Table 108. Clocking module clocking

Module	MODULE_CLK	REG_INTF_CLK
FXOSC	See FXOSC clocking.	
SIRC	See SIRC clocking.	
FIRC	See FIRC clocking.	
PLLDIG	See PLLDIG clocking.	
MC_CGM	—	AIPS_SLOW_CLK

23.6.1.3.1 FIRC clocking

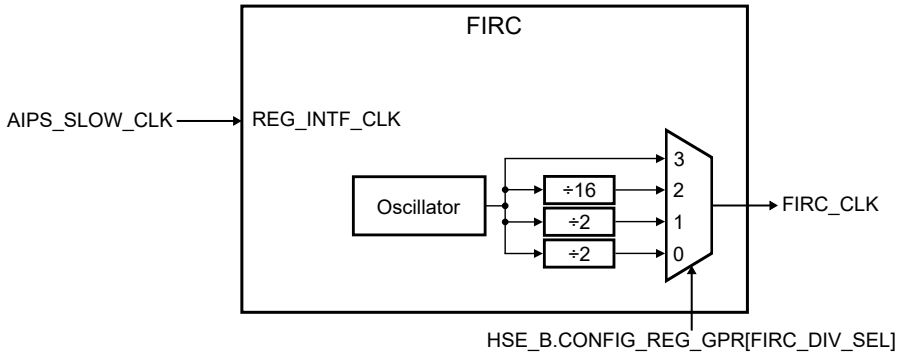


Figure 74. FIRC clocking

23.6.1.3.2 SIRC clocking

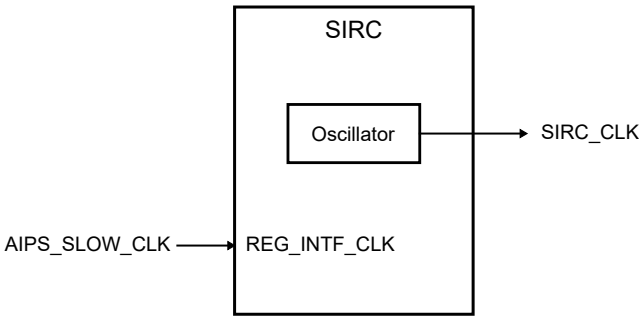


Figure 75. SIRC clocking

23.6.1.3.3 FXOSC clocking

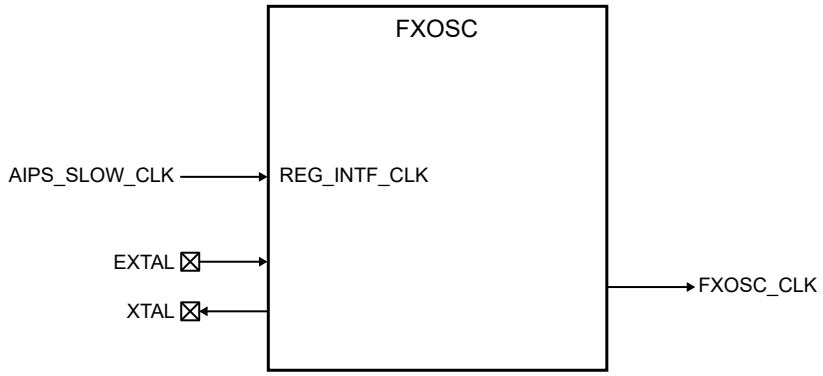


Figure 76. FXOSC clocking

23.6.1.3.4 PLLDIG clocking

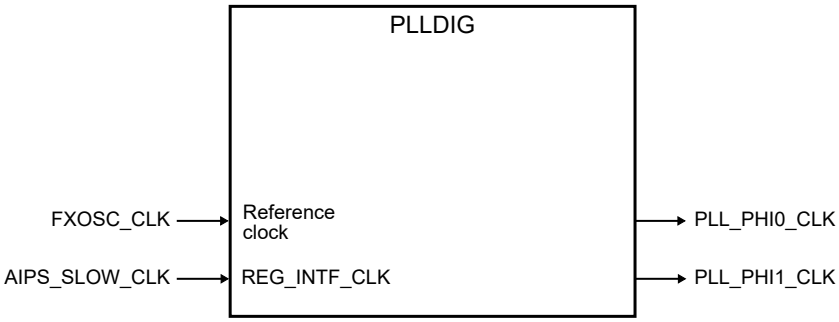


Figure 77. PLLDIG clocking

23.6.1.4 Reset modules

Figure 78 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 109 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

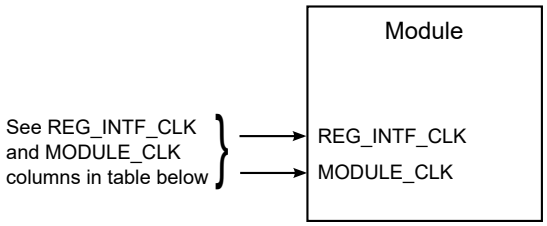


Figure 78. Reset module clocks

Table 109. Reset module clocking

Module	MODULE_CLK	REG_INTF_CLK
MC_RGM	FIRC_CLK	FIRC_CLK

23.6.1.5 Security modules

Figure 79 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 110 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

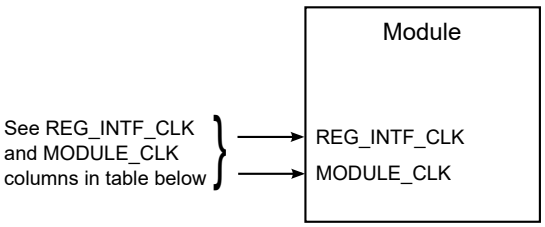


Figure 79. Security module clocks

Table 110. Security module clocking

Module	MODULE_CLK	REG_INTF_CLK
HSE_B	See HSE_B clocking .	
MU_*n*	AIPS_SLOW_CLK	AIPS_SLOW_CLK
DCM	DCM_CLK	DCM_CLK

23.6.1.5.1 HSE_B clocking

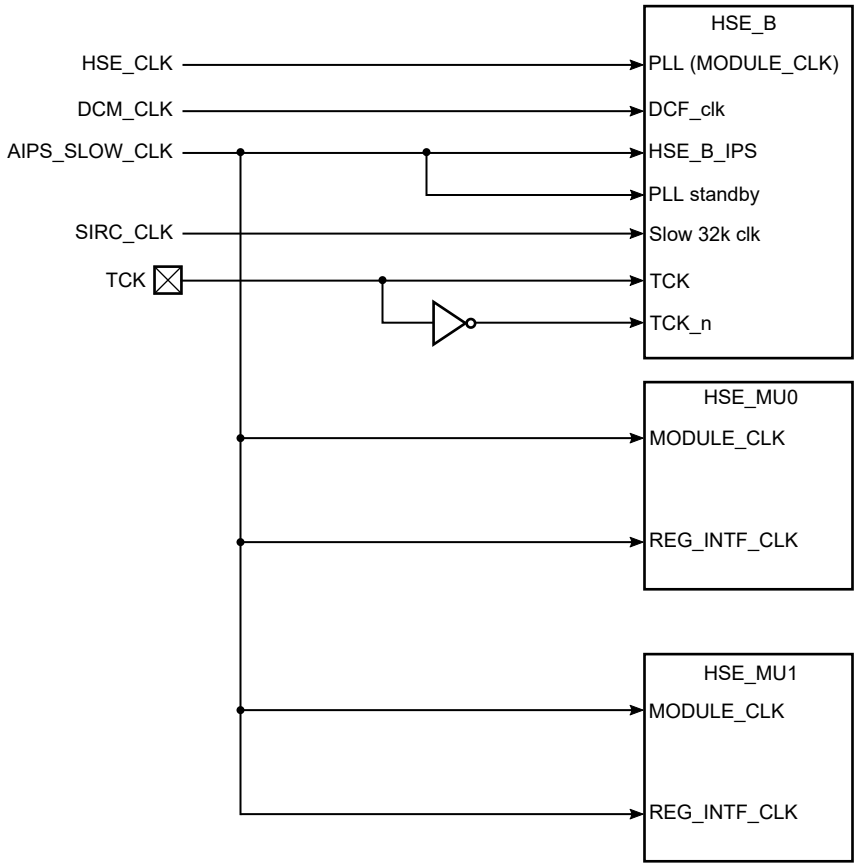


Figure 80. HSE_B clocking

23.6.1.6 Power-management modules

Figure 81 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 111 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

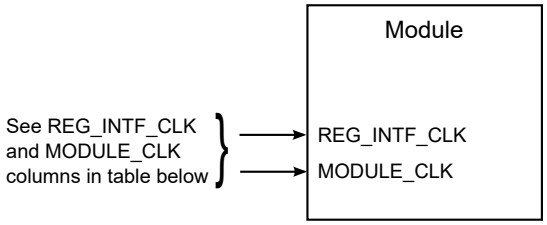


Figure 81. Power-management module clocks

Table 111. Power-management module clocking

Module	MODULE_CLK	REG_INTF_CLK
PMC	AIPS_SLOW_CLK	AIPS_SLOW_CLK
MC_ME	AIPS_SLOW_CLK	AIPS_SLOW_CLK
MC_PCU	FIRC_CLK	FIRC_CLK
WKPU	AIPS_SLOW_CLK	AIPS_SLOW_CLK

23.6.1.7 Safety modules

Figure 82 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 112 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

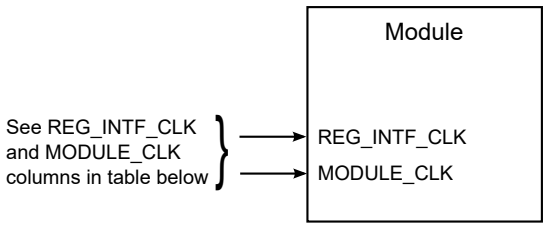


Figure 82. Safety module clocks

Table 112. Safety module clocking

Module	MODULE_CLK	REG_INTF_CLK
EIM	AIPS_PLAT_CLK	AIPS_PLAT_CLK
ERM	See ERM clocking.	
FCCU	See FCCU clocking.	
STCU2	See STCU2 clocking.	
REG_PROT	AIPS_SLOW_CLK	AIPS_SLOW_CLK
CMU_FC	AIPS_SLOW_CLK	AIPS_SLOW_CLK
CMU_FM	AIPS_SLOW_CLK	AIPS_SLOW_CLK
CRC	AIPS_PLAT_CLK	AIPS_PLAT_CLK

23.6.1.7.1 FCCU clocking

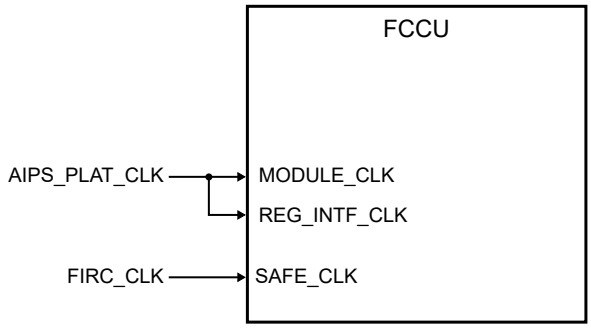


Figure 83. FCCU clocking

23.6.1.7.2 STCU2 clocking

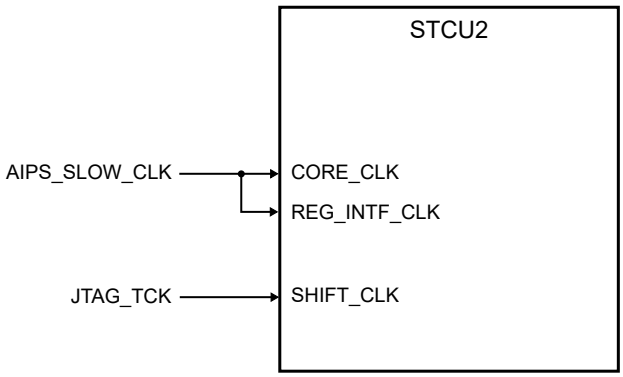


Figure 84. STCU2 clocking

23.6.1.7.3 ERM clocking

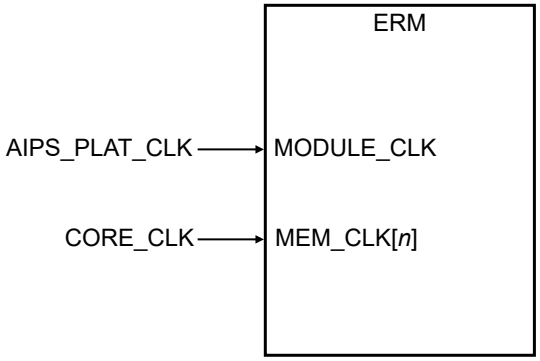


Figure 85. ERM clocking

NOTE

MEM_CLK[20:23] are not used. Source clock for MEM_CLK[0:19] is CORE_CLK.

23.6.1.8 ADC and motor control modules

Figure 86 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 113 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

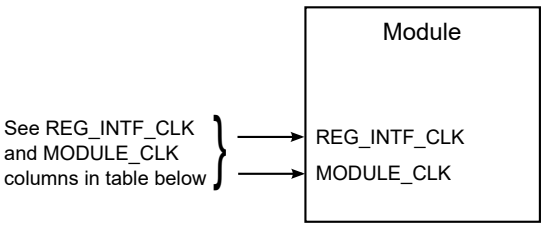


Figure 86. Motor control module clocks

Table 113. Motor control module clocking

Module	MODULE_CLK	REG_INTF_CLK
ADC	See ADC_*n* clocking.	
LCU	CORE_CLK	
eMIOS	See eMIOS_*n* clocking.	
BCTU	See BCTU clocking.	
TRGMUX	AIPS_SLOW_CLK	
eTPU	See eTPU clocking	
DSPSS	See Coolflux clocking	
eFlexPWM	See eFlexPWM clocking	
SD-ADC	See SD-ADC clocking	
SWG	See SWG clocking	
IGF	See IGF clocking	

23.6.1.8.1 ADC_*n* clocking

The following figure shows ADC_*n* clocking configuration.

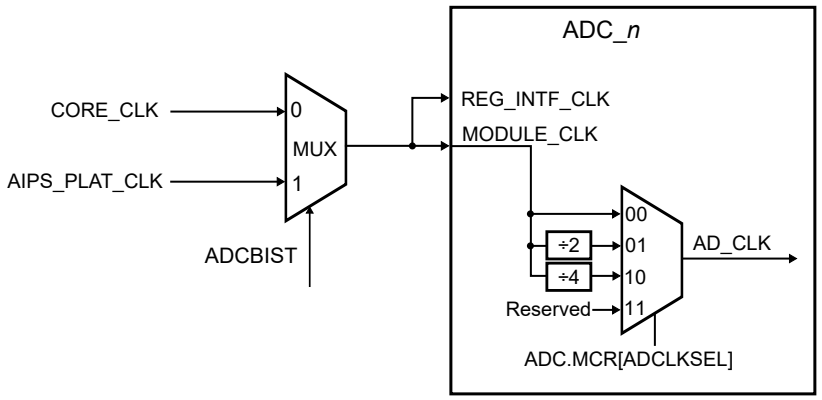


Figure 87. ADC_*n* clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

In normal mode, CORE_CLK is used for ADC and in bist mode, AIPS_PLAT_CLK is used.

The prescaler can be bypassed when using FIRC_CLK as the source (see MC_CGM mux 0 clocks for FIRC_CLK use details). The prescaler must be controlled such that the AD_CLK frequency is less than or equal to 80 MHz.

The minimum operating speed of AD_CLK is 6 MHz using the following configuration:

1. Use FIRC_CLK (48 MHz) as clock source (MC_CGM.MUX_0_CSC[SELCTL] equal to 0000b).
2. Divide FIRC_CLK by 2 for CORE_CLK speed (MC_CGM.MUX_0_DC_0[DIV] equal to 1 (FIRC_CLK divide by 2 = 24 MHz)).
3. Write ADC.MCR[ADCCLKSEL] equal to 10b to divide the FIRC_CLK further by 4 (AD_CLK = 6 MHz).

However, at this lower speed, the ADC_*n* results will be degraded.

23.6.1.8.2 eMIOS_*n* clocking

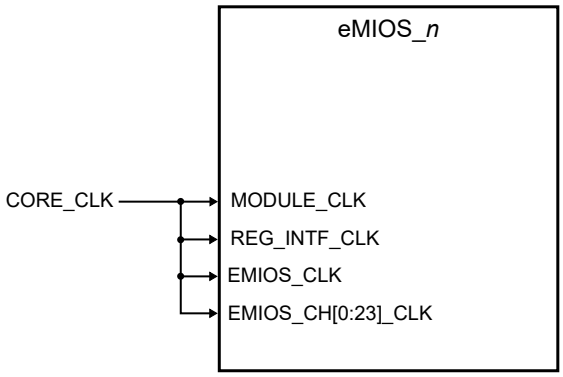


Figure 88. eMIOS_*n* clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

NOTE

eMIOS will be clocked at 160 MHz.

23.6.1.8.3 BCTU clocking

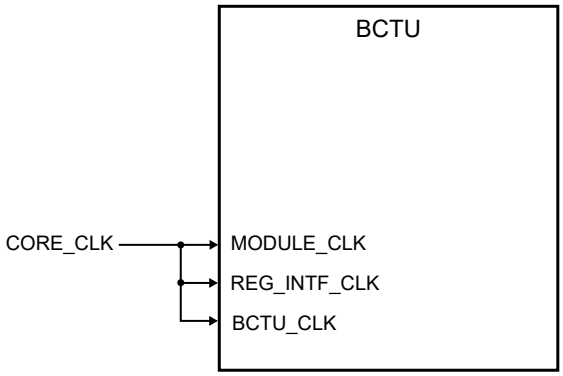


Figure 89. BCTU clocking

NOTE

BCTUs will be clocked by the peripheral clock (160MHz).

23.6.1.8.4 eTPU clocking

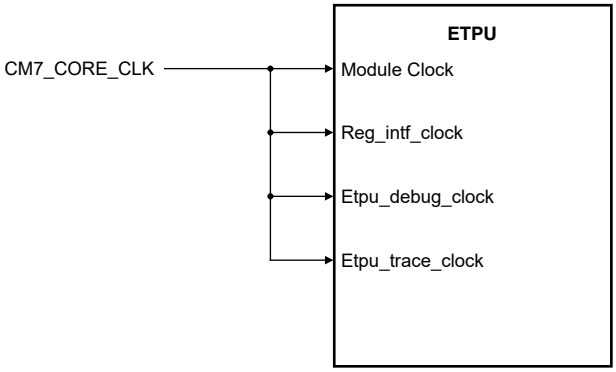


Figure 90. eTPU clocking

eTPU bus interface is clocked at 320 MHz

eTPU functional clock will be 320 MHz

eTPU memories(SCM and SDM) will run at 320 MHz

23.6.1.8.5 Coolflux clocking

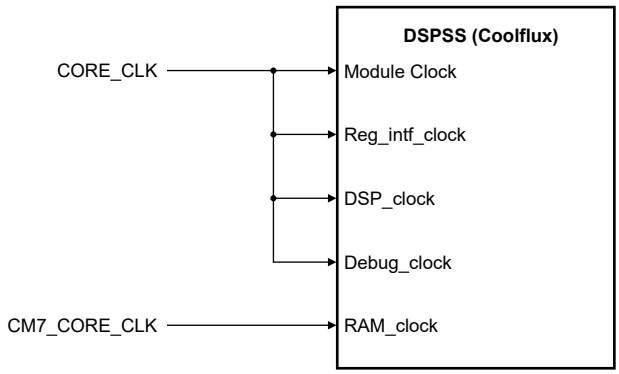


Figure 91. Coolflux clocking

DSP clock is connected to CORE_CLK(160 MHz)

MODULE_CLK is 160 MHz. It is fixed phase shift of 1-cycle of 320MHz w.r.t DSP clock and synchronous with DSP and RAM clock

RAM clock is 320MHz. It is synchronous to CORE/eDMA and DSP clock.

23.6.1.8.6 eFlexPWM clocking

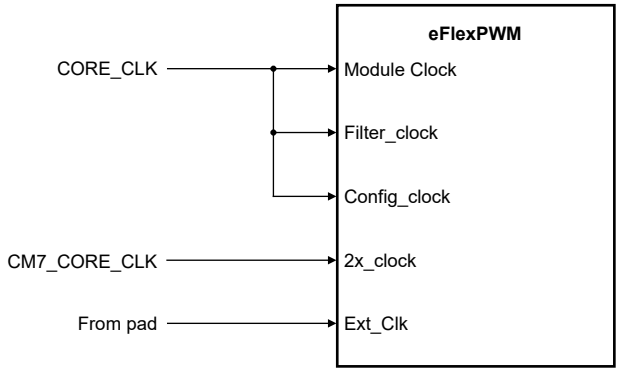


Figure 92. eFlexPWM clocking

The nano-edge block is clocked at 2x the eFlexPWM block.

The eFlexPWM is clocked by a 160MHz clock

23.6.1.8.7 SD-ADC clocking

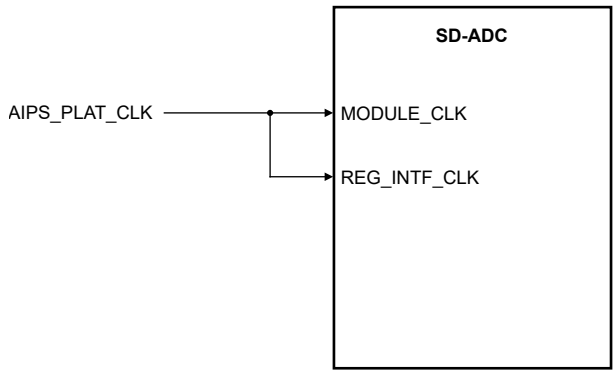


Figure 93. SD-ADC clocking

SD-ADC is clocked at 80 MHz

23.6.1.8.8 SWG clocking

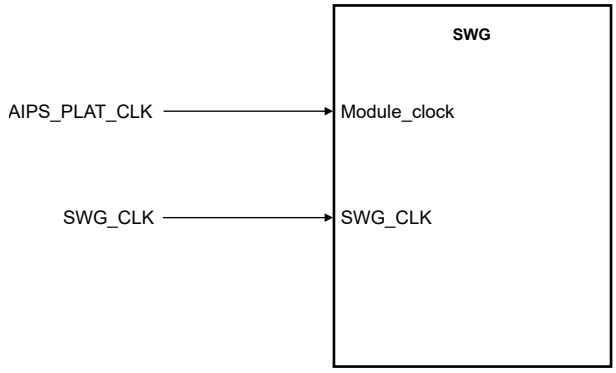


Figure 94. SWG clocking

The SWG is clocked at 20MHz.

Table 114. SIUL2 options for SWG_ref_clk

SWG signal	I/O signal	Port	MSCR*a*	MSCR fields			IMCR*b*	IMCR[SSS]
				OBE	IBE	SSS		
SWG_ext_ref_clk	SWG_ext_ref_clk	PTA22	22	0	1	X	948	0001b
		PTB10	42	0	1	X		0011b
		PTE9	137	0	1	X		0010b
		PTE23	151	0	1	X		0100b
		PTF0	160	0	1	X		0101b

23.6.1.8.9 IGF clocking

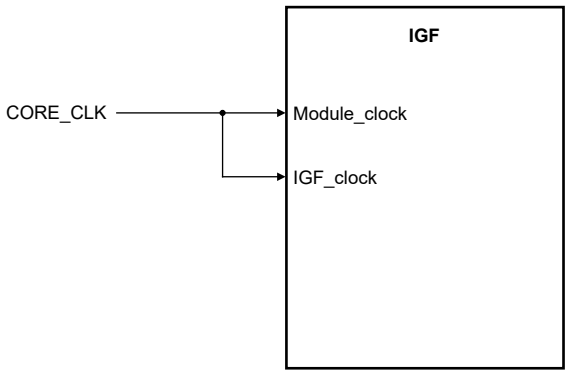


Figure 95. IGF clocking

The IGF is clocked by a 160MHz clock.

23.6.1.9 Timer modules

Figure 96 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 115 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

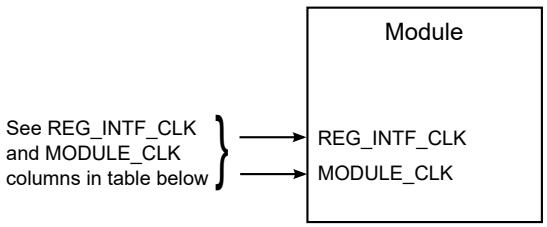


Figure 96. Timer module clocks

Table 115. Timer module clocking

Module	MODULE_CLK	REG_INTF_CLK
PIT	See PIT_*n* clocking.	
SWT	See SWT_*n* clocking.	
STM_*n*	STM0_CLK	STM0_CLK
RTC	See RTC clocking.	

23.6.1.9.1 PIT_*n* clocking

The following figure shows the PIT_*n* clocking configuration. The related tables show the use case configuration.

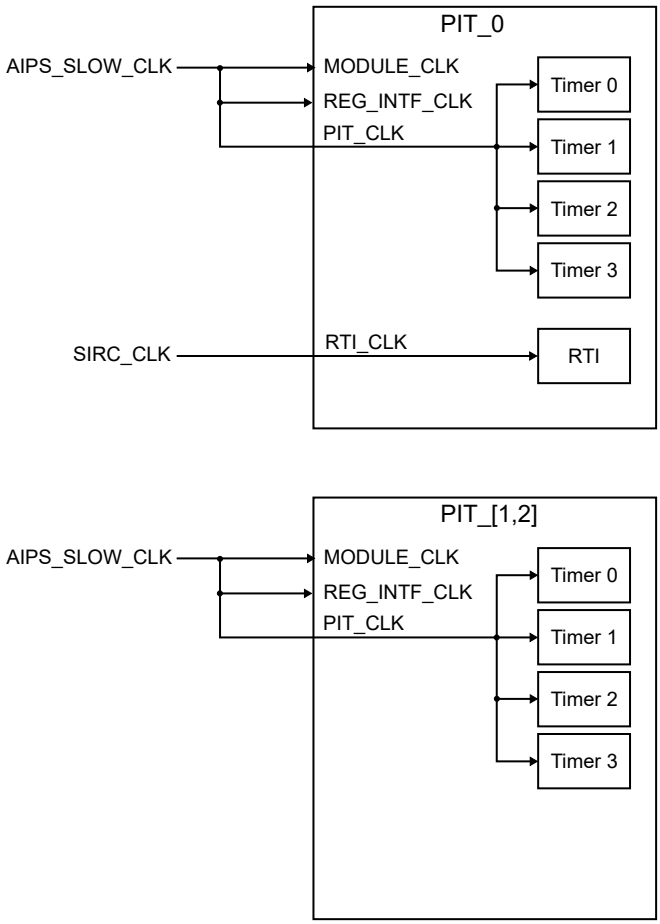


Figure 97. PIT_*n* clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

Table 116. PIT_0 modes of operation

MC_ME.PRTN0_COFB1_CLKEN[REQ44]	PIT_0.MCR[MDIS]	PIT_0.MCR[MDIS_RTI]	Mode	Application
0	X	X	PIT_0 clock gated (minimum power)	Module clock gated and unused / Standby mode, PIT and RTI unused
1	0	0	Both PIT and RTI enabled	Run mode
1	0	1	PIT running, RTI disabled	Run mode with only PIT active
1	1	0	PIT disabled, RTI enabled	Standby mode with RTI enabled
1	1	1	Both PIT and RTI disabled	Standby mode with RTI disabled

Table 117. PIT_[1,2] modes of operation

MC_ME.PRTN*n*_COFB1_CLKEN[REQ[45,63]] [1]	PIT_[1,2].MCR[MDIS]	Mode	Application
0	X	PIT_[1,2] clock gated (minimum power)	Module clock gated and unused, Standby mode
1	0	PIT_[1,2] enabled	Run mode
1	0	PIT_[1,2] running	Run mode with PIT active
1	1	PIT_[1,2] disabled	Standby mode

1. PIT_1 and PIT_2 MC_ME partition registers used are:
   - PIT_1 - MC_ME.PRTN0_COFB1_CLKEN[REQ45]
   - PIT_2 - MC_ME.PRTN1_COFB1_CLKEN[REQ63]

23.6.1.9.2 SWT_*n* clocking

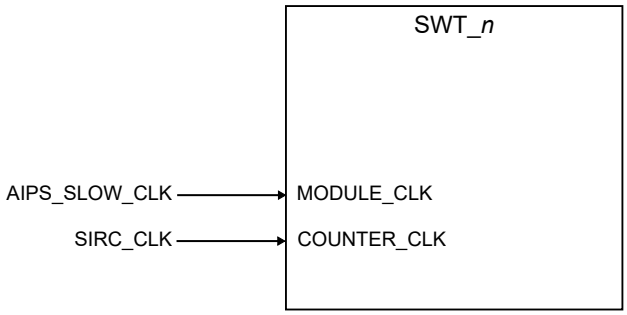


Figure 98. SWT_*n* clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

23.6.1.9.3 RTC clocking

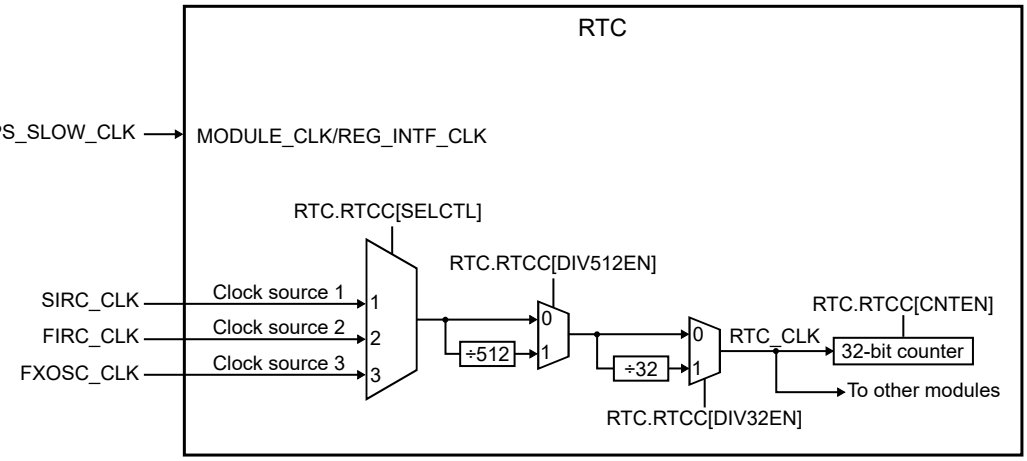


Figure 99. RTC clocking

NOTE

The RTC is available in Standby mode. Although bus clock is gated, the RTC can run on FIRC_CLK, SIRC_CLK, FXOSC_CLK.

23.6.1.10 Debug modules

Figure 100 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 118 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

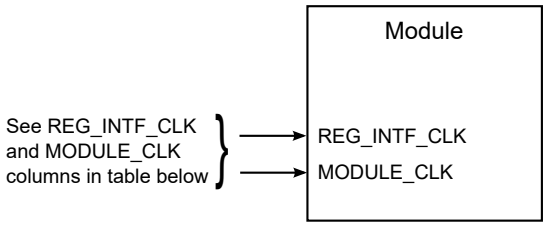


Figure 100. Debug module clocks

Table 118. Debug module clocking

Module	MODULE_CLK	REG_INTF_CLK
JTAGC	See JTAGC clocking.	
JDC	See JDC clocking.	

23.6.1.10.1 JTAGC clocking

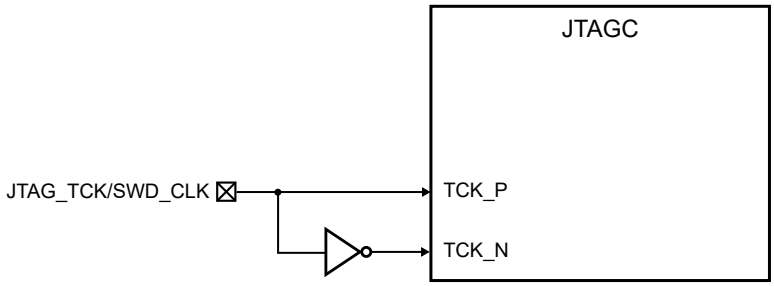


Figure 101. JTAGC clocking

23.6.1.10.2 JDC clocking

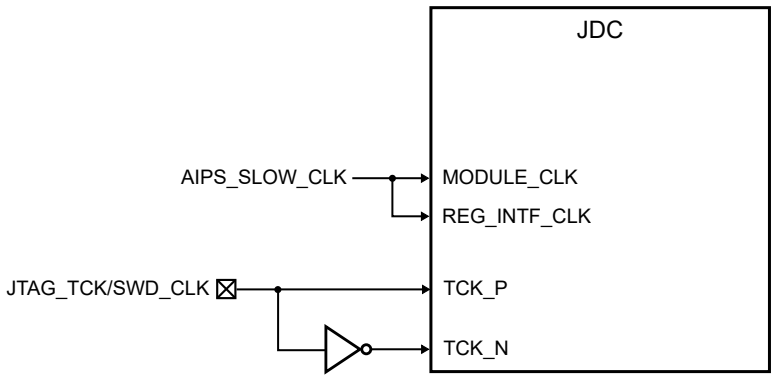


Figure 102. JDC clocking

23.6.1.11 Analog modules

Figure 103 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 119 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

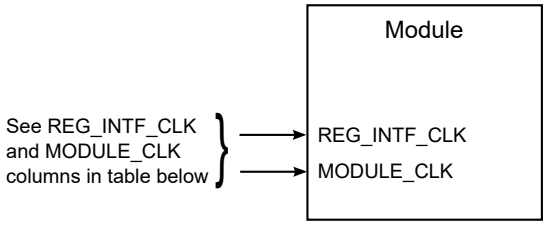


Figure 103. Analog module clocks

Table 119. Analog module clocking

Module	MODULE_CLK	REG_INTF_CLK
LPCMP	See LPCMP_*n* clocking.	
Temperature Sensor	AIPS_SLOW_CLK	AIPS_SLOW_CLK

23.6.1.11.1 LPCMP_*n* clocking

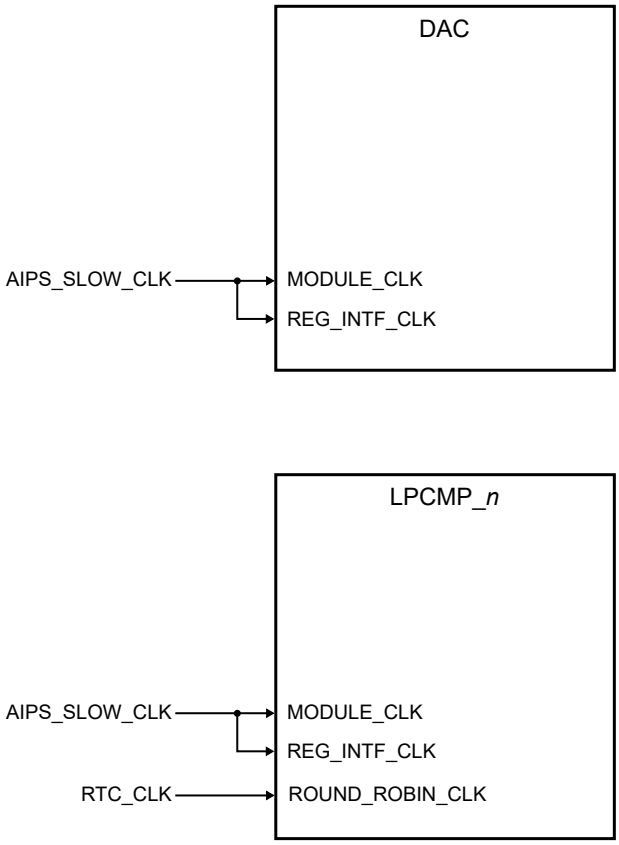


Figure 104. LPCMP_*n* clocking

NOTE

See Feature comparison for details on this module's availability on your chip variant.

23.6.1.12 Memory modules

Figure 105 shows the REG_INTF_CLK and MODULE_CLK connections, and Table 120 shows the REG_INTF_CLK and MODULE_CLK signals used by these modules. Any module diagram that does not explicitly show a REG_INTF_CLK uses the same source for REG_INTF_CLK as used by MODULE_CLK.

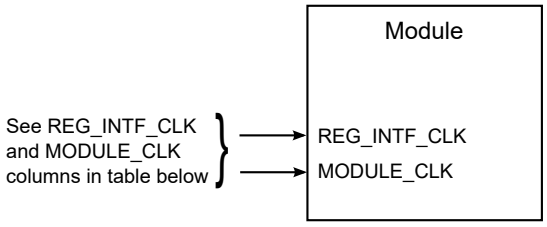


Figure 105. Memory module clocks

Table 120. Memory module clocking

Module	MODULE_CLK	REG_INTF_CLK
PFLASH/ FLASH	CORE_CLK	AIPS_SLOW_CLK
PRAM/ SRAM	CORE_CLK	AIPS_SLOW_CLK

23.6.2 Mapping of IPs and different clock modes

All IPs work in high performance clock mode but there are some IPs which don't support low performance modes (i.e. C, D, E, and E2). See the below table for details.

Table 121. Mapping of IPs and different clock modes

Peripheral instance	Mode A+	Mode B	Mode C	Mode D	Mode E	Mode E2
Yes: Supported No: Not supported	Core_clk:320MHz, PLAT_CLK: 160MHz	240/120	FIRC/2	FIRC	FIRC 2MHz	FIRC 750KHz
ADC 0	Yes	Yes	Yes	Yes	Yes	Yes
ADC 1	Yes	Yes	Yes	Yes	Yes	Yes
ADC 2	Yes	Yes	Yes	Yes	Yes	Yes
ADC 3	Yes	Yes	Yes	Yes	Yes	Yes
ADC 4	Yes	Yes	Yes	Yes	Yes	Yes
ADC 5	Yes	Yes	Yes	Yes	Yes	Yes
ADC 6	Yes	Yes	Yes	Yes	Yes	Yes
adc_bist	Yes	Yes	Yes	Yes	Yes	Yes
BCTU	Yes	Yes	Yes	Yes	Yes	Yes
BCTU 1	Yes	Yes	Yes	Yes	Yes	Yes
Coolflux	Yes	Yes	Yes	Yes	Yes	Yes
GMAC	Yes	Yes	No[1]	No[1]	No[1]	No[1]
eMIOS0	Yes	Yes	Yes	Yes	Yes	Yes
Enhanced FlexPWM 0	Yes	Yes	Yes	Yes	Yes	Yes
Enhanced FlexPWM 1	Yes	Yes	Yes	Yes	Yes	Yes
eTPU	Yes	Yes	Yes[2]	Yes[2]	Yes[2]	Yes[2]
FlexCAN 0	Yes	Yes	No[3]	No[3]	No[3]	No[3]
FlexCAN 1	Yes	Yes	No[3]	No[3]	No[3]	No[3]
FlexCAN 2	Yes	Yes	No[3]	No[3]	No[3]	No[3]
FlexCAN 3	Yes	Yes	No[3]	No[3]	No[3]	No[3]

Table continues on the next page...

Table 121. Mapping of IPs and different clock modes (continued)

Peripheral instance	Mode A+	Mode B	Mode C	Mode D	Mode E	Mode E2
Yes: Supported No: Not supported	Core_clk:320MHz, PLAT_CLK: 160MHz	240/120	FIRC/2	FIRC	FIRC 2MHz	FIRC 750KHz
FlexCAN 4	Yes	Yes	No[3]	No[3]	No[3]	No[3]
FlexCAN 5	Yes	Yes	No[3]	No[3]	No[3]	No[3]
FlexIO	Yes	Yes	Yes	Yes	Yes	Yes
LCU0	Yes	Yes	Yes	Yes	Yes	Yes
LCU1	Yes	Yes	Yes	Yes	Yes	Yes
LPCMP 0	Yes	Yes	Yes	Yes	Yes	Yes
LPCMP 1	Yes	Yes	Yes	Yes	Yes	Yes
LPI2C 0	Yes	Yes	Yes	Yes	Yes[4]	Yes[4]
LPI2C 1	Yes	Yes	Yes	Yes	Yes[4]	Yes[4]
LPSPI 0	Yes	Yes	Yes	Yes	Yes	Yes
LPSPI 1	Yes	Yes	Yes	Yes	Yes	Yes
LPSPI 2	Yes	Yes	Yes	Yes	Yes	Yes
LPSPI 3	Yes	Yes	Yes	Yes	Yes	Yes
LPSPI 4	Yes	Yes	Yes	Yes	Yes	Yes
LPSPI 5	Yes	Yes	Yes	Yes	Yes	Yes
LPUART 0	Yes	Yes	Yes	Yes	Yes	Yes
LPUART 1	Yes	Yes	Yes	Yes	Yes	Yes
LPUART 2	Yes	Yes	Yes	Yes	Yes	Yes
LPUART 3	Yes	Yes	Yes	Yes	Yes	Yes
Microsecond Channel	Yes	Yes	Yes	Yes	Yes	Yes
PIT0	Yes	Yes	Yes	Yes	Yes	Yes
PIT1	Yes	Yes	Yes	Yes	Yes	Yes
PIT2	Yes	Yes	Yes	Yes	Yes	Yes
QuadSPI	Yes	Yes	No[5]	No[5]	No[5]	No[5]
RTC	Yes	Yes	Yes	Yes	Yes	Yes
SDADC 0	Yes	Yes	Yes	Yes	Yes	Yes
SDADC 1	Yes	Yes	Yes	Yes	Yes	Yes
SDADC 2	Yes	Yes	Yes	Yes	Yes	Yes

Table continues on the next page...

Table 121. Mapping of IPs and different clock modes (continued)

Peripheral instance	Mode A+	Mode B	Mode C	Mode D	Mode E	Mode E2
Yes: Supported No: Not supported	Core_clk:320MHz, PLAT_CLK: 160MHz	240/120	FIRC/2	FIRC	FIRC 2MHz	FIRC 750KHz
SDADC 3	Yes	Yes	Yes	Yes	Yes	Yes
STM 0	Yes	Yes	Yes	Yes	Yes	Yes
STM 1	Yes	Yes	Yes	Yes	Yes	Yes
STM 2	Yes	Yes	Yes	Yes	Yes	Yes
SWG 0	Yes	Yes	Yes	Yes	Yes	Yes
SWG 1	Yes	Yes	Yes	Yes	Yes	Yes
SWT 0	Yes	Yes	Yes	Yes	Yes	Yes
SWT 1	Yes	Yes	Yes	Yes	Yes	Yes
SWT 2	Yes	Yes	Yes	Yes	Yes	Yes
TMU	Yes	Yes	Yes	Yes	Yes	Yes
TRGMUX	Yes	Yes	Yes	Yes	Yes	Yes
TRGMUX 1	Yes	Yes	Yes	Yes	Yes	Yes
Zipwire	Yes	Yes	Yes	Yes	Yes	Yes

1. GMAC requires PLL generated clocks to operate. However, EMAC mode can be supported.
2. STAC cannot be used.
3. Flexcan @5Mbps with 16Tq is supported only for clocking mode A+. The bus domain clock frequency must always be greater than the oscillator domain clock frequency. Hence, FIRC modes are not supported.
4. High speed mode of I2C cannot be supported.
5. Ratio required between sfck and ahb clock cannot be maintained.

NOTE

In system clocking configurations where CORE_CLK and AIPS_PLAT_CLK are configured for operation at same frequency, the RAM wait states and flash memory read/write wait cycles need to be configured. See Clock Option B in Gasket Configurations section for RAM wait states and gasket configurations for clocking options.

The PLL should only be enabled if it is used as the system clock source. When the FIRC is used directly as the system clock, the PLL must be disabled.

PLL can be locked at minimum 640 MHz and then 8 MHz can be achieved with dividers in series - PLL divider(divide by 16) and CGM divider(divide by 5).

23.6.3 Peripheral data rates

Table 122. Peripheral data rates

Peripheral	Maximum data rate
	S32K396
ADC	See the *S32K396 Data Sheet* for details.
eMIOS[1]	Able to shift PWM edge by 1 ÷ (160 MHz) = 6.25 ns.
BCTU[2]	BCTU to generate triggers at 160 MHz.
LCU	Same domain as EMIOS and BCTU.
QuadSPI	• Flash memory interface: SDR 120 MHz • DDR and hyperflash not supported
EMAC	See the section EMAC instance and configuration in the "Ethernet Media Access Controller (EMAC)" chapter for details.
FlexCAN[3]	8 Mbps
LPI2C[4]	400 Kbps in fast mode.
LPSPI[5]	• LPSPI0 is to have a high clock rate of 20 Mbps • LPSPI1–LPSPI5 can be 10 Mbps
LPUART	See the section Baud rate generation in the "Low Power Universal Asynchronous Receiver/ Transmitter (LPUART)" chapter and Table 102 for details
FlexIO[6]	The different protocol data rates supported by FlexIO are listed below. For master mode, max baud rate is FLEXIO_CLK ÷ 4. For slave mode, max baud rate is FLEXIO_CLK ÷ 6. The baud rate is controlled by TIMCMP (lower 8 bits in 8-bit mode and 16 bits in 16-bit mode). • UART: 19200 bps • I2C: 400 Kbps • SPI: 10 Mbps • I2S: 12.288 Mbps
Trace	• Fast-speed pins: 120 MHz • Standard plus pins: 25 MHz
Zipwire	Modes for 320Mbps or 480Mbps (raw throughput)

1. See section Global clock prescaler (GCP) in the "Enhanced Modular IO Subsystem (eMIOS)" chapter for details.
2. See section Triggers in the "Enhanced Modular IO Subsystem (eMIOS)" chapter.
3. See the section Protocol timing in the "CAN (FlexCAN)" chapter for data rate calculation details.
4. See the section Clocking in the "Low Power Inter-Integrated Circuit (LPI2C)" chapter for LPI2C_CLK frequency details.
5. See the section Clocking in the "Low Power Serial Peripheral Interface (LPSPI)" chapter.
6. See the section Application information and FlexIO instances and configuration in the "Flexible I/O (FlexIO)" chapter and FlexIO clocking for baud configuration details.

23.6.3.1 Core and peripheral clock control

The chip provides provisions for core and peripheral clock gating. The next sections describe the details on clock gating possibilities and controls (see Power Management Controller (PMC) and Mode Entry Module (MC_ME) for details).

23.6.3.2 Clock gating

Application core clocks are gated by individual MC_ME core clock enable bits. Additionally, application cores can be clock gated by executing WFI (see the "Mode Entry Module (MC_ME)" chapter for details).

NOTE

In the MC_ME chapter, PCTL is replaced by PRTNx COFBy CLKEN. Please look through every reference made by PCTL in correspondence with PRTNx COFBy CLKEN.

Table 123. MC_ME partition core mapping

Core	MC_ME partition	MC_ME clock enable register field
Cortex-M7_0	0	MC_ME.PRTN0_CORE0_PCONF[CCE]
Cortex-M7_1	0	MC_ME.PRTN0_CORE1_PCONF[CCE]
CM7_2 (Cortex M7_2/3)	0	MC_ME_PRTN0_CORE4_PCONF[CCE]

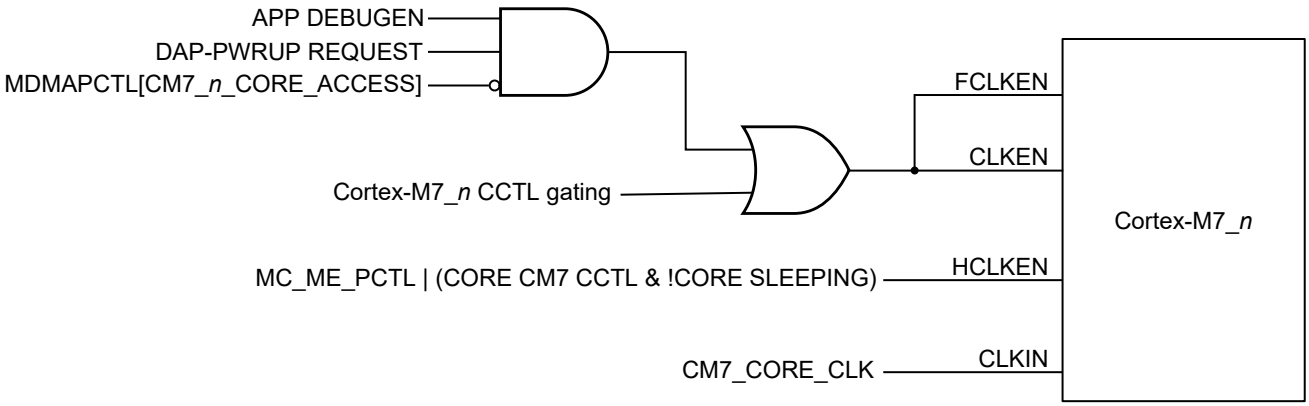


Figure 106. Cortex-M7 core clock gating

To support core debug across functional reset, challenge response done (application debug enable) gating is done so that the debugger can access core debug logic. When the debugger completes its programming with core debug logic, it must program the MDM_AP DAP control bit to shift the control of CLKIN and FCLK to CCTL.

See the section "MDM_AP register descriptions" in the Debug Subsystem chapter and the Memory Map chapter for details.

There are two cases in which other masters can access the TCM of each core:

- When the TCM is used as system memory—HCLK will always remain on if TCM PCTL is 1.
- In applications where TCM is not used as system memory, TCM PCTL is written to 0. TCM will then function as the core's memory and HCLK will be gated on WFI.

Ensure that the TCM AHBS interface is not accessed with HCLK disabled. In such case, the read/write transactions do not result in any error response.

23.6.3.3 Peripheral clock gating

See the tables in section "Peripheral clock gating" for the chip partitions, plus peripheral initialization and shutdown details.

23.7 Clocking details

23.7.1 System clock frequency limitations

Table 124. System clock frequency limitations

System clock node	System clock divider	Maximum frequency allowed	Remarks
CORE_CLK	MC_CGM.MUX_0_DC_0[DIV]	• 160 MHz	CORE_CLK is always greater than or equal to AIPS_PLAT_CLK.
AIPS_PLAT_CLK	MC_CGM.MUX_0_DC_1[DIV]	80 MHz	AIPS_PLAT_CLK is always less than or equal to CORE_CLK.
AIPS_SLOW_CLK	MC_CGM.MUX_0_DC_2[DIV]	40 MHz	AIPS_SLOW_CLK is always less than or equal to AIPS_PLAT_CLK.
HSE_CLK	MC_CGM.MUX_0_DC_3[DIV]	120 MHz	When CORE_CLK is equal to or less than 120 MHz, HSE_CLK can be equal to CORE_CLK. When CORE_CLK is higher than 120 MHz, HSE_CLK must be half of the CORE_CLK.
DCM_CLK	MC_CGM.MUX_0_DC_4[DIV]	48 MHz	DCM_CLK
LBIST_CLK	MC_CGM.MUX_0_DC_5[DIV]	48 MHz	LBIST clock
QSPI_MEM_CLK	MC_CGM.MUX_0_DC_6[DIV]	320 MHz	QSPI_MEM_CLK is always equal to CM7_CORE_CLK except in 1:1 mode.
CM7_CORE_CLK	MC_CGM.MUX_0_DC_7[DIV]	320 MHz	CM7_CORE_CLK is always greater than or equal to CORE_CLK

NOTE

The frequencies in the table above are maximum frequencies for a specific clock. However, any clock frequency selected must adhere to the same clock divider ratios shown in System clocking configurations.

23.7.2 System clocking configurations

The chip supports only the clocking modes listed in Table 125. All clock configurations are implemented by appropriate register settings. No other settings are allowed.

Table 125. System clocking configurations

Clocking options	Mode A+	Mode B	Mode C	Mode D	Mode E	Mode E2
	Very high-performance mode	Reduced speed mode	Boot default	FIRC divider bypassed	Low speed Run mode, clocked by divided FIRC	Very low speed Run mode, clocked by divided FIRC
System clock source (SYS_CLK)	PLL_PHI0_CLK	PLL_PHI0_CLK	FIRC_CLK ÷ 2	FIRC_CLK	(FIRC_CLK ÷ 2) ÷8[1]	(FIRC_CLK ÷ 16)÷4[1]
PLL VCO frequency	960 MHz	960 MHz	—	—	—	—

Table continues on the next page...

Table 125. System clocking configurations (continued)

Clocking options	Mode A+	Mode B	Mode C	Mode D	Mode E	Mode E2
	Very high-performance mode	Reduced speed mode	Boot default	FIRC divider bypassed	Low speed Run mode, clocked by divided FIRC	Very low speed Run mode, clocked by divided FIRC
PLL_PHI1_CLK	480 MHz (VCO ÷ 2)	480 MHz (VCO ÷ 2)	—	—	—	—
PLL_PHI0_CLK	320 MHz (VCO ÷ 3)	240 MHz (VCO ÷ 4)	—	—	—	—
CM7_CORE_CLK	320 MHz	240 MHz	24 MHz	48 MHz	3 MHz	750 KHz
CORE_CLK (AXBS, SRAM, AIPS0, flash memory controller port clock, QSPI memory clock, fast-speed peripherals clock)	160 MHz (SYS_CLK)	120 MHz (SYS_CLK)	24 MHz (FIRC_CLK ÷ 2)	48 MHz (FIRC)	3 MHz ((FIRC ÷ 2) ÷ 8)	750 kHz ((FIRC ÷ 8) ÷ 8)
QSPI mem clock	320 MHz	240 MHz	—	—	—	—
AIPS_PLAT_CLK (medium-speed peripheral clock	80 MHz	60 MHz	24 MHz	48 MHz	3 MHz	750 kHz
AIPS_SLOW_CLK (slow-speed peripheral clock)	40 MHz	30 MHz	12 MHz	24 MHz	1.5 MHz	375 kHz
DCM/DCF_CLK	40 MHz	30 MHz	24 MHz	48 MHz	3 MHz	750 kHz
HSE_CLK	80 MHz	120 MHz	24 MHz	48 MHz	3 MHz	750 kHz
LBIST_CLK	40 MHz	30 MHz	—	—	—	—
QSPI_SFCK	120 MHz	120 MHz(QSPI only)80 MHz (QSPI+ ENET RMII)	—	—	—	—

1. Divide by 8 and divide by 4 are done at system clock divider by configuring MC_CGM.MUX_0_DC_0[DIV].

NOTE

In system clocking configurations where CORE_CLK and AIPS_PLAT_CLK are configured for operation at same frequency, the RAM wait states and flash memory read/write wait cycles need to be configured. See Clock Option B in Gasket Configurations section for RAM wait states and gasket configurations for clocking options.

The PLL should only be enabled if it is used as the system clock source. When the FIRC is used directly as the system clock, the PLL must be disabled.

PLL can be locked at minimum 640 MHz and then 8 MHz can be achieved with dividers in series - PLL divider(divide by 16) and CGM divider(divide by 5).

23.7.2.1 Option A+ - High Performance mode (CM7_CORE_CLK @ 320 MHz)

Table 126. Option A+ - High Performance mode (CM7_CORE_CLK @ 320 MHz)

Clocking options	Clock frequencies
PLL VCO frequency	960 MHz
PLLODIV2_CLK (PLLDIG.PLLDV[ODIV2])	960 MHz (01h)
FIRC_CLK (HSE_B.CONFIG_REG_GPR[FIRC_DIV_SEL])	—
PLL_PHI1_CLK-related clocks [1]	
PLL_PHI1_CLK (PLLDIG.PLLODIV_1[DIV])	480 MHz (0001b)
QSPI_SFCK	120 MHz
TRACE_CLK	**For fast pads**
	120 MHz
	For Standard plus pads
	24 MHz
PLL_PHI0_CLK-related clocks [2]	
PLL_PHI0_CLK (PLLDIG.PLLODIV_0[DIV])	320 MHz (0010b)
CM7_CORE_CLK (MC_CGM.MUX_0_DC_7[DIV])	320 MHz (0000b)
CORE_CLK • AXBS • SRAM • Flash memory controller port clock • AIPS0 (high-speed peripheral clock)	160 MHz (0001b)

Table continues on the next page...

Table 126. Option A+ - High Performance mode (CM7_CORE_CLK @ 320 MHz) (continued)

Clocking options	Clock frequencies
(MC_CGM.MUX_0_DC_0[DIV])	
QSPI_MEM_CLK (MC_CGM.MUX_0_DC_6[DIV])	320 MHz (0000b)
AIPS_PLAT_CLK (medium-speed peripheral clock) (MC_CGM.MUX_0_DC_1[DIV])	80 MHz (0011b)
AIPS_SLOW_CLK (slow-speed peripheral clock) (MC_CGM.MUX_0_DC_2[DIV])	40 MHz (0111b)
DCM_CLK (MC_CGM.MUX_0_DC_4[DIV])	40 MHz (0111b)
HSE_CLK (MC_CGM.MUX_0_DC_3[DIV])	80 MHz (0011b)
LBIST_CLK (MC_CGM.MUX_0_DC_5[DIV])	40 MHz (0111b)

1. MC_CGM.MUX_10_CSC[SELCTL] and MC_CGM.MUX_11_CSC[SELCTL] must equal 1001b.
2. MC_CGM.MUX_0_CSC[SELCTL] must equal 1000b.

23.7.2.2 Option B - Reduced Speed mode (CM7_CORE_CLK @ 240 MHz)

Table 127. Option B - Reduced Speed mode (CM7_CORE_CLK @ 240 MHz)

Clocking options	Clock frequencies	
PLL VCO frequency	960 MHz	
PLLODIV2_CLK (PLLDIG.PLLDV[ODIV2])	960 MHz (01h)	
FIRC_CLK (HSE_B.CONFIG_REG_GPR[FIRC_DIV_SEL])	—	
PLL_PHI1_CLK-related clocks [1]		
PLL_PHI1_CLK (PLLDIG.PLLODIV_1[DIV])	480 MHz (0001b)	320 MHz (0010b)
QSPI_SFCK	120 MHz	80 MHz
TRACE_CLK	**For fast pads**	
	120 MHz	80 MHz
	For Standard plus pads	

Table continues on the next page...

Table 127. Option B - Reduced Speed mode (CM7_CORE_CLK @ 240 MHz) (continued)

Clocking options	Clock frequencies	
	24 MHz	20 MHz
PLL_PHI0_CLK-related clocks [2]		
PLL_PHI0_CLK (PLLDIG.PLLODIV_0[DIV])	240 MHz (011b)	
CM7_CORE_CLK (MC_CGM.MUX_0_DC_7[DIV])	240 MHz (0000b)	
CORE_CLK • AXBS • SRAM • Flash memory controller port clock • AIPS0 (high-speed peripheral clock) (MC_CGM.MUX_0_DC_0[DIV])	120 MHz (0001b)	
QSPI_MEM_CLK (MC_CGM.MUX_0_DC_6[DIV])	240 MHz (000b)	
AIPS_PLAT_CLK (medium-speed peripheral clock) (MC_CGM.MUX_0_DC_1[DIV])	60 MHz (0011b)	
AIPS_SLOW_CLK (slow-speed peripheral clock) (MC_CGM.MUX_0_DC_2[DIV])	30 MHz (0111b)	
DCM_CLK (MC_CGM.MUX_0_DC_4[DIV])	30 MHz (0111b)	
HSE_CLK (MC_CGM.MUX_0_DC_3[DIV])	120 MHz (0001b)	60 MHz (0011b)
LBIST_CLK (MC_CGM.MUX_0_DC_5[DIV])	30 MHz (0111b)	

1. MC_CGM.MUX_10_CSC[SELCTL] and MC_CGM.MUX_11_CSC[SELCTL] must equal 1001b.
2. MC_CGM.MUX_0_CSC[SELCTL] must equal 1000b.

23.7.2.3 Option C - Boot Standby mode (CM7_CORE_CLK @ 24 MHz)

Table 128. Option C - Boot Standby mode (CM7_CORE_CLK @ 24 MHz)

Clocking options	Clock frequencies
PLL VCO frequency	—

Table continues on the next page...

Table 128. Option C - Boot Standby mode (CM7_CORE_CLK @ 24 MHz) (continued)

Clocking options	Clock frequencies
PLLODIV2_CLK (PLLDIG.PLLDV[ODIV2])	—
FIRC_CLK (HSE_B.CONFIG_REG_GPR[FIRC_DIV_SEL])	24 MHz[1] (00b)
PLL_PHI1_CLK-related clocks [2]	
PLL_PHI1_CLK (PLLDIG.PLLODIV_1[DIV])	—
QSPI_SFCK	—
TRACE_CLK	—
PLL_PHI0_CLK-related clocks [3]	
PLL_PHI0_CLK (PLLDIG.PLLODIV_0[DIV])	—
LBIST_CLK (MC_CGM.MUX_0_DC_5[DIV])	—
QSPI_MEM_CLK (MC_CGM.MUX_0_DC_6[DIV])	—
CM7_CORE_CLK (MC_CGM.MUX_0_DC_7[DIV])	24 MHz (0000b)
CORE_CLK • AXBS • SRAM • Flash memory controller port clock • AIPS0 (high-speed peripheral clock) (MC_CGM.MUX_0_DC_0[DIV])	24 MHz (0000b)
AIPS_PLAT_CLK (medium-speed peripheral clock) (MC_CGM.MUX_0_DC_1[DIV])	24 MHz (0000b)
AIPS_SLOW_CLK (slow-speed peripheral clock) (MC_CGM.MUX_0_DC_2[DIV])	12 MHz (0001b)
DCM_CLK (MC_CGM.MUX_0_DC_4[DIV])	24 MHz (0000b)

Table continues on the next page...

Table 128. Option C - Boot Standby mode (CM7_CORE_CLK @ 24 MHz) (continued)

Clocking options	Clock frequencies
HSE_CLK (MC_CGM.MUX_0_DC_3[DIV])	24 MHz (0000b)

1. The FIRC_DIV_SEL is configured by the sBAF code. It is set to 11b after reset or normal standby exit and FIRC_CLK is 48 MHz. In case of fast standby exit, FIRC_DIV_SEL is 00b and FIRC_CLK is 24 MHz.
2. MC_CGM.MUX_10_CSC[SELCTL] and MC_CGM.MUX_11_CSC[SELCTL] values are don't care since QSPI_SFCK and TRACE_CLK are not used in this use case.
3. MC_CGM.MUX_0_CSC[SELCTL] must equal 0.

23.7.2.4 Option D - Low-Speed RUN mode (CM7_CORE_CLK @ 48 MHz)

Table 129. Option D - Low-Speed RUN mode (CM7_CORE_CLK @ 48 MHz)

Clocking options (SYS_CLK = FIRC_CLK)	Clock frequencies
PLL VCO frequency	—
PLLODIV2_CLK (PLLDIG.PLLDV[ODIV2])	—
FIRC_CLK (HSE_B.CONFIG_REG_GPR[FIRC_DIV_SEL])	48 MHz (11b)
PLL_PHI1_CLK-related clocks [1]	
PLL_PHI1_CLK (PLLDIG.PLLODIV_1[DIV])	—
QSPI_SFCK	—
TRACE_CLK	—
PLL_PHI0_CLK-related clocks [2]	
PLL_PHI0_CLK (PLLDIG.PLLODIV_0[DIV])	—
LBIST_CLK (MC_CGM.MUX_0_DC_5[DIV])	—
QSPI_MEM_CLK (MC_CGM.MUX_0_DC_6[DIV])	—
CM7_CORE_CLK (MC_CGM.MUX_0_DC_7[DIV])	48 MHz (0000b)

Table continues on the next page...

Table 129. Option D - Low-Speed RUN mode (CM7_CORE_CLK @ 48 MHz) (continued)

Clocking options (SYS_CLK = FIRC_CLK)	Clock frequencies
CORE_CLK • AXBS • SRAM • Flash memory controller port clock • AIPS0 (high-speed peripheral clock) (MC_CGM.MUX_0_DC_0[DIV])	48 MHz (0000b)
AIPS_PLAT_CLK (medium-speed peripheral clock) (MC_CGM.MUX_0_DC_1[DIV])	48 MHz (0000b)
AIPS_SLOW_CLK (slow-speed peripheral clock) (MC_CGM.MUX_0_DC_2[DIV])	24 MHz (0001b)
DCM_CLK (MC_CGM.MUX_0_DC_4[DIV])	48 MHz (0000b)
HSE_CLK (MC_CGM.MUX_0_DC_3[DIV])	48 MHz (0000b)

1. MC_CGM.MUX_10_CSC[SELCTL] and MC_CGM.MUX_11_CSC[SELCTL] values are don't care since QSPI_SFCK and TRACE_CLK are not used in this use case.
2. MC_CGM.MUX_0_CSC[SELCTL] must equal 0.

23.7.2.5 Option E - Low-Speed Run mode (CM7_CORE_CLK @ 3 MHz)

Table 130. Option E - Low-Speed Run mode (CM7_CORE_CLK @ 3 MHz)

Clocking options	Clock frequencies
PLL VCO frequency	—
PLLODIV2_CLK (PLLDIG.PLLDV[ODIV2])	—
FIRC_CLK (HSE_B.CONFIG_REG_GPR[FIRC_DIV_SEL])	3 MHz (10b)
PLL_PHI1_CLK-related clocks [1]	
PLL_PHI1_CLK (PLLDIG.PLLODIV_1[DIV])	—
QSPI_SFCK	—
TRACE_CLK	—

Table continues on the next page...

Table 130. Option E - Low-Speed Run mode (CM7_CORE_CLK @ 3 MHz) (continued)

Clocking options	Clock frequencies
PLL_PHI0_CLK-related clocks [2]	
PLL_PHI0_CLK (PLLDIG.PLLODIV_0[DIV])	—
LBIST_CLK (MC_CGM.MUX_0_DC_5[DIV])	—
QSPI_MEM_CLK (MC_CGM.MUX_0_DC_6[DIV])	—
CM7_CORE_CLK (MC_CGM.MUX_0_DC_7[DIV])	3 MHz (0000b)
CORE_CLK • AXBS • SRAM • Flash memory controller port clock • AIPS0 (high-speed peripheral clock) (MC_CGM.MUX_0_DC_0[DIV])	3 MHz (0000b)
AIPS_PLAT_CLK (medium-speed peripheral clock) (MC_CGM.MUX_0_DC_1[DIV])	3 MHz (0000b)
AIPS_SLOW_CLK (slow-speed peripheral clock) (MC_CGM.MUX_0_DC_2[DIV])	1.5 MHz (0001b)
DCM_CLK (MC_CGM.MUX_0_DC_4[DIV])	3 MHz (0000b)
HSE_CLK (MC_CGM.MUX_0_DC_3[DIV])	3 MHz (0000b)

1. MC_CGM.MUX_10_CSC[SELCTL] and MC_CGM.MUX_11_CSC[SELCTL] values are don't care since QSPI_SFCK and TRACE_CLK are not used in this use case.
2. MC_CGM.MUX_0_CSC[SELCTL] must equal 0.

NOTE

For FIRC_CLK frequency modes less than 24 MHz, safety modules like the CMU_F*x_n* must be disabled for safety applications, because safety applications are to run on the PLL clocks. The CMU_F*x_n* will cause erroneous FHH events if not disabled.

23.7.2.6 Option E2 - Very-Low-Speed Run mode (CM7_CORE_CLK @ 750 kHz)

Table 131. Option E2 - Very-Low-Speed Run mode (CM7_CORE_CLK @ 750 kHz)

Clocking options (SYS_CLK = (FIRC_CLK ÷ 8) ÷ 8)	Clock frequencies
PLL VCO frequency	—
PLLODIV2_CLK (PLLDIG.PLLDV[ODIV2])	—
FIRC_CLK (HSE_B.CONFIG_REG_GPR[FIRC_DIV_SEL])	3 MHz (10b)
PLL_PHI1_CLK-related clocks [1]	
PLL_PHI1_CLK (PLLDIG.PLLODIV_1[DIV])	—
QSPI_SFCK	—
TRACE_CLK	—
PLL_PHI0_CLK-related clocks [2]	
PLL_PHI0_CLK (PLLDIG.PLLODIV_0[DIV])	—
LBIST_CLK (MC_CGM.MUX_0_DC_5[DIV])	—
QSPI_MEM_CLK (MC_CGM.MUX_0_DC_6[DIV])	—
CM7_CORE_CLK (MC_CGM.MUX_0_DC_7[DIV])	750 KHz (0011b)
CORE_CLK • AXBS • SRAM • Flash memory controller port clock • AIPS0 (high-speed peripheral clock) (MC_CGM.MUX_0_DC_0[DIV])	750 KHz (0011b)
AIPS_PLAT_CLK (medium-speed peripheral clock) (MC_CGM.MUX_0_DC_1[DIV])	750 KHz (0011b)
AIPS_SLOW_CLK (slow-speed peripheral clock) (MC_CGM.MUX_0_DC_2[DIV])	375 KHz (0111b)

Table continues on the next page...

Table 131. Option E2 - Very-Low-Speed Run mode (CM7_CORE_CLK @ 750 kHz) (continued)

Clocking options (SYS_CLK = (FIRC_CLK ÷ 8) ÷ 8)	Clock frequencies
DCM_CLK (MC_CGM.MUX_0_DC_4[DIV])	750 KHz (0011b)
HSE_CLK (MC_CGM.MUX_0_DC_3[DIV])	750 KHz (0011b)

1. MC_CGM.MUX_10_CSC[SELCTL] and MC_CGM.MUX_11_CSC[SELCTL] values are don't care since QSPI_SFCK and TRACE_CLK are not used in this use case.
2. MC_CGM.MUX_0_CSC[SELCTL] must equal 0.

NOTE

For FIRC_CLK frequency modes less than 24 MHz, safety modules like the CMU_F*x_n* must be disabled for safety applications, because safety applications are to run on the PLL clocks. The CMU_F*x_n* will cause erroneous FHH events if not disabled.

23.7.3 Gasket configurations in various clocking modes

Table 132. Gasket configurations in various clocking modes

Mode A+		Mode B		Mode C		Mode D		Mode E		Mode E2	
CM7_CORE_CLK-320 MHz CORE_CLK-160 MHz		CM7_CORE_CLK-240 MHz CORE_CLK-120 MHz		CM7_CORE_CLK-24 MHz CORE_CLK-24 MHz		CM7_CORE_CLK-48 MHz CORE_CLK-48 MHz		CM7_CORE_CLK-3 MHz CORE_CLK-3 MHz		CM7_CORE_CLK-750 KHz CORE_CLK-750 KHz	
Gasket	**Config**	**Gasket**	**Config**	**Gasket**	**Config**	**Gasket**	**Config**	**Gasket**	**Config**	**Gasket**	**Config**
CM7_0 ahbp/ ahbm	2:1	CM7_0	2:1	CM7_0	bypassed	CM7_0	bypassed	CM7_0	bypassed	CM7_0	bypassed
CM7_1 ahbp/ ahbm	2:1	CM7_1	2:1	CM7_1	bypassed	CM7_1	bypassed	CM7_1	bypassed	CM7_1	bypassed
CM7_2 ahbp/ ahbm	2:1	CM7_2	2:1	CM7_2	bypassed	CM7_2	bypassed	CM7_2	bypassed	CM7_2	bypassed
HSE	1:2	HSE	1:1	HSE	bypassed	HSE	bypassed	HSE	bypassed	HSE	bypassed
eDMA	1:1	eDMA	1:1	eDMA	Bypassed	eDMA	Bypassed	eDMA	Bypassed	eDMA	Bypassed
eDMA	1:1	eDMA	1:1	eDMA	Bypassed		Bypassed	eDMA	Bypassed	eDMA	Bypassed
eMAC	1:2	eMAC	1:2	eMAC	1:1	eMAC	1:1	eMAC	1:1	eMAC	1:1
Zipwir e	1:1	Zipwire	1:1	Zipwire	1:1	Zipwire	1:1	Zipwire	1:1	Zipwire	1:1

Table continues on the next page...

Table 132. Gasket configurations in various clocking modes (continued)

Mode A+		Mode B		Mode C		Mode D		Mode E		Mode E2	
BDRAM[1]64:32	1:2	BDRAM 64:32	1:2	BDRAM 64:32	1:1	BDRAM 64:32	1:1	BDRAM 64:32	1:1	BDRAM 64:32	1:1
QUAD SPI	1:1	QUAD SPI	1:1	QUAD SPI	bypassed	QUAD SPI	bypassed	QUAD SPI	bypassed	QUAD SPI	bypassed
RAM	WS enabled[2]	RAM	WS enabled[2]	RAM	WS disabled[3]	RAM	WS disabled[3]	RAM	WS disabled[3]	RAM	WS disabled[3]

1. BDRAM is the gasket between system AXBS S3 port and AHB splitter as shown in Figure 5.
2. WS enabled means PRCRx[FT_DIS] = 1'b1
3. WS disabled means PRCRx[FT_DIS] = 1'b0

23.7.4 Default clock configuration

At reset recovery, the chip runs on the FIRC_CLK as the default configuration as shown in Option C - Boot Standby mode (CM7_CORE_CLK @ 24 MHz). Clocking configuration Option_C is the default configuration out of reset with the HSE_B core as the boot core. The Cortex-M7_*n* application core clocks are gated by default. You need to enable the core clocks by the configuring the corresponding core clock enable bits shown in Core Clock Gating.

23.7.5 PCFS

The chip supports software-controllable PCFS for MC_CGM MUX_0 (see section "Progressive Clock Frequency Switching (PCFS)" in the "Clock Generation Module (MC_CGM)" chapter for details). PCFS increases and decreases the frequency in steps, avoiding any overshoots or undershoots. When a functional reset event occurs with PCFS enabled, the PCFS process runs and is then followed by the divider configuration updates.

23.7.6 Updating dividers: crossbar halt handshake

The clock divider update process consists of the crossbar halt handshake sequence (see section "Clock dividers update" in the "Clock Generation Module (MC_CGM)" chapter for the clock divider update process). A divider update asserts a request to the crossbar switch to halt any transaction that is in process. The dividers are updated when the crossbar switch acknowledges the request for halt. The halt request disables the crossbar switch gaskets in the following order:

1. Core gaskets (HSE_B gaskets)
2. Crossbar switch (AXBS)
3. Flash AXBS bridge
4. PRAM/SRAM gasket

Dividers are updated after the gaskets acknowledge the halt request.

23.7.7 Changing system clock configurations

Software sequence for switching clock configurations from FIRC to PLL or PLL to PLL:

1. Before changing clock dividers/clock switching, the communication modules must be disabled by software. This ensures that erroneous communications do not occur during the clock transition.
2. All peripherals must be clock-gated using the MC_ME PCTL configurations.
3. All cores must be clock-gated, except the core being used to control the clock switching.
4. System clock switching can be done by configuration of MC_CGM_MUX_0_CSC[SELCTL]

Software sequence for switching clock configurations from PLL to FIRC clock switching:

1. Before changing clock dividers/clock switching, communication modules must be disabled by software. This ensures that erroneous communications do not occur during the clock transition.
2. All the peripherals must be clock-gated using the MC_ME PCTL configurations.
3. All cores must be clock-gated, except the core being used to control the clock switching.
4. System clock switching can be done by configuration of MC_CGM_MUX_0_CSC[SELCTL].

NOTE

Refer to the Clock divider update section in the MC_CGM chapter, which outlines the procedure for updating the dividers.

NOTE

When enabling PLL, the PMC last mile regulator should be enabled first by configuring PMC_CONFIG[LMEN]. The last mile regulator must be disabled after PLL is disabled.

23.8 Clock monitoring

The chip contains an independent clock monitoring mechanism which signals malfunctions in the clocking system. This chip consists of 7 Clock Monitoring Units (CMU_F*x*_[0:6]) for monitoring system clock and clocking module outputs. Figure 107 and Figure 108 show a lower-level view of the clocking monitoring system. Table 133 describes each CMU instance. Each CMU instance provides an independent interrupt or reset indication when the clock signal is out of range or lost. The CMU_FM_*n* provides a timeout indication in case there is a loss of metered clock. Your software must periodically check the CMU_FM_1 and CMU_FM_2 status within the chip FTTI (as specified in the Safety Manual).

NOTE

You must disable the CMU corresponding to the system clocks if the application changes the system clock source or changes the system clock divider configuration.

You must disable the CMU monitoring a clock source before disabling the clock source, then enable it after enabling the clock source.

The CMUs should be turned ON only after device has moved to PLL source (wherein LMR is ON).

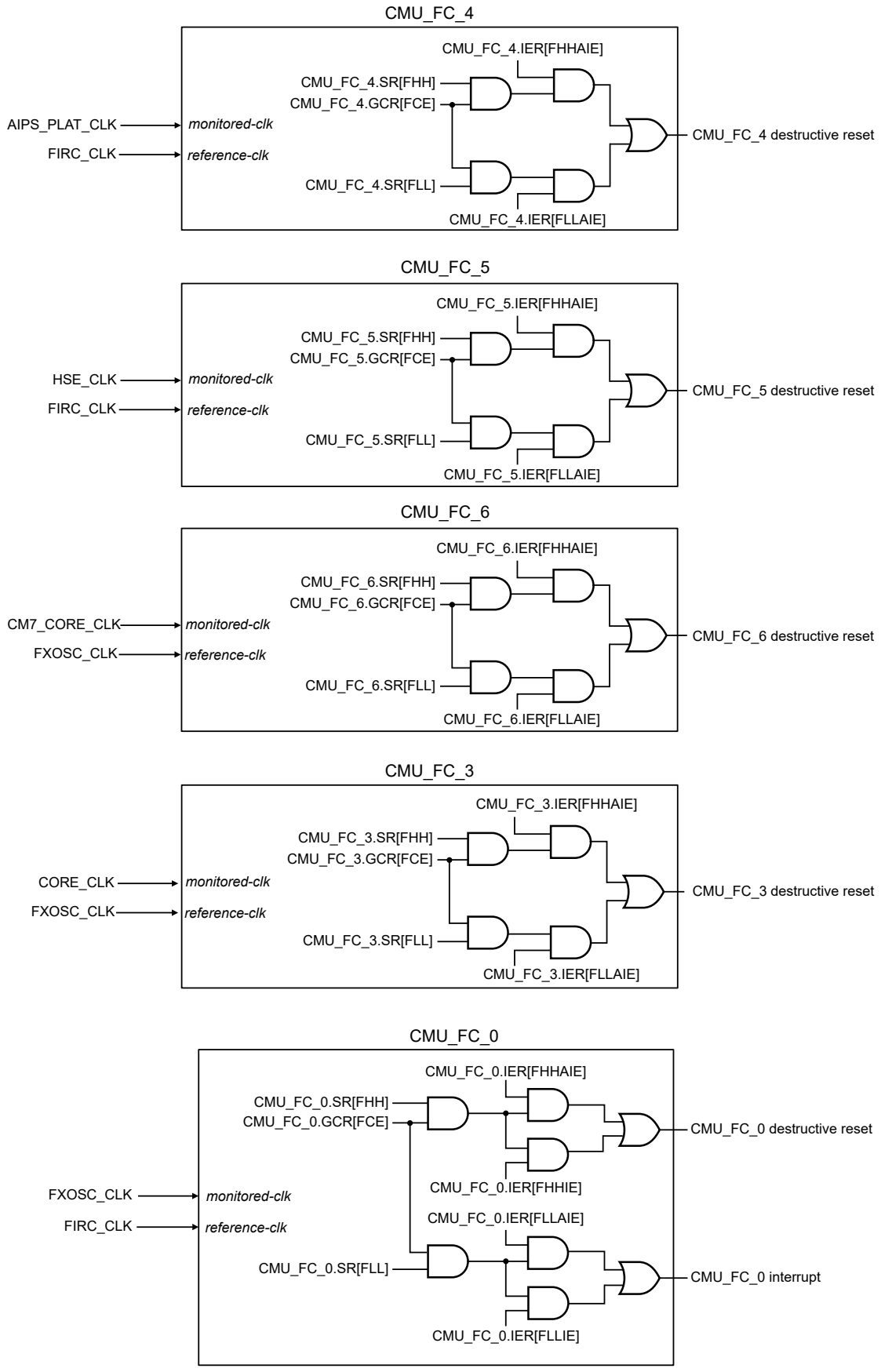


Figure 107. Frequency checking (FC) instances

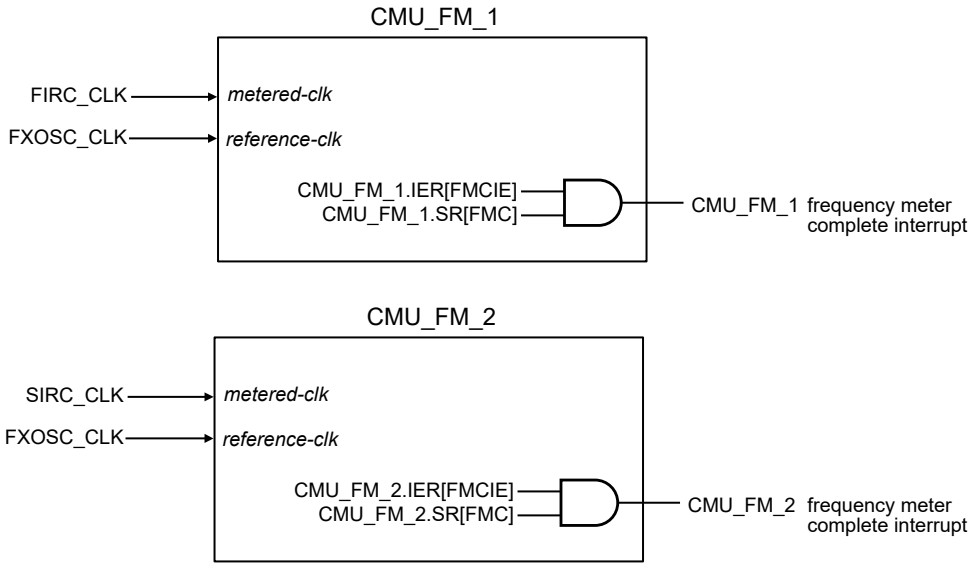


Figure 108. Frequency metering (FM) instances

Table 133. System clock monitors

CMU	Reference clock	Monitored or metered clock	Failure reaction	Monitoring type description
CMU_FC_0	FIRC_CLK	FXOSC_CLK	Destructive reset or interrupt	Precision over and under frequency
CMU_FM_1	FXOSC_CLK	FIRC_CLK	Interrupt	Current frequency measurement periodically triggered by software
CMU_FM_2	FXOSC_CLK	SIRC_CLK	Interrupt	Current frequency measurement periodically triggered by software
CMU_FC_3	FXOSC_CLK	CORE_CLK	Destructive reset	Precision over and under frequency
CMU_FC_4	FIRC_CLK	AIPS_PLAT_CLK	Destructive reset	Precision over and under frequency
CMU_FC_5	FIRC_CLK	HSE_CLK	Destructive reset	Precision over and under frequency
CMU_FC_6	FXOSC_CLK	CM7_CORE_CLK	Destructive reset	Precision over and under frequency

23.9 Glossary

MODULE_CLK	Module operating clock
REG_INTF_CLK	Module register interface clock used for register read and write
PCFS	Progressive Clock Frequency Switching (see section PCFS for details)
POR	Power On Reset
SBC	System Basis Chip (see NXP SBC portfolio)

FLL	Frequency lower than low frequency reference
FHH	Frequency higher than high frequency reference
FTTI	Fault Tolerance Time Interval

Chapter 24
Clock Generation Module (MC_CGM)

24.1 Chip-specific MC_CGM information

24.1.1 Associated content references

See the Clocking chapter for details pertaining to these:

- Chip clocking
- MC_CGM clock source mapping (see the "MC_CGM clock sources mapping" section for this)
- MC_CGM clock multiplexers (see the "MC_CGM clock multiplexers" section for this)

CAUTION

MC_CGM clock multiplexer configurations to non-supported and reserved clock sources are prohibited and can result in chip malfunctioning.

24.2 Introduction

The clock generation module (MC_CGM) is used to set up the configurable clock domains used by various chip blocks as per the application needs. It includes the clock multiplexers that allow software to select the desired clock sources for these domains. This is managed by the MC_CGM to ensure that the changing of the clock selection from one source to another occurs in a glitch-less fashion. In addition, the MC_CGM includes the clock dividers that can be configured by software.

See following figure for the MC_CGM block diagram:

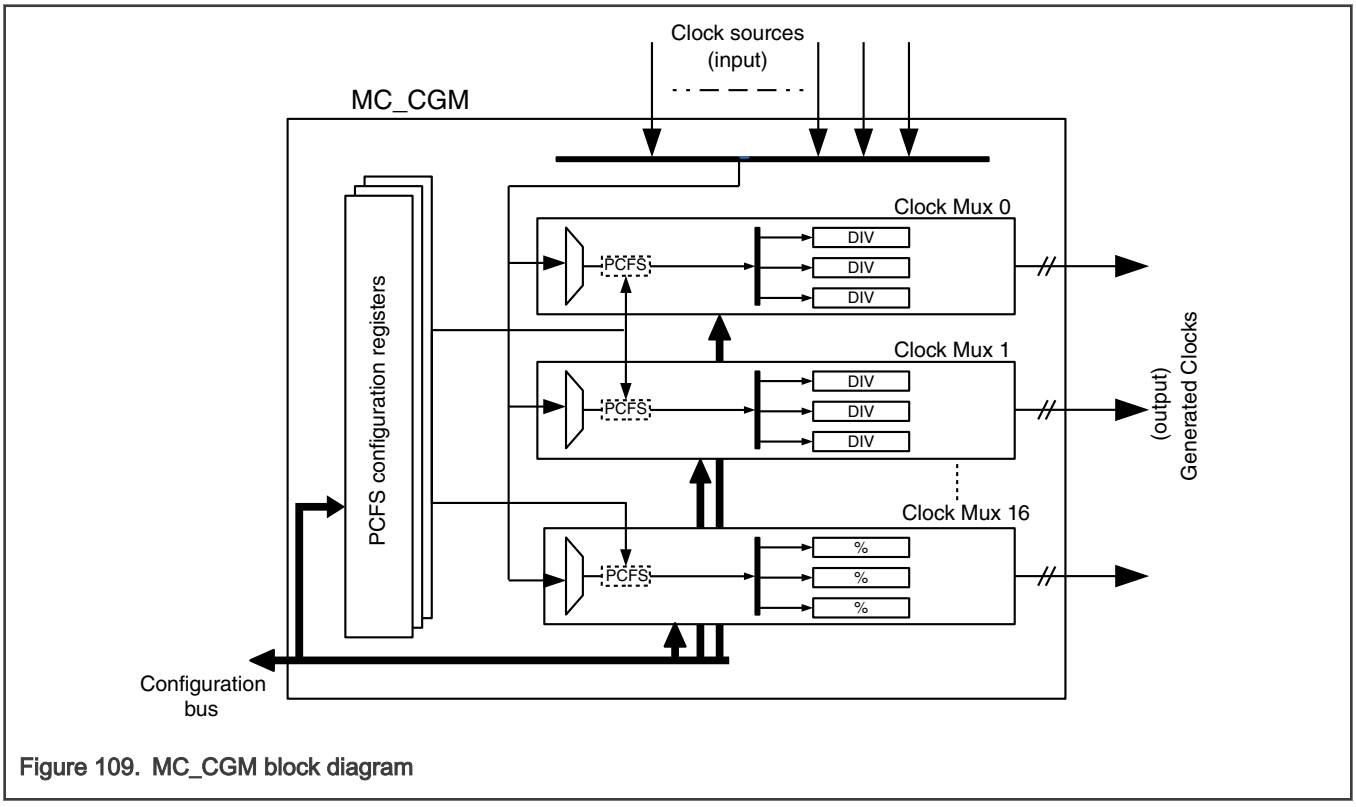


Figure 109. MC_CGM block diagram

NOTE

The block diagram is generic and does not necessarily reflect any specific MC_CGM implementation.

24.3 Features

MC_CGM includes the following features:

- Implements software configurable clock multiplexers for selecting from various clock sources
- Provides hardware-controlled multiplexers that guarantee glitchless transition, while the software-controlled multiplexers need a software sequence to ensure such a transition
- Provides software configurable automatic PCFS on certain clocks to minimize the impact of a sudden power consumption change through a gentle ramp-down and -up of the clock frequency when switching clock sources
- Implements software configurable clock dividers

24.4 Functional description

24.4.1 Clock selection multiplexer

Each of the clock multiplexers inside the MC_CGM either implements a fully hardware-controlled clock multiplexer or a software-controlled clock multiplexer. The following sections describe the two variants of the clock multiplexer.

24.4.1.1 Hardware-controlled clock multiplexer

In hardware-based clock multiplexing, the underlying assumption is that under some conditions, error or reset states, software may not be active. Therefore, the clock switching is fully hardware based and is glitchless. To facilitate clock switching requests with software, the MUX_n_CSC and MUX_n_CSS registers implement request and status for the clock multiplexer, the rest is managed in hardware. Using these registers, the software can monitor the state of the hardware-based clock multiplexer and also make clock switching requests. It is recommended that a new clock switch request is given only when there are no pending/ongoing clock switching requests. However, a switch to the safe clock, that is, FIRC, can be performed at any instance of time. A switch to the safe clock is always completed. Software should ensure that while making a software-based switch to safe clock, the register configuration clock should be available, at least for completing the write to the MUX_n_CSC register. This means that the clock should be running for the register write to complete. Hardware clock multiplexer also supports hardware-based switch to safe clock, which is requested externally to MC_CGM (for example, by MC_RGM). For a hardware-based switch to safe clock, it is not required to have a register configuration clock for MC_CGM.

NOTE

- "Switch to safe clock" from software is requested by programming the MUX_n_CSC[SAFE_SW] bit field only and not by combining the MUX_n_CSC[CLK_SW] and MUX_n_CSC[SELCTL] bit fields of the MUX_n_CSC register. Writes to other fields are ignored when requesting switch for safe clock.
- After the switch to the safe clock requested by the MC_RGM has completed, the MC_RGM also requests the clock dividers to switch to their default values. This hardware-triggered divider update can be monitored in the same manner as for software-configured updates, and software should use it to ensure that the configuration update has completed before reconfiguring the clocks.
- Write accesses to the MUX_n_CSC register with clock select pointing to the "reserved" input clock source are aborted with bus transfer errors.

See Figure 110 that shows the flowchart representation for the sequence of steps to be followed when making a clock switch request to hardware-controlled clock multiplexer. Switch to safe clock can be requested at any instance of time, and for clarity reasons, it is not shown in Figure 110.

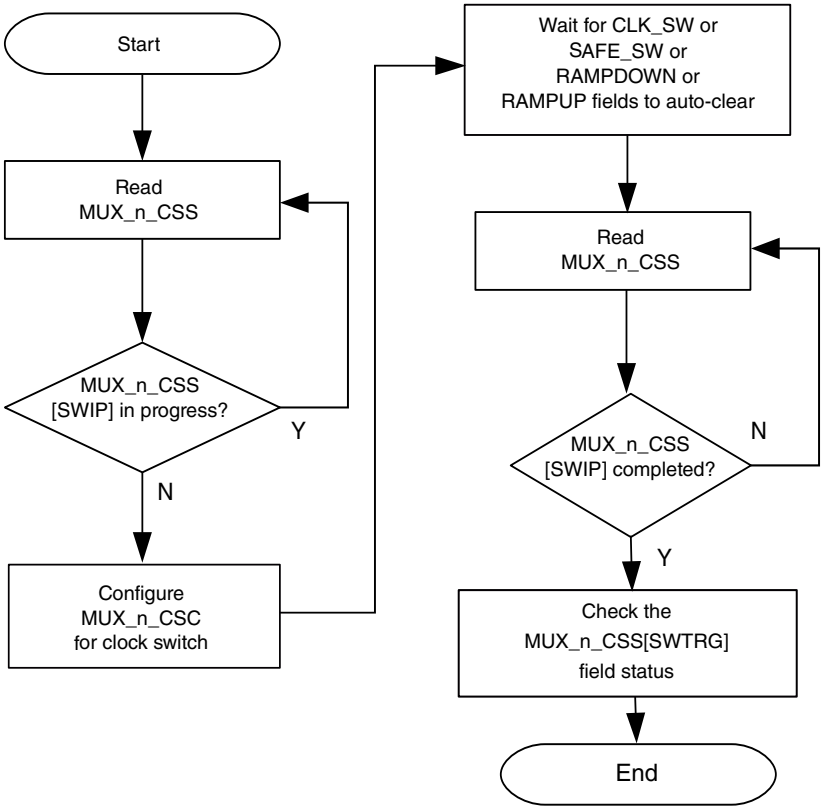


Figure 110. Flow for clock switch request on hardware-controlled clock multiplexer

NOTE

- A switch to the safe clock command always leads to a ramp-down from the currently selected clock and then a switch to "safe clock", except when there is an ongoing clock switch requested by the software without ramp-up and ramp-down. A safe clock switch request when there is an ongoing clock switch without ramp-up or ramp-down results in a switch to the safe clock without performing a ramp-down (either by MC_RGM or provided using the MUX_n_CSC register) does not perform a ramp-down before switching to "safe clock".
- The above flowchart steps can be preceded by points 1 and 3 below:
  1. Disable the divider.
  2. Switch clocks through hardware multiplexer.
  3. Enable and configure the dividers (atomic write instruction).

24.4.1.2 Software-controlled clock multiplexer

In software-based clock multiplexing, the underlying assumption is that the software is always available and there are no error or reset conditions in the chip. This implies that a glitchless switch between input clock sources of MC_CGM MUX can be achieved by following a sequence of steps in software. The software-based clock multiplexer implements a clock gate at the output of the clock mux. The software can gate the selected clock of MC_CGM MUX using a synchronous/graceful clock gate bit (that is, MUX_n_CSC[CG]) or a forced clock gate bit (that is, MUX_n_CSC[FCG]). The hardware does not guarantee that any glitches will escape when using forced clock gating. When a forced clock gate bit is written to 1, the internal clock gate forcefully gates the selected clock to logic-0, therefore, to avoid clock glitches, it should be ensured that the selected clock source is not running. See Figure 111 that shows the flowchart representation for the sequence of steps to be followed when making a clock switch request to software-controlled clock multiplexer. No switch to safe clock is supported in software-controlled clock multiplexer.

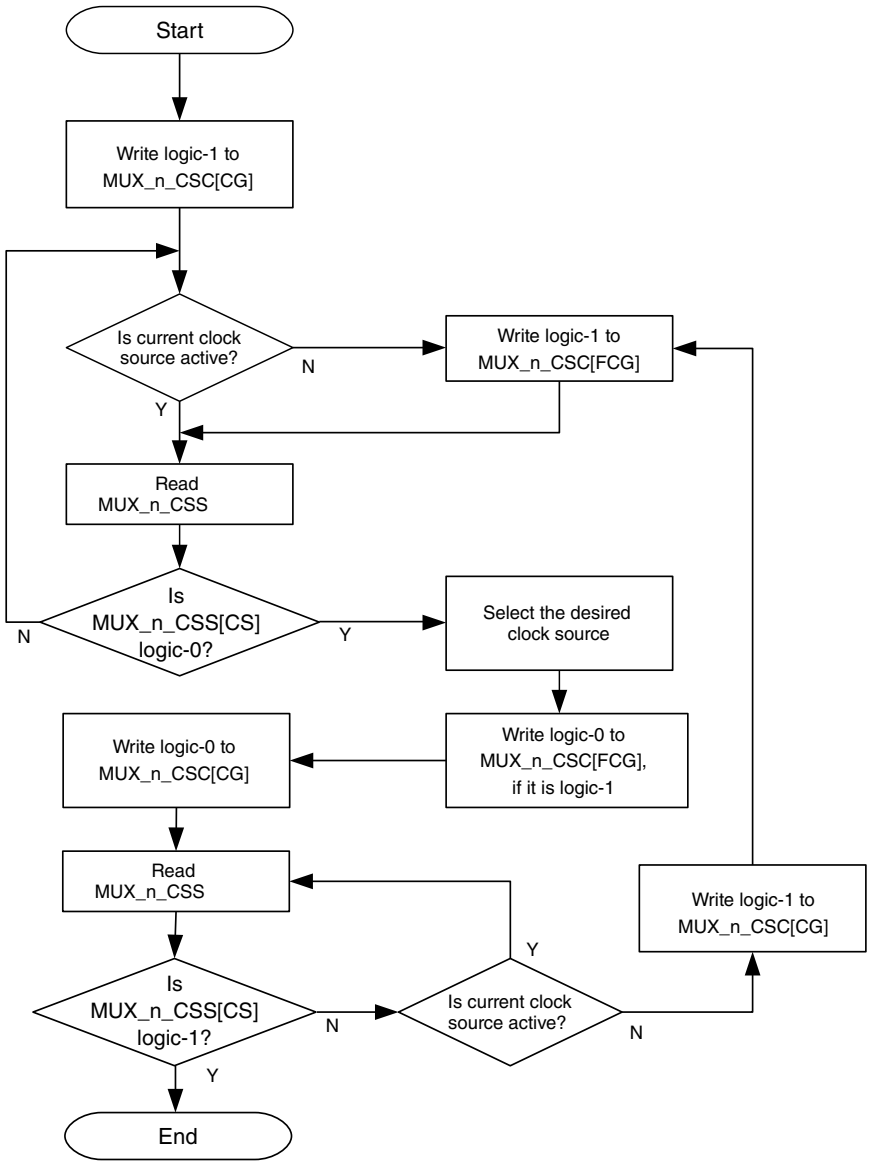


Figure 111. Flow for clock switch request on software controlled clock multiplexer

NOTE

- Ensure that before using the force gate bit, any IP or other logic using the clock of MC_CGM MUX is in the inactive state or a clock glitch resulting from usage of forced gating does not effect the IP (that is, it is clock gated after the MC_CGM).
- In Figure 111, the clock source to be selected should be active at the time of clock switch, else the MUX_n_CSS[CS] field will remain set to logic-0. In case the clock source to be selected becomes inactive (that is, loss of clock, and so on) during the switching operation, the switch to another clock source can be initiated by writing both the MUX_n_CSC[CG] and MUX_n_CSC[FCG] fields to logic-1.
- Writing a 'reserved' value for the MUX_n_CSC[SELCTL] field may result in an unpredictable clock at the output of the clock multiplexer.

NOTE

The above flowchart steps can be preceded by points 1 and 3 below:

1. Disable the divider.
2. Switch clocks through software multiplexer.
3. Enable and configure the dividers (atomic write instruction).

24.4.2 PCFS

MC_CGM implements PCFS when changing clock source at an MC_CGM clock mux. The PCFS is only implemented in a hardware-controlled clock multiplexer and not in a software-controlled clock multiplexer. It allows a gradual load change for a power/voltage supply unit by employing a gradual frequency changeover from one to another. The frequency changeover is achieved by clock division of input clock source with a sequence of division values, where frequency ramp down and ramp up is achieved when the sequence of division values are ascending and descending in nature, respectively. As the clock division (fractional) is implemented in digital logic, therefore, it is a coarse-level clock division rather than being an accurate-level division, implying that the duty cycle of the progressively divided clock can vary with time.

The PCFS feature is utilized when a drain current to frequency relationship is known, that is, for a given drain current what is the maximum allowed change in frequency (f_{chg}). The f_{chg} is the first input parameter for PCFS and other parameters for PCFS are specified or calculated in relation to FIRC.

The PCFS hardware generates the clock division factors based on certain values that are programmed into the PCFS configuration register. The following pseudo codes represent the generation of clock division value sequence (d_i).

```
/* ramp down division values (d_n) with k steps*/
      delta_1 = RATE/1000;
      delta_2 = RATE/1000;
      d_0     = 1.0;
      for i=1 to k-1 do
        d_i = d_i-1 + delta_1;
        delta_1 = delta_1 + delta_2;
      endfor
```

```
/* ramp up division values (d_n) with k steps*/
      delta_1 = RATE*k/1000;
      delta_2 = RATE/1000;
      d_0     = 1.0 + RATE*k*(k+1)/2;
      for i=1 to k-1 do
        d_i = d_i-1 - delta_1;
        delta_1 = delta_1 - delta_2;
    endfor
```

As the generation of clock division values is not a closed-bounded function, calculating RATE for a given f_{chg} is an iterative process. Find a value of RATE that produces a clock division sequence, which when used does not lead to a frequency change greater than f_{chg}. See Table 134 that tabulates some of the RATE values against a_{max}, where

$$a_{max}=f_{chg}/F_i$$

where, F_i is the frequency of i^{th} input clock source of the clock mux.

Table 134. PCFS RATE values

a_{max}	PCFS rate
0.005	12
0.01	48

Table continues on the next page...

Table 134. PCFS RATE values (continued)

a_{max}	PCFS rate
0.15	112
0.20	184

The last clock division factor in case of ramp-down or the first clock in case of ramp-up (following a ramp-down procedure), should be such that clock switch from any input clock source to another should be termed as safe, indicating that load changes have sustainable power effects. This frequency level is referred to as "safe frequency", equivalent to frequency of FIRC referred to as "safe clock" with frequency "safe clock frequency" (f_{safe}). The last clock division factor in the sequence of clock division factors happens after "k" steps. The factor k (=steps) is calculated by using the following formula:

```
k = ceil(0.5 + sqrt(0.25 - (2000 * (1 -(Fi/fsafe)) / RATE)))
```

Using the above formula, all the PCFS register configuration values can be calculated for a given frequency of a clock source:

```
PCFS_DIVEi.DIV = (Fi/fsafe)*1000-1;
        PCFS_DIVCi.INIT = RATE * k;
        PCFS_DIVCi.RATE = RATE;
        PCFS_DIVSi.DIV  = 999 + (RATE * k * (k+1)/2);
```

See Figure 112 that shows a graphical representation of the change in frequency, which happens during PCFS ramp-down and ramp-up.

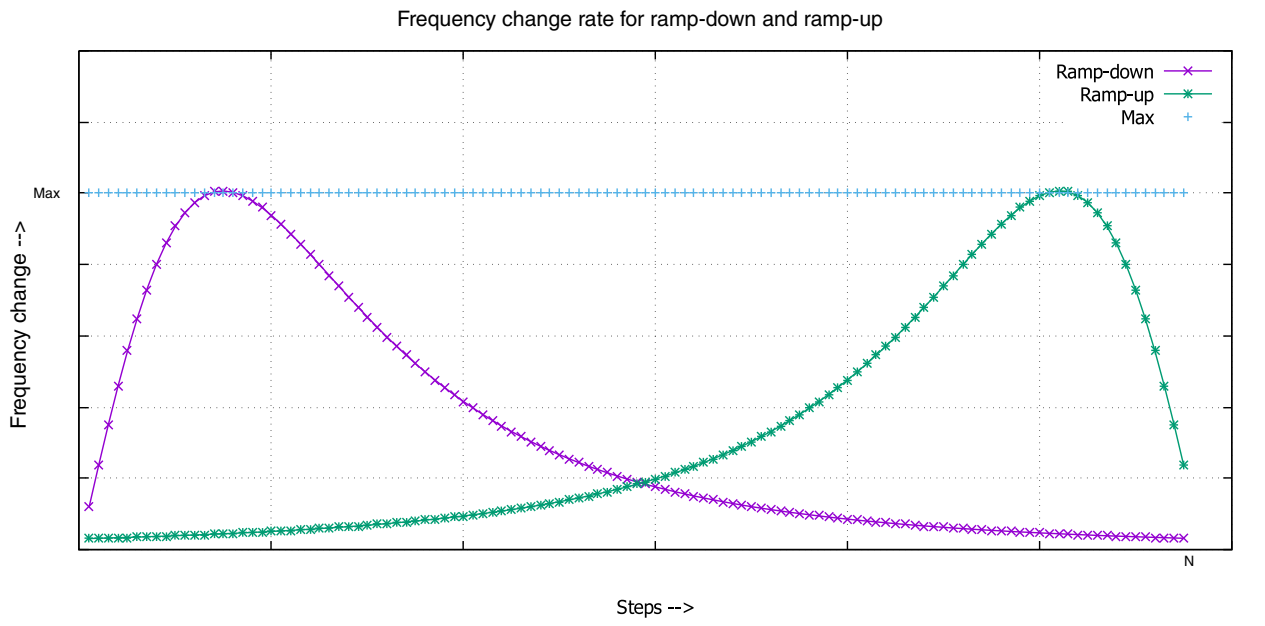


Figure 112. PCFS steps vs frequency changes

For any given clock source, if its frequency is less than that of FIRC, then its corresponding registers should be programmed to default values, where the default values are such that PCFS divider start and PCFS divider end values are same and equal to divide-by-1. The default values ensure that no progressive clock division is done when a clock switch request is given to switch from or to that source.

NOTE

Calculate the minimum frequency during the PCFS RAMPDOWN and RAMPUP operations by using the formula:

```
(FIRC/((PCFS_DIVE+1)/1000)) MHz
```

24.4.2.1 PCFS control

The PCFS operation is configured by a set of configuration registers. One set pertains to the calculation of the clock division factors, which are PCFS_DIVC, PCFS_DIVE, PCFS_DIVS, and PCFS_SDUR, while the registers MUX_n_CSC and MUX_n_CSS implement trigger and status of the PCFS operation. The clock division factors are expected to be programmed before any other MC_CGM operation is initiated and remain unchanged. All the registers corresponding to the clock division factors should be programmed with FIRC as the configuration clock and before doing any clock switch or PCFS operation on any of the MC_CGM mux. It should be noted that the default values of the register corresponding to clock division factors are such that only the clock division factor is calculated by hardware that is divide-by-1. The PCFS operation is always triggered when the safe clock request is generated except when there is an on-going clock switch without ramp-up or ramp-down. Therefore, the software needs to ensure that the PCFS configuration is complete and correct.

While configuring MUX_n_CSC, only valid PCFS and clock switch requests should be provided. PCFS or clock switch requests should only be provided if the PCFS operation is in the idle state. If there is an ongoing PCFS operation, it is recommended not to provide any new PCFS triggers (except switch to safe clock) until the ongoing operation is completed. Switch to safe clock via hardware or by register configuration can be provided at any instance of time and is always completed. Valid combinations of PCFS and clock switches triggers are listed in Table 135. All the PCFS commands should be atomic in nature, which means a single register write should provide complete PCFS sequence to be executed that is ramp-down, clock switch, and ramp-up.

Table 135. Valid PCFS and clock switch requests

PCFS operation state	Command
Idle	Ramp-down, clock switch, and ramp-up
Idle	Clock switch only (without ramp-up or ramp-down)

When a switch to safe clock is provided by writing to MUX_n_CSC, then writes to other register fields are ignored.

24.4.2.2 Clock source power-up and selection

This section provides guidelines for powering up a given clock source and selecting it at the MC_CGM clock multiplexer.

Following is the power-up procedure for a clock source:

1. Configure the parameter, if any.
2. Configure the power-up (or power-down) control field.
3. Wait for the power-up status indication.

After a power-up indication, the clock source can be selected to provide output clock at an MC_CGM clock multiplexer. A clock-monitoring setup can also be activated on the powered-up clock source.

See Figure 113 that shows a flow chart representation of this sequence.

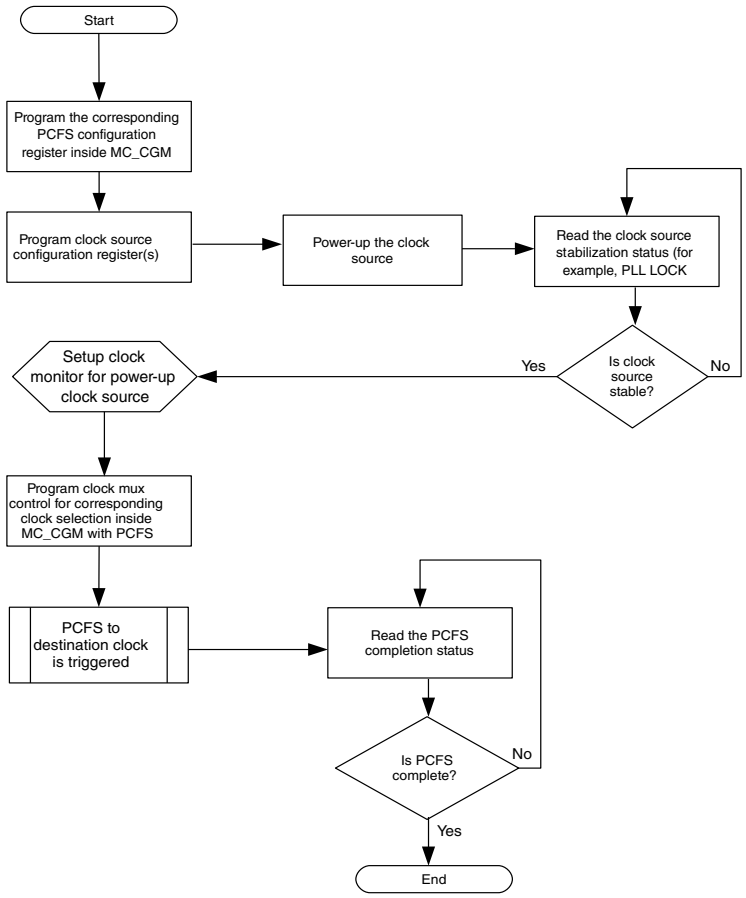


Figure 113. Clock source power-up and selection procedure

24.4.2.3 Clock source power-down and deselection

This section provides guidelines for powering down a given clock source and deselecting it at MC_CGM clock multiplexer.

Following is the power-down procedure for a clock source:

1. Deselect the clock source at all MC_CGM clock multiplexers.
2. Configure the power-up (or power-down) control field.
3. Wait for the power-down status indication.

See Figure 114 that shows a flow chart representation of this sequence.

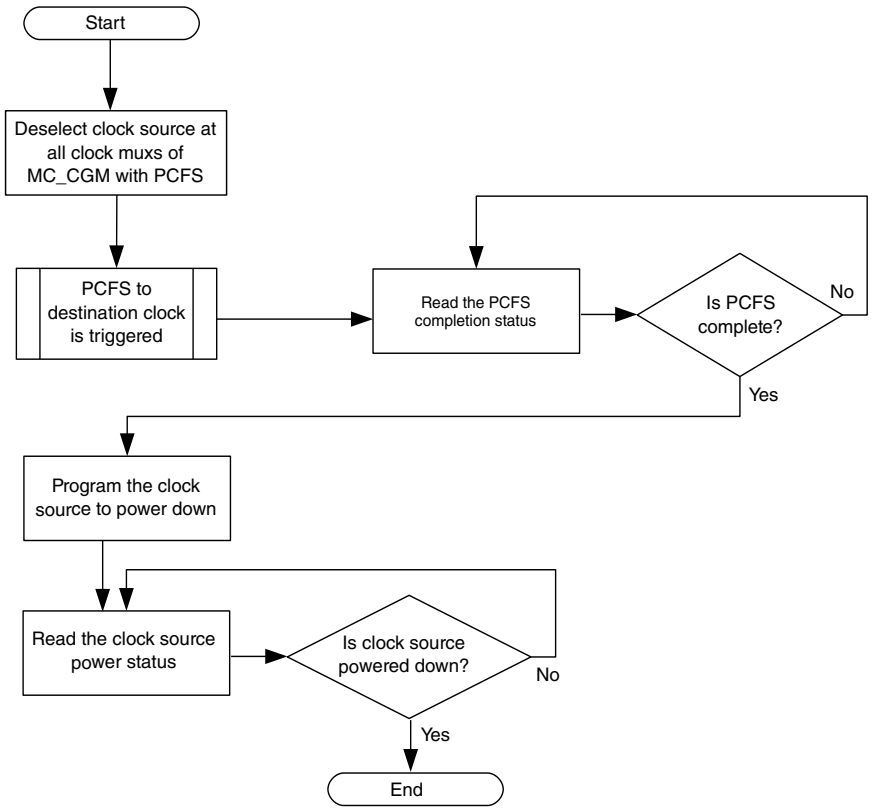


Figure 114. Clock source power-down and clock source deselection procedure

24.4.2.4 Clock switch with load change

This section provides guidelines to switch between two high-frequency clock sources along with load changes in the system. Load change is referred to switching ON or OFF of logic/peripherals in the system, which has an effect of significant capacitance changes on the chip. This triggers the voltage regulation for the chip.

When a large number of peripherals or digital logic is enabled or disabled, it is recommended that this step should be performed at a low frequency. Independent of whether a clock switch is required, this criteria needs to be met. When a clock switch is required at two high frequencies, the recommended sequence is as follows:

1. Intermediately switch to FIRC.
2. Change load (that is, enable/disable peripherals).
3. Switch to the target clock.

See the following figure that shows a flow chart representation of this sequence.

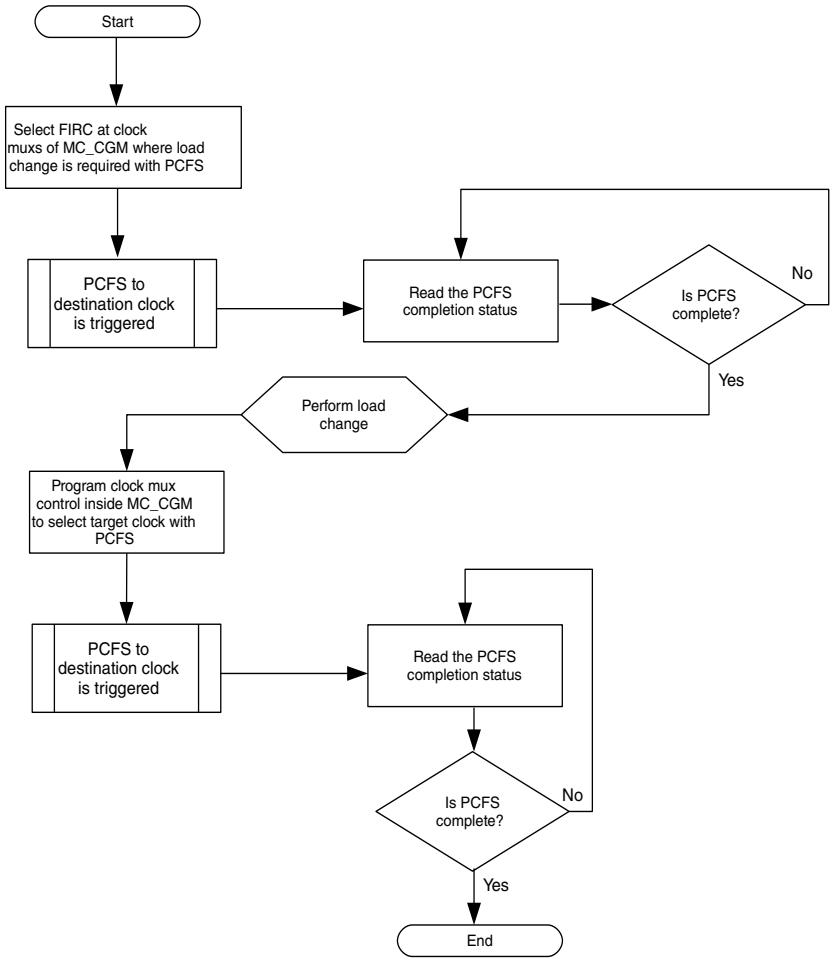


Figure 115. Clock switch with load change procedure

24.4.3 Clock dividers

Clock dividers are used for the generation of a divided clock that is used for running IPs or peripherals. The MC_CGM provides the following built-in dividers at each clock mux:

- 50% clock dividers

Each divider can be controlled by the Divider Enable (DE) bit and the Division Value (DIV) field. If a divider has its DE bit set to logic-0 in the respective configuration register, then that divider is disabled and the output divided clock is held to logic-0. If the DE bit is logic-1, the divider is enabled and provides a divided clock according to the value set in the DIV field.

24.4.3.1 50% clock divider

50% duty cycle dividers generate a real divided clock. The division factor is always an integer but is not restricted to even numbers. The rising edge of the divided clock is always synchronous to the rising edge of the divider source clock, but the falling edge is synchronous to the rising edge or the falling edge depending on whether the division factor is even or odd, respectively. If the input clock has a duty cycle of 50%, the divided output clock maintains the same 50% duty cycle. See Figure 116 that shows the 50% clock divider operation and its associated signals.

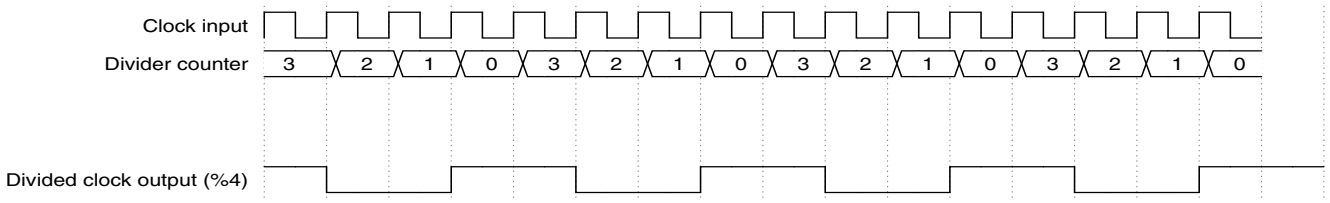


Figure 116. 50% clock divider programmed for divide by 4 (DIV=3)

A 50% divided clock can be considered asynchronous (not edge aligned) to other divided clocks from dividers at the same clock mux. 50% clock dividers are implemented without an active closed loop, and are expected not to get stuck if the input clock glitches for a single cycle.

24.4.3.2 Clock dividers update

To update the division value or the divider enable, the software should follow the procedure as shown in Figure 117. These updates happen only after the current division cycle has elapsed. However, if the phase of the clock divider is updated, the update happens independently from the state of the division cycle. Any update to the clock divider fields does not result in clock glitch either at the divided clock output or the phase-divided clock output.

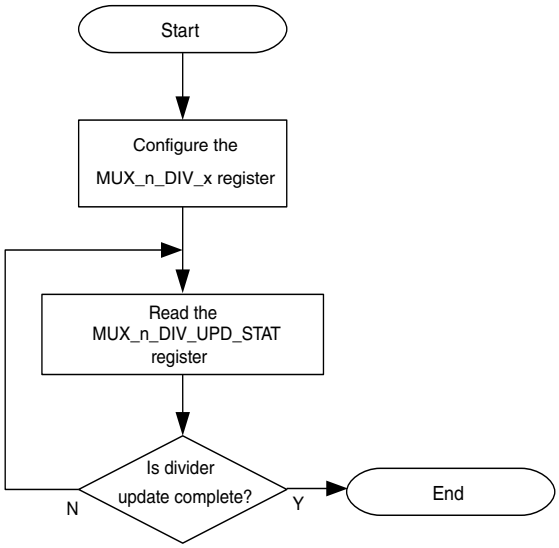


Figure 117. Flow for clock divider programming update

Following is the procedure for updating the dividers using the common trigger update:

1. Configure the MUX_n_DIV_TRIG_CTRL register.
2. Wait for the update to finish (until MUX_n_DIV_UPD_STAT is 0).
3. Update the clock dividers (only 50%) per the divider update procedure.
4. After the divider update is finished, perform a write operation on the MUX_n_DIV_TRIG register.
5. Wait for the update to finish, that is, until MUX_n_DIV_UPD_STAT is 0. During this period, the following process takes place:
   - Halt handshake is initiated if configured in step 1.
   - Clock dividers is updated only when AXBS is halted (that is, halt acknowledgment is received by MC_CGM). It is initiated, else the dividers are updated at alignment.
   - After the clock dividers are updated, MUX_n_DIV_UPD_STAT is asserted to 0.

- When the bit fields MUX_x_DIV_TRIG_CTRL[TCTL] and MUX_x_DIV_TRIG_CTRL[HHEN] are set to 1, then any write operation on trigger register will assert (MUX_n_DIV_UPD_STAT). Once the dividers are updated and aligned (MUX_n_DIV_UPD_STAT) will be deasserted.

NOTE

- The MUX_x_DIV_TRIG_CTRL[HHEN] bit should only be set when MUX_x_DIV_TRIG_CTRL[TCTL] is set, otherwise it may lead to misalignment of the dividers.
- In case of divider initialization by MC_RGM, a halt handshake protocol is initiated if the corresponding register bit is set and the clock dividers are initialized after the halt handshake protocol completion.

6. This completes the divider update.
7. When multiple writes to the dividers of same clock MUX is made without waiting for the previous update status signal to finish may lead to misalignment of the dividers.

For aligned dividers, the LCM of the division values programmed in the dividers of respective clock mux should be less than 100.

NOTE

Performing multiple writes to the divider without waiting for the earlier update to complete can lead to misalignment of the dividers.

Recommended software sequence for ensuring no undivided output at MC_CGM:

1. Reset is de-asserted
2. MC_RGM goes to IDLE
3. Enable the clock dividers of MC_CGM to provide FIRC clock so that reset of fixed dividers can be lifted.
4. Program the MC_CGM as per use case division values.
5. Switch the clock of MC_CGM Mux to desired one, and run the system.

24.5 MC_CGM register descriptions

MC_CGM implements a set of clock multiplexers that share PCFS configuration registers. MC_CGM registers have the following properties:

- All registers are 32-bit wide.
- Only 32-bit read and write accesses are supported.
- Read/write accesses of less than 32 bits terminate with an error.
- Writes to read-only register fields in writable registers are ignored and do not provide an error response.
- Writes to read-only registers are aborted with an error response.

24.5.1 MC_CGM memory map

MC_CGM base address: 402D_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	PCFS Step Duration (PCFS_SDUR)	32	RW	0000_0000h
58h	PCFS Divider Change 8 Register (PCFS_DIVC8)	32	RW	0000_0000h
5Ch	PCFS Divider End 8 Register (PCFS_DIVE8)	32	RW	0000_03E7h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
60h	PCFS Divider Start 8 Register (PCFS_DIVS8)	32	RW	0000_03E7h
300h	Clock Mux 0 Select Control Register (MUX_0_CSC)	32	RW	0000_0000h
304h	Clock Mux 0 Select Status Register (MUX_0_CSS)	32	R	0008_0000h
308h	Clock Mux 0 Divider 0 Control Register (MUX_0_DC_0)	32	RW	8000_0000h
30Ch	Clock Mux 0 Divider 1 Control Register (MUX_0_DC_1)	32	RW	8000_0000h
310h	Clock Mux 0 Divider 2 Control Register (MUX_0_DC_2)	32	RW	8001_0000h
314h	Clock Mux 0 Divider 3 Control Register (MUX_0_DC_3)	32	RW	8000_0000h
318h	Clock Mux 0 Divider 4 Control Register (MUX_0_DC_4)	32	RW	8000_0000h
31Ch	Clock Mux 0 Divider 5 Control Register (MUX_0_DC_5)	32	RW	8007_0000h
320h	Clock Mux 0 Divider 6 Control Register (MUX_0_DC_6)	32	RW	8000_0000h
324h	Clock Mux 0 Divider 7 Control Register (MUX_0_DC_7)	32	RW	8000_0000h
334h	Clock Mux 0 Divider Trigger Control Register (MUX_0_DIV_TRIG_CTRL)	32	RW	0000_0000h
338h	Clock Mux 0 Divider Trigger Register (MUX_0_DIV_TRIG)	32	W	0000_0000h
33Ch	Clock Mux 0 Divider Update Status Register (MUX_0_DIV_UPD_STAT)	32	R	0000_0000h
340h	Clock Mux 1 Select Control Register (MUX_1_CSC)	32	RW	0000_0000h
344h	Clock Mux 1 Select Status Register (MUX_1_CSS)	32	R	0008_0000h
348h	Clock Mux 1 Divider 0 Control Register (MUX_1_DC_0)	32	RW	0000_0000h
37Ch	Clock Mux 1 Divider Update Status Register (MUX_1_DIV_UPD_STAT)	32	R	0000_0000h
380h	Clock Mux 2 Select Control Register (MUX_2_CSC)	32	RW	0000_0000h
384h	Clock Mux 2 Select Status Register (MUX_2_CSS)	32	R	0008_0000h
388h	Clock Mux 2 Divider 0 Control Register (MUX_2_DC_0)	32	RW	0000_0000h
3BCh	Clock Mux 2 Divider Update Status Register (MUX_2_DIV_UPD_STAT)	32	R	0000_0000h
3C0h	Clock Mux 3 Select Control Register (MUX_3_CSC)	32	RW	0000_0000h
3C4h	Clock Mux 3 Select Status Register (MUX_3_CSS)	32	R	0008_0000h
3C8h	Clock Mux 3 Divider 0 Control Register (MUX_3_DC_0)	32	RW	0000_0000h
3FCh	Clock Mux 3 Divider Update Status Register (MUX_3_DIV_UPD_STAT)	32	R	0000_0000h
400h	Clock Mux 4 Select Control Register (MUX_4_CSC)	32	RW	0000_0000h

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Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
404h	Clock Mux 4 Select Status Register (MUX_4_CSS)	32	R	0008_0000h
408h	Clock Mux 4 Divider 0 Control Register (MUX_4_DC_0)	32	RW	0000_0000h
43Ch	Clock Mux 4 Divider Update Status Register (MUX_4_DIV_UPD_STAT)	32	R	0000_0000h
440h	Clock Mux 5 Select Control Register (MUX_5_CSC)	32	RW	0000_0000h
444h	Clock Mux 5 Select Status Register (MUX_5_CSS)	32	R	0002_0000h
448h	Clock Mux 5 Divider 0 Control Register (MUX_5_DC_0)	32	RW	8001_0000h
47Ch	Clock Mux 5 Divider Update Status Register (MUX_5_DIV_UPD_STAT)	32	R	0000_0000h
480h	Clock Mux 6 Select Control Register (MUX_6_CSC)	32	RW	0000_0000h
484h	Clock Mux 6 Select Status Register (MUX_6_CSS)	32	R	0002_0000h
488h	Clock Mux 6 Divider 0 Control Register (MUX_6_DC_0)	32	RW	8001_0000h
4BCh	Clock Mux 6 Divider Update Status Register (MUX_6_DIV_UPD_STAT)	32	R	0000_0000h
4C0h	Clock Mux 7 Select Control Register (MUX_7_CSC)	32	RW	0000_0000h
4C4h	Clock Mux 7 Select Status Register (MUX_7_CSS)	32	R	0008_0000h
4C8h	Clock Mux 7 Divider 0 Control Register (MUX_7_DC_0)	32	RW	0000_0000h
4FCh	Clock Mux 7 Divider Update Status Register (MUX_7_DIV_UPD_STAT)	32	R	0000_0000h
500h	Clock Mux 8 Select Control Register (MUX_8_CSC)	32	RW	0000_0000h
504h	Clock Mux 8 Select Status Register (MUX_8_CSS)	32	R	0008_0000h
508h	Clock Mux 8 Divider 0 Control Register (MUX_8_DC_0)	32	RW	0000_0000h
53Ch	Clock Mux 8 Divider Update Status Register (MUX_8_DIV_UPD_STAT)	32	R	0000_0000h
540h	Clock Mux 9 Select Control Register (MUX_9_CSC)	32	RW	0000_0000h
544h	Clock Mux 9 Select Status Register (MUX_9_CSS)	32	R	0008_0000h
548h	Clock Mux 9 Divider 0 Control Register (MUX_9_DC_0)	32	RW	0000_0000h
57Ch	Clock Mux 9 Divider Update Status Register (MUX_9_DIV_UPD_STAT)	32	R	0000_0000h
580h	Clock Mux 10 Select Control Register (MUX_10_CSC)	32	RW	0000_0000h
584h	Clock Mux 10 Select Status Register (MUX_10_CSS)	32	R	0008_0000h
588h	Clock Mux 10 Divider 0 Control Register (MUX_10_DC_0)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
5BCh	Clock Mux 10 Divider Update Status Register (MUX_10_DIV_UPD_STAT)	32	R	0000_0000h
5C0h	Clock Mux 11 Select Control Register (MUX_11_CSC)	32	RW	0000_0000h
5C4h	Clock Mux 11 Select Status Register (MUX_11_CSS)	32	R	0002_0000h
5C8h	Clock Mux 11 Divider 0 Control Register (MUX_11_DC_0)	32	RW	8000_0000h
5FCh	Clock Mux 11 Divider Update Status Register (MUX_11_DIV_UPD_STAT)	32	R	0000_0000h
600h	Clock Mux 12 Select Control Register (MUX_12_CSC)	32	RW	0000_0000h
604h	Clock Mux 12 Select Status Register (MUX_12_CSS)	32	R	0008_0000h
608h	Clock Mux 12 Divider 0 Control Register (MUX_12_DC_0)	32	RW	0000_0000h
63Ch	Clock Mux 12 Divider Update Status Register (MUX_12_DIV_UPD_STAT)	32	R	0000_0000h
640h	Clock Mux 13 Select Control Register (MUX_13_CSC)	32	RW	0000_0000h
644h	Clock Mux 13 Select Status Register (MUX_13_CSS)	32	R	0008_0000h
648h	Clock Mux 13 Divider 0 Control Register (MUX_13_DC_0)	32	RW	0000_0000h
67Ch	Clock Mux 13 Divider Update Status Register (MUX_13_DIV_UPD_STAT)	32	R	0000_0000h
6C0h	Clock Mux 15 Select Control Register (MUX_15_CSC)	32	RW	0000_0000h
6C4h	Clock Mux 15 Select Status Register (MUX_15_CSS)	32	R	0008_0000h
6C8h	Clock Mux 15 Divider 0 Control Register (MUX_15_DC_0)	32	RW	0000_0000h
6FCh	Clock Mux 15 Divider Update Status Register (MUX_15_DIV_UPD_STAT)	32	R	0000_0000h
700h	Clock Mux 16 Select Control Register (MUX_16_CSC)	32	RW	0000_0000h
704h	Clock Mux 16 Select Status Register (MUX_16_CSS)	32	R	0008_0000h
708h	Clock Mux 16 Divider 0 Control Register (MUX_16_DC_0)	32	RW	0000_0000h
73Ch	Clock Mux 16 Divider Update Status Register (MUX_16_DIV_UPD_STAT)	32	R	0000_0000h

24.5.2 PCFS Step Duration (PCFS_SDUR)

Offset

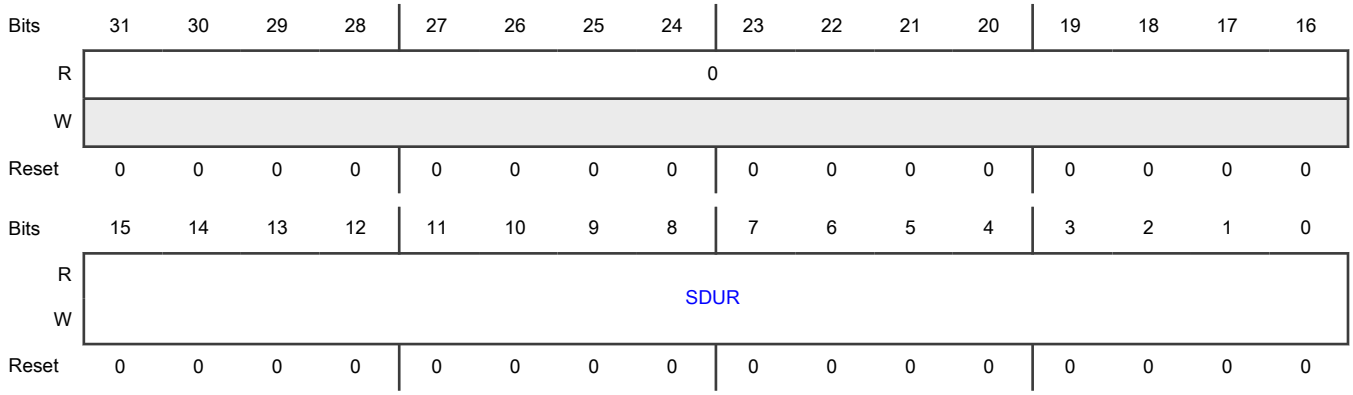
Register	Offset
PCFS_SDUR	0h

Function

This register specifies the step duration of each PCFS step. The value provided in this register specifies the PCFS step duration in terms of the number of cycles of FIRC.

This register is reset only by a destructive reset. For details, see PCFS.

Diagram



Fields

Field	Function
31-16 —	This field is reserved and reads return zeros.
15-0 SDUR	Step duration Count value of the step duration

24.5.3 PCFS Divider Change 8 Register (PCFS_DIVC8)

Offset

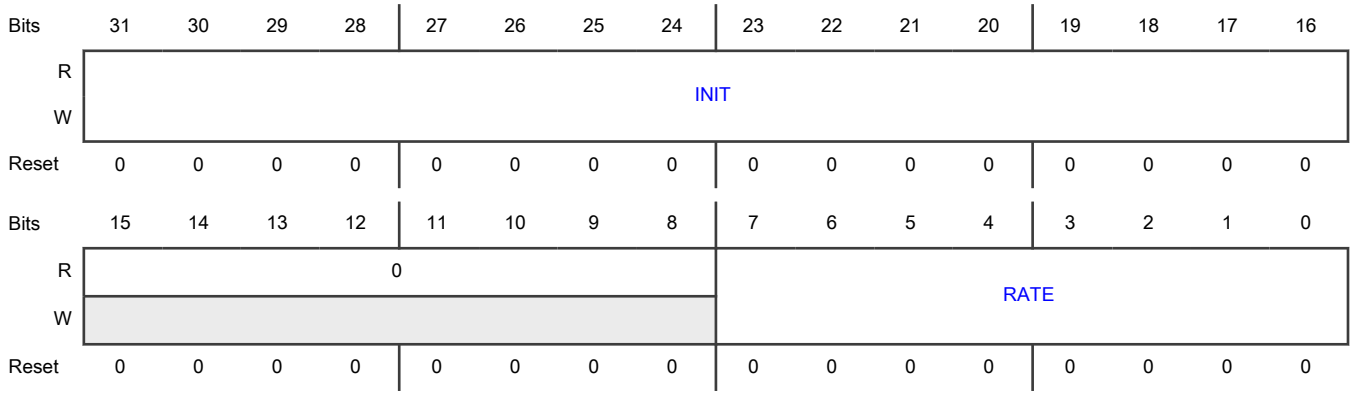
Register	Offset
PCFS_DIVC8	58h

Function

This register defines the rate of frequency change and initial change value on frequency ramp-up for the Progressive Clock Frequency switching of PLL_PHI0_CLK.

This register is reset only on destructive reset.

Diagram



Fields

Field	Function
31-16 INIT	Divider change initial value This field provides the initial change value of the clock divider for the clock ramp-up phase of PLL_PHI0_CLK.
15-8 —	This field is reserved and reads return zeros.
7-0 RATE	Divider change rate This value controls the change value of the clock divider for the clock ramp-up and ramp-down phase of PLL_PHI0_CLK.

24.5.4 PCFS Divider End 8 Register (PCFS_DIVE8)

Offset

Register	Offset
PCFS_DIVE8	5Ch

Function

This register defines the final division value on frequency ramp-down for the progressive system clock switching of PLL_PHI0_CLK.

This registers is reset only on destructive reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0												DIVE			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DIVE															
W																
Reset	0	0	0	0	0	0	1	1	1	1	1	0	0	1	1	1

Fields

Field	Function
31-20 —	This field is reserved and reads return zeros.
19-0 DIVE	Divider end value This field provides the end value of the clock divider for the PLL_PHI0_CLK ramp-down phase.

24.5.5 PCFS Divider Start 8 Register (PCFS_DIVS8)

Offset

Register	Offset
PCFS_DIVS8	60h

Function

This register defines the initial division value on frequency ramp-up for the progressive system clock switching of PLL_PHI0_CLK.

This register is reset only on destructive reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0												DIVS			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DIVS															
W																
Reset	0	0	0	0	0	0	1	1	1	1	1	0	0	1	1	1

Fields

Field	Function
31-20 —	This field is reserved and reads return zeros.
19-0 DIVS	Divider start value This field provides the start value of the clock divider for the PLL_PHI0_CLK ramp-up phase

24.5.6 Clock Mux 0 Select Control Register (MUX_0_CSC)

Offset

Register	Offset
MUX_0_CSC	300h

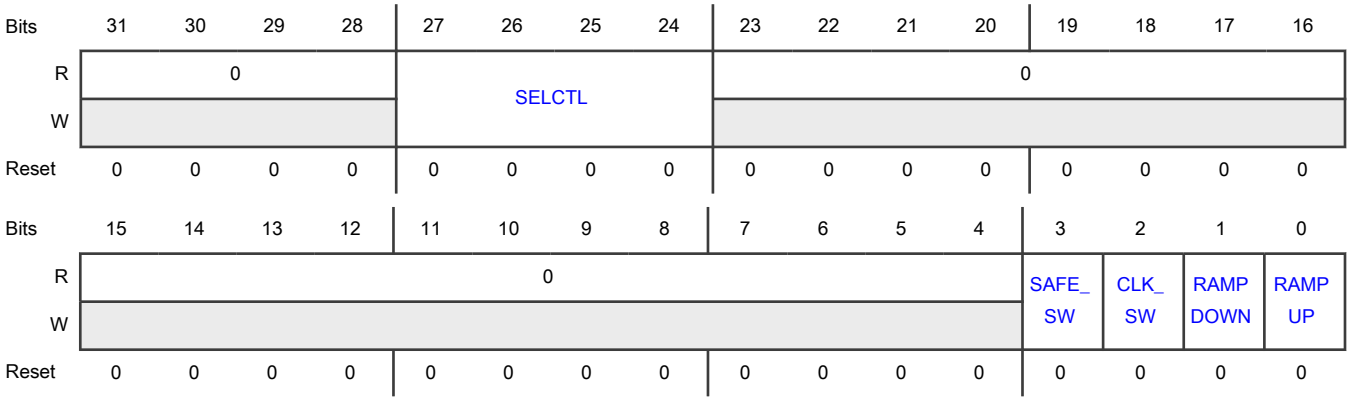
Function

This register provides the clock source selection control for clock mux 0. Clock mux 0 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

An update to all the PCFS-related fields of this register must be an atomic write, which means a single write must update the CLK_SW, RAMPDOWN, and RAMPUP fields. It is necessary to set both RAMPUP and RAMPDOWN bits together even if you want to trigger either RAMPUP or RAMPDOWN process otherwise the desired PCFS sequence will not be executed.

Diagram



Fields

Field	Function
31-28	This field is reserved and reads return zeros.

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Field	Function
—	
27-24 SELCTL	Clock source selection control Selects the source clock for clock mux 0. The reserved values are not displayed. 0000b - FIRC 1000b - PLL_PHI0_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 0. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1 RAMPDOWN	PCFS ramp-down Writing 1 to this bit makes a PCFS ramp-down request to clock mux 0. After a PCFS ramp-down operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
0 RAMPUP	PCFS ramp-up Writing 1 to this bit makes a PCFS ramp-up request to clock mux 0. After a PCFS ramp-up operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.

24.5.7 Clock Mux 0 Select Status Register (MUX_0_CSS)

Offset

Register	Offset
MUX_0_CSS	304h

Function

This register provides the current clock source selection status for clock mux 0.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	RAMP DOWN	RAMP UP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	This field is reserved and reads return zeros.
27-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 0. The reserved values are not displayed. 0000b - FIRC 1000b - PLL_PHI0_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive.

Table continues on the next page...

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Field	Function
	110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 0. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 0. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1 RAMPDOWN	PCFS ramp-down This field provides an indication of whether a PCFS ramp-down operation was requested during the previous/ongoing request on clock mux 0. **NOTE** In case of safe clock switching, the ramp-down operation runs internally, but the value of the corresponding status field is not set to 1. 0b - No ramp-down operation was requested. 1b - Ramp-down operation was requested.
0 RAMPUP	PCFS ramp-up This field provides an indication of whether a PCFS ramp-up operation was requested during the previous/ongoing request on clock mux 0. 0b - No ramp-up operation was requested. 1b - Ramp-up operation was requested.

24.5.8 Clock Mux 0 Divider 0 Control Register (MUX_0_DC_0)

Offset

Register	Offset
MUX_0_DC_0	308h

Function

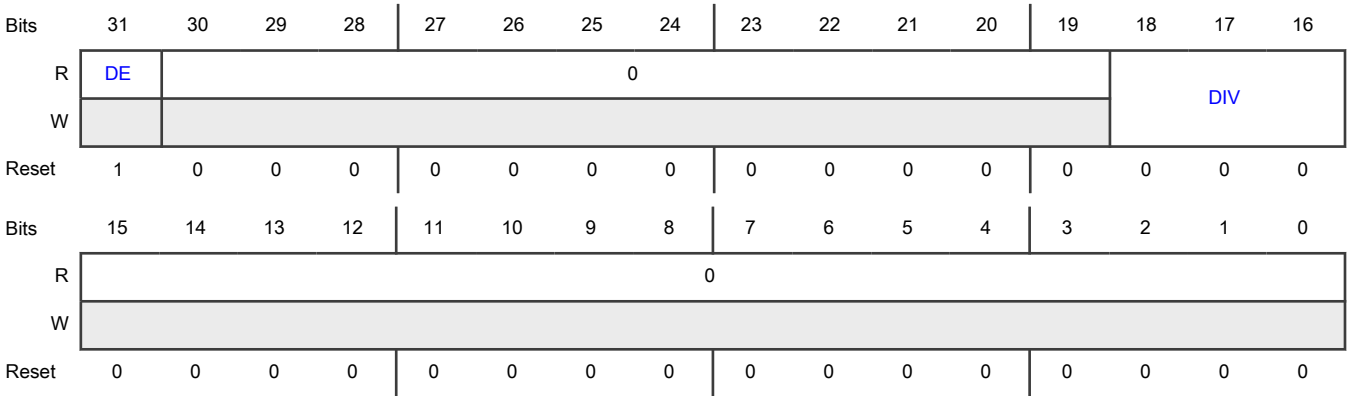
This register controls the clock divider 0 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.9 Clock Mux 0 Divider 1 Control Register (MUX_0_DC_1)

Offset

Register	Offset
MUX_0_DC_1	30Ch

Function

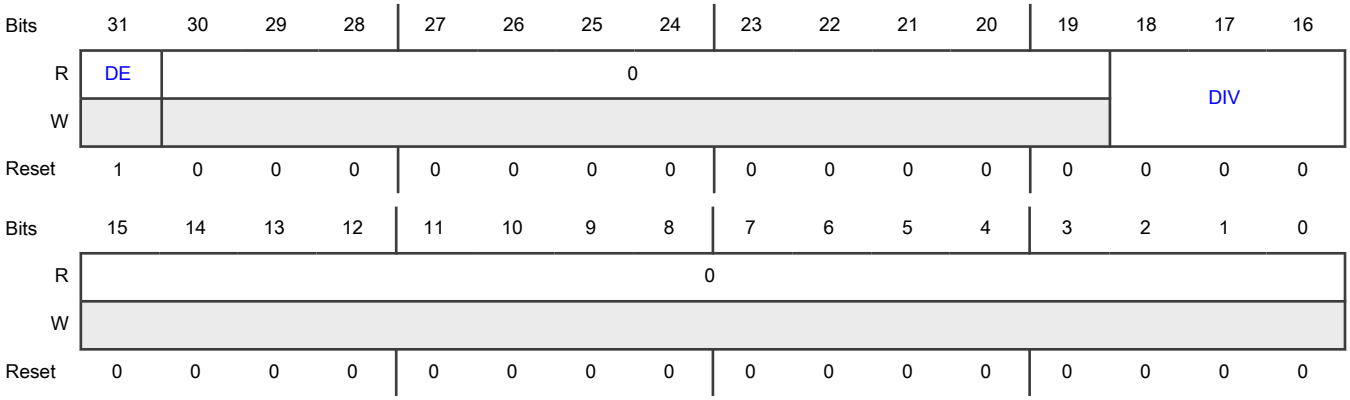
This register controls the clock divider 1 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.10 Clock Mux 0 Divider 2 Control Register (MUX_0_DC_2)

Offset

Register	Offset
MUX_0_DC_2	310h

Function

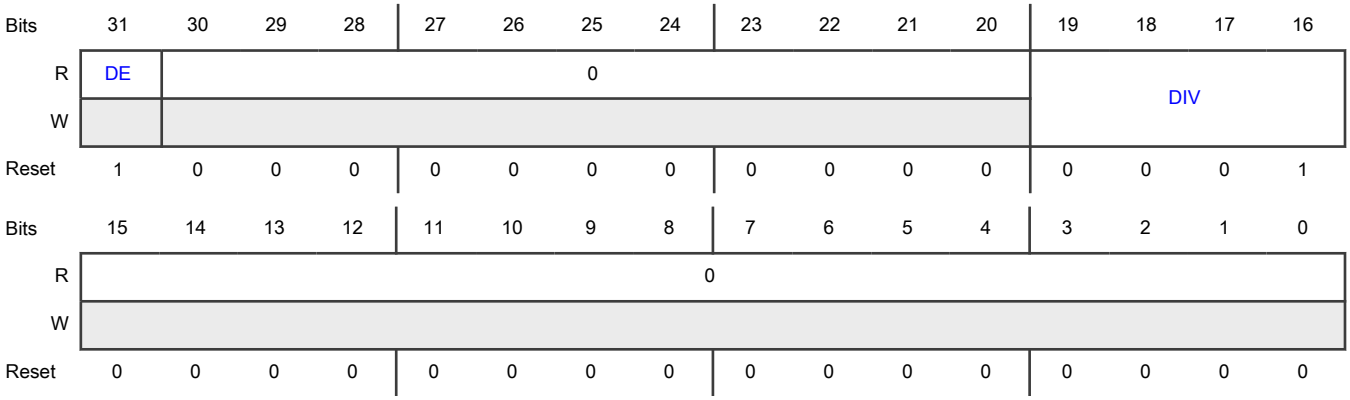
This register controls the clock divider 2 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-20 —	This field is reserved and reads return zeros.
19-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.11 Clock Mux 0 Divider 3 Control Register (MUX_0_DC_3)

Offset

Register	Offset
MUX_0_DC_3	314h

Function

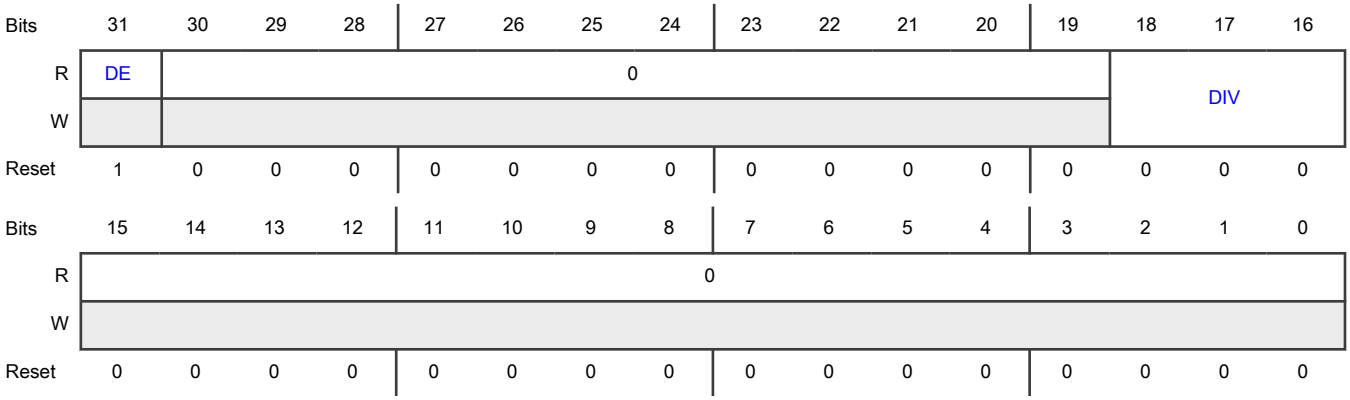
This register controls the clock divider 3 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.12 Clock Mux 0 Divider 4 Control Register (MUX_0_DC_4)

Offset

Register	Offset
MUX_0_DC_4	318h

Function

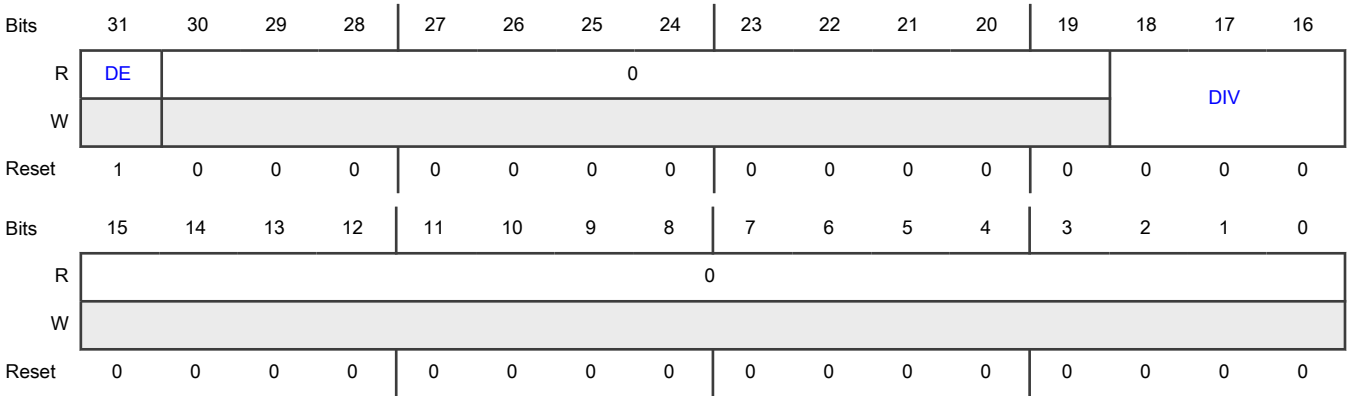
This register controls the clock divider 4 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.13 Clock Mux 0 Divider 5 Control Register (MUX_0_DC_5)

Offset

Register	Offset
MUX_0_DC_5	31Ch

Function

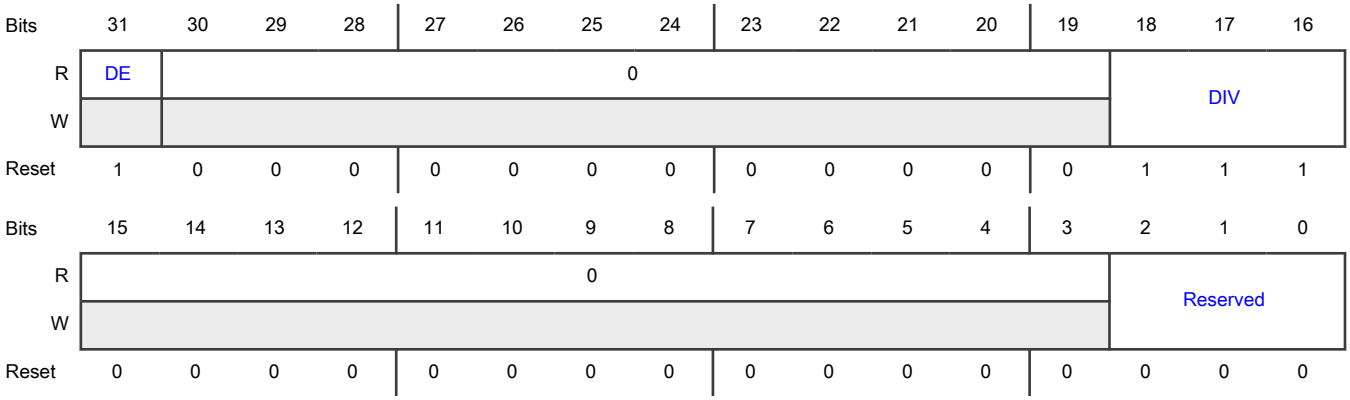
This register controls the clock divider 5 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-3 —	Reserved

Table continues on the next page...

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Field	Function
2-0 —	Reserved

24.5.14 Clock Mux 0 Divider 6 Control Register (MUX_0_DC_6)

Offset

Register	Offset
MUX_0_DC_6	320h

Function

This register controls the clock divider 6 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DE	0											DIV			
W																
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-19	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.15 Clock Mux 0 Divider 7 Control Register (MUX_0_DC_7)

Offset

Register	Offset
MUX_0_DC_7	324h

Function

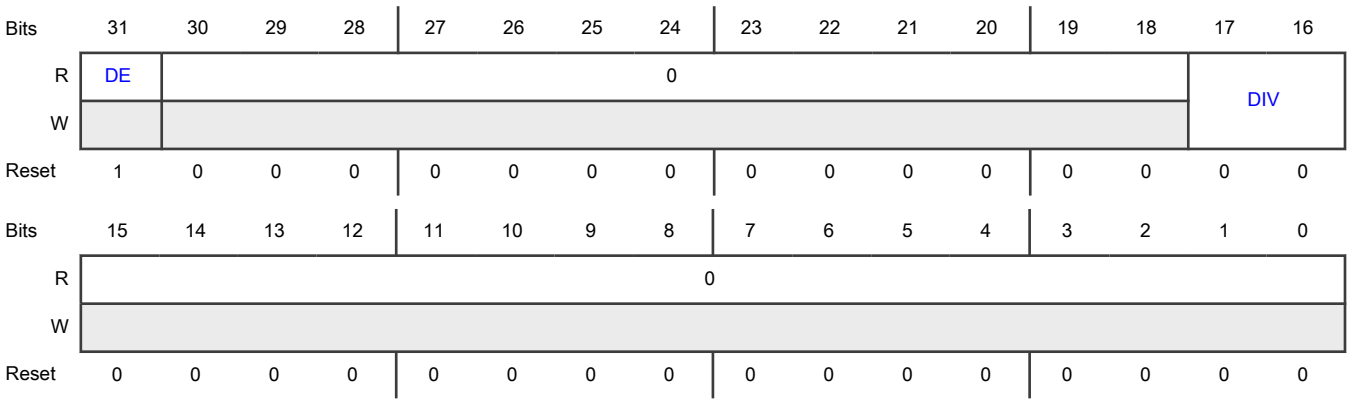
This register controls the clock divider 7 for clock mux 0.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Unused 1b - Divider is enabled.
30-18 —	This field is reserved and reads return zeros.
17-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.16 Clock Mux 0 Divider Trigger Control Register (MUX_0_DIV_TRIG_CTRL)

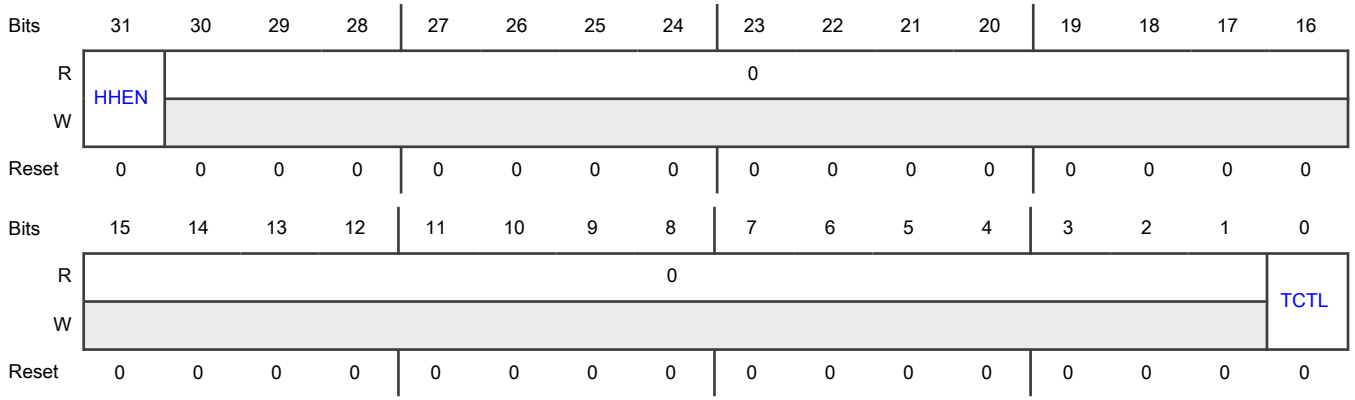
Offset

Register	Offset
MUX_0_DIV_TRIG_CTRL	334h

Function

This register selects whether the dividers associated with clock mux 0 are updated immediately on writing to the corresponding divider configuration register (referred to as immediate divider update) or only on writing to the MC_CGM_MUX_0_DIV_TRIG register (referred to as common trigger update). When common trigger update is configured, this register also controls initiation of the halt handshake protocol with the on-chip AXBS. Software is required to configure HHEN field for handshaking with on-chip AXBS when the ratio of division value among the clock dividers need to be changed.

Diagram



Fields

Field	Function
31 HHEN	Halt handshake enable This field controls the initiation of the halt handshake protocol with AXBS when a common trigger divider update is initiated. 0b - No halt handshake protocol is initiated. 1b - Halt handshake protocol is initiated.
30-1 —	This field is reserved and reads return zeros.
0 TCTL	Trigger control This field controls the divider update configuration between immediate and common update. 0b - Immediate divider update 1b - Common trigger divider update

24.5.17 Clock Mux 0 Divider Trigger Register (MUX_0_DIV_TRIG)

Offset

Register	Offset
MUX_0_DIV_TRIG	338h

Function

This register provides a common trigger for the clock dividers (only 50% duty cycle dividers) of clock mux 0. Writing any value to this register provides a trigger to the dividers. This register should only be written after appropriately configuring the MC_CGM_MUX_0_DIV_TRIG_CTRL register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W	TRIGGER															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W	TRIGGER															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TRIGGER	Trigger for divider update

24.5.18 Clock Mux 0 Divider Update Status Register (MUX_0_DIV_UPD_STAT)

Offset

Register	Offset
MUX_0_DIV_UPD_STAT	33Ch

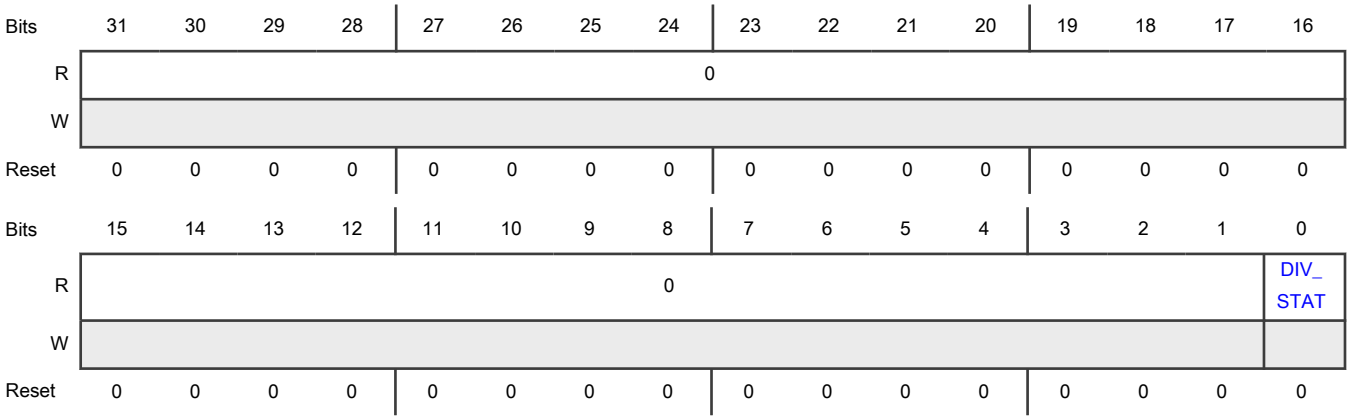
Function

This register provides the update status of the clock dividers corresponding to clock mux 0. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.

Table continues on the next page...

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Field	Function
0 DIV_STAT	Divider status for clock mux 0 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.19 Clock Mux 1 Select Control Register (MUX_1_CSC)

Offset

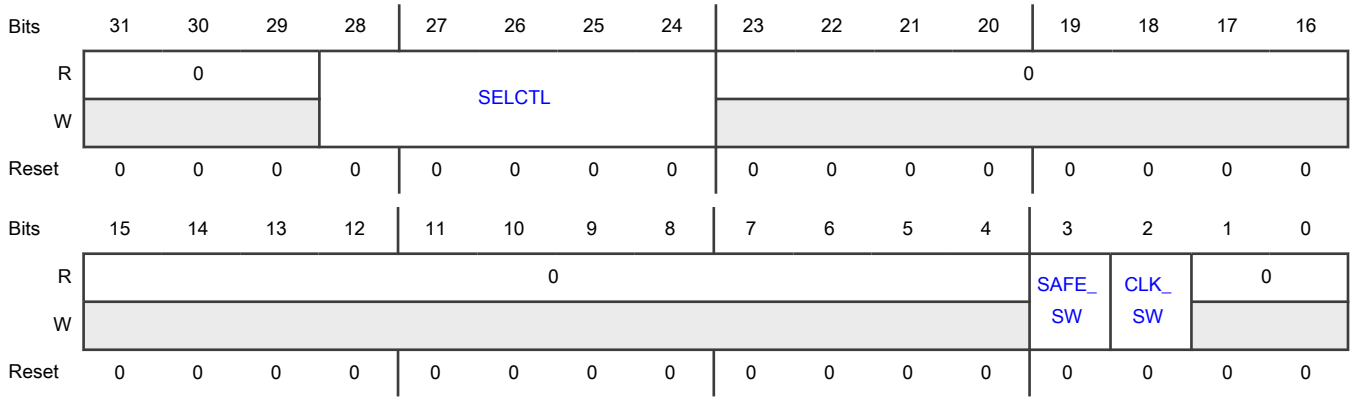
Register	Offset
MUX_1_CSC	340h

Function

This register provides the clock source selection control for clock mux 1. Clock mux 1 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 1. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 1. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.20 Clock Mux 1 Select Status Register (MUX_1_CSS)

Offset

Register	Offset
MUX_1_CSS	344h

Function

This register provides the current clock source selection status for clock mux 1.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 1. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 1. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 1. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.21 Clock Mux 1 Divider 0 Control Register (MUX_1_DC_0)

Offset

Register	Offset
MUX_1_DC_0	348h

Function

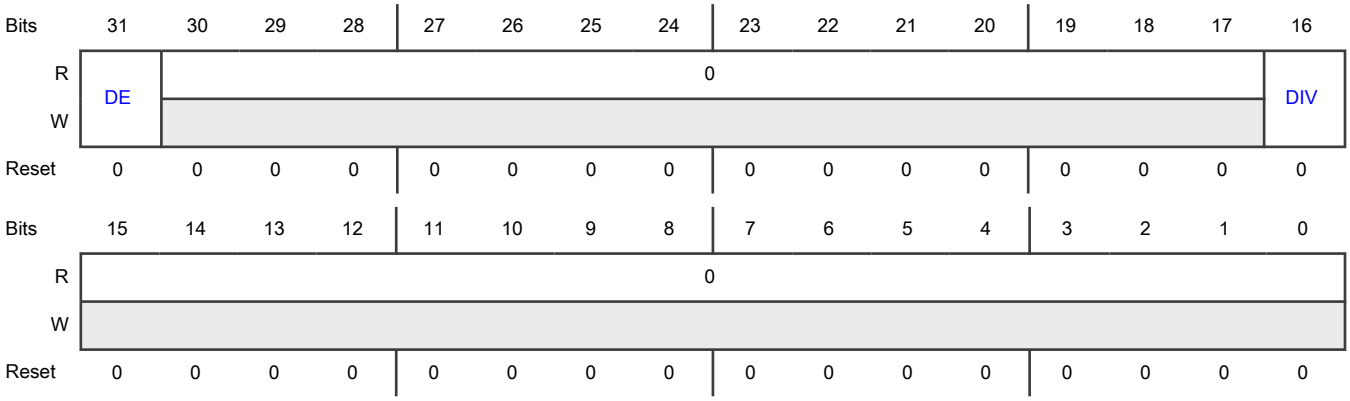
This register controls the clock divider 0 for clock mux 1.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-17 —	This field is reserved and reads return zeros.
16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.22 Clock Mux 1 Divider Update Status Register (MUX_1_DIV_UPD_STAT)

Offset

Register	Offset
MUX_1_DIV_UPD_STAT	37Ch

Function

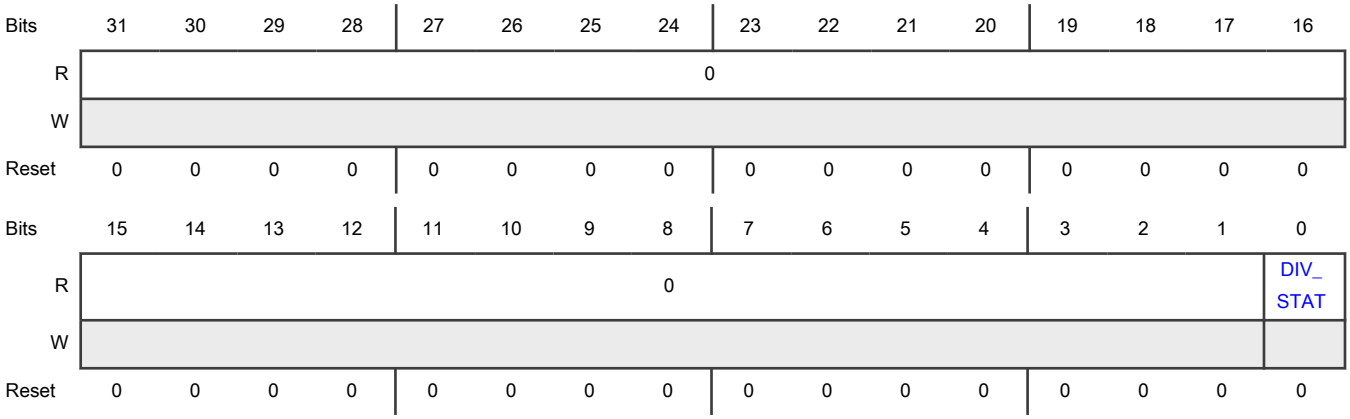
This register provides the update status of the clock dividers corresponding to clock mux 1. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other

clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 1 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.23 Clock Mux 2 Select Control Register (MUX_2_CSC)

Offset

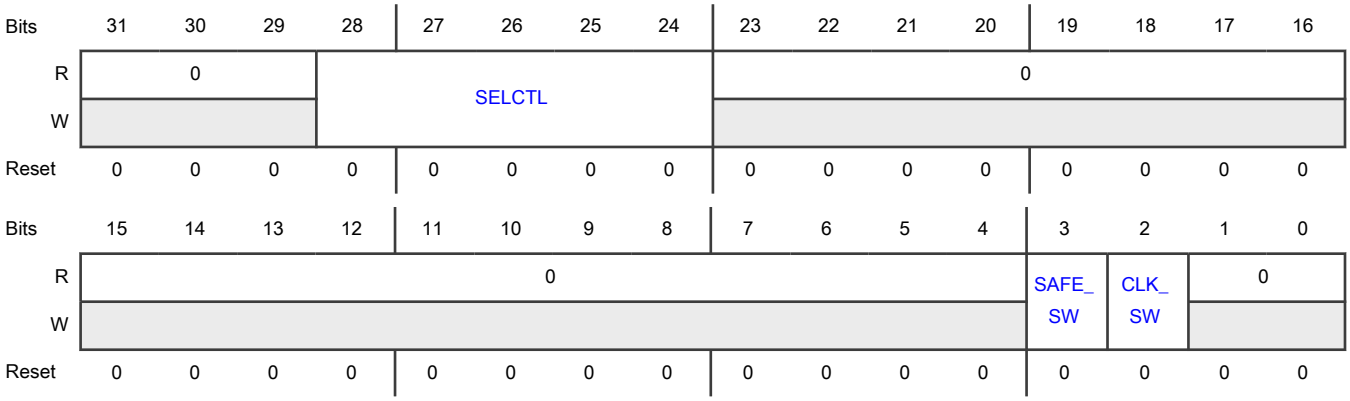
Register	Offset
MUX_2_CSC	380h

Function

This register provides the clock source selection control for clock mux 2. Clock mux 2 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 2. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 2. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.24 Clock Mux 2 Select Status Register (MUX_2_CSS)

Offset

Register	Offset
MUX_2_CSS	384h

Function

This register provides the current clock source selection status for clock mux 2.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 2. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 2. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ ongoing request on clock mux 2. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.25 Clock Mux 2 Divider 0 Control Register (MUX_2_DC_0)

Offset

Register	Offset
MUX_2_DC_0	388h

Function

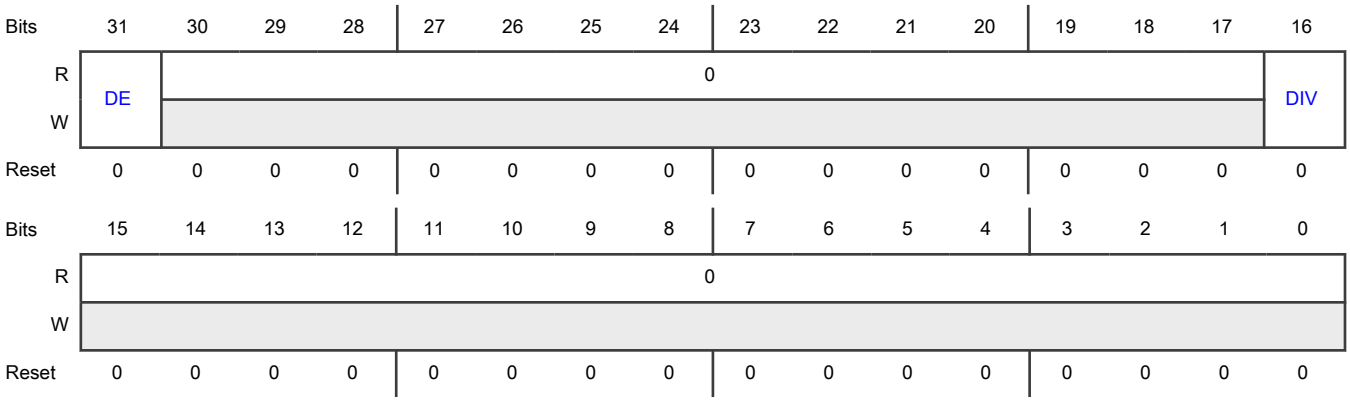
This register controls the clock divider 0 for clock mux 2.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-17 —	This field is reserved and reads return zeros.
16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.26 Clock Mux 2 Divider Update Status Register (MUX_2_DIV_UPD_STAT)

Offset

Register	Offset
MUX_2_DIV_UPD_STAT	3BCh

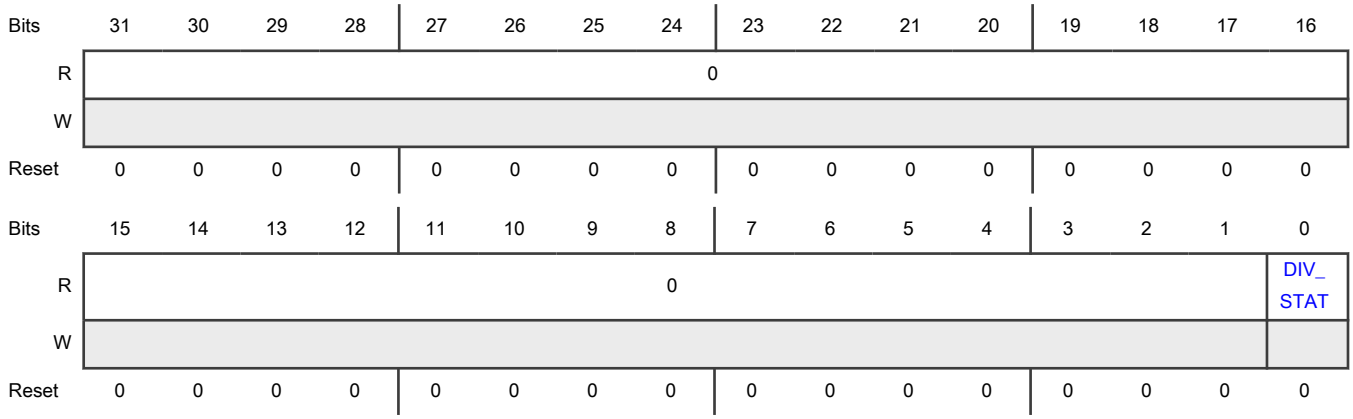
Function

This register provides the update status of the clock dividers corresponding to clock mux 2. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 2 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.27 Clock Mux 3 Select Control Register (MUX_3_CSC)

Offset

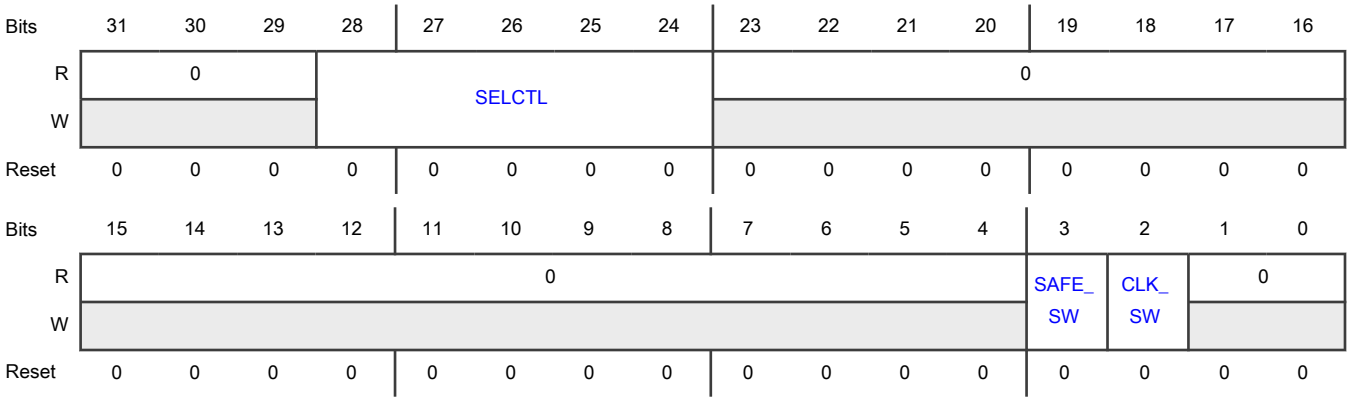
Register	Offset
MUX_3_CSC	3C0h

Function

This register provides the clock source selection control for clock mux 3. Clock mux 3 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 3. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 3. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.28 Clock Mux 3 Select Status Register (MUX_3_CSS)

Offset

Register	Offset
MUX_3_CSS	3C4h

Function

This register provides the current clock source selection status for clock mux 3.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0			SELSTAT					0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 3. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 3. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 3. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.29 Clock Mux 3 Divider 0 Control Register (MUX_3_DC_0)

Offset

Register	Offset
MUX_3_DC_0	3C8h

Function

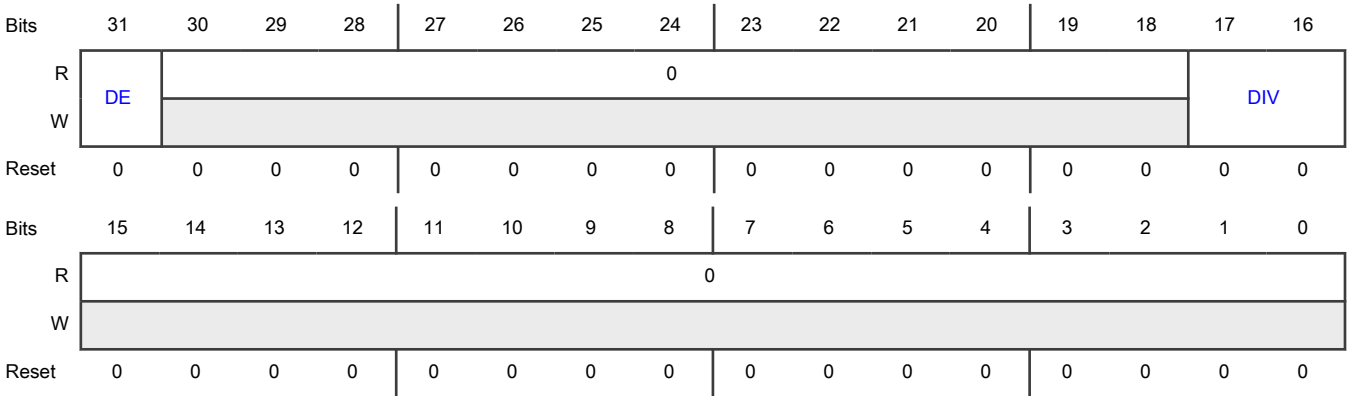
This register controls the clock divider 0 for clock mux 3.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-18 —	This field is reserved and reads return zeros.
17-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.30 Clock Mux 3 Divider Update Status Register (MUX_3_DIV_UPD_STAT)

Offset

Register	Offset
MUX_3_DIV_UPD_STAT	3FCh

Function

This register provides the update status of the clock dividers corresponding to clock mux 3. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															DIV_STAT
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 3 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.31 Clock Mux 4 Select Control Register (MUX_4_CSC)

Offset

Register	Offset
MUX_4_CSC	400h

Function

This register provides the clock source selection control for clock mux 4. Clock mux 4 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELCTL				0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 4. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 4. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.32 Clock Mux 4 Select Status Register (MUX_4_CSS)

Offset

Register	Offset
MUX_4_CSS	404h

Function

This register provides the current clock source selection status for clock mux 4.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 4. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 4. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 4. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.33 Clock Mux 4 Divider 0 Control Register (MUX_4_DC_0)

Offset

Register	Offset
MUX_4_DC_0	408h

Function

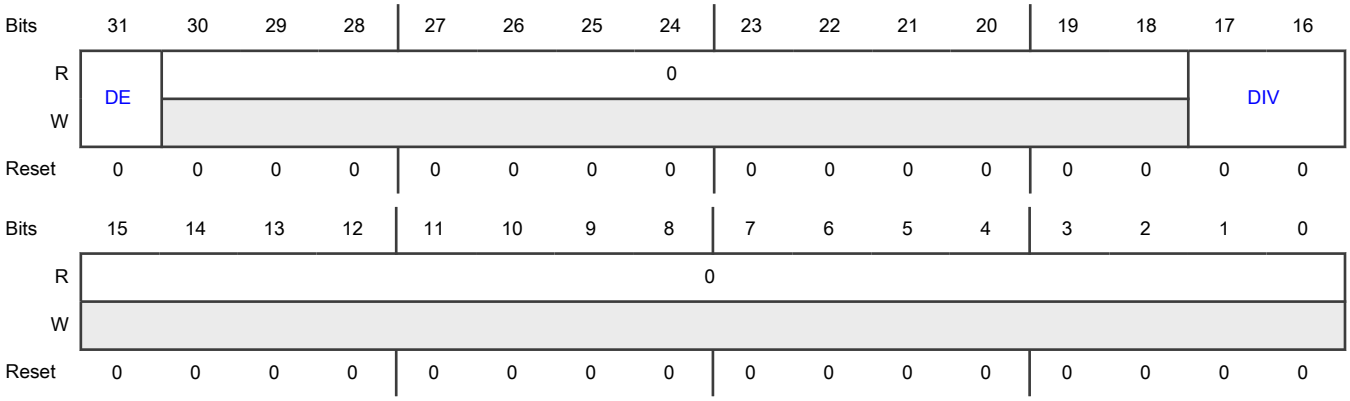
This register controls the clock divider 0 for clock mux 4.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-18 —	This field is reserved and reads return zeros.
17-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.34 Clock Mux 4 Divider Update Status Register (MUX_4_DIV_UPD_STAT)

Offset

Register	Offset
MUX_4_DIV_UPD_STAT	43Ch

Function

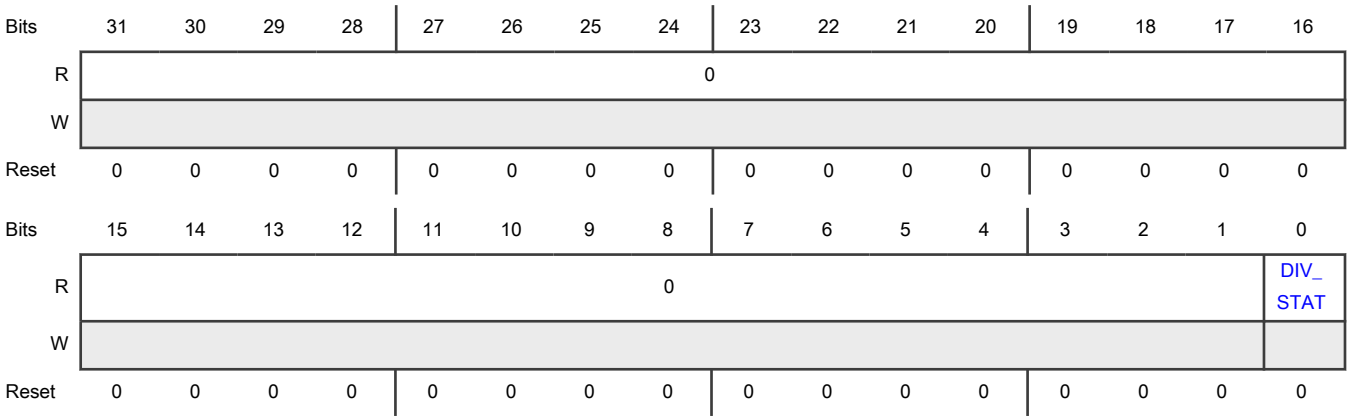
This register provides the update status of the clock dividers corresponding to clock mux 4. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other

clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 4 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.35 Clock Mux 5 Select Control Register (MUX_5_CSC)

Offset

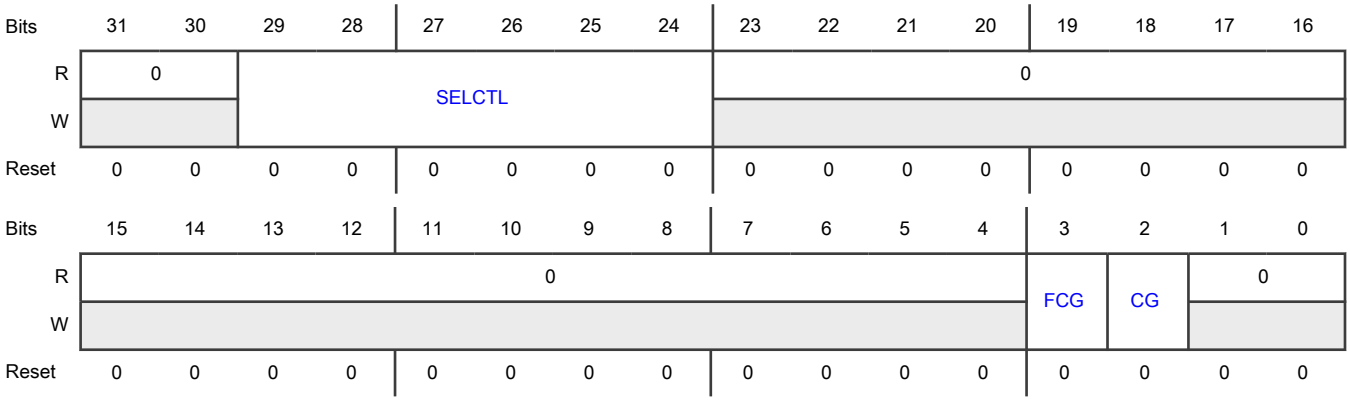
Register	Offset
MUX_5_CSC	440h

Function

This register provides the clock source selection control of clock mux 5. Clock mux 5 implements software control clock switching, and a graceful clock switch can be performed by executing a sequence of steps in software. See "Software-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-30 —	This field is reserved and reads return zeros.
29-24 SELCTL	Clock source selection control Selects the source clock for clock mux 5. The reserved values are not displayed. 00_0000b - FIRC 00_0001b - SIRC 00_0010b - FXOSC 01_0111b - AIPS_SLOW_CLK 11_0010b - Reserved
23-4 —	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 FCG	Force clock gate Writing 1 to this bit gates the clock at the output of clock mux 5 to logic-0 irrespective of the logic level of the currently selected clock. Clock gating using this bit should only be performed when it is insured that current clock source is inactive.
2 CG	Clock gate Writing 1 to this bit gates the clock at the output of clock mux 5 to logic-0. Using this bit it is insured that no glitches are resulted when gating the clock.
1-0 —	This field is reserved and reads return zeros.

24.5.36 Clock Mux 5 Select Status Register (MUX_5_CSS)

Offset

Register	Offset
MUX_5_CSS	444h

Function

This register provides the current clock source selection status for clock mux 5.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				0		CS	GRIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
29-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 5. The reserved values are not displayed. 00_0000b - FIRC 00_0001b - SIRC 00_0010b - FXOSC 01_0111b - AIPS_SLOW_CLK 11_0010b - Reserved
23-20 —	This field is reserved and reads return zeros.
19-18 —	This field is reserved and reads return zeros.
17 CS	Clock status This field indicates state of the clock at the output of the clock mux. 0b - Clock is gated to logic-0 at output of clock mux 1b - Clock mux is transparent. Active clock pulses at input of clock mux results in same number of pulses at its output
16 GRIP	Gating request is in progress. When a clock gate request is given this bit indicates if the clock gating at the output of mux has completed or not. 0b - Clock source gating or ungating has completed. 1b - Clock source gating or ungating is in progress.
15-0 —	This field is reserved and reads return zeros.

24.5.37 Clock Mux 5 Divider 0 Control Register (MUX_5_DC_0)

Offset

Register	Offset
MUX_5_DC_0	448h

Function

This register controls the clock divider 0 for clock mux 5.

This divider is a 50% duty cycle divider.

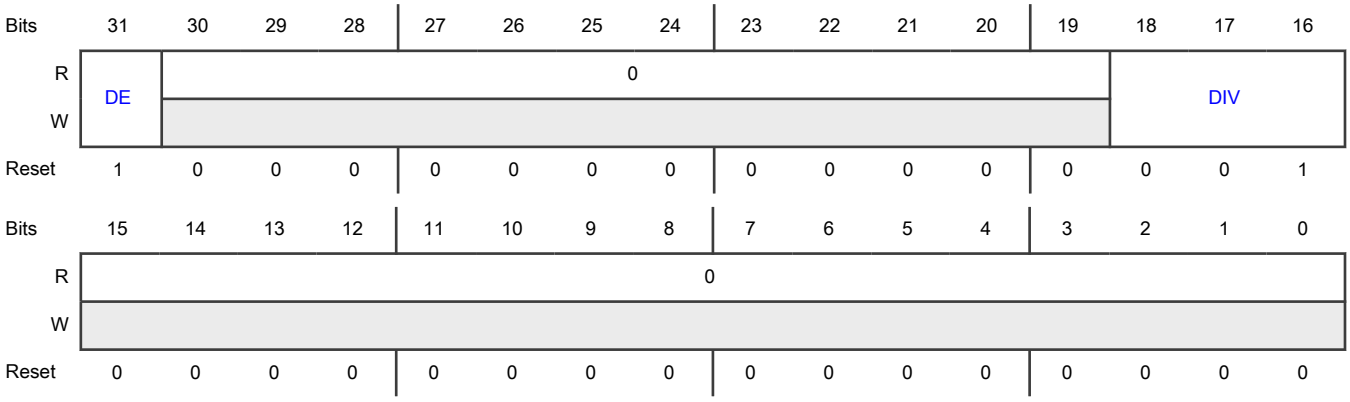
NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

NOTE

Software-controlled clock multiplexer dividers are not expected to return to the default state on the hardware transitions and handshakes occurring as part of the functional reset entry sequence (only hardware-controlled clock multiplexer dividers return to the default state).

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.38 Clock Mux 5 Divider Update Status Register (MUX_5_DIV_UPD_STAT)

Offset

Register	Offset
MUX_5_DIV_UPD_STAT	47Ch

Function

This register provides the update status of the clock dividers corresponding to clock mux 5. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															DIV_STAT
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 5 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.39 Clock Mux 6 Select Control Register (MUX_6_CSC)

Offset

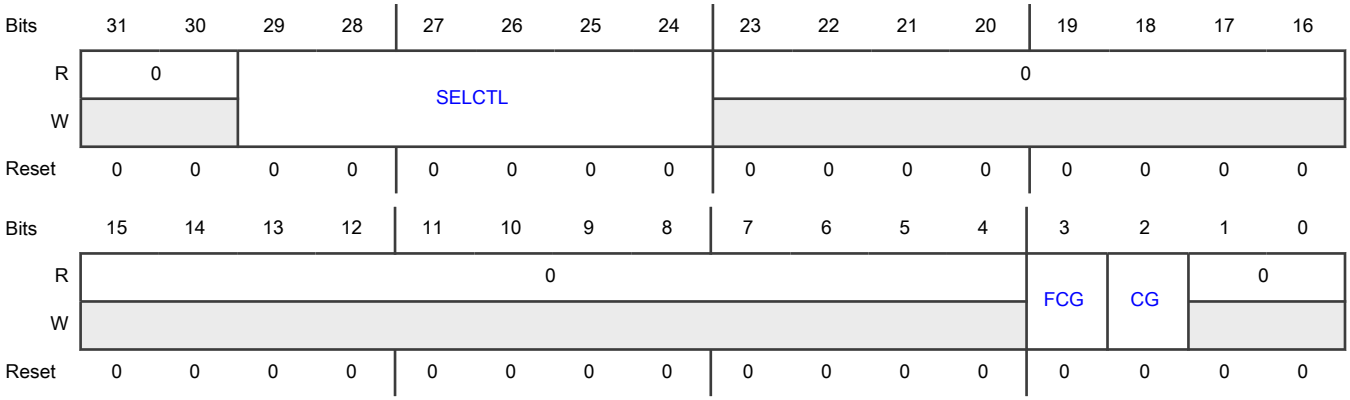
Register	Offset
MUX_6_CSC	480h

Function

This register provides the clock source selection control of clock mux 6. Clock mux 6 implements software control clock switching, and a graceful clock switch can be performed by executing a sequence of steps in software. See "Software-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-30	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
29-24 SELCTL	Clock source selection control Selects the source clock for clock mux 6. The reserved values are not displayed. 00_0000b - FIRC 00_0001b - SIRC 00_0010b - FXOSC 00_1000b - PLL_PHI0_CLK 00_1001b - PLL_PHI1_CLK 01_0000b - CORE_CLK 01_0011b - HSE_CLK 01_0101b - CM7_CORE_CLK 01_0110b - AIPS_PLAT_CLK 01_0111b - AIPS_SLOW_CLK 01_1000b - EMAC_RMII_MII_TX_CLK 01_1001b - EMAC_MII_RX_CLK 01_1011b - LFAST_REF_EXT_CLK 01_1100b - Reserved 11_0011b - Reserved 11_0100b - Reserved 11_0101b - Reserved 11_0110b - Reserved 11_0111b - Reserved 11_1000b - Reserved 11_1001b - Reserved 11_1010b - Reserved 11_1011b - Reserved 11_1100b - Reserved 11_1101b - Reserved 11_1110b - Reserved
23-4 —	This field is reserved and reads return zeros.
3 FCG	Force clock gate

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Writing 1 to this bit gates the clock at the output of clock mux 6 to logic-0 irrespective of the logic level of the currently selected clock. Clock gating using this bit should only be performed when it is insured that current clock source is inactive.
2 CG	Clock gate Writing 1 to this bit gates the clock at the output of clock mux 6 to logic-0. Using this bit it is insured that no glitches are resulted when gating the clock.
1-0 —	This field is reserved and reads return zeros.

24.5.40 Clock Mux 6 Select Status Register (MUX_6_CSS)

Offset

Register	Offset
MUX_6_CSS	484h

Function

This register provides the current clock source selection status for clock mux 6.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		SELSTAT						0				0		CS	GRIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
29-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 6. The reserved values are not displayed. 00_0000b - FIRC 00_0001b - SIRC 00_0010b - FXOSC 00_1000b - PLL_PHI0_CLK 00_1001b - PLL_PHI1_CLK 01_0000b - CORE_CLK 01_0011b - HSE_CLK 01_0101b - CM7_CORE_CLK 01_0110b - AIPS_PLAT_CLK 01_0111b - AIPS_SLOW_CLK 01_1000b - EMAC_RMII_MII_TX_CLK 01_1001b - EMAC_MII_RX_CLK 01_1011b - LFAST_REF_EXT_CLK 01_1100b - Reserved 11_0011b - Reserved 11_0100b - Reserved 11_0101b - Reserved 11_0110b - Reserved 11_0111b - Reserved 11_1000b - Reserved 11_1001b - Reserved 11_1010b - Reserved 11_1011b - Reserved 11_1100b - Reserved 11_1101b - Reserved 11_1110b - Reserved
23-20 —	This field is reserved and reads return zeros.
19-18 —	This field is reserved and reads return zeros.
17	Clock status

Table continues on the next page...

Table continued from the previous page...

Field	Function
CS	This field indicates state of the clock at the output of the clock mux. 0b - Clock is gated to logic-0 at output of clock mux 1b - Clock mux is transparent. Active clock pulses at input of clock mux results in same number of pulses at its output
16 GRIP	Gating request is in progress. When a clock gate request is given this bit indicates if the clock gating at the output of mux has completed or not. 0b - Clock source gating or ungating has completed. 1b - Clock source gating or ungating is in progress.
15-0 —	This field is reserved and reads return zeros.

24.5.41 Clock Mux 6 Divider 0 Control Register (MUX_6_DC_0)

Offset

Register	Offset
MUX_6_DC_0	488h

Function

This register controls the clock divider 0 for clock mux 6.

This divider is a 50% duty cycle divider.

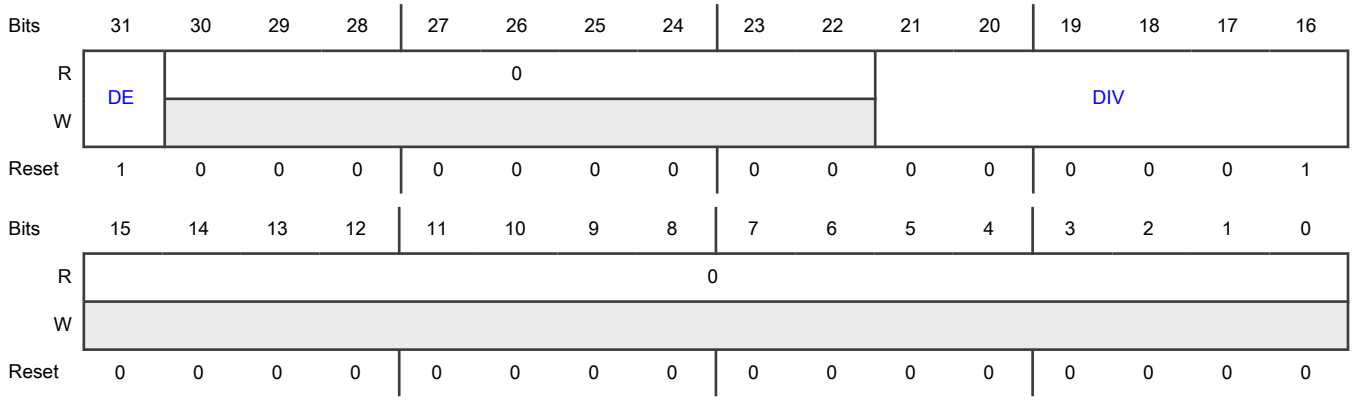
NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

NOTE

Software-controlled clock multiplexer dividers are not expected to return to the default state on the hardware transitions and handshakes occurring as part of the functional reset entry sequence (only hardware-controlled clock multiplexer dividers return to the default state).

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-22 —	This field is reserved and reads return zeros.
21-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.42 Clock Mux 6 Divider Update Status Register (MUX_6_DIV_UPD_STAT)

Offset

Register	Offset
MUX_6_DIV_UPD_STAT	4BCh

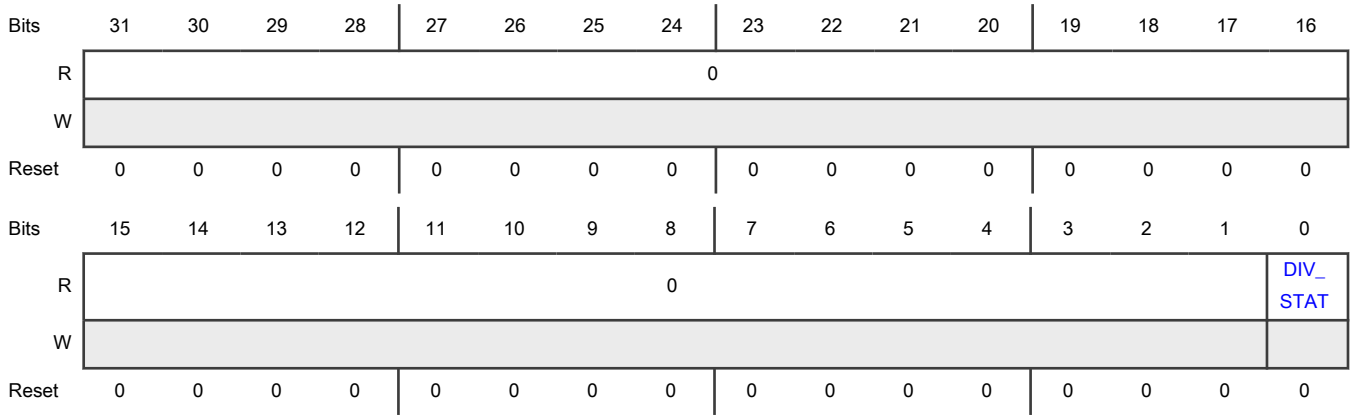
Function

This register provides the update status of the clock dividers corresponding to clock mux 6. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 6 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.43 Clock Mux 7 Select Control Register (MUX_7_CSC)

Offset

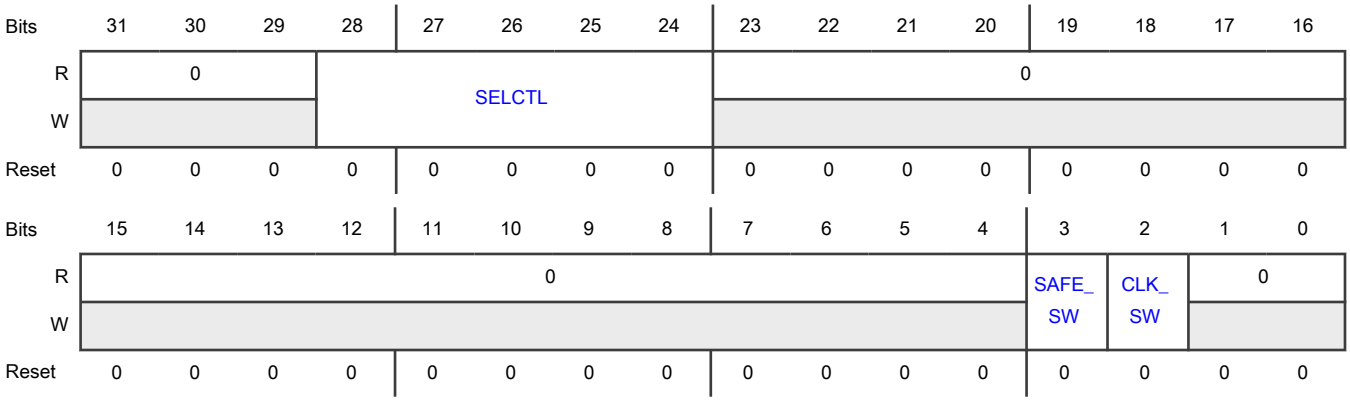
Register	Offset
MUX_7_CSC	4C0h

Function

This register provides the clock source selection control for clock mux 7. Clock mux 7 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 7. The reserved values are not displayed. 0_0000b - FIRC 1_1000b - EMAC_RMII_MII_TX_CLK 1_1001b - EMAC_MII_RX_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 7. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.44 Clock Mux 7 Select Status Register (MUX_7_CSS)

Offset

Register	Offset
MUX_7_CSS	4C4h

Function

This register provides the current clock source selection status for clock mux 7.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 7. The reserved values are not displayed. 0_0000b - FIRC 1_1000b - EMAC_RMII_MII_TX_CLK 1_1001b - EMAC_MII_RX_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 7. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 7. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.45 Clock Mux 7 Divider 0 Control Register (MUX_7_DC_0)

Offset

Register	Offset
MUX_7_DC_0	4C8h

Function

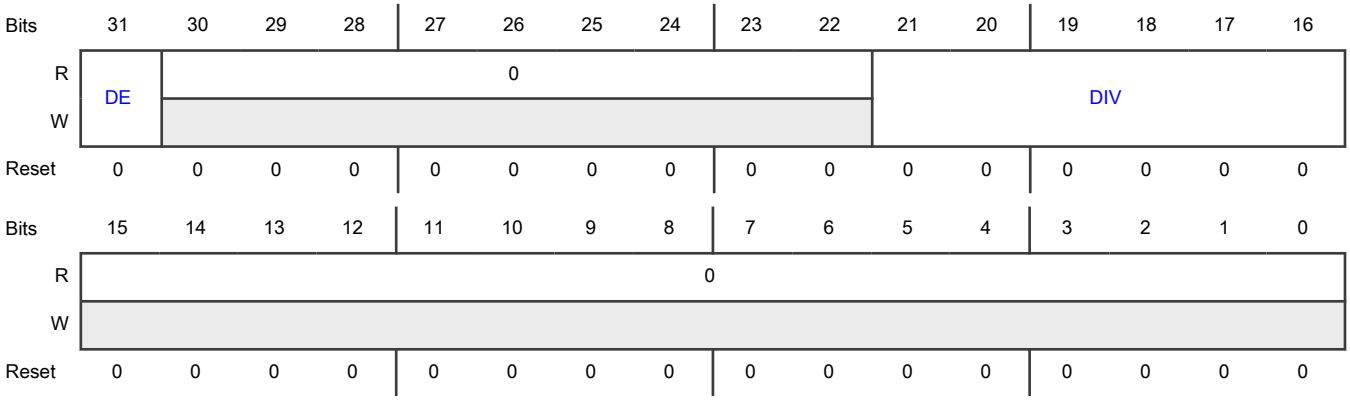
This register controls the clock divider 0 for clock mux 7.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-22 —	This field is reserved and reads return zeros.
21-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.46 Clock Mux 7 Divider Update Status Register (MUX_7_DIV_UPD_STAT)

Offset

Register	Offset
MUX_7_DIV_UPD_STAT	4FCh

Function

This register provides the update status of the clock dividers corresponding to clock mux 7. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															DIV_STAT
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 7 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.47 Clock Mux 8 Select Control Register (MUX_8_CSC)

Offset

Register	Offset
MUX_8_CSC	500h

Function

This register provides the clock source selection control for clock mux 8. Clock mux 8 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELCTL				0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 8. The reserved values are not displayed. 0_0000b - FIRC 1_1000b - EMAC_RMII_MII_TX_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 8. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.48 Clock Mux 8 Select Status Register (MUX_8_CSS)

Offset

Register	Offset
MUX_8_CSS	504h

Function

This register provides the current clock source selection status for clock mux 8.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 8. The reserved values are not displayed. 0_0000b - FIRC 1_1000b - EMAC_RMII_MII_TX_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 8. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 8. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.49 Clock Mux 8 Divider 0 Control Register (MUX_8_DC_0)

Offset

Register	Offset
MUX_8_DC_0	508h

Function

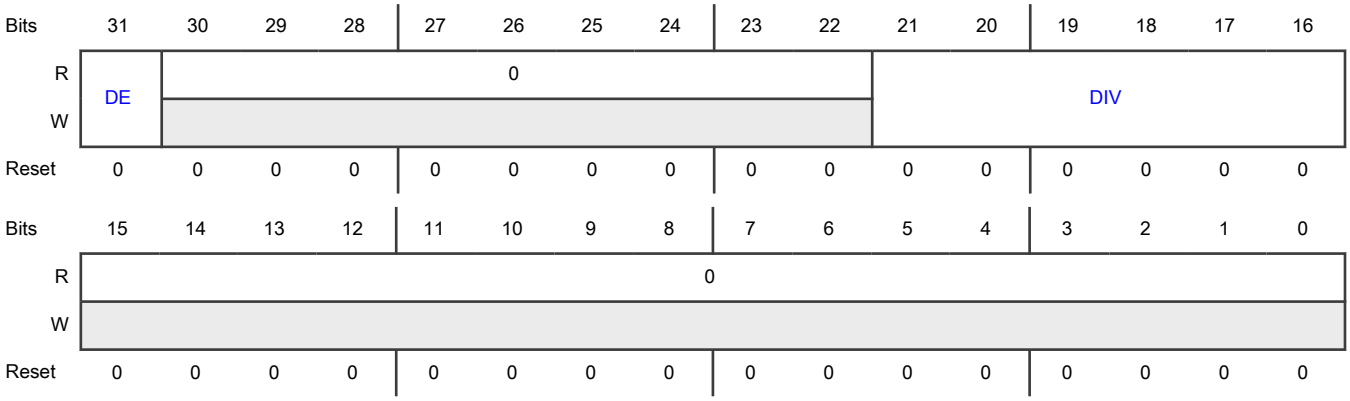
This register controls the clock divider 0 for clock mux 8.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-22 —	This field is reserved and reads return zeros.
21-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.50 Clock Mux 8 Divider Update Status Register (MUX_8_DIV_UPD_STAT)

Offset

Register	Offset
MUX_8_DIV_UPD_STAT	53Ch

Function

This register provides the update status of the clock dividers corresponding to clock mux 8. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other

clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															DIV_STAT
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 8 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.51 Clock Mux 9 Select Control Register (MUX_9_CSC)

Offset

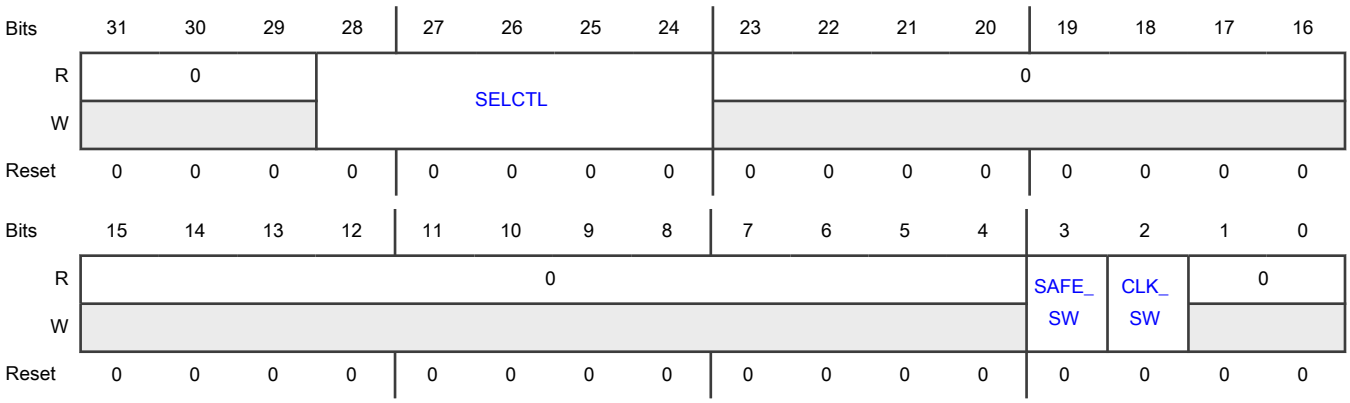
Register	Offset
MUX_9_CSC	540h

Function

This register provides the clock source selection control for clock mux 9. Clock mux 9 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 9. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 0_1000b - PLL_PHI0_CLK 1_1000b - EMAC_RMII_MII_TX_CLK 1_1001b - EMAC_MII_RX_CLK
23-4 —	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 9. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.52 Clock Mux 9 Select Status Register (MUX_9_CSS)

Offset

Register	Offset
MUX_9_CSS	544h

Function

This register provides the current clock source selection status for clock mux 9.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 9. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 0_1000b - PLL_PHI0_CLK 1_1000b - EMAC_RMII_MII_TX_CLK 1_1001b - EMAC_MII_RX_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 9. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ ongoing request on clock mux 9. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.53 Clock Mux 9 Divider 0 Control Register (MUX_9_DC_0)

Offset

Register	Offset
MUX_9_DC_0	548h

Function

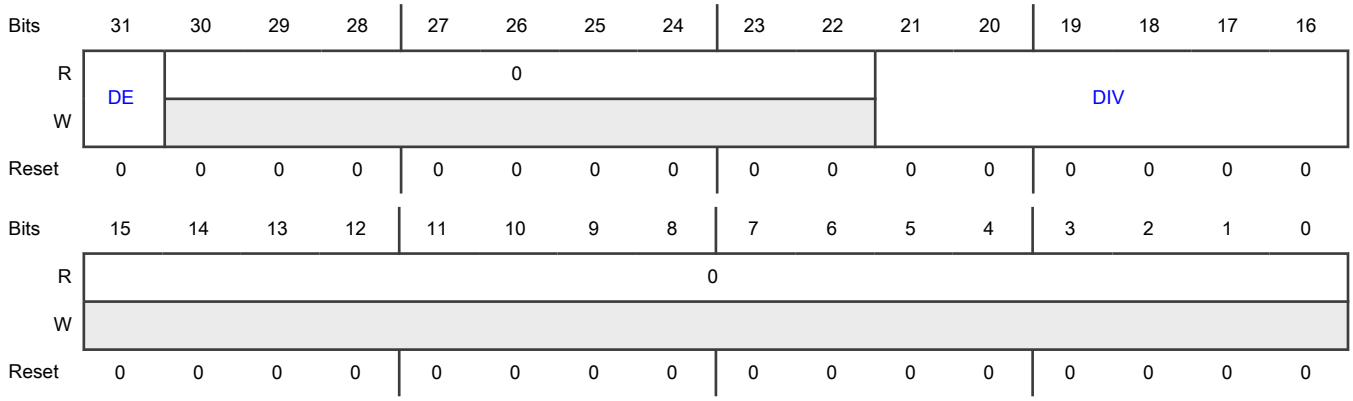
This register controls the clock divider 0 for clock mux 9.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-22 —	This field is reserved and reads return zeros.
21-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.54 Clock Mux 9 Divider Update Status Register (MUX_9_DIV_UPD_STAT)

Offset

Register	Offset
MUX_9_DIV_UPD_STAT	57Ch

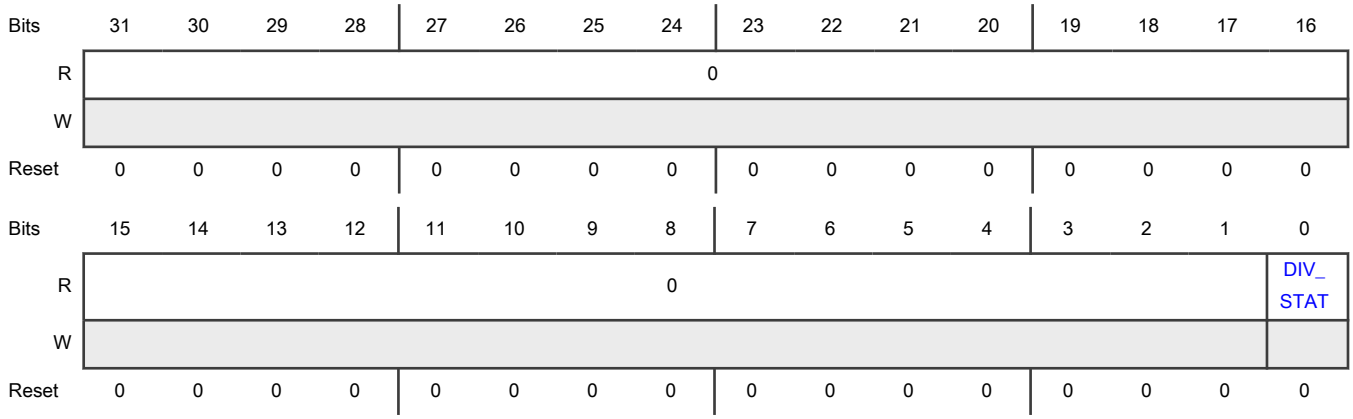
Function

This register provides the update status of the clock dividers corresponding to clock mux 9. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 9 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.55 Clock Mux 10 Select Control Register (MUX_10_CSC)

Offset

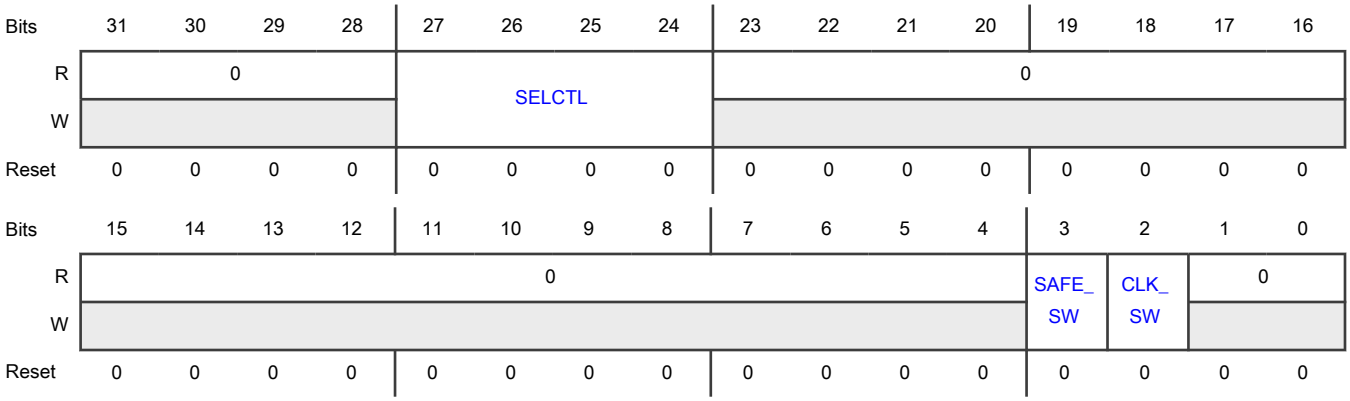
Register	Offset
MUX_10_CSC	580h

Function

This register provides the clock source selection control for clock mux 10. Clock mux 10 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-28 —	This field is reserved and reads return zeros.
27-24 SELCTL	Clock source selection control Selects the source clock for clock mux 10. The reserved values are not displayed. 0000b - FIRC 0010b - FXOSC 1001b - PLL_PHI1_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 10. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.56 Clock Mux 10 Select Status Register (MUX_10_CSS)

Offset

Register	Offset
MUX_10_CSS	584h

Function

This register provides the current clock source selection status for clock mux 10.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	This field is reserved and reads return zeros.
27-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 10. The reserved values are not displayed. 0000b - FIRC 0010b - FXOSC 1001b - PLL_PHI1_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch.

Table continues on the next page...

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Field	Function
	NOTE If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 10. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 10. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.57 Clock Mux 10 Divider 0 Control Register (MUX_10_DC_0)

Offset

Register	Offset
MUX_10_DC_0	588h

Function

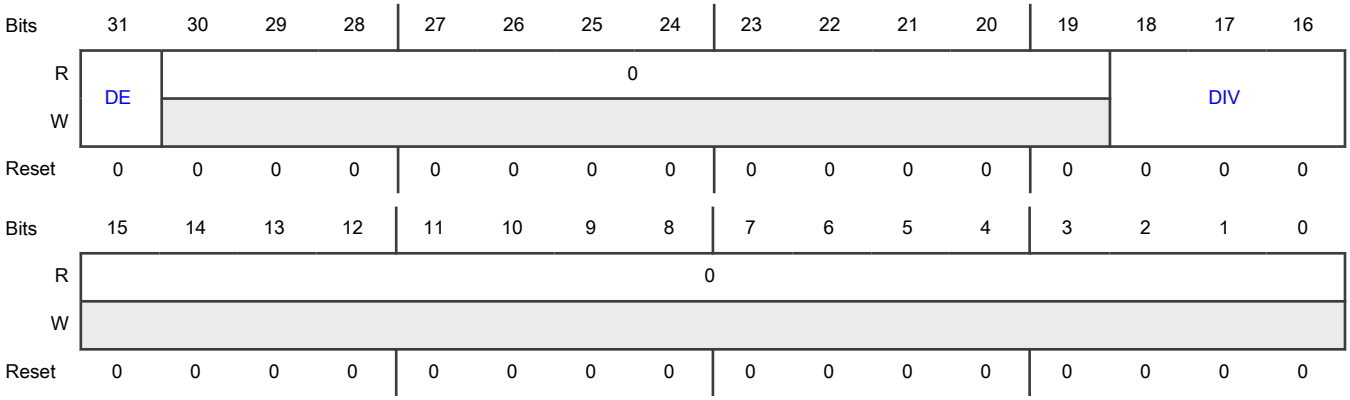
This register controls the clock divider 0 for clock mux 10.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.58 Clock Mux 10 Divider Update Status Register (MUX_10_DIV_UPD_STAT)

Offset

Register	Offset
MUX_10_DIV_UPD_STAT	5BCh

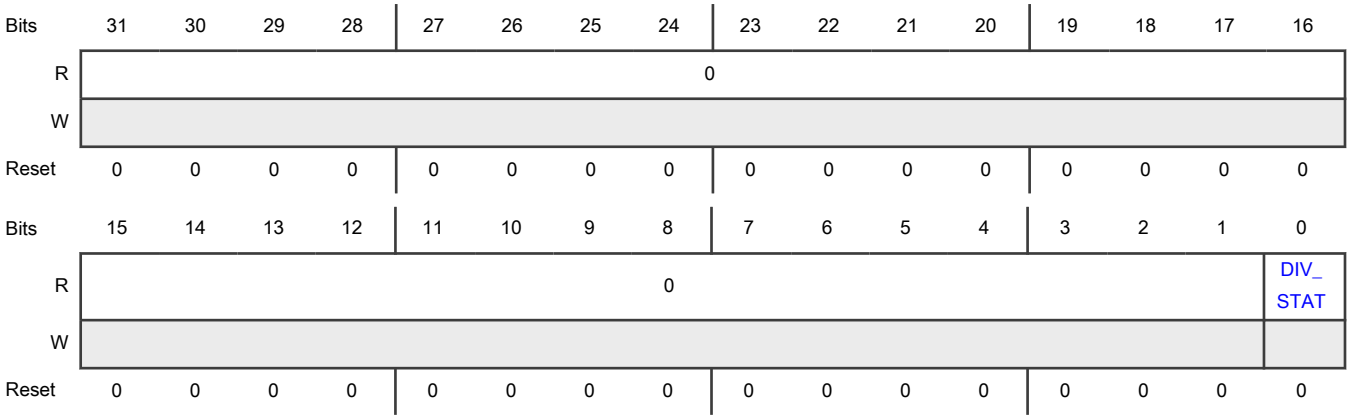
Function

This register provides the update status of the clock dividers corresponding to clock mux 10. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 10 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.59 Clock Mux 11 Select Control Register (MUX_11_CSC)

Offset

Register	Offset
MUX_11_CSC	5C0h

Function

This register provides the clock source selection control of clock mux 11. Clock mux 11 implements software control clock switching, and a graceful clock switch can be performed by executing a sequence of steps in software. See "Software-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELCTL				0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												FCG	CG	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
27-24 SELCTL	Clock source selection control Selects the source clock for clock mux 11. The reserved values are not displayed. 0000b - FIRC 0010b - FXOSC 1000b - PLL_PHI0_CLK 1001b - PLL_PHI1_CLK
23-4 —	This field is reserved and reads return zeros.
3 FCG	Force clock gate Writing 1 to this bit gates the clock at the output of clock mux 11 to logic-0 irrespective of the logic level of the currently selected clock. Clock gating using this bit should only be performed when it is insured that current clock source is inactive.
2 CG	Clock gate Writing 1 to this bit gates the clock at the output of clock mux 11 to logic-0. Using this bit it is insured that no glitches are resulted when gating the clock.
1-0 —	This field is reserved and reads return zeros.

24.5.60 Clock Mux 11 Select Status Register (MUX_11_CSS)

Offset

Register	Offset
MUX_11_CSS	5C4h

Function

This register provides the current clock source selection status for clock mux 11.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				0		CS	GRIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	This field is reserved and reads return zeros.
27-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 11. The reserved values are not displayed. 0000b - FIRC 0010b - FXOSC 1000b - PLL_PHI0_CLK 1001b - PLL_PHI1_CLK
23-20 —	This field is reserved and reads return zeros.
19-18 —	This field is reserved and reads return zeros.
17 CS	Clock status This field indicates state of the clock at the output of the clock mux. 0b - Clock is gated to logic-0 at output of clock mux 1b - Clock mux is transparent. Active clock pulses at input of clock mux results in same number of pulses at its output
16 GRIP	Gating request is in progress. When a clock gate request is given this bit indicates if the clock gating at the output of mux has completed or not. 0b - Clock source gating or ungating has completed.

Table continues on the next page...

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Field	Function
	1b - Clock source gating or ungating is in progress.
15-0 —	This field is reserved and reads return zeros.

24.5.61 Clock Mux 11 Divider 0 Control Register (MUX_11_DC_0)

Offset

Register	Offset
MUX_11_DC_0	5C8h

Function

This register controls the clock divider 0 for clock mux 11.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

NOTE

Software-controlled clock multiplexer dividers are not expected to return to the default state on the hardware transitions and handshakes occurring as part of the functional reset entry sequence (only hardware-controlled clock multiplexer dividers return to the default state).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DE	0											DIV			
W																
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-20 —	This field is reserved and reads return zeros.
19-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.62 Clock Mux 11 Divider Update Status Register (MUX_11_DIV_UPD_STAT)

Offset

Register	Offset
MUX_11_DIV_UPD_STAT	5FCh

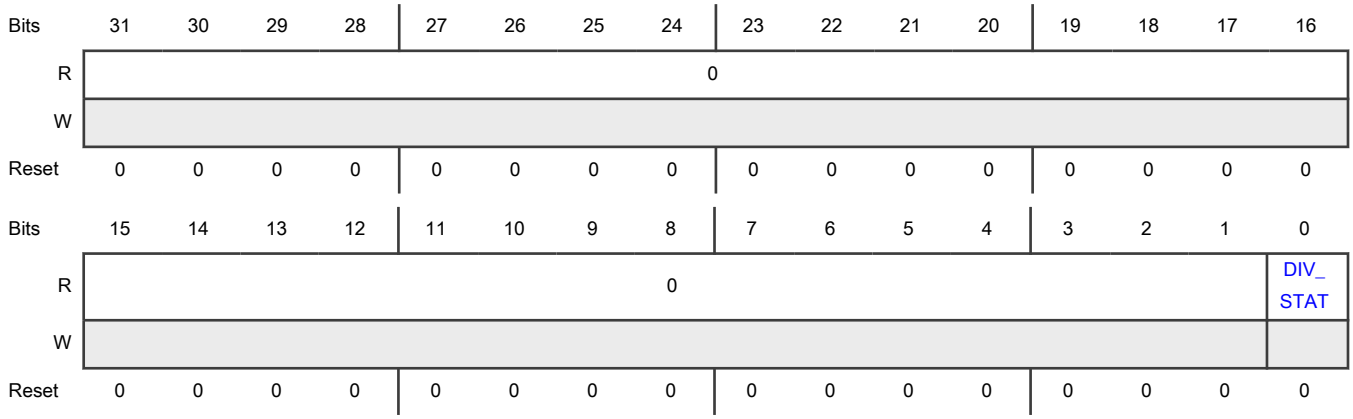
Function

This register provides the update status of the clock dividers corresponding to clock mux 11. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 11 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.63 Clock Mux 12 Select Control Register (MUX_12_CSC)

Offset

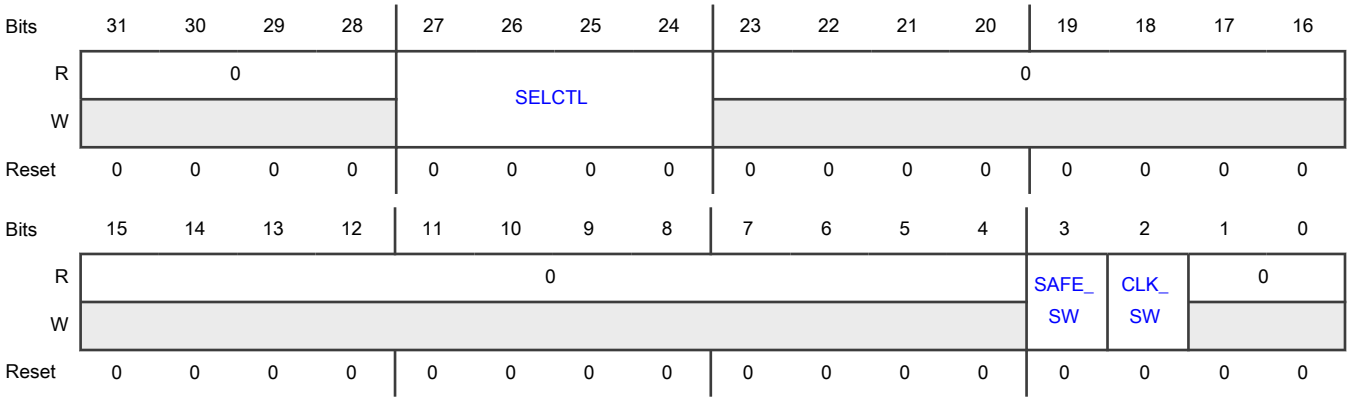
Register	Offset
MUX_12_CSC	600h

Function

This register provides the clock source selection control for clock mux 12. Clock mux 12 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-28 —	This field is reserved and reads return zeros.
27-24 SELCTL	Clock source selection control Selects the source clock for clock mux 12. The reserved values are not displayed. 0000b - FIRC 0010b - FXOSC 1000b - PLL_PHI0_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 12. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.64 Clock Mux 12 Select Status Register (MUX_12_CSS)

Offset

Register	Offset
MUX_12_CSS	604h

Function

This register provides the current clock source selection status for clock mux 12.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	This field is reserved and reads return zeros.
27-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 12. The reserved values are not displayed. 0000b - FIRC 0010b - FXOSC 1000b - PLL_PHI0_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch.

Table continues on the next page...

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Field	Function
	NOTE If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 12. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 12. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.65 Clock Mux 12 Divider 0 Control Register (MUX_12_DC_0)

Offset

Register	Offset
MUX_12_DC_0	608h

Function

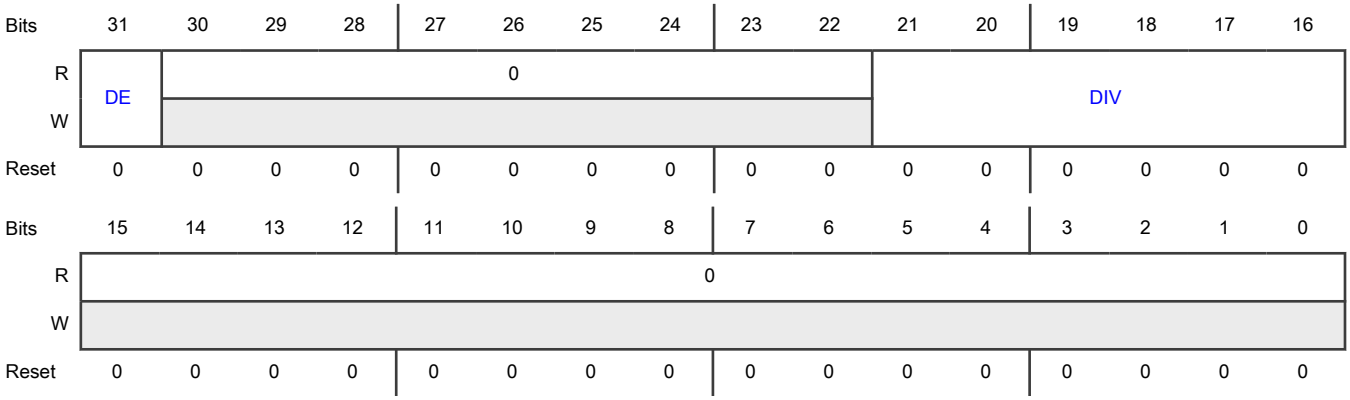
This register controls the clock divider 0 for clock mux 12.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-22 —	This field is reserved and reads return zeros.
21-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.66 Clock Mux 12 Divider Update Status Register (MUX_12_DIV_UPD_STAT)

Offset

Register	Offset
MUX_12_DIV_UPD_STAT	63Ch

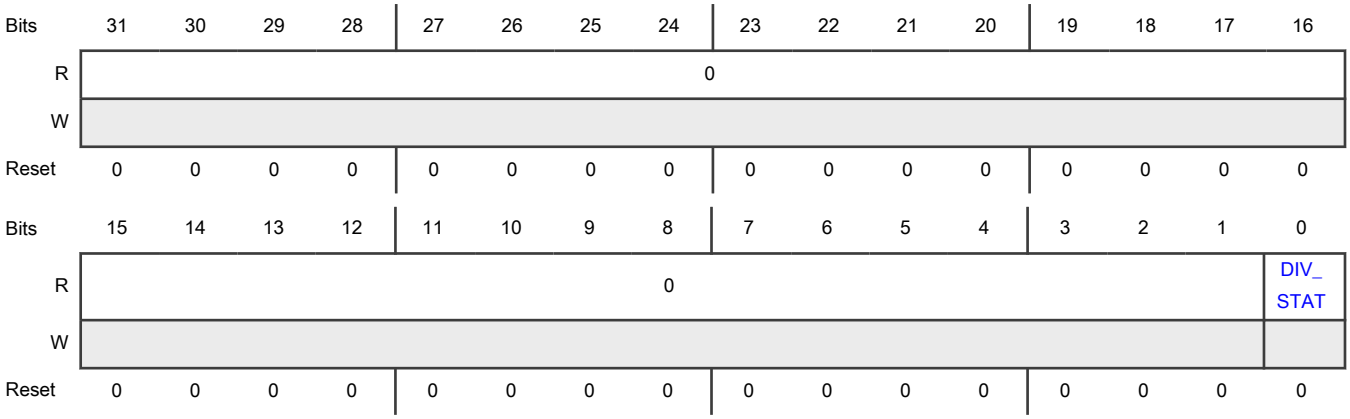
Function

This register provides the update status of the clock dividers corresponding to clock mux 12. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 12 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.67 Clock Mux 13 Select Control Register (MUX_13_CSC)

Offset

Register	Offset
MUX_13_CSC	640h

Function

This register provides the clock source selection control for clock mux 13. Clock mux 13 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELCTL				0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 13. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 13. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.68 Clock Mux 13 Select Status Register (MUX_13_CSS)

Offset

Register	Offset
MUX_13_CSS	644h

Function

This register provides the current clock source selection status for clock mux 13.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 13. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0110b - AIPS_PLAT_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 13. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 13. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.69 Clock Mux 13 Divider 0 Control Register (MUX_13_DC_0)

Offset

Register	Offset
MUX_13_DC_0	648h

Function

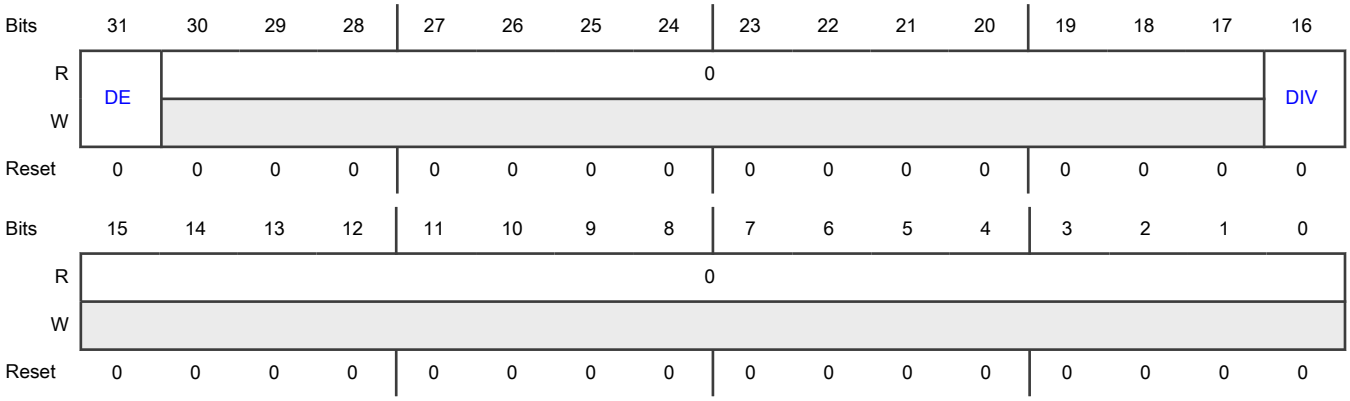
This register controls the clock divider 0 for clock mux 13.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-17 —	This field is reserved and reads return zeros.
16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.70 Clock Mux 13 Divider Update Status Register (MUX_13_DIV_UPD_STAT)

Offset

Register	Offset
MUX_13_DIV_UPD_STAT	67Ch

Function

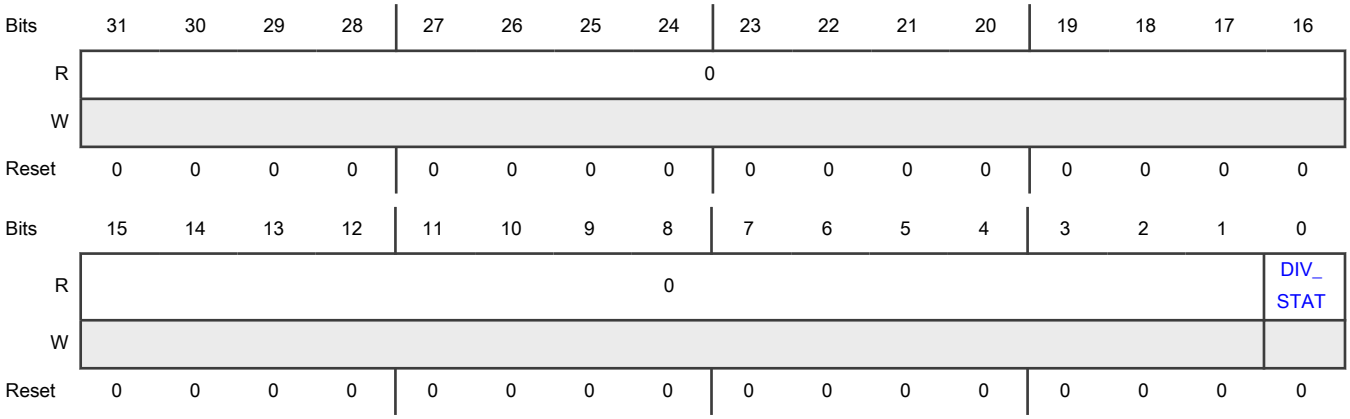
This register provides the update status of the clock dividers corresponding to clock mux 13. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other

clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 13 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.71 Clock Mux 15 Select Control Register (MUX_15_CSC)

Offset

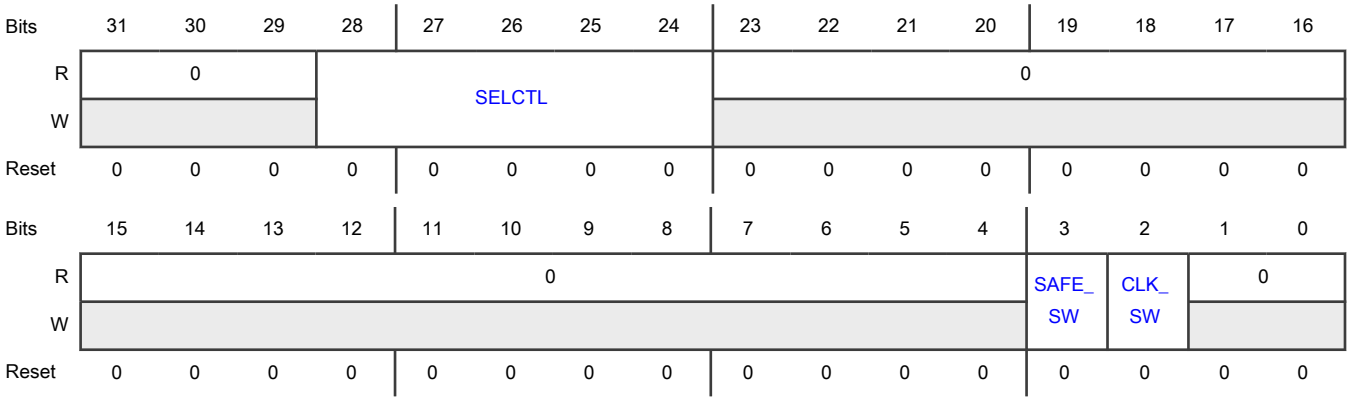
Register	Offset
MUX_15_CSC	6C0h

Function

This register provides the clock source selection control for clock mux 15. Clock mux 15 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 15. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0111b - AIPS_SLOW_CLK 1_1011b - LFAST_REF_EXT_CLK
23-4 —	This field is reserved and reads return zeros.
3	Safe clock request

Table continues on the next page...

Table continued from the previous page...

Field	Function
SAFE_SW	Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 15. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.72 Clock Mux 15 Select Status Register (MUX_15_CSS)

Offset

Register	Offset
MUX_15_CSS	6C4h

Function

This register provides the current clock source selection status for clock mux 15.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 15. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_0111b - AIPS_SLOW_CLK 1_1011b - LFAST_REF_EXT_CLK
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch. **NOTE** If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 15. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ ongoing request on clock mux 15. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.73 Clock Mux 15 Divider 0 Control Register (MUX_15_DC_0)

Offset

Register	Offset
MUX_15_DC_0	6C8h

Function

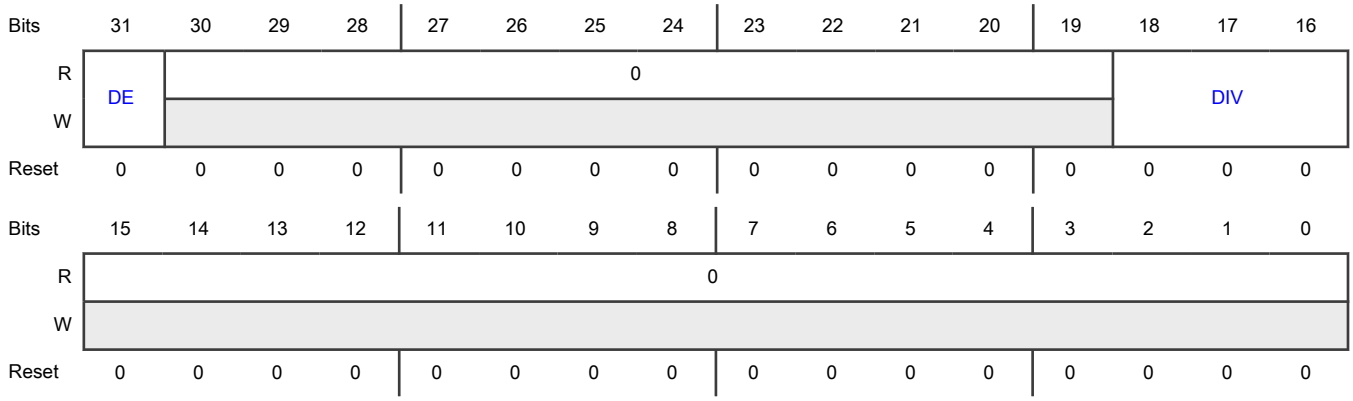
This register controls the clock divider 0 for clock mux 15.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-19 —	This field is reserved and reads return zeros.
18-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.74 Clock Mux 15 Divider Update Status Register (MUX_15_DIV_UPD_STAT)

Offset

Register	Offset
MUX_15_DIV_UPD_STAT	6FCh

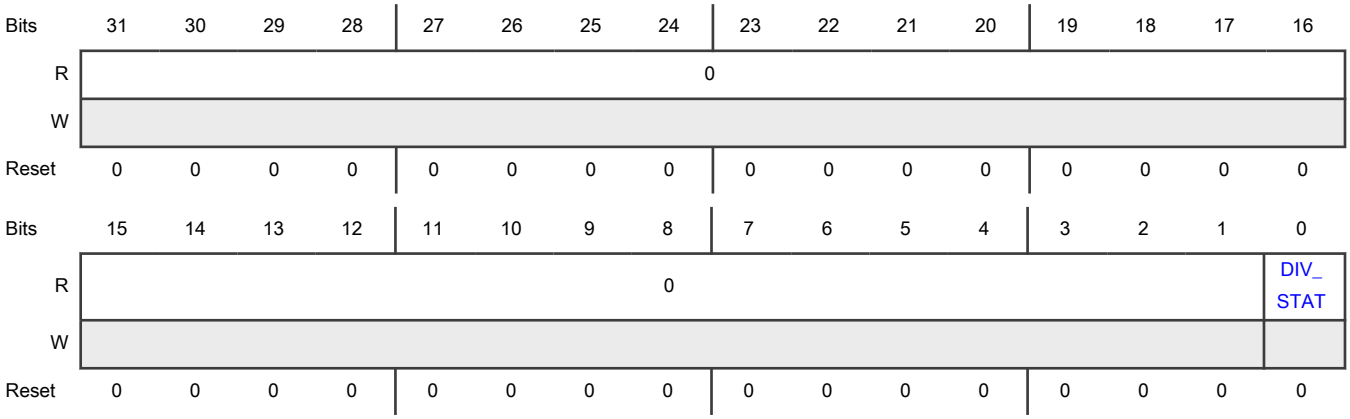
Function

This register provides the update status of the clock dividers corresponding to clock mux 15. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 15 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field. **NOTE** This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.5.75 Clock Mux 16 Select Control Register (MUX_16_CSC)

Offset

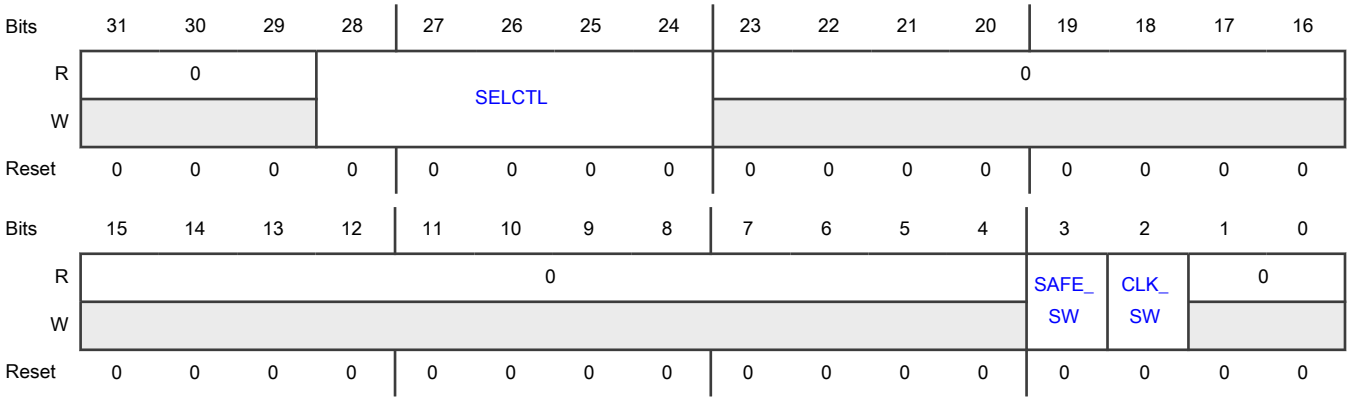
Register	Offset
MUX_16_CSC	700h

Function

This register provides the clock source selection control for clock mux 16. Clock mux 16 implements hardware control clock switching ensuring that the clock switch happens in a graceful manner (without glitches). See the "Hardware-controlled clock multiplexer" section for details.

This register is reset on destructive reset only.

Diagram



Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELCTL	Clock source selection control Selects the source clock for clock mux 16. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_1100b - Reserved
23-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request Writing 1 to this bit makes a safe clock switch request to FIRC. After a safe clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
2 CLK_SW	Clock switch Writing 1 to this bit makes a clock switch request to clock mux 16. After a clock switch operation is requested, this bit is auto cleared and a corresponding bit in the status register is set.
1-0 —	This field is reserved and reads return zeros.

24.5.76 Clock Mux 16 Select Status Register (MUX_16_CSS)

Offset

Register	Offset
MUX_16_CSS	704h

Function

This register provides the current clock source selection status for clock mux 16.

This register is reset on destructive reset only.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				SELSTAT				0				SWTRG			SWIP
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												SAFE_SW	CLK_SW	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	This field is reserved and reads return zeros.
28-24 SELSTAT	Clock source selection status This value indicates the current source selected for clock mux 16. The reserved values are not displayed. 0_0000b - FIRC 0_0010b - FXOSC 1_1100b - Reserved
23-20 —	This field is reserved and reads return zeros.
19-17 SWTRG	Switch trigger cause This value indicates the cause for the latest clock source switch.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE If the clock fails, followed by multiple safe clock switch requests for MC_CGM hardware clock mux, the value of the SWTRG field can be either 4 or 5. 000b - Reserved 001b - Switch after request succeeded. 010b - Switch after the request failed because of an inactive target clock and the current clock is FIRC. 011b - Switch after the request failed because of an inactive current clock and the current clock is FIRC. 100b - Switch to FIRC because of a safe clock request or reset succeeded. 101b - Switch to FIRC because of a safe clock request or reset succeeded, but the previous current clock source was inactive. 110b - Reserved 111b - Reserved
16 SWIP	Switch in progress **NOTE** New clock switch request can only be given three clock cycles after the completion of the previous request. 0b - Clock source switching is complete. 1b - Clock source switching is in progress.
15-4 —	This field is reserved and reads return zeros.
3 SAFE_SW	Safe clock request This field provides an indication of whether a switch to safe clock operation was requested during the previous/ongoing request on clock mux 16. 0b - No safe clock switch operation was requested. 1b - Safe clock switch operation was requested.
2 CLK_SW	Clock switch This field provides an indication of whether a clock switch operation was requested during the previous/ongoing request on clock mux 16. 0b - No clock switch operation was requested. 1b - Clock switch operation was requested.
1-0 —	This field is reserved and reads return zeros.

24.5.77 Clock Mux 16 Divider 0 Control Register (MUX_16_DC_0)

Offset

Register	Offset
MUX_16_DC_0	708h

Function

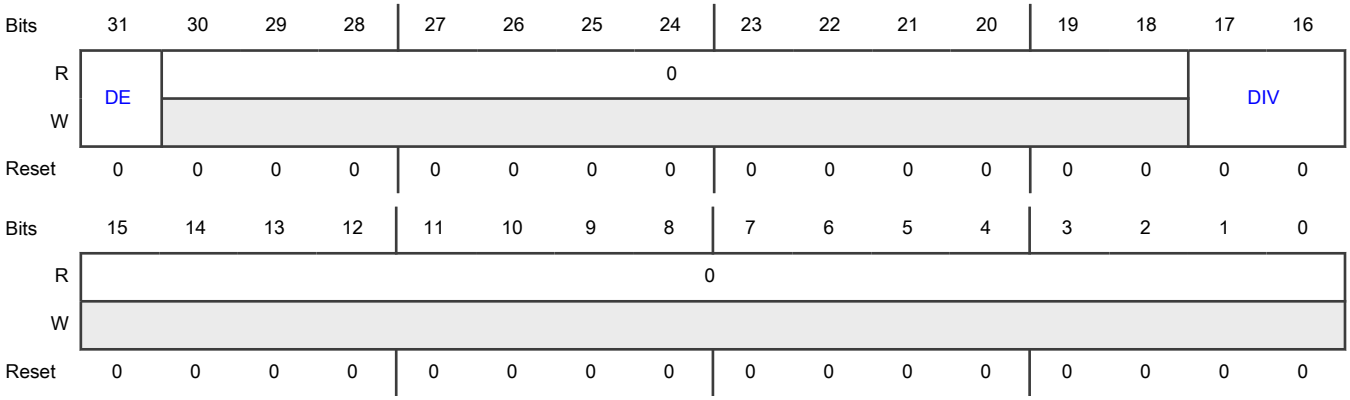
This register controls the clock divider 0 for clock mux 16.

This divider is a 50% duty cycle divider.

NOTE

The update to the fields of this register should be an atomic write, that is, one single write should update the complete register.

Diagram



Fields

Field	Function
31 DE	Divider enable 0b - Divider is disabled. 1b - Divider is enabled.
30-18 —	This field is reserved and reads return zeros.
17-16 DIV	Division value This field provides the division value for the clock divider. The clock period of the clock after division is 'DIV+1' times the time period of the current input clock to the divider.
15-0 —	This field is reserved and reads return zeros.

24.5.78 Clock Mux 16 Divider Update Status Register (MUX_16_DIV_UPD_STAT)

Offset

Register	Offset
MUX_16_DIV_UPD_STAT	73Ch

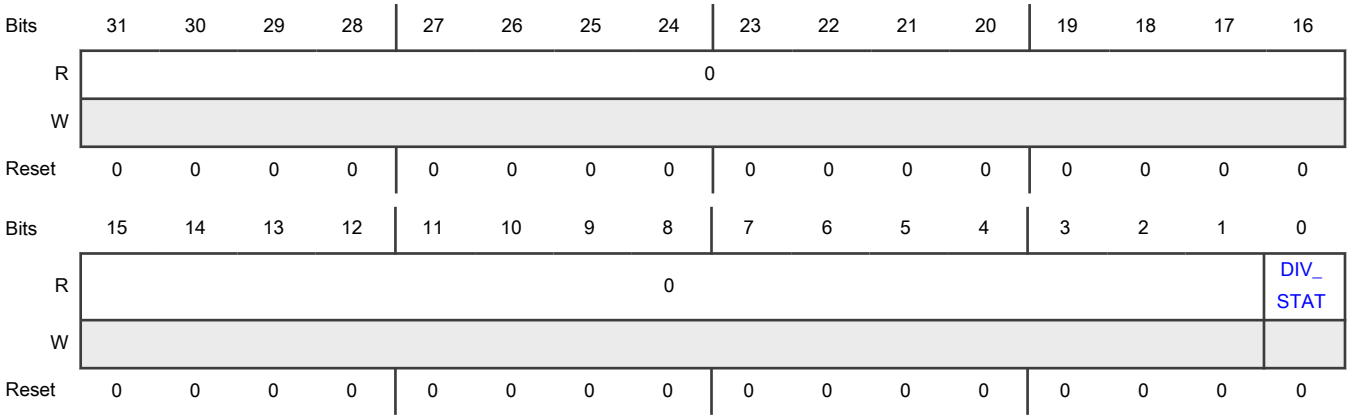
Function

This register provides the update status of the clock dividers corresponding to clock mux 16. When a write operation on any divider control register is performed, the divider status bit in this register is set to logic-1. The bit is set to logic-0 when the divider has sampled the new divider configuration. Performing multiple writes without tracking the status bit on same or other clock dividers inside the same clock mux leads to inconsistent reporting, that is, the divider status maybe be set to logic-0 when the corresponding divider update is pending.

NOTE

Read accesses to MUX_n_DIV_UPD_STAT always complete without returning bus transfer error independent of whether any divider(s) are implemented inside MC_CGM clock mux.

Diagram



Fields

Field	Function
31-1 —	This field is reserved and reads return zeros.
0 DIV_STAT	Divider status for clock mux 16 On reading MUX_n_DIV_UPD_STAT after updating a divider control register, if the value of this field is fixed to 1 because of an error in the selected clock source, perform the following steps to switch the mux to a new clock source: 1. Switch the mux to a working clock source without polling this field. 2. Update MUX_n_DC_m and poll this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This field clears once divider configuration is updated or on destructive reset. If functional reset comes when this field is 1 then it can remain fixed to 1 until divider input clock is restored. 0b - No divider configuration update is pending. 1b - Divider configuration update on at least one divider associated with this multiplexer is pending.

24.6 Glossary

PCFS	Progressive clock frequency switching
LCM	Least common multiple

Chapter 25
Fast Internal RC Oscillator (FIRC)

25.1 Overview

The FIRC digital interface controls the internal 48 MHz RC oscillator system.

25.1.1 Features

FIRC can be disabled in Standby mode via software.

- Status register provides the current operating state:
  - On and stable
  - Off or on but not stable

25.2 External signals

This module has no external signals.

25.3 Initialization

This module does not require initialization.

25.4 FIRC register descriptions

25.4.1 FIRC memory map

FIRC base address: 402D_0000h

Offset	Register	Width (In bits)	Access	Reset value
4h	Status Register (Status_Register)	32	R	0000_0001h
8h	Standby Enable Register (STDBY_ENABLE)	32	RW	0000_0000h

25.4.2 Status Register (Status_Register)

Offset

Register	Offset
Status_Register	4h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved															STATUS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-1 —	Reserved
0 STATUS	Status bit for FIRC 0b - FIRC is off or unstable. 1b - FIRC is on and stable.

25.4.3 Standby Enable Register (STDBY_ENABLE)

Offset

Register	Offset
STDBY_ENABLE	8h

Function

This register enables or disables FIRC in chip's Standby mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved															STDBY_EN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	RESERVED
0 STDBY_EN	Enables or disables FIRC in chip's Standby mode. 0b - Disabled 1b - Enabled

25.5 Glossary

Standby mode	Power saving mode of the chip

Chapter 26
Slow Internal RC Oscillator (SIRC)

26.1 Overview

The SIRC digital interface controls the slow internal on-chip 32 KHz RC oscillator system.

26.1.1 Features

The SIRC module:

- Status register provides the current operating state:
  - On and stable
  - Off or on but not stable
- Operates at a frequency of 32 kHz in Functional mode

26.2 Operating mode

Only a POR reset will initialize the SIRC. Destructive or Functional resets do not impact the SIRC functionality.

SIRC stabilization occurs after 96 SIRC_CLK cycles.

The SIRC output clock remains invalid until the analog SIRC stabilizes. The output clock does not glitch or overshoot its frequency during enabling or disabling. Also, the clock does not get stuck or produce glitches on a very short hardware disable pulse.

26.3 External signals

This module has no external signals.

26.4 Initialization

This module does not require initialization.

26.5 SIRC register descriptions

26.5.1 SIRC memory map

Access to registers use 8-bit, 16-bit, or 32-bit addressing.

SIRC base address: 402C_8000h

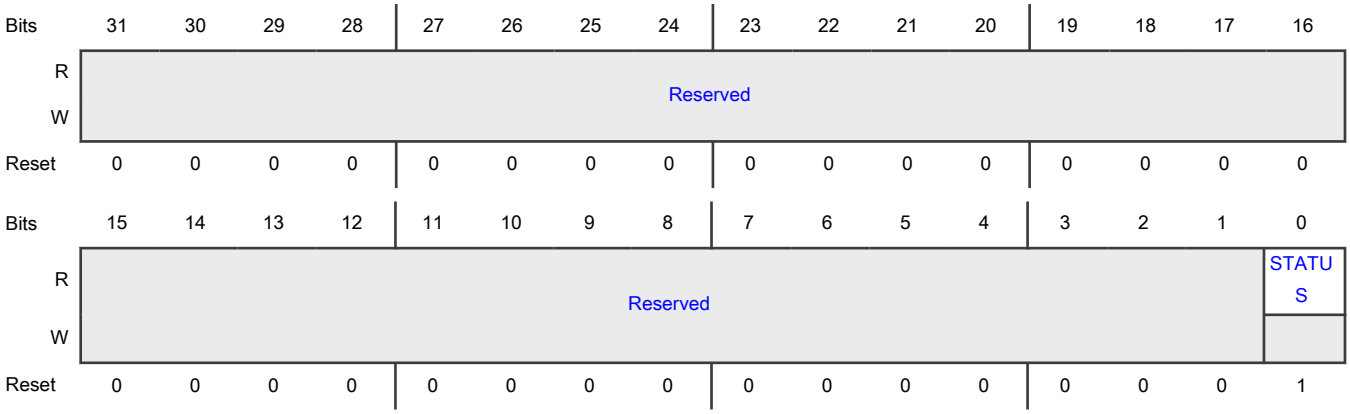
Offset	Register	Width (In bits)	Access	Reset value
4h	Status Register (SR)	32	R	0000_0001h
Ch	Miscellaneous input (MISCELLANEOUS_IN)	32	RW	0000_0000h

26.5.2 Status Register (SR)

Offset

Register	Offset
SR	4h

Diagram



Fields

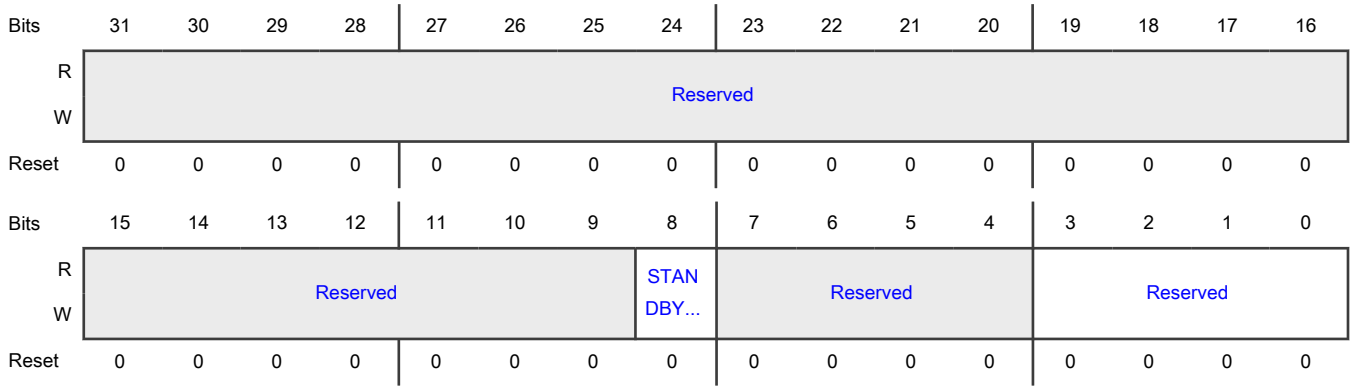
Field	Function
31-1 —	Reserved
0 STATUS	Status bit for SIRC 0b - SIRC is off or unstable 1b - SIRC is on and stable

26.5.3 Miscellaneous input (MISCELLANEOUS_IN)

Offset

Register	Offset
MISCELLANEOUS_IN	Ch

Diagram



Fields

Field	Function
31-9 —	Reserved
8 STANDBY_ENABLE	Standby Enable for SIRC 0b - SIRC disables in Standby mode 1b - SIRC enables in Standby mode
7-4 —	Reserved
3-0 —	Reserved

Chapter 27
Fast Crystal Oscillator Digital Controller (FXOSC)

27.1 Chip-specific FXOSC information

27.1.1 FXOSC configuration

The default value of FXOSC.CTRL[EOCV] depends on the configuration given for this bit in Table 159.

27.2 Overview

The Fast Crystal Oscillator (FXOSC) generates a clock which can be used at the SoC level. The FXOSC has a digital interface to control and configure the oscillator. When FXOSC is powered down at any time, it is designed not to generate any glitch at the output clock. A counter inside FXOSC handles different stabilization times. CG cell is clock gating cell, it gates the clock till stabilization time.

27.2.1 Block diagram

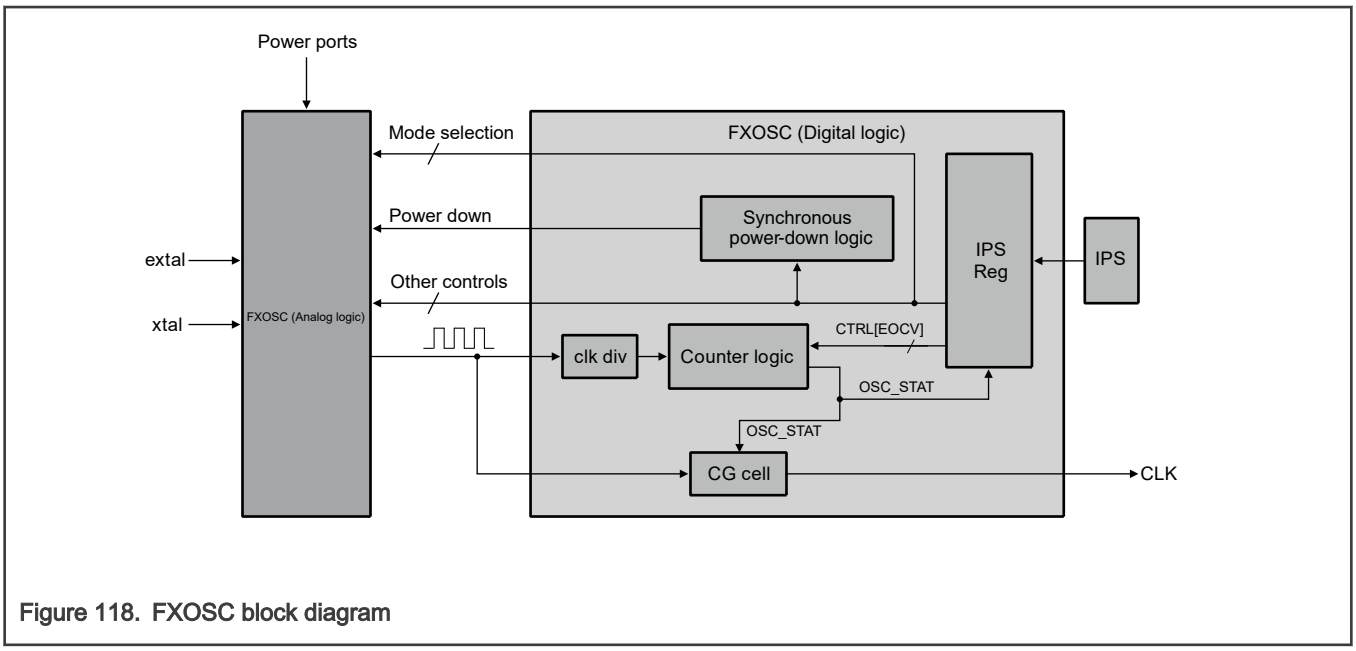


Figure 118. FXOSC block diagram

27.2.2 Features

FXOSC features are as follows:

- Status register shows current module state.
- Control register can:
  - Select a mode of operation:
    - Crystal mode
    - Single-Input Bypass mode using EXTAL clock input
  - Disable the module (Power-Down mode)

27.3 Functional description

The table below shows configuration settings for the different FXOSC modes set by the CTRL register:

Table 136. FXOSC operation mode settings

Mode	CTRL[OSCON]	CTRL[OSC_BYP]	CTRL[COMP_EN]	FXOSC_CLK
Power-Down mode	0	X	X	0
Crystal mode	1	0	1	Crystal clock
Single-Input Bypass mode	1	1	0	EXTAL

Power-Down mode is the FXOSC default condition after any reset: POR, Destructive, or Functional.

27.3.1 Clock generation in Crystal mode

FXOSC_CLK start when counter value reaches FXOSC_CTRL[EOCV] × 128.

27.3.2 Clock generation in Single-Input Bypass mode

This mode bypasses the oscillator and uses a single-input external clock (EXTAL input) for FXOSC_CLK. See the chip-specific FXOSC information for Bypass mode applications.

27.3.3 Clocking

This module has no clocking considerations.

27.3.4 Interrupts

This module has no interrupts.

27.4 External signals

This module has no external signals.

27.5 Initialization

Initializing FXOSC

Initialize FXOSC as follows:

1. Write the desired value to CTRL[OSC_BYP] and CTRL[COMP_EN] to select an operation mode as shown in Table 136.

   NOTE

   FXOSC must be disabled when the operation mode is modified.

2. Configure CTRL[GM_SEL].
   - In Crystal mode configure the transconductance based on the module specification in the chip data sheet.
   - In Single-Input Bypass mode write 0000b to this field.

   NOTE

   In Crystal mode FXOSC will not function with zero transconductance (GM_SEL = 0000b).

3. Set CTRL[EOCV] calculating the value as follows:
   - EOCV (in decimal) = (stabilization time in ns) ÷ (4×128×(period of clock in ns))

4. Write 1 to CRTL[OSCON] to enable FXOSC.

NOTE

When the FXOSC is used in Bypass mode, the clock from the external source can only be used after the FXOSC is enabled

5. Confirm the clock is stable (STAT[OSC_STAT] = 1) before using it.

NOTE

See Hardware design guide for further details and the recommended circuit for each mode.

Disabling FXOSC

Write 0 to CRTL[OSCON] to disable FXOSC when FXOSC_CLK is running and stable.

FXOSC enters Power-down mode after at least four crystal clocks. No glitches occur during the transition to Power-Down mode because synchronizers are used.

NOTE

After disabling FXOSC:

- Wait for at least 2µs before enabling FXOSC again.
- You must not change other values in FXOSC registers for at least 16 FXOSC_CLK cycles.

27.6 FXOSC register descriptions

This section provides the descriptions of all registers used for configuring the FXOSC.

27.6.1 FXOSC memory map

Use 8-bit, 16-bit, or 32-bit addressing to access registers.

FXOSC base address: 402D_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	FXOSC Control Register (CTRL)	32	RW	019D_00C0h
4h	Oscillator Status Register (STAT)	32	R	0000_0000h

27.6.2 FXOSC Control Register (CTRL)

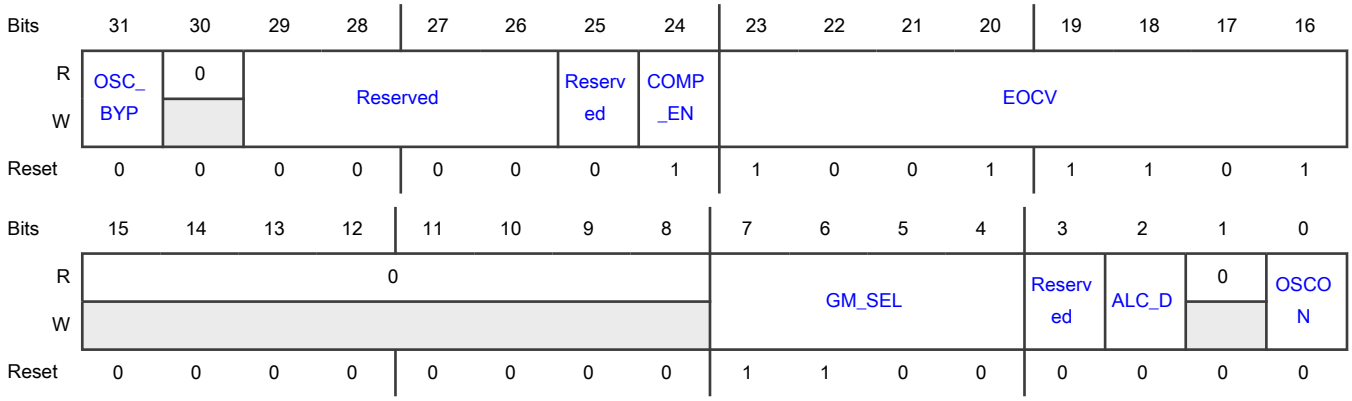
Offset

Register	Offset
CTRL	0h

Function

Configures FXOSC operation.

Diagram



Fields

Field	Function
31 OSC_BYP	Oscillator bypass Bypasses the internal oscillator. 0b - Internal oscillator not bypassed 1b - Internal oscillator bypassed
30 —	Reserved
29-26 —	Reserved
25 —	Reserved
24 COMP_EN	Comparator enable Enables or disables the comparator. • For Crystal mode set this field to 1. • For Single-Input Bypass mode set this field to 0. 0b - Comparator disabled 1b - Comparator enabled
23-16 EOCV	End of count value Specifies the end-of-count. The oscillator counter runs on the crystal clock divided by 4 and counts up to EOCV × 128. This counting period ensures that the external oscillator clock signal is stable before the system selects FXOSC as a source.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE • You must set EOCV to the appropriate value to allow clock and duty cycle to stabilize and guarantee that OSC_STAT becomes set within the crystal startup time. — In Crystal mode, EOCV value must to be calculated to appropriate value based on the crystal specification using the equation in Initializing FXOSC. — In Single-Input Bypass mode, EOCV value is irrelevant. FXOSC holds the counter in reset. • Before modifying EOCV, FXOSC must be disabled.
15-8 —	Reserved
7-4 GM_SEL	Crystal overdrive protection Selects the transconductance applied by the FXOSC amplifier. This setting depends on crystal specification. **NOTE** • In Crystal mode FXOSC will not function with zero transconductance (GM_SEL = 0000b). • For details on how to set this field, see Initializing FXOSC. 0000b - 0x 0001b - 0.1004x 0010b - 0.2009x 0011b - 0.3013x 0100b - 0.2343x 0101b - 0.3348x 0110b - 0.4345x 0111b - 0.5349x 1000b - 0.4679x 1001b - 0.5684x 1010b - 0.6681x 1011b - 0.7678x 1100b - 0.7016x 1101b - 0.8013x 1110b - 0.9003x 1111b - 1x
3	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
2 ALC_D	Automatic level controller enable The ALC feature of the FXOSC internal circuit automatically adjusts the bias current of the crystal oscillator's amplifier. It must be used in crystal oscillator mode. During startup the EXTAL/XTAL amplitude would be lower, so the ALC circuit dynamically increases the bias current of the internal amplifier to provide higher current and make crystal oscillator startup faster in normal oscillator mode. After EXTAL/XTAL amplitude has increased to a steady state, the ALC circuit automatically reduces the amplifier's bias current to save power. 0b - Enables automatic level controller 1b - Disables automatic level controller
1 —	Reserved
0 OSCON	Crystal oscillator power-down control Enables or disables FXOSC 0b - Disables FXOSC 1b - Enables FXOSC

27.6.3 Oscillator Status Register (STAT)

Offset

Register	Offset
STAT	4h

Function

Shows current state of FXOSC.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	OSC_STAT	0														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 OSC_STAT	Crystal oscillator status Indicates the crystal oscillator status. **NOTE** OSC_STAT value is not valid if transconductance is set to 0. 0b - Crystal oscillator is off or on but not stable. 1b - Crystal oscillator is on and providing a stable clock.
30-0 —	Reserved

Chapter 28
PLL Digital Interface (PLLDIG)

28.1 Chip-specific PLLDIG information

28.1.1 PLL-supported accesses and frequencies

The PLLODIV_0 and PLLODIV_1 registers support only word accesses. When you write to these registers, you must retain the default values of the reserved fields.

PLLDIG supports a down-spread modulation of up to 320 MHz PLL PHI clock output only.

28.2 Overview

PLL can multiply or divide the frequency of a given clock input.

28.2.1 Block diagram

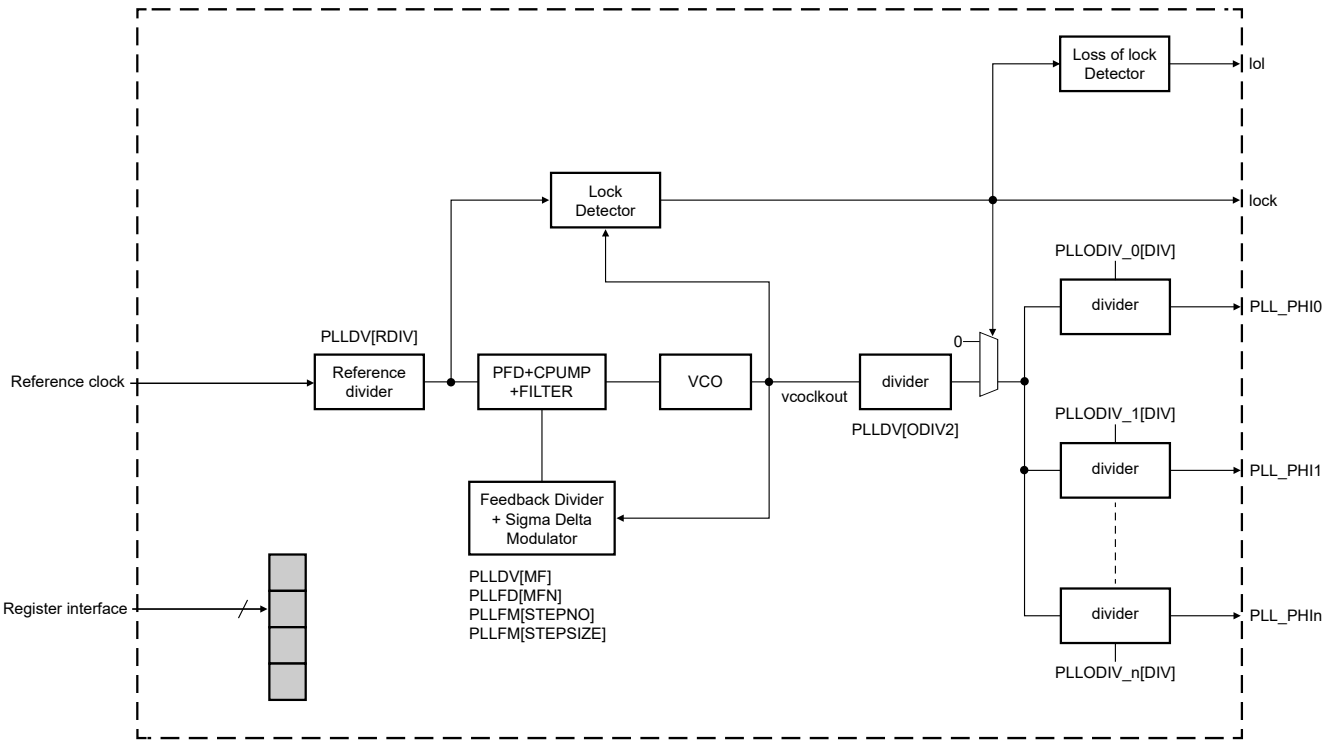


Figure 119. Block diagram

The number of output dividers can vary with the module instance. See the Clocking chapter to confirm the number of PLL output dividers.

28.2.2 Features

PLL includes the following features:

- Programmable frequency modulation
- Multiple integer dividers on PLL outputs
- Lock detection circuitry reports when PLL achieves frequency lock

- Continuous monitoring of lock status to report Loss of Lock (LOL) condition
- Powering down the module for low-power operation (Power-Down mode)

28.3 Functional description

This section explains PLL operation and configuration.

28.3.1 Modes of operation

Table 137. Modes of operation

PLLCR[PLLPD]	PLLFD[SDMEN]	PLLFM[SSCGBYP]	Description
1	x	x	PLL is disabled.
0	0	1	Functional mode – PLL operates in integer-only mode. See Clock configuration.
0	1	1	Functional mode – PLL operates in Fractional mode (non-Frequency modulation). See Clock configuration.
0	1	0	Functional mode – PLL operates in Frequency Modulation mode. See Frequency modulation.

28.3.2 Input clock frequency

PLL is designed to operate over a specified input clock frequency range. PLL source frequency limits are discussed in this chip's data sheet.

28.3.3 Clock configuration

See the equations below and the corresponding register configuration that determine the relationship between VCO frequency (f_{VCO}) and PLL reference frequency.

- Integer-only mode:
  - When PLLDV[RDIV] is 0:

$$f_{\text{pll_VCO}} = f\text{pll_ref} \times \text{PLLDV[MFI]}$$

Equation 1. PLL VCO frequency in integer-only mode when PLLDV[RDIV] is 0

  - When PLLDV[RDIV] is not 0:

$$f_{\text{pll_VCO}} = \frac{f_{\text{pll_ref}}}{\text{PLLDV[RDIV]}} \times \text{PLLDV[MFI]}$$

Equation 2. PLL VCO frequency in integer-only mode when PLLDV[RDIV] is not 0

- Fractional mode:
  - When PLLDV[RDIV] is 0:

$$f_{\text{pll_VCO}} = f_{\text{pll_ref}} \times \left(\text{PLLDV[MFI]} + \frac{\text{PLLFD[MFN]}}{18432}\right)$$

Equation 3. PLL VCO frequency in Fractional mode when PLLDV[RDIV] is 0

  - When PLLDV[RDIV] is not 0:

$$f_{\text{pll_VCO}} = \frac{f_{\text{pll_ref}}}{\text{PLLDV[RDIV]}} \times \left(\text{PLLDV[MFI]} + \frac{\text{PLLFD[MFN]}}{18432}\right)$$

Equation 4. PLL VCO frequency in Fractional mode when PLLDV[RDIV] is not 0

See the equation below and the corresponding register configuration that determine the relationship between reference and PLL_PHI*n* output frequencies.

$$f_{\text{pll_phi}} = \frac{f_{\text{pll_VCO}}}{\text{PLLDV[ODIV2]} \times \left(\text{PLLDIV_}n\text{[DIV]} + 1\right)}$$

Equation 5. PLL PHI output frequency

When configuring PLL, you must not violate the maximum system clock frequency or maximum and minimum VCO frequency specification of PLL (see this chip's data sheet for frequency limits).

You must disable PLL by writing 1 to PLLCR[PLLPD] before any PLL configuration or input clock are modified.

You must disable PLL by writing 1 to PLLCR[PLLPD] for at least 5 µs before writing 0 to PLLCR[PLLPD] to enable PLL.

The recommended procedure to program PLL and enter Normal mode is shown in Initialization information.

28.3.4 Loss of lock (LOL)

PLL provides LOL indication. The LOL indication can only be generated when PLL is in Functional mode (see Modes of operation). When PLL detects a LOL, it asserts its LOL event output.

PLL does not detect loss of reference clock. If the reference clock stops after PLL achieves lock, PLL continues to indicate lock. It is assumed that monitoring of PLL's reference clock that is done outside PLL is enabled while PLL is in operation.

PLL LOL is intended for detection of gross failures. Use CMUs for accurate frequency monitoring.

28.3.5 Frequency modulation

In Frequency Modulation mode, PLL generates a frequency-modulated clock. The modulation depth and modulation frequency are calculated using the equations shown in Frequency modulation programming.

Write 1 to PLLFM[SPREADCTL] to select down-spread modulation. See Figure 120 that shows an example of down-spread modulation.

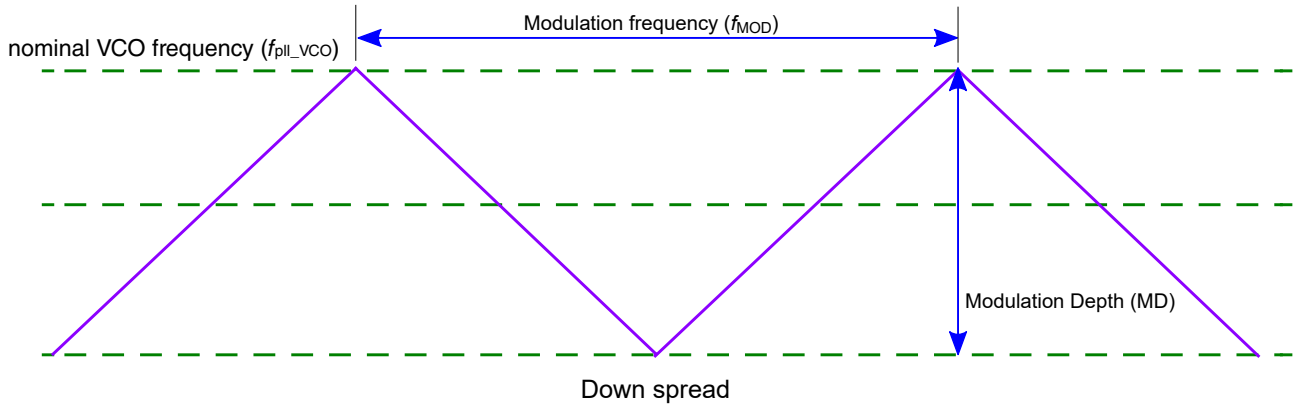


Figure 120. Frequency modulation

28.3.5.1 Frequency modulation programming

Modulation depth and modulation frequency programming uses step number (PLLFM[STEPNO]) and step size (PLLFM[STEPSIZE]). The table below shows variables used during calculations when programming PLL for frequency modulation.

Table 138. Variables for configuring modulation depth and frequency

Variable	Description
f_{REF}	Input clock frequency
f_{MOD}	Expected modulation frequency
MD	Expected modulation depth in percentage
LDF	Loop division factor
f_{pll_VCO}	Nominal VCO frequency

Use the following equations to configure PLL for frequency modulation.

$$LDF = PLLDV[MFI] + \frac{PLLFD[MFN]}{18432}$$

Equation 6. LDF

$$PLLFM[STEPNO] = \frac{f_{REF}}{\left(2 \times f_{MOD} \times PLLDV[RDIV]\right)}$$

Equation 7. Step number

$$PLLFM[STEPSIZE] = \frac{MD \times LDF}{100 \times PLLFM[STEPNO]} \times 18432$$

Equation 8. Step size

Frequency modulation is only possible if the condition shown in Equation 9 is met.

$$(PLLFM[STEPSIZE] \times PLLFM[STEPNO]) < 18432$$

Equation 9. Requirement to achieve FM

You must write 0 to PLLFM[SSCGBYP] and write 1 to PLLFD[SDMEN] to enable frequency modulation.

$$\text{Max (MD \%)} = \frac{(f_{REF} \times 100)}{f_{pll_VCO}}$$

Equation 10. Maximum possible modulation depth when PLL[RDIV] is 0

$$\text{Max (MD \%)} = \frac{(f_{REF} \times 100)}{PLLDV[RDIV] \times f_{pll_VCO}}$$

Equation 11. Maximum possible modulation depth when PLL[RDIV] is not 0

CAUTION

The effective modulation depth may differ from the intended modulation depth because of rounding operations applied to PLLFM[STEPSIZE] and PLLFM[STEPNO].

28.3.6 Interrupt signals

This module has no interrupt signals.

28.4 External signals

This module has no external signals.

28.5 Initialization information

Perform the following steps to initialize PLL:

1. Confirm that PLLODIV_*n*[DE] is 0 for all dividers.
2. Confirm that PLLCR[PLLPD] is 1.
3. Program the following as needed:
   - PLLDV
   - PLLFD
   - PLLFM to the desired value
4. Program PLLDV[ODIV2] and PLLODIV_*n*[DIV] to the desired values.
5. Wait for the PLL reference clock to be stable.
6. Write 0 to PLLCR[PLLPD].
7. Wait for PLLSR[LOCK] to be 1.
8. Write 1 to PLLODIV_*n*[DE].

Perform the following steps to shut down PLL:

1. Write 0 to PLLODIV_n[DE] for all dividers.
2. Write 1 to PLLCR[PLLPD].

28.6 PLLDIG register descriptions

This section provides the memory map and detailed descriptions of registers used for configuring PLL. The table below shows the memory map. Addresses are given as offsets from the module base address. All registers are accessed using 8-bit, 16-bit, or 32-bit addressing.

28.6.1 PLLDIG memory map

PLL base address: 402E_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	PLL Control (PLLCR)	32	RW	8000_0000h
4h	PLL Status (PLLSR)	32	RW	0000_0300h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
8h	PLL Divider (PLLDV)	32	RW	0C3F_1032h
Ch	PLL Frequency Modulation (PLLFM)	32	RW	4000_0000h
10h	PLL Fractional Divider (PLLFD)	32	RW	0000_0000h
18h	PLL Calibration Register 2 (PLLCAL2)	32	RW	0006_0000h
80h - 84h	PLL Output Divider (PLLODIV_0 - PLLODIV_1)	32	RW	0000_0000h

28.6.2 PLL Control (PLLCR)

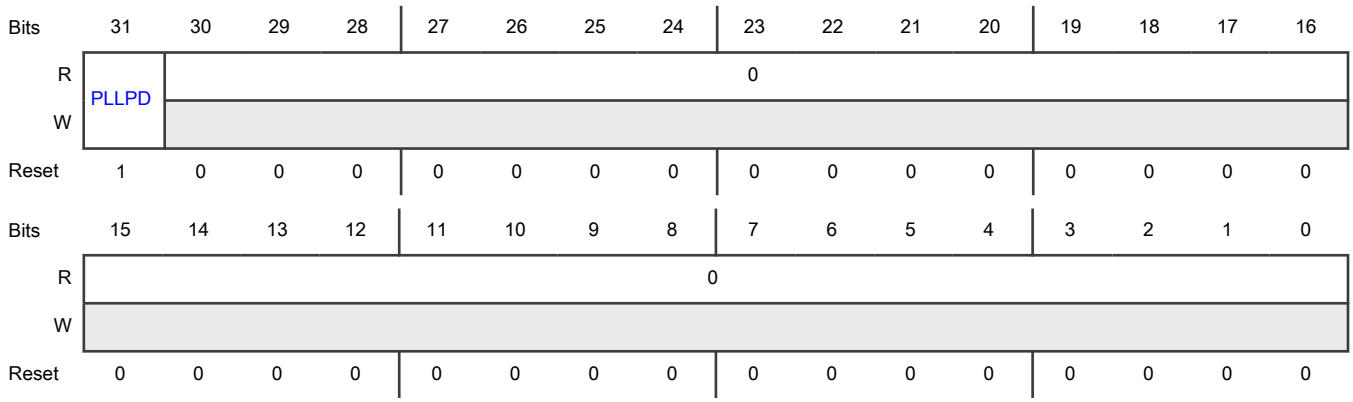
Offset

Register	Offset
PLLCR	0h

Function

Configures PLL functionality.

Diagram



Fields

Field	Function
31 PLLPD	PLL Power Down Powers down or powers up PLL. 0b - Powered up 1b - Powered down

Table continues on the next page...

Table continued from the previous page...

Field	Function
30-0 —	Reserved

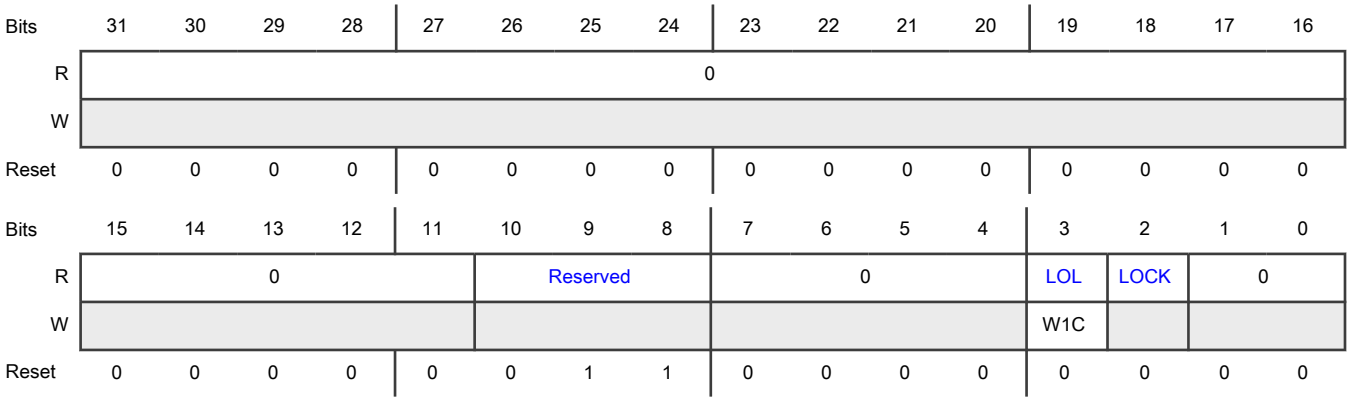
28.6.3 PLL Status (PLLSR)

Offset

Register	Offset
PLLSR	4h

Function
Shows the PLL status.

Diagram



Fields

Field	Function
31-11 —	Reserved
10-8 —	Reserved
7-4 —	Reserved
3 LOL	Loss-Of-Lock Flag Indicates the current PLL lock status.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No loss of lock detected 1b - Loss of lock detected
2 LOCK	Lock Status Indicates that PLL has acquired lock. 0b - Unlocked 1b - Locked
1-0 —	Reserved

28.6.4 PLL Divider (PLLDV)

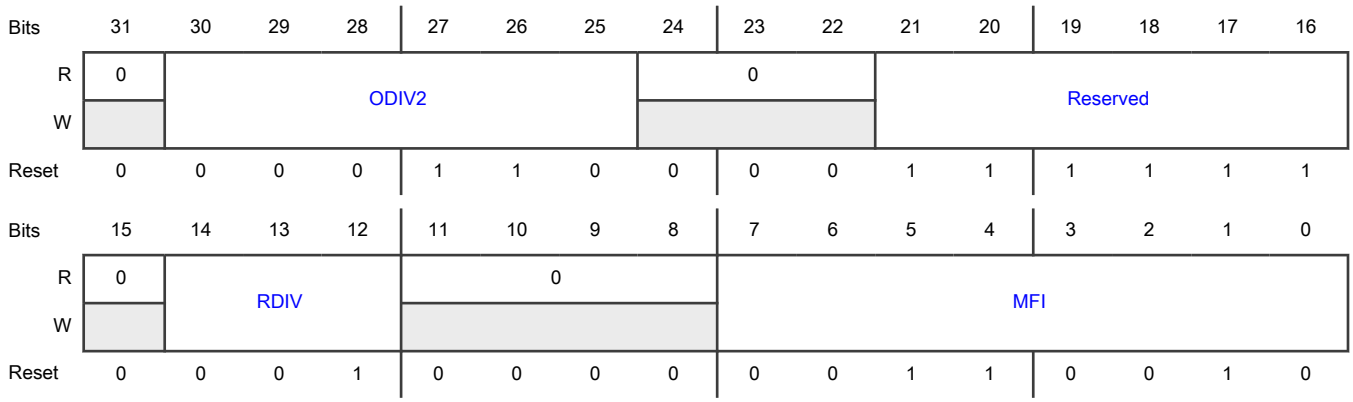
Offset

Register	Offset
PLLDV	8h

Function

Divides input clocks for PLL output generation.

Diagram



Fields

Field	Function
31 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
30-25 ODIV2	Output frequency divider for raw PLL clock. 6-bit field determining the VCO clock post divider for driving the PHI output clock. 000000 – Divide by 1 000001 – Divide by 1 000010 – Divide by 2 000011 – Divide by 3 000100 – Divide by 4 ..... 111111 – Divide by 63
24-22 —	Reserved
21-16 —	Reserved
15 —	Reserved
14-12 RDIV	Input Clock Predivider Sets the input clock divider. The output of the predivider circuit generates the PLL loop reference clock. 000b - Divide by 1 001b - Divide by 1 010b - Divide by 2 011b - Divide by 3 100b - Divide by 4 101b - Divide by 5 110b - Divide by 6 111b - Divide by 7
11-8 —	Reserved
7-0 MFI	Integer Portion Of Loop Divider Sets the value of the divider in the PLL feedback loop. The value specified establishes the multiplication factor applied to the reference frequency. Write the divider value to this field, where the chosen value does not violate VCO frequency specifications.

28.6.5 PLL Frequency Modulation (PLLFM)

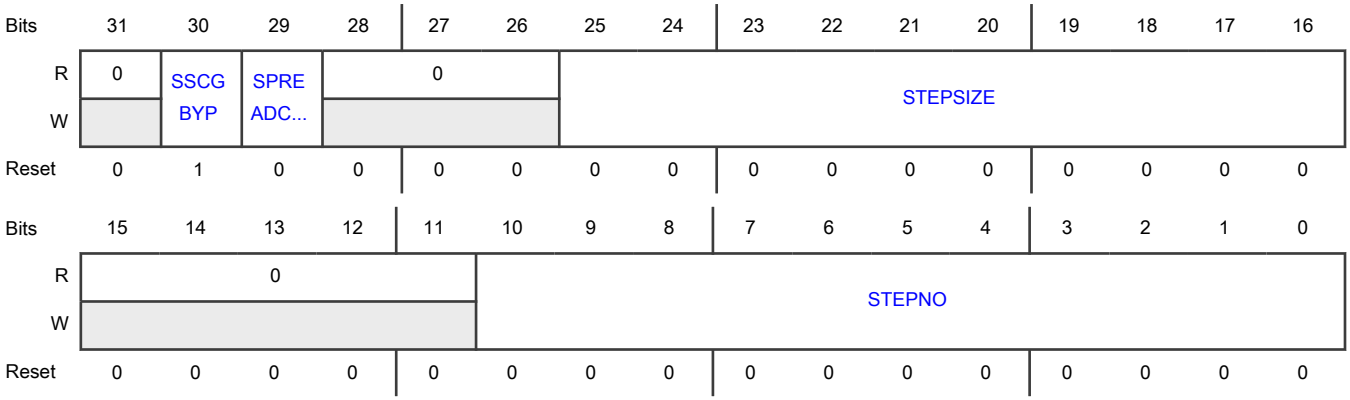
Offset

Register	Offset
PLLFM	Ch

Function

Configures PLL frequency modulation parameters.

Diagram



Fields

Field	Function
31 —	Reserved
30 SSCGBYP	Frequency Modulation (Spread Spectrum Clock Generation) Bypass Bypasses frequency modulation. 0b - Not bypassed 1b - Bypassed
29 SPREADCTL	Modulation Type Selection Indicates that the modulation is spread below the nominal frequency. You must write 1 to this field. 0b - Reserved 1b - Spread below nominal frequency
28-26 —	Reserved
25-16	Frequency Modulation Step Size

Table continues on the next page...

Table continued from the previous page...

Field	Function
STEPSIZE	Provides the step size for modulation depth and frequency in Frequency Modulation mode (see Frequency modulation).
15-11 —	Reserved
10-0 STEPNO	Number Of Steps Of Modulation Period Or Frequency Modulation Provides the number of steps to achieve modulation depth in Frequency Modulation mode (see Frequency modulation).

28.6.6 PLL Fractional Divider (PLLFD)

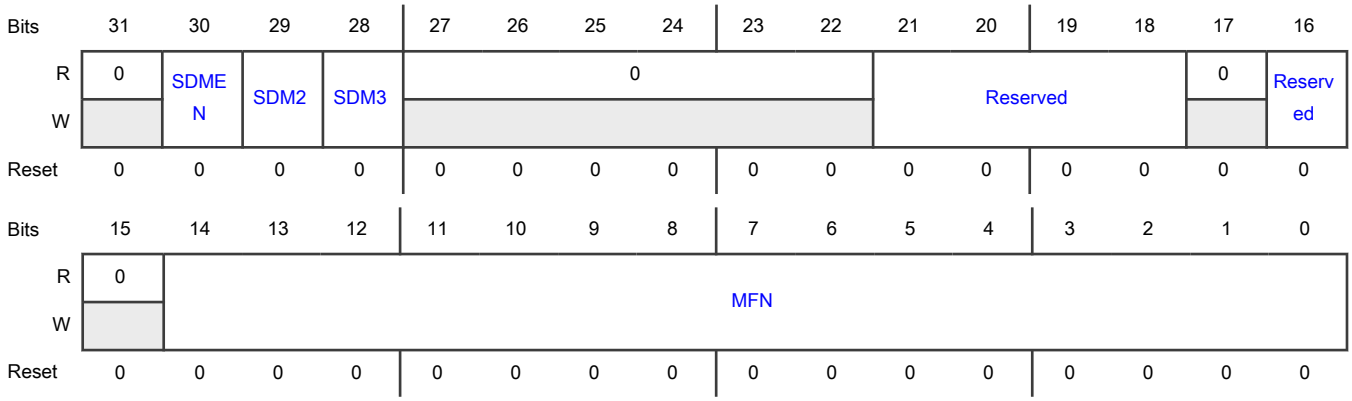
Offset

Register	Offset
PLLFD	10h

Function

Enables and configures frequency modulation.

Diagram



Fields

Field	Function
31 —	Reserved
30 SDMEN	Fractional Mode Enable Enables Fractional mode.

Table continues on the next page...

Table continued from the previous page...

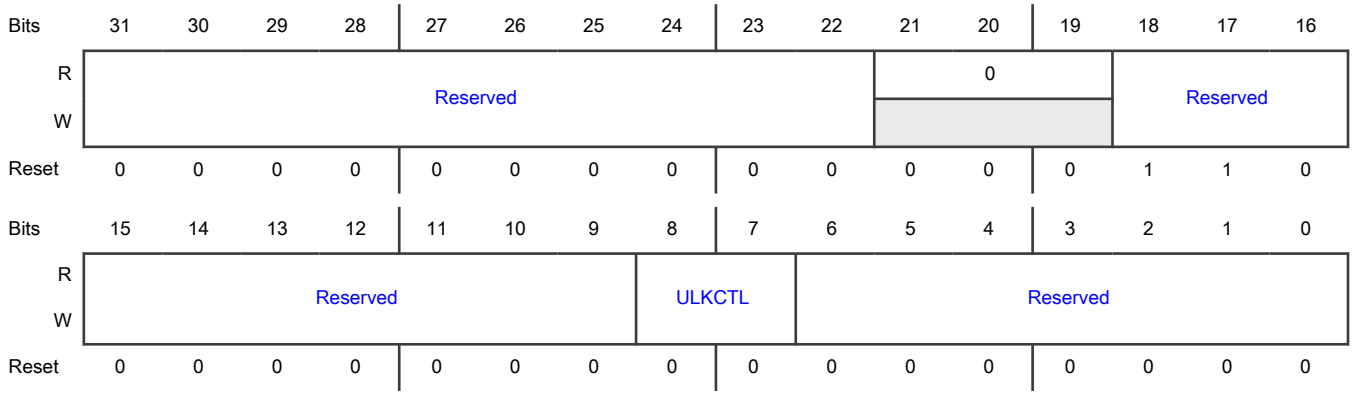
Field	Function
	0b - Disabled 1b - Enabled
29 SDM2	Fractional Mode Configuration When you are in the fractional mode (SDMEN = 1), write 1 to this field. **NOTE** If SDMEN = 1, this field must be written 1.
28 SDM3	Fractional Mode Configuration When you are in the fractional mode (SDMEN = 1), write 1 to this field. **NOTE** If SDMEN = 1, this field must be written 1.
27-22 —	Reserved
21-18 —	Reserved
17 —	Reserved
16 —	Reserved
15 —	Reserved
14-0 MFN	Numerator Of Fractional Loop Division Factor Sets the numerator of the fractional loop division factor. You must write a value of less than 18432 to this field. When Fractional mode is disabled, you must write 000_0000_0000_0000b to this field.

28.6.7 PLL Calibration Register 2 (PLLCAL2)

Offset

Register	Offset
PLLCAL2	18h

Diagram



Fields

Field	Function
31-22 —	Reserved
21-19 —	Reserved
18-16 —	Reserved
15-9 —	Reserved
8-7 ULKCTL	Unlock Control Accuracy Defines the accuracy necessary to achieve unlock. The lock counter determines unlock if the number of VCO clock cycles in the window of reference cycles is outside the number of cycles defined by this field. 00b - Unlock range = Expected value ± 9 (recommended when PLLFM[SSCGBYP] = 1). Unlock range = Expected value ± 9 (recommended when PLLFM[SSCGBYP] = 1) 01b - Unlock range = Expected value ± 17 (recommended when PLLFM[SSCGBYP] = 0). Unlock range = Expected value ± 17 (recommended when PLLFM[SSCGBYP] = 0) 10b - Unlock range = Expected value ± 33 11b - Unlock range = Expected value ± 5
6-0 —	Reserved

28.6.8 PLL Output Divider (PLLODIV_0 - PLLODIV_1)

Offset

Register	Offset
PLLODIV_0	80h
PLLODIV_1	84h

Function

Controls the PLL output clock divider settings.

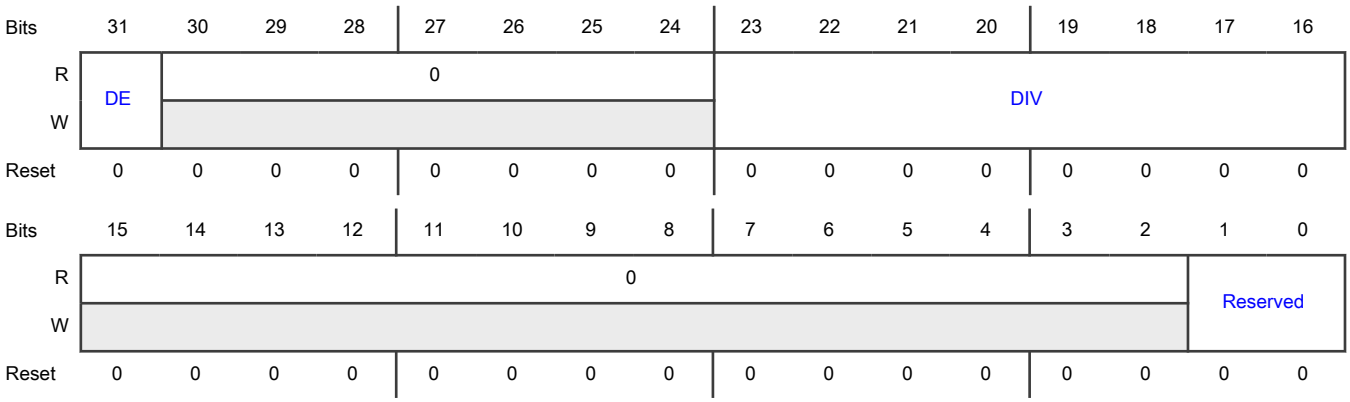
This divider has a 50% duty cycle.

NOTE

These registers support only word accesses. Other write accesses lead to the following:

- Unpredictable behavior
- No transfer error generated

Diagram



Fields

Field	Function
31 DE	Divider Enable Enables PLL output divider. Divider must be disabled before disabling PLL. 0b - Disabled 1b - Enabled
30-24 —	Reserved
23-16	Division Value

Table continues on the next page...

Table continued from the previous page...

Field	Function
DIV	Provides the division value for the output clock divider. The clock period of the clock after division is DIV + 1 times the time period of the divider input clock.
15-2 —	Reserved
1-0 —	Reserved Do not write any value other than the reset value.

Chapter 29
Reset

29.1 Introduction

This chip's reset logic consists of a reset sequence that leads the chip to a fixed deterministic state after predefined reset events occur. These events can pertain to chip failure events, the chip's special operating conditions, or certain software-governed events to initiate a chip reset sequence. This chapter discusses the chip reset scheme and related topics such as:

- Types of reset reactions
- Reset event sources
- Chip reset sequences
  - POR
  - Destructive reset
  - Functional reset
- RAM retention across functional reset
- Reset pin (RESET_b) behavior
- Debug system reset
- Signal-level reset flow

29.2 Chip reset types and reactions

29.2.1 Chip reset blocks

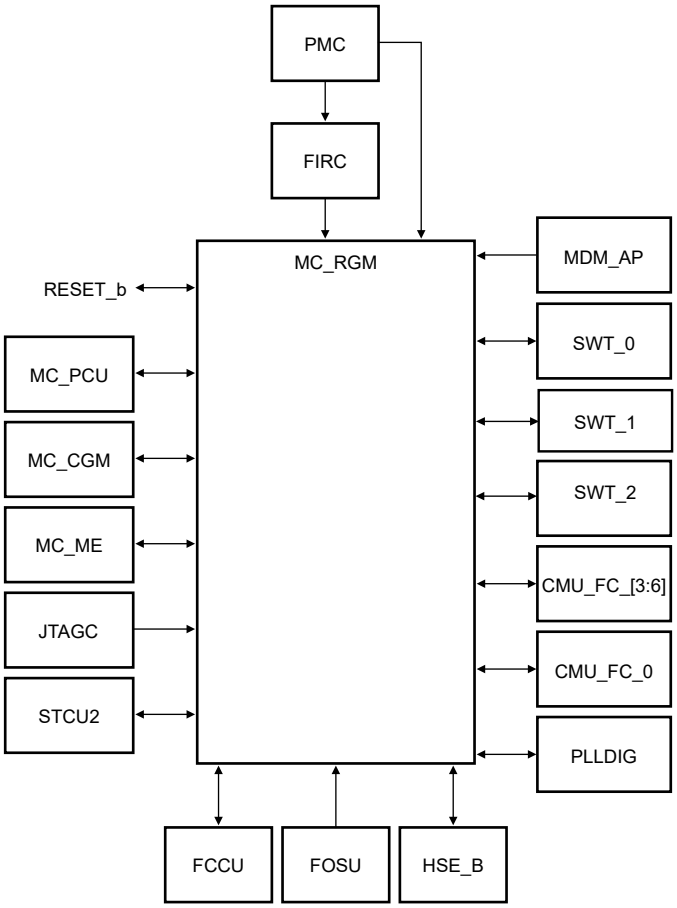


Figure 121. Chip reset blocks

29.2.2 Chip reset types

Table 139. Chip reset types

Reset event type	Functional description
POR	Leads to a complete chip reset.
Destructive	Leads most parts of the chip, except a few modules, to reset. SRAM content is lost after this reset event.
Functional	Leads all the communication peripherals and cores to reset. The communication protocols' sanity is not guaranteed and they are assumed to be reinitialized after reset. The SRAM content, and the functionality of certain modules, is preserved across functional reset.

29.2.3 High-level reset sequence overview

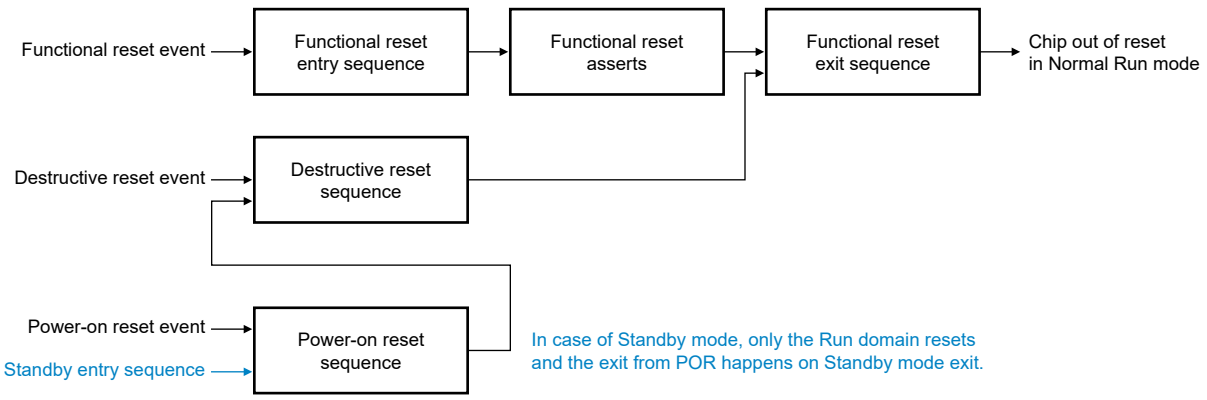


Figure 122. High-level reset sequence overview

29.2.3.1 Reset event reactions

Table 140. Reset event reactions

Reset event type	Triggered from	Reaction
POR	Anywhere	Moves to the beginning of the power-on sequence
Destructive reset	Power-on sequence	No reset sequence change
	Anywhere in the chip operation except in the power-on-sequence	Moves to the beginning of the destructive reset sequence
Functional reset	Out-of-reset	Moves to the beginning of the functional reset entry sequence
	Anywhere within the functional reset sequence	No reset sequence change

29.2.3.2 Chip action after reset event

For each reset event, immediately after MC_RGM captures it, the chip performs these actions:

1. Writes 1 to the corresponding reset event status fields in MC_RGM.DES and MC_RGM.FES (see the MC_RGM chapter for more information).
2. Places its pins in their default states (see the IOMUX file attached to this document for more information).
3. Asserts the RESET_b pin.

NOTE

After self-test completes, you can configure RESET_b assertion using MC_RGM.FES[ST_DONE].

4. Enters the reset sequence as described in Reset event reactions, depending on the current state and reset event type.

29.3 Reset sources—POR, destructive, and functional

MC_RGM records reset events in MC_RGM.FES and MC_RGM.DES, indicating the source of functional reset events and destructive reset events, respectively. You must read these fields to identify the reset source on reset recovery.

Also, read DCM.DCMROPP4 register in event of a POR WDG generated POR event.

For POR reset events, refer to Power Management Controller (PMC) and Power-on Reset Watchdog (POR_WDG) chapters.

29.3.1 POR sources

Table 141. POR sources

Source module	Field in MC_RGM.DES	RESET_b assertion	Description
PMC	F_POR	Always	VDD_LV POR
			LVR on 1.1 V supply in Standby mode
			LVR on 1.1 V supply in Run mode
			LVR on 2.5 V supply in Standby mode
			LVR on 2.5 V supply in Run mode
			LVR on VDD_HV_A supply in Standby mode
			LVR on VDD_HV_A supply in Run mode
			LVR on VDD_HV_B supply in Standby mode
			LVR on VDD_HV_B supply in Run mode
POR_WDG			POR_WDG timeout (see the POR_WDG chapter for more information)

NOTE

You cannot escalate or demote POR to an interrupt.

29.3.2 Stages of the POR sequence

Table 142. Stages of the POR sequence

Stage	Process
PWRUP	1. Starts after a POR event (for example, a POR source assert). 2. Waits for the power-up sequence to complete. 3. Exits when all the POR sources clear. 4. Transitions to the FIRC_STRT stage after the procedure completes.
FIRC_STRT	1. Enters this stage after exiting the PWRUP stage. **NOTE** FIRC_CLK becomes available after it is stable. The duration depends on the clock startup time (see the chip datasheet for more information). The MC_RGM state machine proceeds further after FIRC_CLK is available. 2. Transitions to the destructive reset sequence after the procedure completes.

29.3.3 Destructive reset sources

Table 143. Destructive reset sources

Source module[1]	Field in MC_RGM.DES	Description
FOSU	FCCU_FTR	FCCU failure to react

Table continues on the next page...

Table 143. Destructive reset sources (continued)

Source module[1]	Field in MC_RGM.DES	Description
STCU2	STCU_URF	STCU2 unrecoverable fault
MC_RGM	MC_RGM_FRE	Functional reset escalation
CMU_FC_0	FXOSC_FAIL	FXOSC failure
PLL	PLL_LOL	PLL loss of lock
CMU_FC_3	CORE_CLK_FAIL	Core clock failure
CMU_FC_4	AIPS_PLAT_CLK_FAIL	AIPS_PLAT_CLK failure
CMU_FC_5	HSE_CLK_FAIL	HSE_CLK failure
MC_CGM	SYS_DIV_FAIL	System clock dividers alignment failure
CMU_FC_6	CM7_CORE_CLK_FAIL	CM7_CORE_CLK failure
MC_ME	SW_DEST	Software destructive reset
MDM_AP	DEBUG_DEST	Debug destructive reset
RESET_b pin	MC_RGM.FES[F_EXR]	RESET_b pin assertion

1. All destructive resets can be escalated, but only the PLL LOL destructive reset can be demoted to an interrupt (see Destructive reset event bypass for PLL LOL destructive reset bypass details).

NOTE

All reset sources in the table above assert the RESET_b pin.

29.3.4 Destructive sequence stage description

Table 144. DEST0 description

Stage	Process
DEST0	1. Asserts reset to the entire chip, except logic running on POR. 2. Waits for all the destructive reset events to clear. 3. Waits for the minimum destructive reset assertion duration of eight FIRC_CLK cycles. 4. Deasserts after stage completion.

29.3.5 Functional reset sources

Table 145. Functional reset sources

Source module	Field in MC_RGM.FES	RESET_b assertion	Demotable to IRQ by MC_RGM.FERD register[1]	Escalation[2]	Description
FCCU soft reaction[3]	FCCU_RST	Always	Yes[4]	Yes	FCCU reset reaction
STCU2	ST_DONE	Configurable	No	No	Self-test done
SWT0	SWT0_RST	Always	Yes	Yes	SWT reset request

Table continues on the next page...

Table 145. Functional reset sources (continued)

Source module	Field in MC_RGM.FES	RESET_b assertion	Demotable to IRQ by MC_RGM.FERD register[1]	Escalation[2]	Description
SWT1	SWT1_RST	Always	Yes	Yes	SWT reset request
SWT2	SWT2_RST	Always	Yes	Yes	SWT reset request
JTAGC	JTAG_RST	Always	Yes	No	JTAG reset
MC_ME	SW_FUNC	Always	No	Yes	Software functional reset
MDM_AP	DEBUG_FUNC	Always	Yes	Yes	Debug functional reset

1. See Functional reset demotion to an interrupt for more information.
2. See Reset escalation for more information.
3. An FCCU soft functional reset is a chip functional reset (see the FCCU chapter for more information).
4. Controlled by MC_RGM.FERD[D_FCCU_RST].

29.3.6 Functional reset sequence descriptions

Table 146. Functional reset sequence descriptions

Stage	Series of events
Functional reset entry sequences	
FUNC0	This stage starts after any functional reset event. The FCCU fault monitoring and CMU_F*x_n* monitoring for FLL events is masked in this step to avoid any false fault or reset.
FUNC1	In this stage, a halt sequence that includes daisy chaining of all the gaskets halts, disabling the crossbar. The stage completes after the halt-handshake sequence completes. For details on the crossbar halt-handshake scheme, refer to System RAM retention across functional reset.
FUNC2	In this stage, MC_RGM triggers the MC_CGM hardware clock multiplexers to switch to FIRC_CLK. • Software-based clock multiplexers do not support switching to FIRC_CLK on functional reset. • If PCFS is enabled, the system clock switching can be done via PCFS. This stage completes after MC_CGM switches the system clock to FIRC.
FUNC3	In this stage, MC_RGM triggers all the MC_CGM hardware-based clock multiplexers with PCFS enabled or disabled to move their dividers to default values. • Software-based clock multiplexers do not support this feature. This stage completes after all the clock multiplexer dividers initialize to their corresponding default values.
FUNC4	In this stage, PLLDIG turns off synchronously. The stage completes after PLLDIG turns off.
FUNC5	FXOSC_CLK switches off synchronously.

Table continues on the next page...

Table 146. Functional reset sequence descriptions (continued)

Stage	Series of events
	The FUNC4 and FUNC5 stages ensure that PLLDIG disables cleanly to ensure there are no glitches on the PLLDIG clock because of reset. The stage completes after FXOSC switches off.
FUNC6	In this stage, clocks of modules that are a part of LBIST and working on the destructive reset are enabled to meet their synchronous reset requirements, if any. For the self-test logic, in self-test, the destructive reset deasserts after this stage completes and after safe stating is removed. **NOTE** In the self-test sequence, the logic, which is a part of self-test (LBIST logic) resets when self-test completes. All the parts of logic in self-test (POR, destructive, and functional reset) reset after self-test completes whereas the rest of the chip undergoes a functional reset sequence because of self-test completion (MC_RGM.FES[ST_DONE] = 1). See the Safety Overview and STCU2 chapters for more information on the self-test operation.
FUNC7	MC_RGM asserts the functional reset and triggers a counter running on FIRC_CLK (for up to 64 cycles) to enable clocks for the modules having synchronous reset requirements. Flash memory comes out of reset after this stage completes. **NOTE** The flash memory resets after a functional reset event but comes out of reset, before the rest of the modules do, at the start of the functional reset exit sequence. The rest of the modules reset when the functional reset comes out of reset at the end of the functional reset exit sequence. Therefore, the reset to flash memory is an early functional reset that deasserts earlier than the functional reset, even if asserted at the same time.
Functional reset exit sequences	
FUNC8	This stage consists of flash memory and MC_RGM handshaking. Flash memory indicates the completion of its initialization to MC_RGM.
FUNC9	DCM initiates the scanning of flash memory DCF records. This state completes after the flash memory scanning completes. See the DCF clients file attached to this document for more information.
FUNC10	In this stage, DCM initiates the trim loading sequence for analog blocks. The analog blocks are loaded with the configured trimmed values in this stage, which completes after a trim-loading sequence completes.
FUNC11	In this stage, MG_RGM stops driving RESET_b and checks that the signal does not assert externally. If you enable low-power debug, MC_RGM waits for a debug acknowledge. The completion of this stage indicates that MC_RGM completed the reset sequence, deasserting the functional reset to the system.

NOTE

Any of the reset sources may trigger the reset sequence at any time during operation [NXP: The exception is external reset and other functional Resets are ignored when device is already under functional Reset].

29.4 Reset and boot sequence

The chip reset sequence consists of several reset stages based on the occurrence of a particular reset event. All reset events follow the same chip reset sequence; only the entry points vary depending on the type of reset event. MC_RGM triggers each stage after the previous stage completes. These stages execute in a specific order, which ensures a deterministic state of the chip when a reset event completes.

Figure 123 shows a high-level representation of the chip startup sequence.

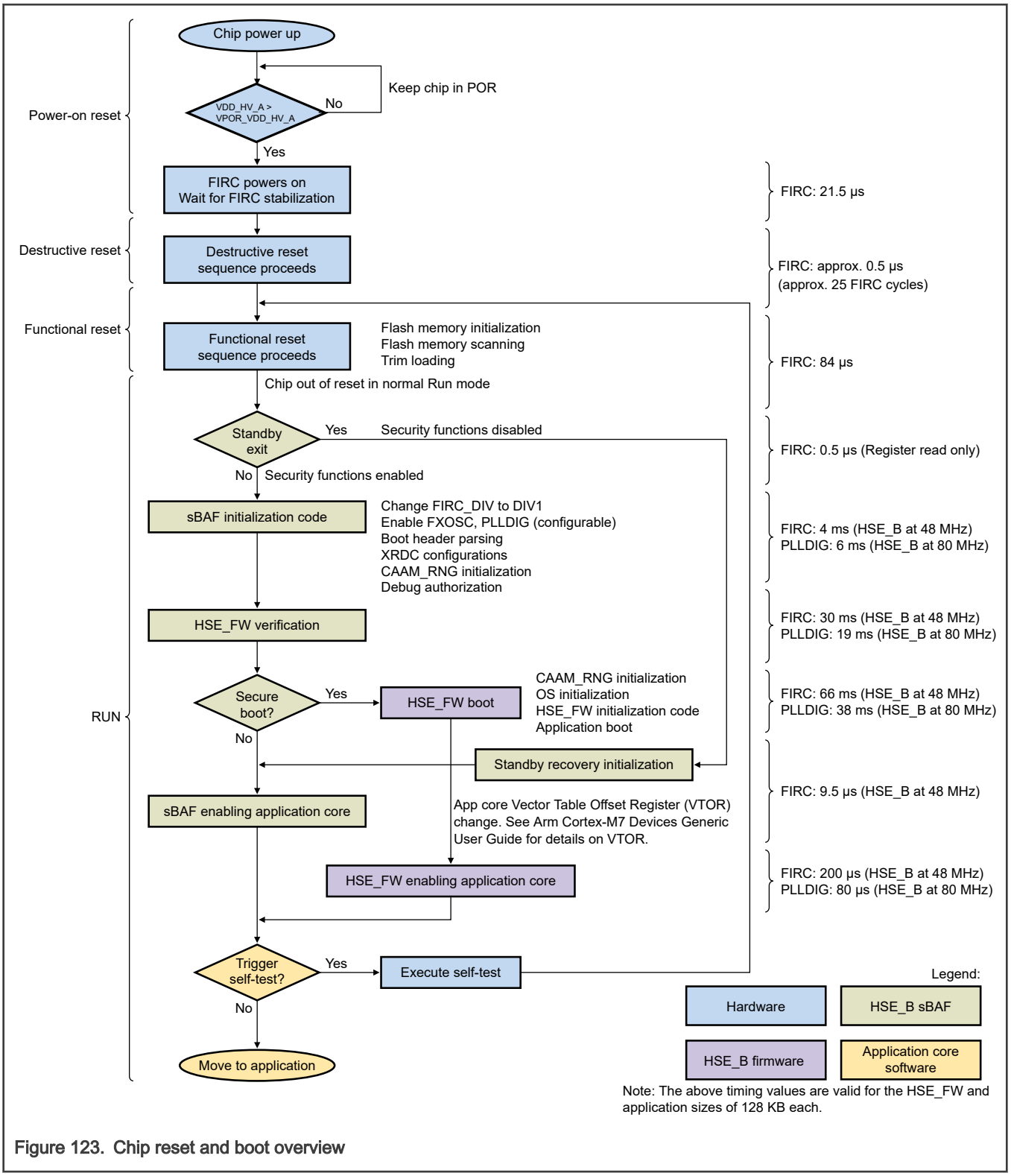


Figure 123. Chip reset and boot overview

29.4.1 POR

This stage starts when the POR event occurs, that is, when a POR source asserts.

NOTE

The logic in the Standby power domain does not reset in the chip Standby mode entry sequence.

The POR sequence consist of two stages:

1. Power-up (PWRUP)
2. FIRC oscillator start (FIRC_STRT)

See POR sequence for more information and Stages of the POR sequence for POR stages and their descriptions.

29.4.1.1 POR sequence

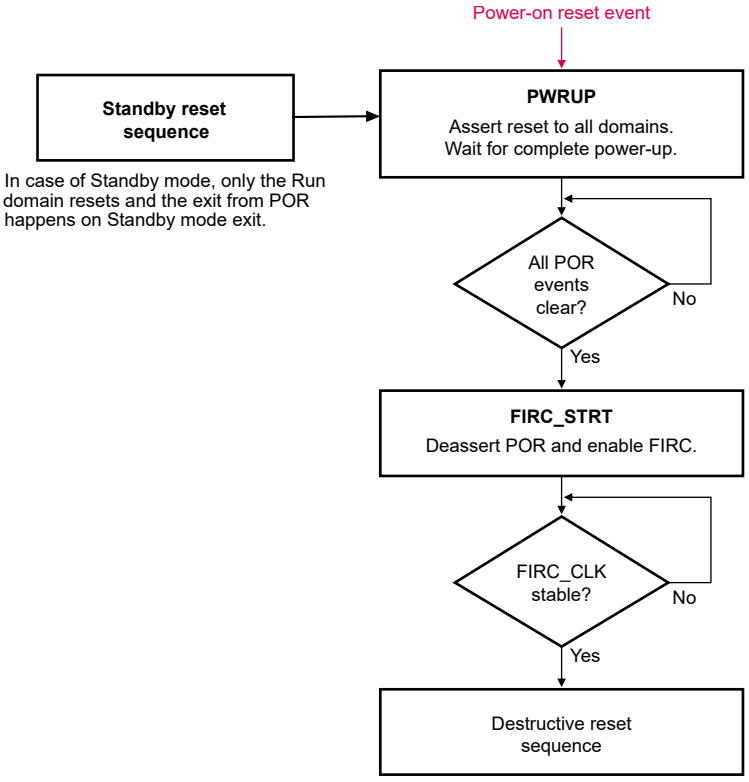


Figure 124. POR flow

29.4.2 Destructive reset

The chip enters a destructive reset sequence after the POR sequence or any destructive reset event completes. Destructive reset sequence illustrates the destructive reset sequence and Destructive sequence stage description discusses the stages of destructive sequence.

29.4.2.1 Destructive reset sequence

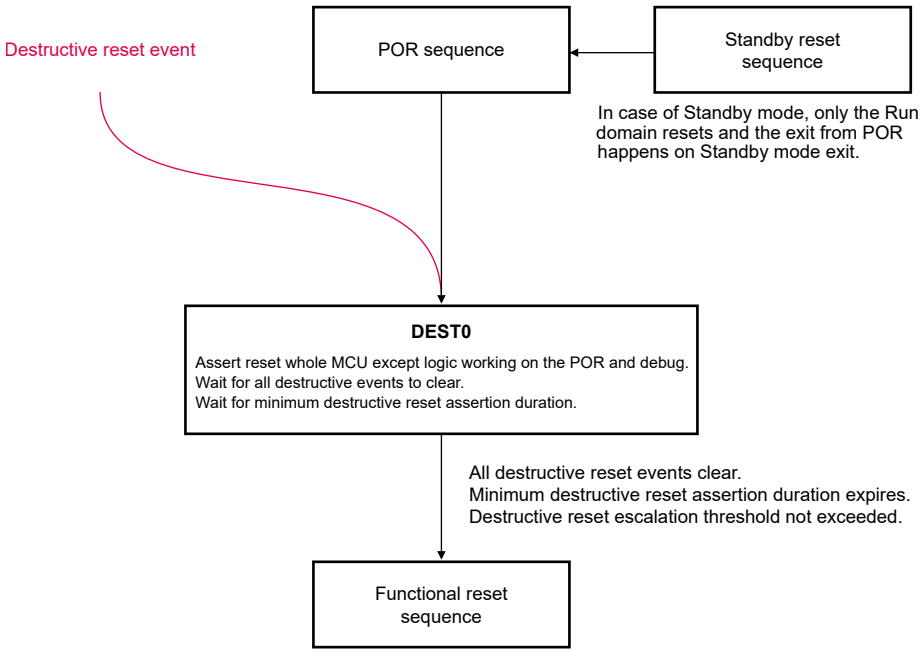


Figure 125. Destructive reset sequence

29.4.2.1.1 Destructive sequence stage description

Table 147. DEST0 description

Stage	Process
DEST0	1. Asserts reset to the entire chip, except logic running on POR. 2. Waits for all the destructive reset events to clear. 3. Waits for the minimum destructive reset assertion duration of eight FIRC_CLK cycles. 4. Deasserts after stage completion.

29.4.2.2 Destructive reset event bypass

This chip supports a destructive reset event demotion mechanism that the application software configures. In case of destructive reset bypass enabled, an interrupt event occurs instead of reset(demotion). Table 148 discusses details related to GPR configuration and corresponding interrupt identification.

Table 148. Destructive reset event bypass

Destructive reset event	Destructive reset event description	DCM field to bypass reset event	NVIC interrupt ID
MC_RGM.DES[PLL_LOL]	PLL loss of lock	DCM.DCMRWP3[9]	212

29.4.3 Functional reset

The chip enters the functional reset sequence when any of the following events occur:

- Functional reset

- POR or destructive reset (after the DEST0 stage completion)

On any functional reset event, the chip starts a functional reset entry sequence before the functional reset asserts and ensures the stability of logic running on a destructive reset and POR. On a destructive reset event or POR events the functional reset entry sequence does not execute.

The functional reset exit sequence consists of steps that ensure proper initialization of the chip after functional reset recovery.

29.4.3.1 Functional reset sequence

Functional reset flow illustrates the functional reset flow and Functional reset sequence descriptions discusses the functional reset stages and their descriptions.

Stages FUNC0 to FUNC6 present the functional reset entry sequence. It occurs on any functional reset event before the functional reset. In other words, when a functional reset event occurs, MC_RGM holds the asserted reset and executes the functional reset entry sequence. After the sequence completes, MC_RGM resets the chip presented by the functional reset assert block in Figure 122, which remains in Run mode during the functional reset entry sequence.

Stages FUNC7 to FUNC11 present the functional reset exit sequence, which occurs after a functional reset event before deasserting the chip reset. This includes handshaking with the flash memory and analog blocks, ensuring correct operation after reset exit.

29.4.3.1.1 Functional reset flow

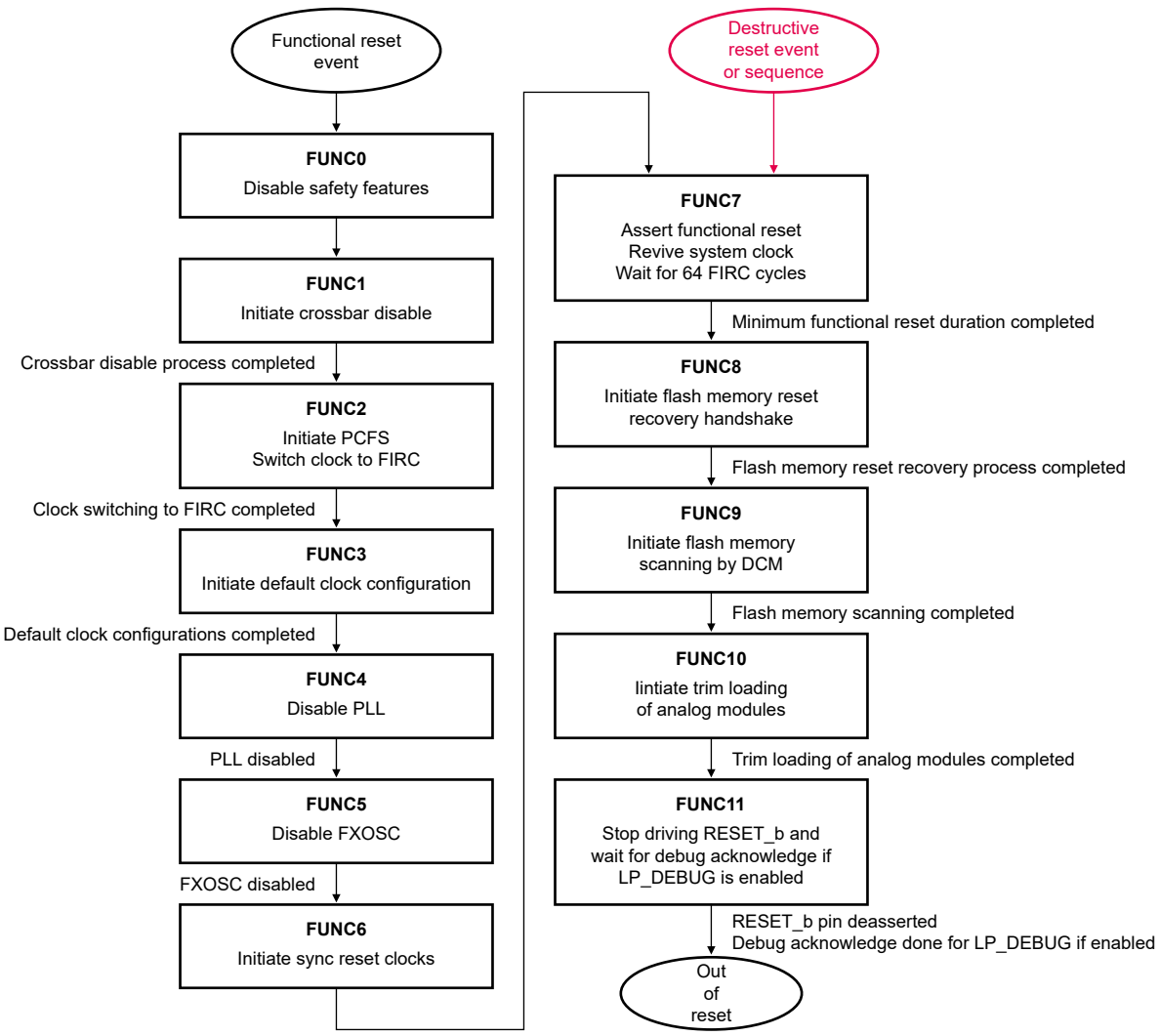


Figure 126. Functional reset flow

29.4.3.2 FUNC9 and FUNC10 stage bypass for faster Standby mode exit

The FIRC and PMC trimming values are retained across Standby mode (its scanning and trim loading are bypassed) which does not cause any impact.

See the "Faster Standby Mode exit" section in the "Power Management" chapter for more information.

29.4.3.3 Standby reset sequence

Standby entry sequence will trigger reset to all the logics in Run domain and will not affect any logic in Standby domain.

Wake-up from Standby mode removes the resets to the Run domain in the standby entry sequence.

See the "Module reset status" section in the "Reset Overview" chapter for the logic present in Run domain.

29.4.3.4 Reset function redirection

Resets may escalate or demote to an IRQ, depending on the chip configuration.

29.4.3.4.1 Functional reset demotion to an interrupt

This chip supports the reset sequence demotion feature for functional resets. You can configure a functional reset to create an interrupt instead of a reset (see the MC_RGM chapter for details).

29.4.3.4.2 Reset escalation

The chip supports the reset escalation feature. If multiple functional or destructive resets occur, the related reset can escalate to a higher priority reset sequence (see the "Functional reset escalation" and "Destructive reset escalation" sections in the MC_RGM chapter).

29.4.3.4.2.1 Destructive reset escalation

You can enable destructive reset escalation by configuring a DCF client. You must also configure the destructive count threshold in MC_RGM.DRET (see "Destructive Reset Escalation Enable Register (DEST_RST_ESC):dcf_client_dest_rst_esc" in the DCF file attached to this document). The fields in the dcf_client_dest_rst_esc register correspond with the fields in MC_RGM.DES.

After being configured, MC_RGM immediately asserts a destructive reset escalation when the destructive event count reaches the threshold count in MC_RGM.DRET[DRET]. When the destructive and escalation reset assert, the reset sequence immediately enters the DEST0 state. The reset sequencing remains in DEST0 until a POR event occurs. If enabled, the destructive reset escalation counter increments with each destructive reset event. The application software clears the destructive reset escalation counter by writing any value to MC_RGM.DRET[DRET].

NOTE

You can configure GPR settings to allow demotion of PLL loss of lock destructive resets to interrupts instead of escalation (DCMRWP3[DEST_RST9_AS_IPI]). See Destructive reset event bypass for more information.

29.5 Reset timing diagram

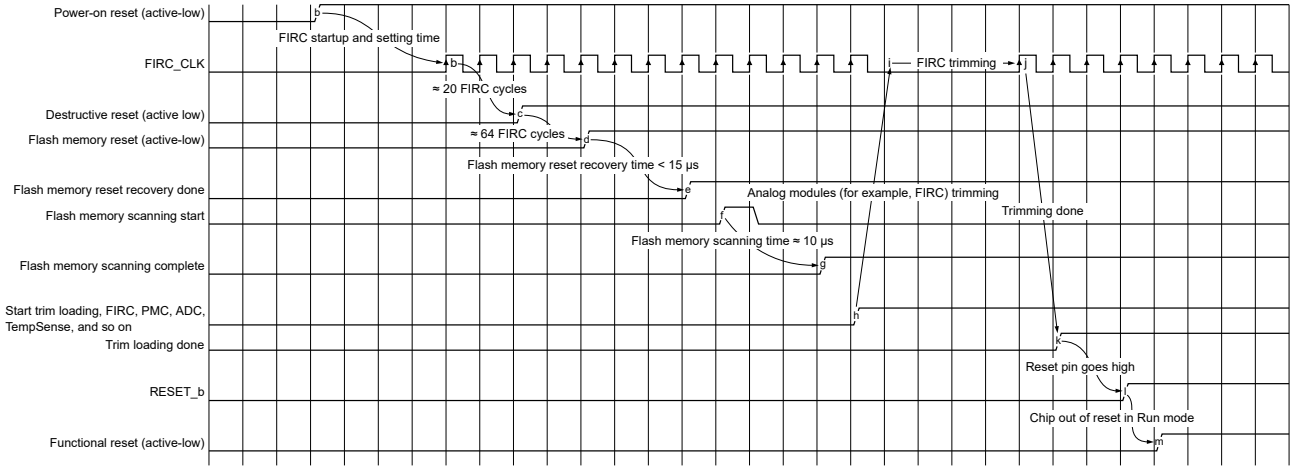


Figure 127. Reset timing diagram

29.6 Chip status after reset deassertion

Table 149. Chip status after reset deassertion

Function or feature	After POR deassertion	After destructive reset deassertion	After functional reset deassertion
Clock sources	• FIRC_CLK and SIRC_CLK on • Others off	• FIRC_CLK and SIRC_CLK on • Others off	• FIRC_CLK and SIRC_CLK on • Others off
Clock selection	FIRC_CLK	FIRC_CLK	FIRC_CLK
Clock dividers	Default configuration	Default configuration	Default configuration
Reset status flags	For a device POR event, MC_RGM.DES[F_POR] equals 1, others equal 0. For a POR_WDG event, DCM_GPR.DCMROPP4[0] equals 1, others equal 0.	MC_RGM.DES, MC_RGM.FES[F_EXR] captures the reset source event.	MC_RGM.FES captures the reset source event. The MC_RGM.FES[F_EXR] captures the pin reset event source, which is a destructive reset source. So for functional reset status, the bit MC_RGM.FES[F_EXR] should be ignored.
MC_ME previous mode	Reset	Reset	Reset
FCCU fault information	Cleared	Cleared	Retained
SRAM content	Invalid	Invalid	Retained
DCF configurations in DCM	Reset value	Existing loaded value (reset value after POR)	Reloaded from flash memory
Cores	All off	All off	Cores initialized as per application configuration
Logic on POR[1]	Out of reset with default configuration	Out of reset with default configuration	Out of reset with default configuration
Logic on destructive reset [1]	Under reset with default configuration	Out of reset with default configuration	Out of reset with default configuration
Logic on functional reset [1]	Under reset with default configuration	Under reset with default configuration	Out of reset with default configuration

1. For the list of peripherals affected by POR, destructive reset, and functional reset events, see Module reset status.

29.7 Module reset status

Table 150. Module reset status

Module instances[1]	Destructive	Functional	Power domain[2]	Part of LBIST[3]
MC_RGM	Y	Y	Standby	No
PRAM[1:2]	Y	Y	Run	Yes
PFC	Y	Y	Run	Yes

Table continues on the next page...

Table 150. Module reset status (continued)

Module instances[1]	Destructive	Functional	Power domain[2]	Part of LBIST[3]
SIUL_VIRTWRAPPER_PDAC0	Y	Y	Run	No
SIUL_VIRTWRAPPER_PDAC1	Y	Y	Run	No
SIUL_VIRTWRAPPER_PDAC2	Y	Y	Run	No
SIUL_VIRTWRAPPER_PDAC4	Y	Y	Run	No
SIUL_VIRTWRAPPER	Y	Y	Run	No
DCM	Y	Y	Run and Standby[4]	No
TRGMUX	Y	Y	Run	No
WKPU	Y	Y	Standby	No
CMU_FC_[0/3]	Y	Y	Run	CMU 0,3: No
CMU_FM_[1:2]	Y	Y	Run	CMU 1,2: Yes
CMU_FC_[4:6]	Y	Y	Run	CMU 4,5,6: Yes
FIRC	Y	Y	Standby	No
FXOSC	Y	Y	Standby	No
MC_CGM	Y	N[5]	Run	No
MC_ME	Y	Y	Run	No
PLLDIG	Y	Y	Run	No
Configuration GPR	Y	Y	Run	No
eMIOS_0	Y	Y	Run	Yes
PIT_0	Y	Y	Standby[6]	No
PIT_[1:2]	Y	Y	Run	No
FlexCAN_[0:5]	Y	Y	Run	No
FlexIO	Y	Y	Run	No
LPUART_[0:3]	Y	Y	Run	No
LPI2C_[0:1]	Y	Y	Run	No
LPSPI_[0:5]	Y	Y	Run	No
QuadSPI	Y	Y	Run	No
ADC_[0:6]	Y	Y[8]	Run	No
LPCMP_[0:1]	Y	Y	Standby	No
TempSense	Y	Y[8]	Run	No
CRC	Y	Y	Run	Yes
FCCU (+FOSU)	Y	N	Run	Yes
STCU2	Y	N	Run	No

Table continues on the next page...

Table 150. Module reset status (continued)

Module instances[1]	Destructive	Functional	Power domain[2]	Part of LBIST[3]
HSE_B MUA/MUB	Y	Y	Run	No
JDC	Y	Y	Run	No
DMAMUX_[0:3]	Y	Y	Run	No
PMC	Y[7]	N	Standby	No
Flash memory	Y	Y[8]	Run	No
SIRC	Y	Y	Standby	No
BCTU_[0:1]	Y	Y	Run	No
LCU_[0:1]	Y	Y	Run	No
RTC	Y	N[9]	Standby	No
EMAC	Y	Y	Run	No
HSE_B	Y	Y	Run	No
SWT_0	Y	Y	Standby	No
SWT_[1:2]	Y	Y	Run	Yes
STM_[0:2]	Y	Y	Run	No
MSCM	Y	Y	Run	No
ERM_[0:1]	Y	Y	Run	Yes
EIM_[0:2]	Y	Y	Run	Yes
eDMA_0	Y	Y	Run	Yes
eDMA_1	Y	Y	Run	Yes
JTAGC	N	N	Run	No
MDM_AP	Y	N	Run	No
APB_AP	Y	N	Run	No
Cortex-M7_0	Y	Y	Run	No
Cortex-M7_1	Y	Y	Run	No
Cortex-M7_0 AHB-AP	Y	N	Run	No
Cortex-M7_2/3	Y	Y	Run	No
Cortex-M7_1 AHB-AP	Y	N	Run	No
Cortex-M7_2/3 AHB-AP	Y	N	Run	No
MC_PCU	Y	N	Standby	No
TRGMUX_1	Y	Y	Run	No
DSPI_MSC	Y	Y	Run	No
LPUART_MSC	Y	Y	Run	No

Table continues on the next page...

Table 150. Module reset status (continued)

Module instances[1]	Destructive	Functional	Power domain[2]	Part of LBIST[3]
eFlexPWM_[0:1]	Y	Y	Run	No
eTPU	Y	Y	Run	No
Zipwire	Y	Y	Run	No
Coolflux	Y	Y	Run	No
SDADC_[0:3]	Y	Y	Run	No
adc_bist	Y	Y	Run	No

Legends:	
Y	The entire module resets on this particular reset.
Y	Only a portion of the module resets on this particular reset.
N	No portion of the module resets on this particular reset

1. All the modules listed in this table are reset on a POR event. See the memory map file attached to this document for the availability of modules.
2. The modules in the RUN domain get reset on standby exit. The modules in STANDBY domain are not impacted by standby exit and retain their contents. However in case of standby exit via functional reset or destructive reset event, the corresponding flops within the STANDBY domain modules will also get reset.
3. The modules in the LBIST logic get reset on selftest completion.
4. Flash memory scanning logic is available in the Run domain. GPRs and LC decode logic are available in Standby domain.
5. During functional reset stages FUNC2 and FUNC3 (see the Functional reset sequence descriptions for functional reset stage descriptions), MC_CGM.MUX_*n*_CSC and MC_CGM.MUX_*n*_DIV_*m* are automatically set to their default values. The default value of the MC_CGM.MUX_*n*_CSC[SELCTL] selects FIRC_CLK as the source clock for all multiplexers. The default value of the MC_CGM.MUX_*n*_DIV_*m* is register instance specific (see the "MC_CGM register descriptions" section in the Clock Generation Module (MC_CGM) chapter).
6. Only PIT_0 supports the RTI feature, and exists in the Standby domain.
7. PMC registers are reset on a destructive reset. The LVR and POR logic is reset on an LVR or POR (see PMC.CONFIG and PMC.LVSC descriptions for details).
8. Reset on a functional reset; however, reset recovery occurs before the chip functional reset recovery, at the functional reset exit sequence start, for proper trim scanning and loading.
9. RTC operates during a functional reset.

29.8 System RAM retention across functional reset

System RAM retains content during functional reset through the crossbar halt handshake. The system crossbar halts during the functional reset entry sequence. Therefore, the accesses do not cause any content corruption (see Functional reset sequence for more information).

The below sequence is triggered in the functional reset sequence for halt handshake sequence:

1. Send a halt request to the HSE_B AXBS, DMA AXBS, and EMAC IAHB bridges in parallel.
2. Wait for a halt acknowledgement from HSE_AXBS, DMA AXBS, and EMAC IAHB.
3. Send a halt request to the DMA IAHB and HSE_B IAHB gaskets.
4. Wait for a halt acknowledgement from the DMA IAHB and HSE_B IAHB gaskets.
5. Send a halt request to the system AXBS.
6. Wait for a halt acknowledgement from the system AXBS.
7. Send a halt request to a peripheral AXBS.
8. Wait for a halt acknowledgement from a peripheral AXBS.

9. Send a halt request to the TCM IAHB and QSPI IAHB gaskets.
10. Wait for a halt acknowledgement from the TCM IAHB and QSPI IAHB gaskets.
11. Send a halt request to the AIPS0 IAHB and AIPS1 IAHB gaskets.
12. Wait for a acknowledgement from the AIPS0 IAHB and AIPS1 IAHB gaskets.
13. Send a halt request to TCM AXBS.
14. Wait for a halt acknowledgement from TCM AXBS.

After this halt sequence completes, the crossbar halt acknowledgement sequence also completes and the chip proceeds to the FUNC1 stage in the functional reset entry sequence.

NOTE

RAM retention is supported across the functional reset event for system RAMs only and not for HSE_B or peripheral memories.

29.9 Pad state during reset and after reset

SIUL2 controls the GPIO functionality. It sets to its default state on a functional reset, and ensures that every pad initializes to its default state (see the default configurations and reset states of the chip's GPIO in the IOMUX file attached to this document).

29.10 Reset pin

This chip contains a bidirectional reset pin (RESET_b) indicating the reset state. RESET_b multiplexes with the other functions on port PTA5 (see the IOMUX file attached to this document).

The DCF configuration controls the multiplexing capabilities of RESET_b. The default configuration of the RESET_b port is that of a dedicated reset signal (for example, not multiplexed. See the DCF clients file attached to this document for more information).

The RESET_b pin offers the following uses if you configure it for the reset functionality:

- Acts as an external destructive reset source
- Acts as an indicator for the chip reset sequence

NOTE

MC_RGM.FES[F_EXR] captures an externally sourced RESET_b assertion for a destructive reset.

The RESET_b pin also indicates an internally asserted reset to external modules. It has a weak internal pullup. In normal Run mode, it keeps the chip out of reset.

29.10.1 Reset pin control during self-test

You can write 1 to MC_RGM.ERCTRL[ERASSERT] to assert RESET_b (writes only in Supervisor mode), before LBIST or MBIST executes. MC_RGM then asserts RESET_b and tristates the GPIO pins placing them in a safe state. Tristating GPIO ensures a safe state for the chip pins when LBIST or MBIST executes. Following BIST, the chip executes a reset sequence. The chip configures again for the application software, before executing the safety function. MC_RGM.ERCTRL[ERASSERT] clears on a functional reset. See Figure 8 for an illustration.

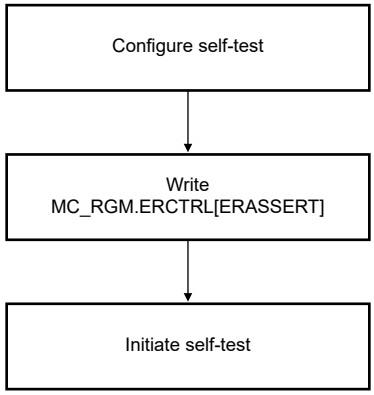


Figure 128. Reset pin control before self-test

Multiple chip configuration scenarios cause RESET_b to react differently after self-test completion:

- You can write 1 to MC_RGM.ERCTRL[ERASSERT] causing RESET_b to assert. This assertion does not impact the reset sequence, and the reset indicates that the chip is not available in Functional mode (although the chip is not in reset sequence).

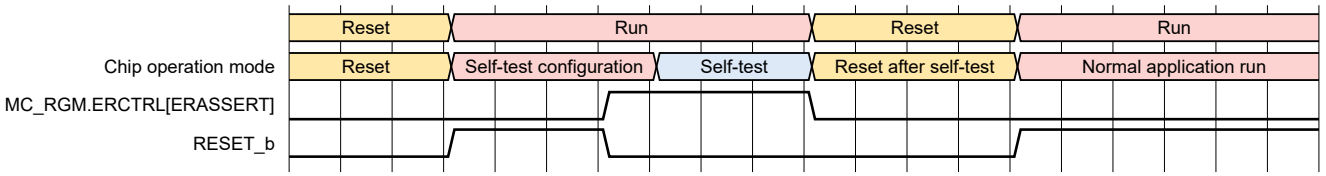


Figure 129. Reaction when MC_RGM.ERCTRL[ERASSERT] = 1 and MC_RGM.FBRE[ST_DONE] = 0

- If MC_RGM.ERCTRL[ERASSERT] = 0 (the default value), the RESET_b pin goes low after self-test completes. After self-test, the chip undergoes a functional reset in which the chip hardware writes 0 to MC_RGM.ERCTRL[ERASSERT]. The RESET_b pin goes high after the reset deasserts.

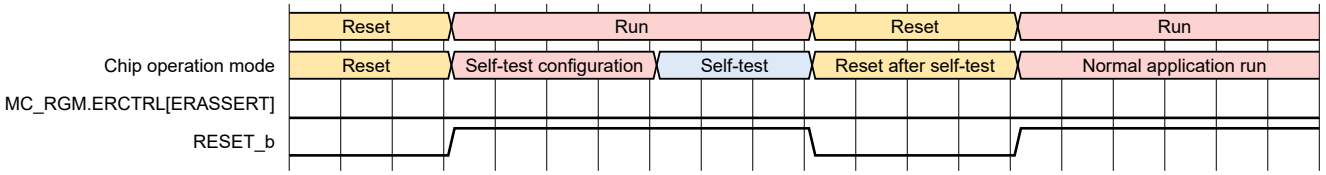


Figure 130. Reaction when MC_RGM.ERCTRL[ERASSERT] = 0 and MC_RGM.FBRE[ST_DONE] = 0

- If MC_RGM.ERCTRL[ERASSERT] = 0 (the default value), but you write 1 to MC_RGM.FBRE[ST_DONE], the RESET_b pin does not assert after self-test completes.

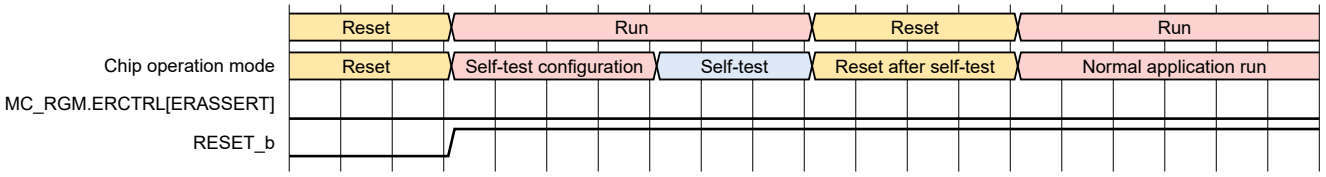


Figure 131. Reaction when MC_RGM.ERCTRL[ERASSERT] = 0 and MC_RGM.FBRE[ST_DONE] = 1

29.11 Reset control in Lockstep mode

In Lockstep mode, a two-cycle delayed lockstep implementation controls the reset to both the application cores, Cortex-M7_0 and Cortex-M7_1. This lockstep implementation means Cortex-M7_0 starts two clock cycles before Cortex-M7_1. You can configure the dcf_client_utest_misc[LOCSTEP_EN] field to control the lockstep (see the DCF clients file attached to this document for more information).

The Cortex-M7 cores consist of two reset domains:

- PORESETn (see PORESETn control in Lockstep mode)
- SYSRESETn (see SYSRESETn control in lockstep)

29.11.1 PORESETn control in Lockstep mode

PORESETn includes debug modules that work across chip warm resets. The PORESETn domain resets on any destructive reset event. PORESETn deasserts after two cycles of reset deassertion synchronization delay, as soon as destructive reset sequence exits. In Lockstep mode, the reset deassertion to Cortex-M7_1 is further delayed by two CORE_CLK cycles as shown in below figures.

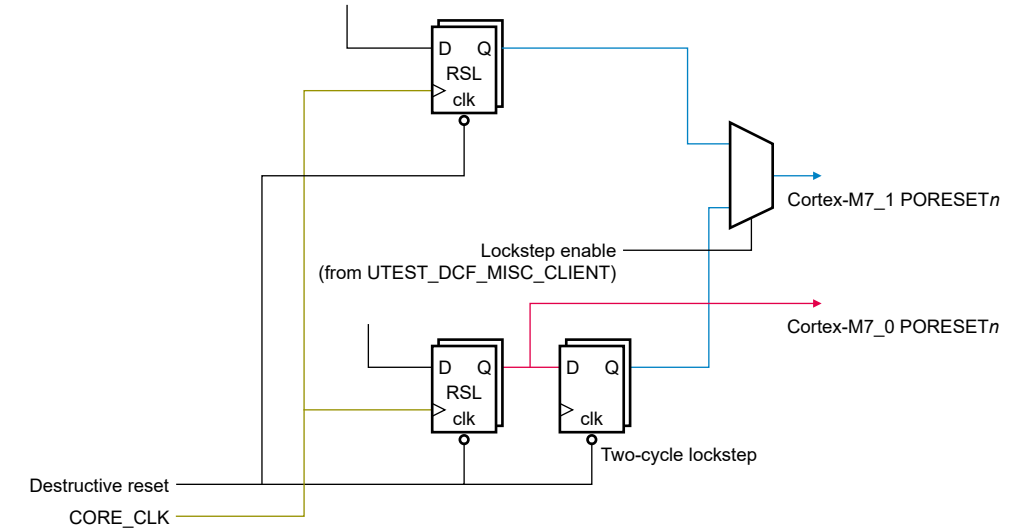


Figure 132. PORESETn control in Lockstep mode for core 0 and 1

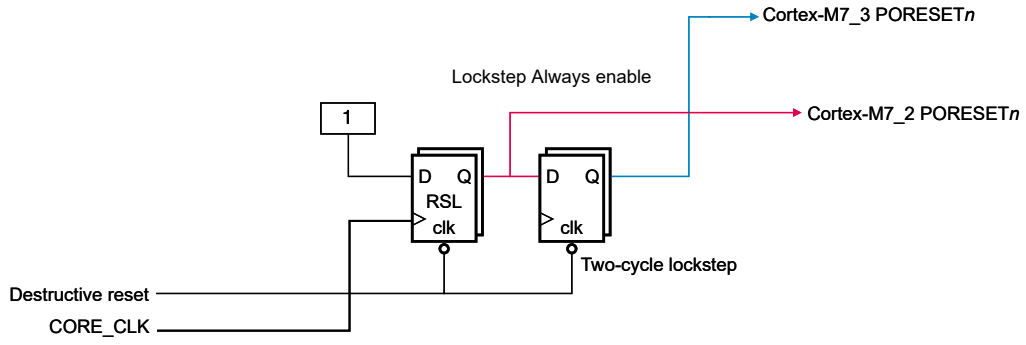


Figure 133. PORESETn control in Lockstep mode for core 2 and 3

29.11.2 SYSRESETn control in lockstep

Most of the components within the Cortex-M7 cores reside in the SYSRESETn domain, except the debug modules. These components reset on any functional reset event. The SYSRESETn reset remains gated even if it exits the functional reset until MC_ME.PRTN0_COREn_PCONF[CCE] enables the core clocks. The debugger can hold the core's SYSRESETn domain in reset, as described in section Application core debug from first instruction.

After a chip's functional reset deasserts, the core clocks are functional, and there is no gating from the debugger, the application core's SYSRESETn is released after a two-cycle reset deassertion synchronizer delay. In Lockstep mode, the reset deassertion to Cortex-M7_1 is delayed by two CORE_CLK cycles, as shown in below figures.

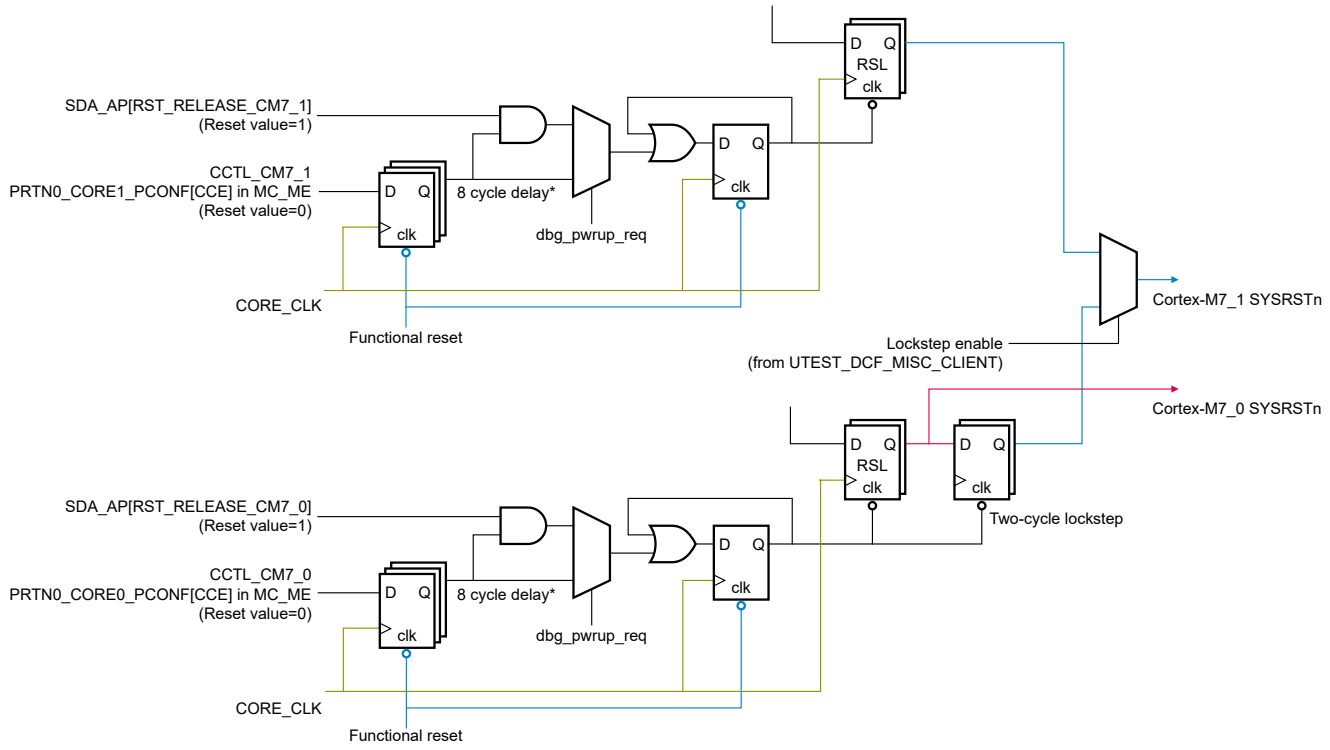


Figure 134. SYSRESETn control in Lockstep mode

29.12 Application core debug from first instruction

The chip supports application core debug starting on the first instruction. This is supported on any functional reset and through a RESET_b pin destructive reset for debug from destructive reset onwards using the following sequence (see SYSRESETn control in lockstep for more information on implementation).

29.12.1 Debug from first instruction on power-up or destructive reset onwards

1. When RESET_b is held low, the chip goes through a destructive reset sequence.
2. When you pull down the RESET_b pin, the chip goes through a destructive reset sequence, exits from the destructive reset, and remains in functional reset, until the reset pin is released.
3. When the RESET_b pin remains pulled down, the debugger configures SDA_AP.SDAAPRSTCTRL[RSTRELTLCM7n] according to the requirements. To enable debug from first instruction, you write 0 to these fields. To disable, you write 1. By default, the debug disables from the first instruction.
4. On releasing the reset pin, the chip exits from the functional reset sequence and chip starts executing.

5. The PORESETn deassertion occurs for the application cores simultaneously (in case of lockstep, Cortex-M7_1 PORESETn deasserts after a two-cycle delay). The corresponding core clock enable gates the deassertion of SYSRESETn to cores. The SYSRESETn to the cores deasserts as follows.
6. On the basis of whether the debugger authentication is performed via challenge, response, or neither of them, you can consider these scenarios:
    a. Debugger not connected (DBG_PWRUP_REQ = 0):
        i. BAF or FW writes to the clock enable control field in MC_ME for application cores, that is, to MC_ME.PRTN0_COREn_PCONF[CCE] for Cortex-M7_n as required for Cortex-M7_0, Cortex-M7_1, and Cortex-M7_2 cores.
        ii. The clock enables in the subsequent clock cycle.
        iii. SYSRESETn deasserts after ten clock cycles (adding eight clock cycles of delay ensures that reset always deasserts when the clock is available; two cycle of reset deassertion delay). In case of lockstep, Cortex-M7_1 reset is delayed by two additional clock cycles.
    b. Debugger connected (DBG_PWRUP_REQ = 1) (Debug from first instruction):
        i. The clock enable control field in MC_ME for application cores, that is, to MC_ME.PRTN0_COREn_PCONF[CCE] for Cortex-M7_n as required for Cortex-M7_0, Cortex-M7_1, and Cortex-M7_2 cores.
        ii. The clock is enabled.
        iii. The debugger waits at least ten clock cycles and then writes 1 to SDA_AP.SDAAPRSTCTRL[RSTRELTLCM7n] for Cortex-M7_n for releasing SYSRESETn of the corresponding core.
        iv. SYSRESETn deasserts after ten clock cycles (adding eight clock cycles of delay ensures that the reset always deasserts when the clock is available; two cycle of reset synchronization delay). In case of lockstep, the Cortex-M7_1 reset is delayed by two additional clock cycles.

29.12.2 Debug from first instruction on functional reset onwards

If you enable debug, on functional reset, the debug connection is retained. That is because the complete debug infrastructure is on destructive reset domain.

29.12.3 Debug on standby exit by wake-up or functional reset

If you enable debug before standby entry, then the Standby domain stores the final status. The configuration for reset release is reset (SDA_AP.SDAAPRSTCTRL[RSTRELTLCM70], SDA_AP.SDAAPRSTCTRL[RSTRELTLCM71], and (SDA_AP.SDAAPRSTCTRL[RSTRELTLCM72] the reset value of each of these fields is 1), which defaults to debug from the first instruction disabled.

You must configure the reset release on standby exit by writing 1 to SDA_AP.SDAAPRSTCTRL[RSTRELTLCM7i]. It uses MC_RGM's low-power debug protocol before reset gets released.

29.13 Glossary

DCF	Device configuration format
POR	Power-on reset
LC	Life cycle

Chapter 30
Reset Generation Module (MC_RGM)

30.1 Chip-specific MC_RGM information

30.1.1 MC_RGM configuration

The "Reset sources—POR, Destructive, and Functional" section of the "Reset Overview" chapter provides information about MC_RGM's reset sources. The chapter also provides details about the chip's reset architecture.

NOTE

The ERCTRL register configuration takes several cycles to be effective. Any further access to MC_RGM must happen after at least nine AIPS_SLOW_CLK cycles of writing to ERCTRL.

NOTE

In the event of a destructive reset occurring while the device is in the functional reset entry sequence, the device undergoes a destructive reset event. MC_RGM.FES[FCCU_RST] might be spuriously set during such a case and should be ignored.

30.1.2 S32K396 reset state machine

The reset sequence of the S32K396 product is depicted in the figure below:

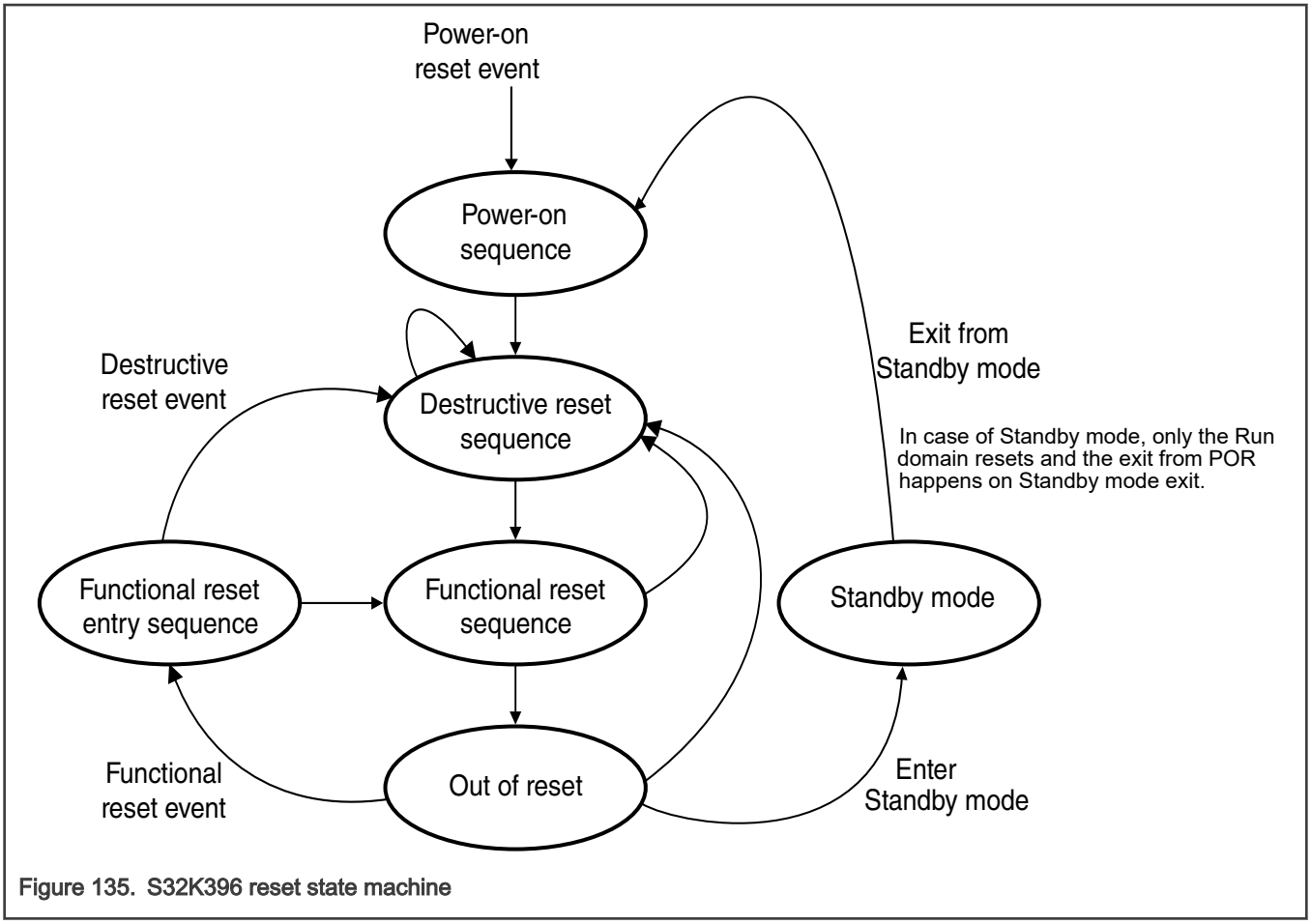


Figure 135. S32K396 reset state machine

30.2 Introduction

The Reset Generation Module (MC_RGM) centralizes the different reset sources and manages the reset sequence of the chip. It provides a register interface and the reset sequencer. There are various registers available in this module to monitor and control the chip reset sequence.

The following figure shows the block diagram of MC_RGM.

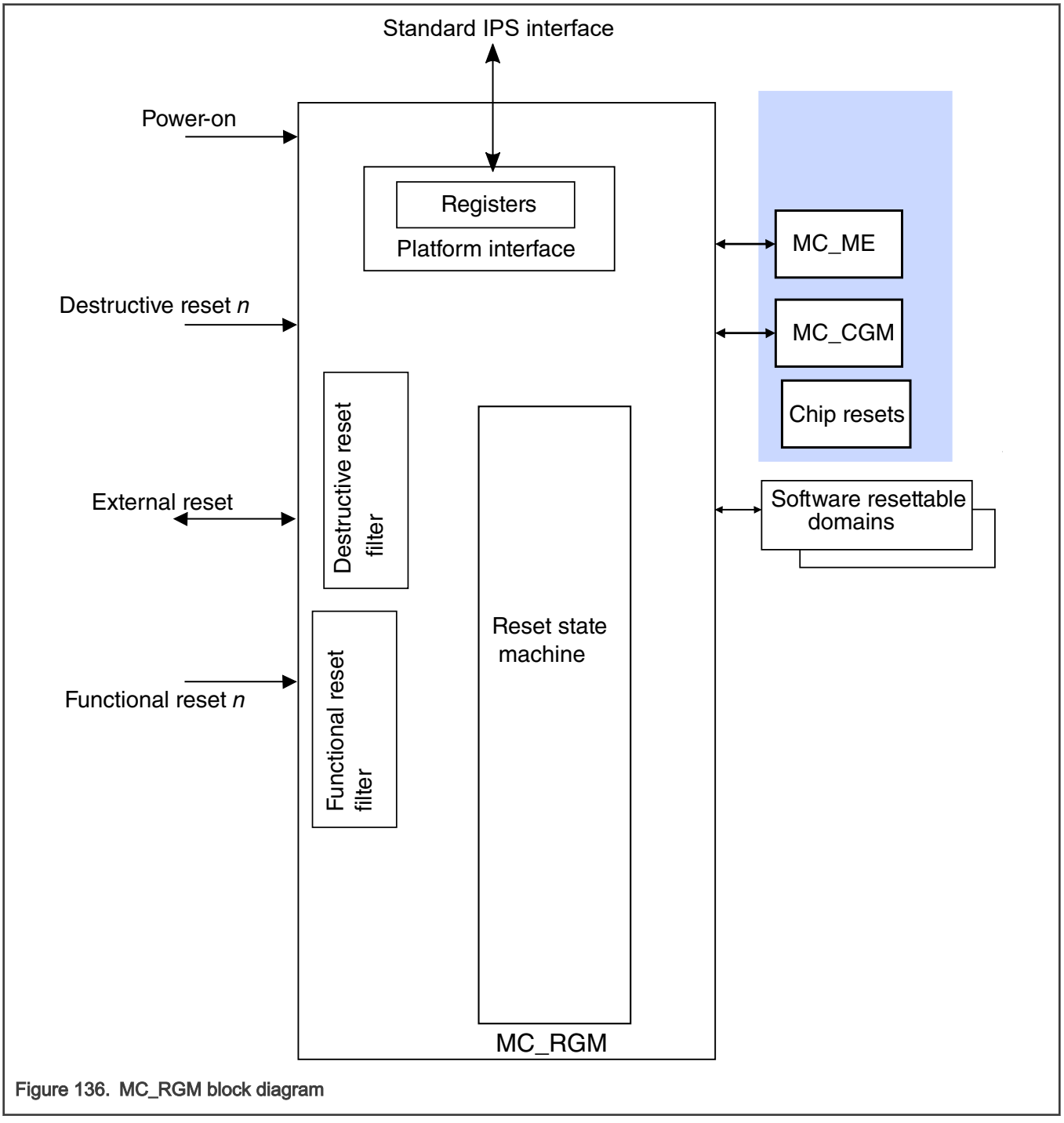


Figure 136. MC_RGM block diagram

30.3 Features

Here are the key features of MC_RGM:

- Destructive and functional reset management
- Capturing the reset sources for each reset sequence (reset status flags)
- Assertion the RESET_B pin to propagate the reset sequence out of chip
- Configurable escalation of recurring 'functional' resets to 'destructive' reset
- Configurable escalation of recurring 'destructive' resets to keep the chip in the reset state until the next power-on reset
- Software controllable reset assertion
- Pad safe state control generation

30.4 Reset sources

The reset sources are organized in three categories: power-on, destructive, and functional.

A power-on reset source is associated with an event typically related to power-up or low-voltage scenarios. When a power-on reset occurs, the full reset sequence is applied to the chip. This resets the full chip, including the MC_RGM, and the memory content must be considered to be invalid.

A destructive reset source is associated with an event related to a critical, usually hardware, error or dysfunction. When a destructive reset event occurs, the full reset sequence is applied to the chip. This resets the full chip ensuring a safe start-up state for both digital and analog modules, and the memory content must be considered to be invalid.

A functional reset source is associated with an event related to a less-critical, usually non-hardware, error or dysfunction. When a functional reset event occurs, a partial reset sequence is applied to the chip. In this case, most digital modules are reset normally, while the state of analog modules or specific digital modules as well as the system memory content is preserved.

30.5 External signal description

The MC_RGM interfaces with the RESET_B pin.

The following table describes the signals that are connected to the I/O pad ring.

Table 151. MC_RGM external signals

Signal name	Reset value	Description
RESET_B	0	Active low external reset. A bidirectional reset pin indicating the reset state.

30.6 RESET_B pin assertion and pin safe state control

The MC_RGM asserts the RESET_B pin when the device is in a reset sequence, and it remains asserted until the end of the reset sequence. During this reset sequence, most of the chip's pins are safe/pad stated according to the values shown in the IOMUX table/spreadsheet. Note that the safe state values may vary according to the reset sequence type.

In addition, the MC_RGM has a feature to assert the RESET_B pin through software, without initiating a reset sequence. This is achieved by writing 1b to the ERCTRL[ERASSERT]. When this occurs, most of the chip's pins are safe-stated according to the values shown in the IOMUX table/spread sheet. The RESET_B assertion and pin safe-stating remain active until the end of the next reset sequence.

This features has to be used only with selftest of the main reset domain.

30.7 Functional description

30.7.1 Reset state machine

The main role of MC_RGM is the generation of the reset sequence that ensures that the correct parts of the chip are reset based on the reset source event.

For each reset event, immediately after it is captured by the MC_RGM, the following takes place:

1. The corresponding reset event status bit is set in the MC_RGM_DES and MC_RGM_FES registers.
2. The pins are put into their default states
3. The RESET_B pin is asserted.

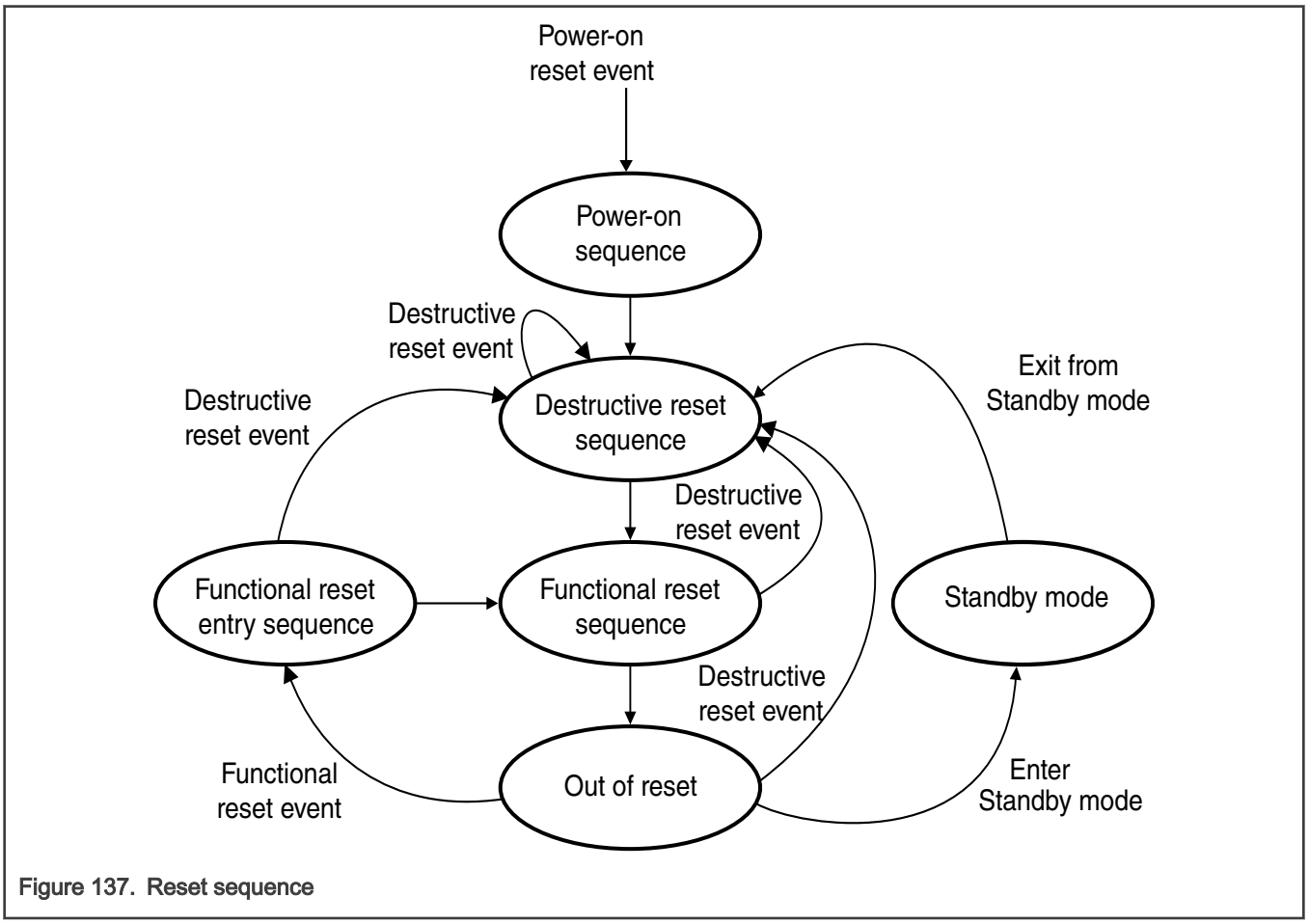


Figure 137. Reset sequence

NOTE

See chip-specific MC_RGM information for chip-specific reset sequence details.

30.7.1.1 Power-on reset sequence

A reset is always generated when the power-on reset source is asserted, and it has priority over all other reset sources. Such a power-on reset forces the reset state machine to enter the power-on sequence resulting in the assertion of all reset signals. The reset state machine starts progressing when the following two conditions are verified:

1. All the power-on reset events are cleared
2. The MC_RGM's clock source (the FIRC) has started up and stabilized

If a power-on reset event has occurred, the DES[F_POR] bit is set.

The power-on reset cannot be demoted by the software.

30.7.1.2 Destructive reset sequence

The 'Destructive reset sequence' is comprised of a single phase, that is DEST0.

This phase is entered immediately from any phase on a power-on, standby reset sequence, or enabled destructive reset event . A destructive reset counter starts immediately on entry in the DEST0 phase. The DEST0 state is exited to functional reset sequence on the rising edge of FIRC immediately after all of the following conditions have been established:

- The DEST0 duration time has expired
- All destructive reset inputs are cleared
- The 'destructive' reset escalator counter has not reached the value in DRET[DRET].

The DEST0 state is immediately exited to the power-on state if a power-on reset event occurs.

30.7.1.3 Functional reset sequence

There are two functional reset sequence, the functional reset entry sequence and the functional reset exit sequence.

30.7.1.3.1 Functional reset entry sequence

The functional reset entry sequence is only entered when a functional reset event occurs during the idle phase.

If a functional reset event occurs during an ongoing reset sequence, the corresponding event status flag is set, and the RESET_B pin is asserted per the reset event's configuration. However, the reset sequence is not influenced, and it continues to progress without interruption.

Functional reset is not asserted during functional reset entry sequence.

The functional reset entry sequence is exited to the DEST0 on the next rising edge of FIRC if a destructive reset event has occurred. The sequence immediately enters the power up sequence if a POR event occurs

In all other cases, the sequence exits to the first stage of functional reset exit sequence.

30.7.1.3.2 Functional reset exit sequence

The functional reset exit sequence is entered either on exit from the destructive reset sequence or on completion of the functional reset entry sequence. The reset state machine exits this sequence and enters the idle phase on verification of the following:

- All the functional reset events are cleared.
- All the processes that take place during the functional reset sequence have completed. For details, see Reset chapter.

If a functional reset event occurs during an ongoing reset sequence, the corresponding event status flag is set, and the RESET_B pin is asserted per the reset event's configuration. However, the reset sequence is not influenced, and it continues to progress without interruption.

30.7.1.4 Idle phase

This is the final phase and is entered on exit from the functional reset exit sequence . When this phase is reached, MC_RGM releases control of the system to the platform and waits for the new reset events that can trigger a reset sequence.

30.7.2 Destructive resets

A destructive reset indicates that an event has occurred after which critical register or memory content can no longer be guaranteed.

The status flag associated with a given destructive reset event (Destructive Event Status Register (DES)) is set when the destructive reset is asserted and the power-on reset is not asserted. It is possible for multiple status bits to be set simultaneously and the software determines which reset source is the most critical for the application.

The low-voltage detector threshold ensures that when the reset corresponding to the core supply low-voltage detect is enabled, the supply is sufficient to have the destructive event correctly propagated through the digital logic. Therefore, if a given destructive reset is enabled, MC_RGM ensures that the associated reset event is correctly triggered to the full system.

An enabled destructive reset triggers a reset sequence starting from the beginning of DEST0.

30.7.3 External reset

MC_RGM manages the external reset coming from RESET_B. The detection of a falling edge on RESET_B starts the reset sequence from the beginning of the destructive reset entry sequence.

The status flag associated with the external reset falling edge event (the FES[F_EXR]) is set when the external reset is asserted and the power-on reset is not asserted.

30.7.4 Functional resets

A functional reset indicates that an event has occurred after which it can be guaranteed that critical register and memory content is still intact.

The status flag associated with a given functional reset event (Functional /External Reset Status Register (FES)) is set when the functional reset is asserted and the power-on reset is not asserted. It is possible for multiple status bits to be set simultaneously and the software determines which reset source is the most critical for the application.

An enabled functional reset triggers a reset sequence starting from the beginning of the functional reset entry sequence.

30.7.5 Alternate event generation

MC_RGM provides alternative events to be generated on reset source assertion. When a reset source is asserted, MC_RGM normally enters the reset sequence. Alternatively, it is possible for some reset source events to be converted from a reset to an interrupt request issued to the core. Alternate event selection for a given reset source is made through the RGM_FERD register as shown in the following table.

Table 152. Functional Reset Disable Register (RGM_FERD) field descriptions

RGM bit FERD value	Generated event
0	Reset
1	Interrupt request

The alternate event is cleared by deasserting the source of the request (that is, at the reset source that caused the alternate request) and also clearing the appropriate RGM_FES status bit.

30.7.6 RESET_B assertion control

The software indicates to the MC_RGM that the RESET_B is to be asserted by writing to the **ERASSERT** bit in the RGM_ERCTRL register. When this bit is set by the software, RESET_B gets asserted. Setting of this field does not impact the reset sequence in any way.

An example where the ERCTRL[ERASSERT] field could be set by the software is when entering the self test sequence, during which RESET_B is to be asserted. This indicates the chip is not available in the functional mode although a reset sequence is not in progress. The deassertion of RESET_B is not controlled by the software. Instead, the RESET_B pin remains asserted until the next time the chip exits a reset sequence.

ERASSERT bit is also cleared during the reset sequence.

MC_RGM asserts the external reset if the reset sequence is triggered by one of the following:

- A power-on reset

- A destructive reset event
- A functional reset event

In this case, external reset is asserted until all conditions for the exiting reset sequence have been met, with the exception of the RESET_B assertion check

NOTE

Software cannot request for external reset to be asserted in HK mode.

30.7.7 Functional reset escalation

Functional reset escalation can be used to generate a destructive reset if a number of functional resets is occurred between software writes to the RGM_FRET register. This function is enabled by writing a non-zero value to the FRET field of this register.

After the functional reset escalation is enabled, MC_RGM increases a counter on each functional reset that causes a reset sequence to be initiated (which means, entrance into FUNC0 from the IDLE phase). This counter is cleared on a write of any value to the RGM_FRET register and on any power-on or destructive reset. If the counter reaches the value in the FRET field of the RGM_FRET register, MC_RGM asserts a destructive reset.

The following figure shows the functional reset escalation counter.

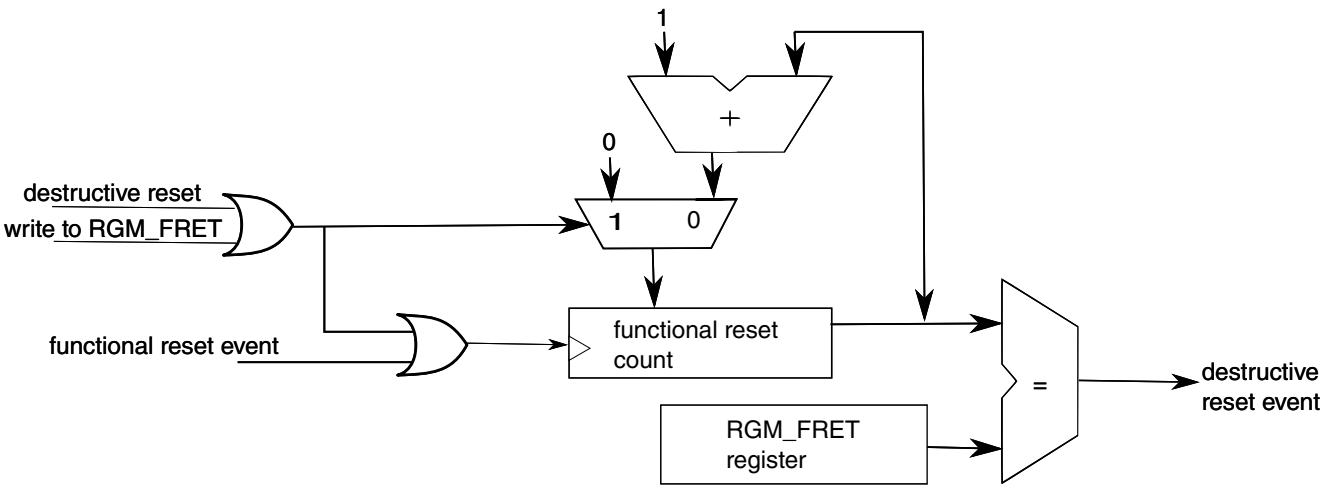


Figure 138. Functional reset escalation counter

NOTE

Functional counter increments for each reset source for which escalation is enabled. For details, see "Reset sources" table in the Reset chapter.

30.7.8 Destructive reset escalation

Destructive reset escalation can be used to keep the chip in the reset state until the power-on triggers a reset sequence if a number of destructive resets are occurred between software writes to the RGM_DRET register. This function is enabled by writing a non-zero value to the DRET field of this register.

After destructive reset escalation is enabled, MC_RGM increases a counter on each destructive reset that is enabled. . This causes a reset sequence to be initiated (that is, entrance into DEST0 from the idle phase or any other reset phase) or an ongoing reset sequence to restart (that is, entrance into DEST0 from any other reset phase). This counter is cleared on a write of any value to the RGM_DRET register and on any power-on reset. If the counter reaches the value in the DRET field of the RGM_DRET register, MC_RGM enters reset DEST0 and stays there until the next power-on reset occurs .

The following figure shows the destructive reset escalation counter.

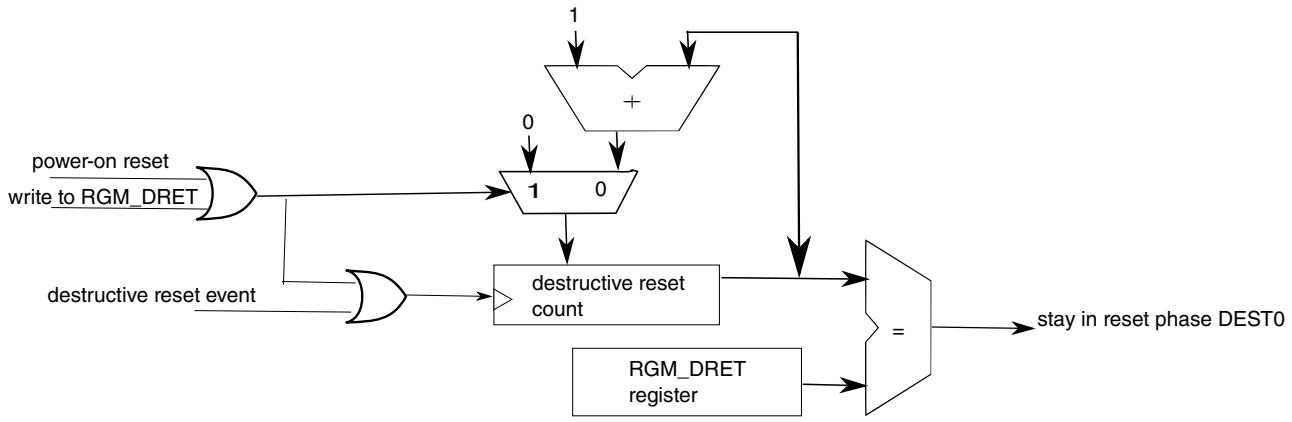


Figure 139. Destructive reset escalation counter

NOTE

Destructive counter increments for each reset source for which escalation is enabled. For details, see "Reset sources" table in the Reset chapter.

30.8 MC_RGM register descriptions

Access to the following locations do not generate transfer error:

- 2Ch

30.8.1 MC RGM Register Map memory map

MC_RGM base address: 4028_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Destructive Event Status Register (DES)	32	RW	0000_0001h
8h	Functional /External Reset Status Register (FES)	32	RW	0000_0000h
Ch	Functional Event Reset Disable Register (FERD)	32	RW	0000_0000h
10h	Functional Bidirectional Reset Enable Register (FBRE)	32	RW	0000_0000h
14h	Functional Reset Escalation Counter Register (FREC)	32	RW	0000_0000h
18h	Functional Reset Escalation Threshold Register (FRET)	32	RW	0000_000Fh
1Ch	Destructive Reset Escalation Threshold Register (DRET)	32	RW	0000_0000h
20h	External Reset Control Register (ERCTRL)	32	RW	0000_0000h
24h	Reset During Standby Status Register (RDSS)	32	RW	0000_0000h

30.8.2 Destructive Event Status Register (DES)

Offset

Register	Offset
DES	0h

Function

This register contains the status of the 'destructive' reset sources. This register can be accessed as read/write in supervisor mode and read-only in user mode. Register bits are cleared on write '1'. This register is reset only on power-on reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	DEBUG_D...	SW_DEST	0	0	0	0	0	0	0	0	0	0	HSE_SNV...	HSE_TMP...	CM7_COR...
W		W1C	W1C											W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SYS_DIV...	HSE_CLK...	0	AIPS_PL...	0	CORE_CL...	PLL_LOL	FXOSC_F...	0	MC_RGM_...	0	STCU_URF	FCCU_FTR	0	0	F_POR
W	W1C	W1C		W1C		W1C	W1C	W1C		W1C		W1C	W1C			W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31 —	Reserved
30 DEBUG_DEST	Flag for 'Destructive' Reset DEBUG_DEST 0b - 'Destructive' reset event DEBUG_DEST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event DEBUG_DEST has occurred.
29 SW_DEST	Flag for 'Destructive' Reset SW_DEST 0b - 'Destructive' reset event SW_DEST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event SW_DEST has occurred.
28 —	Reserved
27	Reserved

Table continues on the next page...

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Field	Function
—	
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 —	Reserved
22 —	Reserved
21 —	Reserved
20 —	Reserved
19 —	Reserved
18 HSE_SNVS_RST	Flag for 'Destructive' Reset HSE_SNVS_RST 0b - 'Destructive' reset event HSE_SNVS_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event HSE_SNVS_RST has occurred.
17 HSE_TMPR_RST	Flag for 'Destructive' Reset HSE_TMPR_RST 0b - 'Destructive' reset event HSE_TMPR_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event HSE_TMPR_RST has occurred.
16 CM7_CORE_CLK_FAIL	Flag for 'Destructive' Reset CM7_CORE_CLK_FAIL 0b - 'Destructive' reset event CM7_CORE_CLK_FAIL has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event CM7_CORE_CLK_FAIL has occurred.
15 SYS_DIV_FAIL	Flag for 'Destructive' Reset SYS_DIV_FAIL

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - 'Destructive' reset event SYS_DIV_FAIL has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event SYS_DIV_FAIL has occurred.
14 HSE_CLK_FAIL	Flag for 'Destructive' Reset HSE_CLK_FAIL 0b - 'Destructive' reset event HSE_CLK_FAIL has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event HSE_CLK_FAIL has occurred.
13 —	Reserved
12 AIPS_PLAT_CLK_FAIL	Flag for 'Destructive' Reset AIPS_PLAT_CLK_FAIL 0b - 'Destructive' reset event AIPS_PLAT_CLK_FAIL has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event AIPS_PLAT_CLK_FAIL has occurred.
11 —	Reserved
10 CORE_CLK_FAIL	Flag for 'Destructive' Reset CORE_CLK_FAIL 0b - 'Destructive' reset event CORE_CLK_FAIL has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event CORE_CLK_FAIL has occurred.
9 PLL_LOL	Flag for 'Destructive' Reset PLL_LOL 0b - 'Destructive' reset event PLL_LOL has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event PLL_LOL has occurred.
8 FXOSC_FAIL	Flag for 'Destructive' Reset FXOSC_FAIL 0b - 'Destructive' reset event FXOSC_FAIL has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event FXOSC_FAIL has occurred.
7 —	Reserved
6 MC_RGM_FRE	Flag for 'Destructive' Reset MC_RGM_FRE 0b - 'Destructive' reset event MC_RGM_FRE has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event MC_RGM_FRE has occurred.

Table continues on the next page...

Table continued from the previous page...

Field	Function
5 —	Reserved
4 STCU_URF	Flag for 'Destructive' Reset STCU_URF 0b - 'Destructive' reset event STCU_URF has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event STCU_URF has occurred.
3 FCCU_FTR	Flag for 'Destructive' Reset FCCU_FTR 0b - 'Destructive' reset event FCCU_FTR has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Destructive' reset event FCCU_FTR has occurred.
2 —	Reserved
1 —	Reserved
0 F_POR	Flag for power-on reset **NOTE** If this field is set, ignore all the fields of Destructive Event Status Register (DES) and Functional /External Reset Status Register (FES) registers at power up. 0b - No power-on event has occurred since the last clear. 1b - A power-on event has occurred.

30.8.3 Functional /External Reset Status Register (FES)

Offset

Register	Offset
FES	8h

Function

This register contains the status of the 'functional' and external reset sources. This register can be accessed as read/write in supervisor mode and read-only in user mode. Register fields are cleared on write '1' if the triggering event has already been cleared at the source. This register is reset only on power-on reset.

NOTE

- The startup self-test functional reset event to MC_RGM initiates a functional reset sequence after which the FES[ST_DONE] is set. This field is sticky in nature and gets cleared if software clears this field.
- If functional reset escalation to destructive reset is disabled, then the status of this register must be ignored if the fields of Destructive Event Status Register (DES) other than DES[F_POR] are set.
- If functional reset escalation to destructive reset is enabled and if the fields of Destructive Event Status Register (DES), other than DES[F_POR], are set, then based on these fields user should check if the cause of the destructive reset was due to functional reset escalation or if it was triggered directly by a destructive reset source, in which case FES needs to be ignored.
- See chip-specific MC_RGM information for applicability of the FES[ST_DONE] field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	DEBUG_F...	SW_FUNC	0	0	0	0	0	0	0	0	HSE_BOO...	0	0	0	HSE_SWT...
W		W1C	W1C									W1C				W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	JTAG_RST	SWT2_RST	SWT1_RST	SWT0_RST	0	ST_DONE	FCCU_RST	0	0	F_EXR
W							W1C	W1C	W1C	W1C		W1C	W1C			W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 DEBUG_FUNC	Flag for 'Functional' Reset DEBUG_FUNC 0b - 'Functional' reset event DEBUG_FUNC has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event DEBUG_FUNC has occurred.
29 SW_FUNC	Flag for 'Functional' Reset SW_FUNC 0b - 'Functional' reset event SW_FUNC has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event SW_FUNC has occurred.
28 —	Reserved
27	Reserved

Table continues on the next page...

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Field	Function
—	
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 —	Reserved
22 —	Reserved
21 —	Reserved
20 HSE_BOOT_RST	Flag for 'Functional' Reset HSE_BOOT_RST 0b - 'Functional' reset event HSE_BOOT_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event HSE_BOOT_RST has occurred.
19 —	Reserved
18 —	Reserved
17 —	Reserved
16 HSE_SWT_RST	Flag for 'Functional' Reset HSE_SWT_RST 0b - 'Functional' reset event HSE_SWT_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event HSE_SWT_RST has occurred.
15 —	Reserved
14	Reserved

Table continues on the next page...

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Field	Function
—	
13 —	Reserved
12 —	Reserved
11 —	Reserved
10 —	Reserved
9 JTAG_RST	Flag for 'Functional' Reset JTAG_RST 0b - 'Functional' reset event JTAG_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event JTAG_RST has occurred.
8 SWT2_RST	Flag for 'Functional' Reset SWT2_RST 0b - 'Functional' reset event SWT2_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event SWT2_RST has occurred.
7 SWT1_RST	Flag for 'Functional' Reset SWT1_RST 0b - 'Functional' reset event SWT1_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event SWT1_RST has occurred.
6 SWT0_RST	Flag for 'Functional' Reset SWT0_RST 0b - 'Functional' reset event SWT0_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event SWT0_RST has occurred.
5 —	Reserved
4 ST_DONE	Flag for 'Functional' Reset ST_DONE 0b - 'Functional' reset event ST_DONE has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event ST_DONE has occurred.
3	Flag for 'Functional' Reset FCCU_RST

Table continues on the next page...

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Field	Function
FCCU_RST	0b - 'Functional' reset event FCCU_RST has not occurred since either the last clear or the last power-on reset assertion. 1b - 'Functional' reset event FCCU_RST has occurred.
2 —	Reserved
1 —	Reserved
0 F_EXR	Flag for External Reset External reset is a source of destructive reset. 0b - No external reset event has occurred since either the last clear or the last power-on reset assertion. 1b - An external reset event has occurred.

30.8.4 Functional Event Reset Disable Register (FERD)

Offset

Register	Offset
FERD	Ch

Function

This register provides dedicated fields to disable functional reset sources. When any of these reset sources are disabled, the associated functional event is demoted to trigger an interrupt request. This register can be accessed as read/write in supervisor mode and read-only in user mode. Each byte can be written to only once after a destructive or power-on reset and this register is reset only on power-on and any destructive reset.

NOTE

It is important to clear the Functional /External Reset Status Register (FES) before writing 1 to any of the fields in this register. Otherwise a interrupt request may occur.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	D_DEBUG...	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	D_JTAG_...	D_SWT2_...	D_SWT1_...	D_SWT0_...	0	0	D_FCCU_...	0	0	Reserved
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 D_DEBUG_FUNC	DEBUG_FUNC Disable Control 0b - Functional reset event DEBUG_FUNC triggers a reset sequence. 1b - Functional reset event DEBUG_FUNC generates an interrupt request.
29 —	Reserved
28 —	Reserved
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 —	Reserved
22	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
21 —	Reserved
20 —	Reserved
19 —	Reserved
18 —	Reserved
17 —	Reserved
16 —	Reserved
15 —	Reserved
14 —	Reserved
13 —	Reserved
12 —	Reserved
11 —	Reserved
10 —	Reserved
9 D_JTAG_RST	JTAG_RST Disable Control 0b - Functional reset event JTAG_RST triggers a reset sequence. 1b - Functional reset event JTAG_RST generates an interrupt request.
8	SWT2_RST Disable Control

Table continues on the next page...

Table continued from the previous page...

Field	Function
D_SWT2_RST	0b - Functional reset event SWT2_RST triggers a reset sequence. 1b - Functional reset event SWT2_RST generates an interrupt request.
7 D_SWT1_RST	SWT1_RST Disable Control 0b - Functional reset event SWT1_RST triggers a reset sequence. 1b - Functional reset event SWT1_RST generates an interrupt request.
6 D_SWT0_RST	SWT0_RST Disable Control 0b - Functional reset event SWT0_RST triggers a reset sequence. 1b - Functional reset event SWT0_RST generates an interrupt request.
5 —	Reserved
4 —	Reserved
3 D_FCCU_RST	FCCU_RST Disable Control 0b - Functional reset event FCCU_RST triggers a reset sequence. 1b - Functional reset event FCCU_RST generates an interrupt request.
2 —	Reserved
1 —	Reserved
0 —	Reserved

30.8.5 Functional Bidirectional Reset Enable Register (FBRE)

Offset

Register	Offset
FBRE	10h

Function

This register enables the generation of an external reset on 'functional' reset.This register can be accessed as read/write in supervisor mode and read-only in user mode. This register is reset on power-on and any 'destructive' reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	BE_DEBU...	BE_SW_F...	0	0	0	0	0	0	0	0	BE_HSE_...	0	0	0	BE_HSE_...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	BE_JTAG...	BE_SWT2...	BE_SWT1...	BE_SWT0...	0	BE_ST_D...	BE_FCCU...	0	0	Reserved
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 BE_DEBUG_FUNC	Bidirectional Reset Enables for 'Functional' Reset DEBUG_FUNC 0b - External reset pin is asserted on a 'Functional' reset DEBUG_FUNC event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset DEBUG_FUNC event.
29 BE_SW_FUNC	Bidirectional Reset Enables for 'Functional' Reset SW_FUNC 0b - External reset pin is asserted on a 'Functional' reset SW_FUNC event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset SW_FUNC event.
28 —	Reserved
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
22 —	Reserved
21 —	Reserved
20 BE_HSE_BOOT_RST	Bidirectional Reset Enables for 'Functional' Reset HSE_BOOT_RST 0b - External reset pin is asserted on a 'Functional' reset HSE_BOOT_RST event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset HSE_BOOT_RST event.
19 —	Reserved
18 —	Reserved
17 —	Reserved
16 BE_HSE_SWT_RST	Bidirectional Reset Enables for 'Functional' Reset HSE_SWT_RST 0b - External reset pin is asserted on a 'Functional' reset HSE_SWT_RST event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset HSE_SWT_RST event.
15 —	Reserved
14 —	Reserved
13 —	Reserved
12 —	Reserved
11 —	Reserved
10	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
9 BE_JTAG_RST	Bidirectional Reset Enables for 'Functional' Reset JTAG_RST 0b - External reset pin is asserted on a 'Functional' reset JTAG_RST event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset JTAG_RST event.
8 BE_SWT2_RST	Bidirectional Reset Enables for 'Functional' Reset SWT2_RST 0b - External reset pin is asserted on a 'Functional' reset SWT2_RST event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset SWT2_RST event.
7 BE_SWT1_RST	Bidirectional Reset Enables for 'Functional' Reset SWT1_RST 0b - External reset pin is asserted on a 'Functional' reset SWT1_RST event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset SWT1_RST event.
6 BE_SWT0_RST	Bidirectional Reset Enables for 'Functional' Reset SWT0_RST 0b - External reset pin is asserted on a 'Functional' reset SWT0_RST event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset SWT0_RST event.
5 —	Reserved
4 BE_ST_DONE	Bidirectional Reset Enables for 'Functional' Reset ST_DONE 0b - External reset pin is asserted on a 'Functional' reset ST_DONE event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset ST_DONE event.
3 BE_FCCU_RST	Bidirectional Reset Enables for 'Functional' Reset FCCU_RST 0b - External reset pin is asserted on a 'Functional' reset FCCU_RST event if the reset is enabled. 1b - External reset pin is not asserted on a 'functional' reset FCCU_RST event.
2 —	Reserved
1 —	Reserved
0 —	Reserved

30.8.6 Functional Reset Escalation Counter Register (FREC)

Offset

Register	Offset
FREC	14h

Function

This register provides the current value of functional reset escalation counter. It can be accessed in read/write, either in supervisor mode. It can be accessed in read in the user mode. This register is reset by power-on reset, destructive reset, when you reconfigure the FREC field to Fh and when you write any value to the Functional Reset Escalation Threshold Register (FRET) register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												FREC			
W													W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved
3-0 FREC	Functional' Reset Escalation Counter This field provides the value of functional reset escalation counter.

30.8.7 Functional Reset Escalation Threshold Register (FRET)

Offset

Register	Offset
FRET	18h

Function

This register sets the threshold for 'functional' reset escalation to a 'destructive' reset. It can be accessed in read/write, either in supervisor mode. It can be accessed in read-only in the user mode. Writing a non-zero value to the FRET field enables the 'functional' reset escalation function. Writing any value to this register resets the 'functional' reset escalation counter. See Functional reset escalation for details on the 'functional' reset escalation function. This register is reset on power-on and any 'destructive' reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												FRET			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

Fields

Field	Function
31-4 —	Reserved
3-0 FRET	'Functional' Reset Escalation Threshold If the value of this field is 0, the 'functional' reset escalation function is disabled. Any other value is the number of 'functional' resets that causes a 'destructive' reset.

30.8.8 Destructive Reset Escalation Threshold Register (DRET)

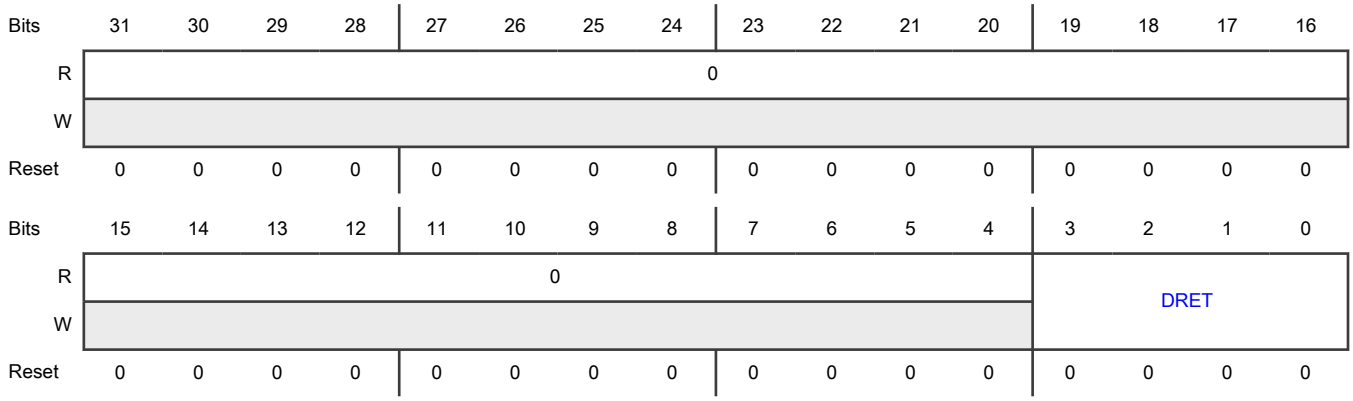
Offset

Register	Offset
DRET	1Ch

Function

This register sets the threshold for 'destructive' reset escalation to keeping the chip in the reset state until the next power-on reset triggers a new reset sequence. It can be accessed in read/write, either in supervisor mode. It can be accessed in read-only in the user mode. Writing a non-zero value to the DRET field enables the 'destructive' reset escalation function. Writing any value to this register resets the 'destructive' reset counter. See Destructive reset escalation for details on the 'destructive' reset escalation function. This register is reset only on power-on reset.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 DRET	'Destructive' Reset Escalation Threshold If the value of this field is 0, the 'destructive' reset escalation function is disabled. Any other value is the number of 'destructive' resets which keeps the chip in the reset state until the next power-on reset triggers a new reset sequence.

30.8.9 External Reset Control Register (ERCTRL)

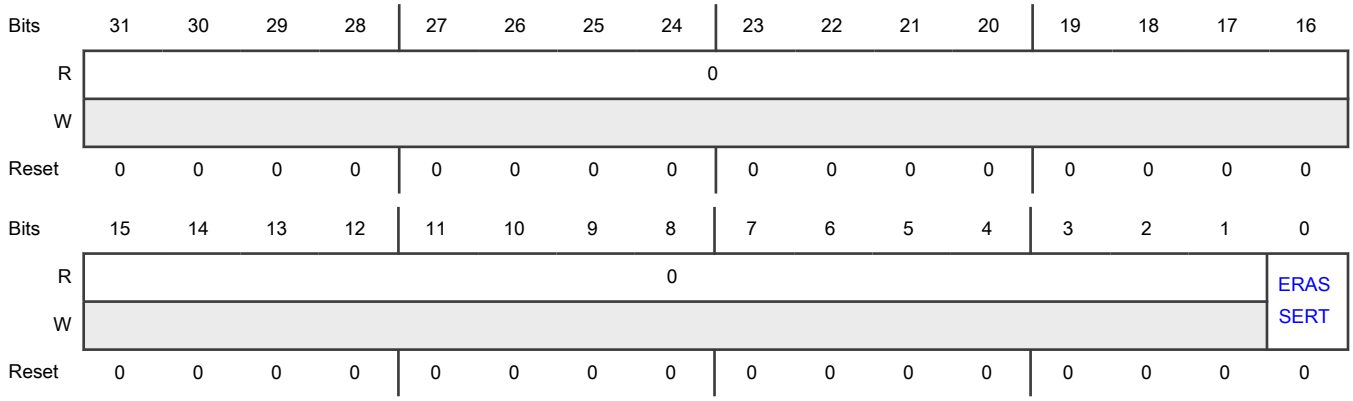
Offset

Register	Offset
ERCTRL	20h

Function

This register allows software to control the assertion of External reset pin. It can be accessed in read/write, in supervisor mode. It can be accessed in read-only in the user mode. This register is reset on all resets.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 ERASSERT	ERASSERT **NOTE** Setting ERASSERT to 1b also safe/pad states most of the chip's pins. See the IOMUX table/spreadsheet for each pin's safe/pad state value. Software must use the ERASSERT field for this purpose only as part of the main reset domain self-test entry procedure. Using it at any other time may result in unpredictable system behavior. 0b - No change 1b - External reset is asserted

30.8.10 Reset During Standby Status Register (RDSS)

Offset

Register	Offset
RDSS	24h

Function

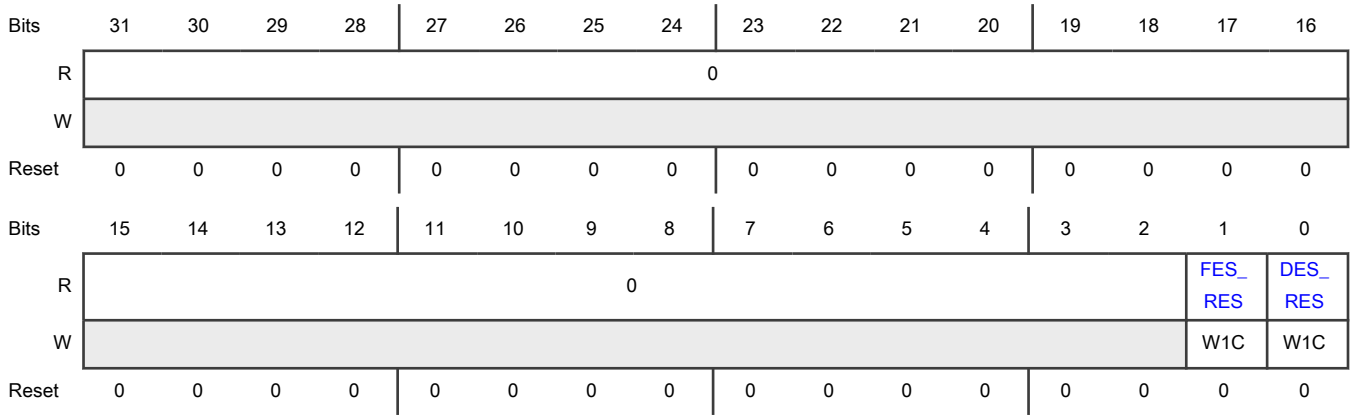
This register provides status of whether a reset event occurred during standby mode. Register bits are cleared on write '1'. This register is reset only on power-on reset.

NOTE

On exiting a reset sequence after standby exit, the software must perform a read operation on MC_ME[PREV_MODE] and RDSS register. If any field of the RDSS register is set, the software must ignore the status reported by MC_ME[PREV_MODE] register otherwise the status of MC_ME[PREV_MODE] register reports the device status.

If MC_ME indicates last mode as RESET, then perform a reset exit in software else a standby exit.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 FES_RES	FES_RES 0b - No functional reset event occurred during standby mode. 1b - Functional reset event occurred during standby mode.
0 DES_RES	DES_RES 0b - No destructive reset event occurred during standby mode. 1b - Destructive reset event occurred during standby mode.

Chapter 31
Power-on Reset Watchdog (POR_WDG)

31.1 Introduction

POR_WDG monitors the chip for stuck or hang scenarios during reset and standby sequences. It generates a chip power-on-reset event to recover the chip in case it remains stuck in reset or standby entry/exit duration for a pre-configured period of time.

POR_WDG consists of a watchdog counter with a configurable threshold. After the threshold is reached POR_WDG generates a chip power-on-reset event.

SIRC clocks POR_WDG.

31.2 Features

- Watchdog Counter with four possible configurable threshold limits (configured by the DCF record).
- DCM_GPR.DCMROPPx registers for capturing the device state when the POR_WDG overflow and trigger the POR.
- Monitors duration of reset, standby entry, and standby exit sequence.

31.3 Configurations

POR_WDG is enabled by default out of reset to actively monitor the chip reset sequence with the default timeout threshold duration. The POR_WDG configuration controls support provisions for enabling or disabling POR_WDG and the counter threshold, as described in the following sections.

31.3.1 Enable/disable configurations

By default POR_WDG is enabled for reset sequence monitoring, as well as standby entry/exit sequence monitoring for stuck scenarios. The following table describes the controls to enable or disable POR_WDG operation.

Table 153. POR_WDG enable/disable control

POR_WDG monitoring	Default configuration	Enable/disable
Reset monitoring	Enabled	dcf_client_utest_misc[8] Enables or disables POR_WDG for reset monitoring. 0: Disable 1: Enable See the DCF clients file attached to this document for details.
Standby entry/exit monitoring	Enabled	DCM's DCMRWP1[8] Enables or disables POR_WDG for standby entry/exit monitoring. 0: Enable 1: Disable See the DCM chapter for details.

31.3.2 Timeout configurations

POR_WDG supports four configurable counter threshold levels for its counter, as listed in the table below. The default POR_WDG timeout is 25 ms.

Table 154. POR_WDG timeout configuration

DCM's DCMRWP1[10]	DCM's DCMRWP1[9]	POR_WDG timeout
0	0	6.25 ms
0	1	12.50 ms
1	0	25.00 ms (default)
1	1	50.00 ms

31.3.3 Event and status registers

POR_WDG provides indication of a POR_WDG event along with the status of the chip at the point when the POR_WDG counter overflows.

POR_WDG event status register: A POR_WDG event is captured in DCM status register DCMROPP4[0].

POR_WDG status registers: The status of the chip at the POR_WDG event is captured in DCM status registers DCMROPP1–DCMROPP3. See the Device Configuration Module General-Purpose Registers (DCM_GPR) chapter for details.

DCM's DCMROPP*n* are reset on a POR caused by PMC and are unaffected by a POR_WDG reset.

31.4 Reset sequence monitoring

31.4.1 Introduction

On every reset event, POR_WDG starts monitoring the duration of the reset sequence (including the functional reset entry sequence, in case of functional reset event).

If the chip does not exit the reset sequence within the POR_WDG timeout threshold, then POR_WDG initiates a POR sequence to recover the chip from a stuck or hung scenario. You can view the POR_WDG status register (DCMROPPn Register) to obtain:

- Diagnostic status
- Chip details in the event of a POR_WDG reset

31.4.2 Inactive windows or bypass operation

POR_WDG monitoring of the reset sequence is inactive in the following conditions:

- POR_WDG is disabled for reset monitoring by chip configuration in UTEST via dcf_client_utest_misc[8]. See the DCF clients file attached to this document for details.
- MC_RGM destructive reset escalation (ensures that the chip stays in reset).
- Extend pin reset by keeping it pressed externally.
- During selftest, when MC_RGM.RGM_ERCTRL[ERASSERT] is configured as 1.

31.4.3 Windows of operation

POR_WDG monitors the reset sequence in the following scenarios:

- Reset pin is active (when chip is in reset, including the functional reset entry sequence).
- Functional reset is asserted (when reset pad is pulled up but functional reset is asserted).
- Unexpected assertion of RUN domain destructive reset.
- Unexpected assertion of RUN domain functional reset.

31.5 Standby entry/exit sequence monitoring

31.5.1 Introduction

On every standby entry or exit event, POR_WDG starts monitoring the standby sequence (standby entry and standby exit sequence).

If the chip does not exit the standby entry or exit sequence within the POR_WDG timeout threshold, POR_WDG initiates a POR sequence to recover the chip from the stuck or hung scenario. You can then check the POR_WDG status registers in DCM to check the chip status when POR_WDG raised the POR to the chip.

31.5.2 Inactive windows/bypass operation

You can configure DCM's DCMRWP1[8] to disable POR_WDG for standby entry and exit sequence monitoring.

31.5.3 Windows of operation

POR_WDG monitors the standby sequence (standby entry and standby exit) in these scenarios:

- Standby entry sequence monitoring: Monitoring from main core WFI execution until PMC acknowledges Low-Power mode entry.
- Standby exit sequence monitoring: Monitoring from wakeup event until the RUN domain reset recovery.

31.6 Glossary

WFI	Wait for Interrupt

Chapter 32
Boot Overview

32.1 Overview

32.1.1 Introduction

This chapter describes the system boot sequence and provides details about boot options.

After the hardware reset sequence completes, the only CPU available is in the HSE subsystem that is referred to as the HSE CPU.

The HSE CPU starts executing firmware code in the HSE code flash memory from a fixed location that contains the SBAF code. This code provides the boot sequence until the control is passed, based on the type of boot:

- Nonsecure boot: Passes control to the customer software that executes on one or all the application cores.
- Secure boot: Passes control to the HSE firmware running on the HSE CPU.

32.2 Appendix

SBAF takes into account the following scenarios to prevent stuck in reset of chip:

- After observing the eight functional resets in the chip, BAF enters Recovery mode sequence to recover the application core's failing status.
- SBAF does not allow the chip's LC to advance to the OEM_PROD or IN_FIELD stage, if the application does not program CUST_DB_PSWD/A.
- SBAF boots the application from the system-RAM during recovery mode sequence to avoid unpredictable behavior.

32.2.1 Features

The features of SBAF are as follows:

- Supports secure and nonsecure Boot modes
- Supports application boot core selection
- Allows chip LC advancement
- Supports debug authorization
- Supports XRDC configuration

32.3 Chip configuration

This section describes the chip configuration details for S32K396 after you program SBAF and clear the HSE firmware feature flag.

If the security is enabled, see the *HSE Firmware Reference Manual* for more information. Please contact NXP sales executive for details.

32.3.1 Memory map

32.3.1.1 Configuration details when the HSE firmware usage feature flag is disabled

Table 155. Configuration details when the HSE firmware usage feature flag is disabled

Memory section	S32K396 configuration
Flash memory	6 MB
IVT locations in priority order[1]	0040_0000h (256 bytes) 0060_0000h (256 bytes) 0080_0000h (256 bytes) 1000_0000h (256 bytes)
Reserved	009F_4000h to 009F_FFFFh (48 KB)
Application flash memory area	0040_0000h to 009F_3FFFh (6096 KB)
Maximum application data flash memory	1000_0000h to 1001_FFFFh (128 KB)

1. For the S32K394, S32K374, and S32K364 devices, 0040_0000h is not available.

32.3.1.2 Configuration details when the HSE_B firmware usage feature flag is enabled

The following table explains the memory sections, which the SBAF uses in case HSE firmware feature flag is enabled in UTEST.

Table 156. Configuration details when the HSE_B firmware usage feature flag is enabled

Memory section	S32K396 configuration
Flash memory	6 MB
IVT locations in priority order[1]	0040_0000h (256 Bytes) 0060_0000h (256 Bytes) 0080_0000h (256 Bytes) 1000_0000h (256 Bytes)
Reserved	0x009D4000 to 0x009FFFFF (176 KB)
Application flash memory area when full memory "HSE firmware" is present	0040_0000h to 009D_3FFFh (5968 KB)
Maximum application data flash memory	1000_0000h to 1001_5FFFh (88 KB)

1. For the S32K394, S32K374, and S32K364 devices, 0040_0000h is not available.

32.3.1.3 AB swap configuration

In this configuration, the flash memory splits into two partitions of equal size, referenced as partition A and partition B.

Table 157. AB swap HSE configuration

Memory section	S32K396 configuration
Flash memory	6 MB
IVT locations in priority order[1]	0040_0000h (256 Bytes) 0060_0000h (256 Bytes) 1000_0000h (256 Bytes)
Reserved code area in active block	0070_0000h to 007F_FFFFh (1 MB)
Reserved code area in passive block	0090_0000h to 009F_FFFFh (1 MB)
Application flash memory area in active block	0060_0000h to 006F_FFFFh (1 MB)
Application flash memory area in passive block	0080_0000h to 008F_FFFFh (1 MB)
Application flash memory area	0x0040_0000 to 0x005F_FFFF (2 MB)
Maximum application data flash memory	1000_0000h to 1001_FFFFh (128 KB)

1. For the S32K394, S32K374, and S32K364 devices, 0040_0000h is not available.

32.4 Common configuration pertaining to the chip

32.4.1 Feature configuration in CUST_DEL Device Life Cycle

The following table describes the status of various features when the chip's LC is in the CUST_DEL stage. The application software configures features directly or indirectly.

Table 158. Feature configuration in CUST_DEL Device Life Cycle

Feature	Configuration information	Status	Configurability
OTA functionality		Disabled	Yes Application requests the HSE firmware or SBAF to enable this feature.
HSE firmware usage feature flag	Indicates whether the firmware installation is allowed in the chip. By default, this flag is unprogrammed, and SBAF assumes that the firmware installation is not allowed.	Unprogrammed	Yes Programmable in the UTEST location (see UTEST flag description for more information).
SBAF firmware		Programmed	No
HSE firmware	You must program the HSE firmware. An encrypted and signed firmware image is always delivered to you.	Not programmed	Yes SBAF can install this feature when

Table continues on the next page...

Table 158. Feature configuration in CUST_DEL Device Life Cycle (continued)

Feature	Configuration information	Status	Configurability
			the application software requests.
Image vector table		Not programmed	Yes The application software can program this feature.
SWT0		Disabled	By SWT bit in boot configuration word.
Boot sequence	Boot sequence is a nonsecure boot, which means, the SBAF boots the application without any authentication.	Nonsecure boot	Yes It can be changed to secure boot by programming the BOOT_SEQ bit in IVT.
Life Cycle		Customer delivery	Yes Advance by SBAF or HSE firmware when requested by application software.
Application core enablement status	Applications cores are booted in recovery mode sequence at address 0x20400100	Recovery mode sequence	Yes Program the required fields in the IVT to enable single or all application cores at the required address.
FIRC frequency value	Configure the FIRC divider by the HSE_B.CONFIG_REG_GPR[FIRC_DIV_SEL] bit.	48 MHz	Yes The application can configure after SBAF moves to WFI in fast standby mode.
Application debug authorization mode	This flag is used to program the authentication method with debugger.	Password-based approach	When the HSE firmware feature flag clears, you cannot change Debug Authorization mode. When the HSE firmware feature flag is set, you can request the HSE firmware to change Debug Authorization mode to Challenge Response mode.

Table continues on the next page...

Table 158. Feature configuration in CUST_DEL Device Life Cycle (continued)

Feature	Configuration information	Status	Configurability
Application core debug status	This flag provides the current status of application core debug.	Enabled	No

32.4.2 UTEST memory location usage by SBAF

See Address LC configuration word for details on LCs.

Table 159. UTEST memory location usage by SBAF

Start address	End address	Size (bytes)	Description	Programmer	Write protected
1B00_0000h	1B00_0007h	8	HSE firmware feature usage flag. See UTEST flag description for more information.	Application software	No
1B00_0040h	1B00_0047h	8	Unique Chip Identifier (UID)	NXP	No
1B00_0050h	1B00_0057h	8	FXOSC configuration flag For more details, see UTEST flag description.	Application software	No
1B00_0080h	1B00_009Fh	32	Debug password (CUST_DB_PSWD_A) After the HSE firmware usage feature flag clears, SBAF uses this location to run the debug authorization feature. SBAF copies this value in the application expected response register. The size of this register is 16 bytes, and 1B00_0090h – 1B00_009Fh is reserved. After the HSE firmware usage feature flag sets, the HSE firmware programs the password at a different location. DCM scans the password during reset only and retains the password in standby.	Application software	No

See the DCF clients file attached to this document for more information.

32.4.3 UTEST flag description

32.4.3.1 HSE firmware usage feature flag

This flag indicates to SBAF that the application intends to use the HSE firmware on the chip. By default, this flag is unprogrammed, and SBAF assumes that the HSE firmware installation is not allowed in the secure samples. However, if application allows the installation of the HSE firmware, the HSE firmware usage feature flag can be programmed in the UTEST at the 1B00_0000h location.

Table 160. HSE firmware usage feature flag

Field type	Description	Remarks
Size	64 bits	
Default value	FFFF_FFFF_FFFF_FFFFh	SBAF does not allow the installation of HSE firmware.
UTEST location	1B00_0000h	
Configurability	Application software in CUST_DEL lifecycle	
Enable flag	Program any value other than the default value	This enables the installation of the HSE firmware.

32.4.3.2 Crystal oscillator configuration flag

See the below table for description of the flag:

Table 161. Flag fields

Field type	Description
Size	64 bits
Default value	FFFF_FFFF_FFFF_FFFFh (Boot via FIRC)
UTEST location	1B00_0050h
Configurability	Application software in any LC

Table 162. Crystal oscillator configuration flag in UTEST

	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48
R	FXOSC_ENABLE_MAGIC_NUMBER															
W																
	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
R																
W																

	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	GMSEL				EOCV											
W																

Table continues on the next page...

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	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CRYSTAL_OSCILLATOR_FREQUENCY															
W																

Table 163. Crystal oscillator configuration bit definition

Field	Description
63-33	FXOSC_ENABLE_MAGIC_NUMBER 0xAAAA_5555h – Enable (FXOSC.CTRL[OSCON] = 0x1) 0xFFFF_FFFFh – Disable (FXOSC.CTRL[OSCON] = 0x0)
31 - 28	Crystal Overdrive Protection (GMSEL) For values = 0h or Fh Uses the default value, Ch.
27 - 20	End Of Count Value (EOCV) For value = 0h Uses the default value, 9Dh.
19 - 16	Reserved
15 - 0	CRYSTAL_OSCILLATOR_FREQUENCY Frequency value of used external crystal oscillator in kHz. The valid crystal frequency range is 8000–40000 kHz.

32.5 Image vector table

The following section describes the fields in the image vector table that the application must program. SBAF scans the IVT after the chip is out of reset. The structure is 256 bytes in size. This structure contains application cores start addresses. IVT must be programmed at least at one of the locations described in Chip configuration.

After reset, SBAF searches for the first valid IVT starting from the lowest address. If there are multiple valid IVT at IVT locations at the same time, the IVT with lowest address is used.

Table 164. Image vector table

Address offset	Size in bytes	Content	Comments
00h	4	IVT header tag	marks the starting of the image vector table location. Its value must be 5AA5_5AA5h.
04h	4	Boot configuration word	Indicates the configuration word that allows you to select the various configurations in which you can boot the chip. See Boot configuration word for more information.

Table continues on the next page...

Table 164. Image vector table (continued)

Address offset	Size in bytes	Content	Comments
08h	4	Reserved	
0Ch	4	Cortex-M7_0 core start address	Specifies the boot address of the Cortex-M7_0 core in the code flash memory area. It must honor core Vector Table Offset Register (VTOR) alignment restrictions. SBAF uses this field only when the HSE firmware usage feature flag is enabled and BOOT_SEQ field is 0.
10h	4	Reserved	
14h	4	Cortex-M7_1 core start address	Specifies the boot address of the Cortex-M7_1 core in the code flash memory area. It must honor core VTOR register alignment restrictions. SBAF uses this field only when the HSE firmware usage feature flag is enabled and BOOT_SEQ field is 0. **NOTE** Cortex-M7_1 is not available in S32K36x.
18h	4	Reserved	
1Ch	4	Cortex-M7_2 core start address	Specifies the boot address of the Cortex-M7_2/3 core in the code flash memory area. It must honor core VTOR register alignment restrictions. SBAF uses this field only when the HSE firmware usage feature flag is enabled and BOOT_SEQ field is 0.
20h	4	Reserved	
24h	4	Address of LC configuration	Specifies the address of the configuration word that allows you to advance the LC. See Address LC configuration word for more information. **NOTE** This is a pointer to LCW, not the LCW value itself.
28h	4	Reserved	
2Ch	4	HSE firmware pointer (FW_IMG)	Pointer to the Flash area containing HSE firmware pink image as provided by NXP (also called as Pink FW_IMG). **NOTE** Pointer to FW-IMG is only valid for FULL_MEM configuration.
30h	4	AppBL	Pointer to application BootLoader structure in Flash
34h	12	Reserved	
40h	4	Start address of application core for secure recovery mode	Entry pointer for secure recovery application

Table continues on the next page...

Table 164. Image vector table (continued)

Address offset	Size in bytes	Content	Comments
44h	4	Length of recovery application	Length in bytes for secure recovery application image
48h	156	Reserved	
E4h	12	Initialization vector (IV) value to be used in the calculation of GMAC	IV as input to IVT GMAC calculation **NOTE** 1. The IV must be randomly generated every time the GMAC is calculated 2. IV value is also included in GMAC calculation
F0h	16	Authentication tag (GMAC)	GMAC value that can be verified (optional) to guarantee IVT authenticity & integrity

32.5.1 Boot configuration word

Informs SBAF to allow booting of selected applications.

Table 165. Boot configuration register

	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved															
W																
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved						FW_USAGE_FLAG_PROGRAM	Reserved	RESET_RECOVERY_MODE	DISABLE_SECURE_RECOVERY_MODE	SWT0_ENABLE	PLL_ENABLE	BOOT_SEQ	CM7_2_ENABLE	CM7_1_ENABLE	CM7_0_ENABLE
W																

Table 166. Boot configuration register field definitions

Field	Description
31 – 10	Reserved

Table continues on the next page...

Table 166. Boot configuration register field definitions (continued)

9	FW_USAGE_FLAG_PROGRAM Enables the HSE Firmware Usage feature flag in UTEST. 0b - Not programmed 1b - Programmed Also, removes the requirement to program 0xA5 marker in DCMRWP1 register during HSE Firmware installation via MU Interface. Only supported if SBAF version is 0.15.0 or above.
8	Reserved
7	RESET_RECOVERY_MODE Indicates recovery mode entry due to multiple resets. 0b - Disabled 1b - Enabled Only supported if SBAF version is 0.15.0 or above.
6	DISABLE_SECURE_RECOVERY_MODE Skips the secure recovery mode in the recovery mode sequence. 0b - Secure recovery mode is not executed 1b - Secure recovery mode is executed Disable the secure recovery mode feature. HSE only attempts JTAG based recovery mode to recover the device in bricking scenarios as explained in "Recovery Mode Sequence" section.
5	SWT0_ENABLE Controls the SWT0 enablement before passing the control to the application core(s). 0b - Disabled 1b - Enabled
4	PLL_ENABLE Enables PLL during secure boot 0b - Configure FXOSC and PLL for secure boot 1b - No clock configuration done FXOSC enablement flag must be enabled in UTEST area. PLL is configured when the BOOT_SEQ field is set to 1.
3	BOOT_SEQ Controls the boot flow of the application when HSE Firmware usage feature flag is enabled. 0b - Nonsecure boot: SBAF starts the application image without any authentication in parallel to the HSE firmware.

Table continues on the next page...

Table 166. Boot configuration register field definitions (continued)

	1b - Secure boot: The HSE firmware executes the application image after authentication. SBAF only starts the HSE firmware after successful authentication.
2	CM7_2_ENABLE Enables the Cortex-M7_2 application core ungating. 0b - Ungated 1b - Gated **NOTE** This field is applicable for devices which support 3 application cores.
1	CM7_1_ENABLE Enables the Cortex-M7_1 application core ungating. 0b - Ungated 1b - Gated **NOTE** This field is applicable for devices which support 2 or 3 application cores.
0	CM7_0_ENABLE Enables the Cortex-M7_0 application core ungating. 0b - Ungated 1b - Gated

32.5.2 Address LC configuration word

This field allows you to advance the LC. To advance LC, you must program a valid 32-bit wide value at an address given in IVT at an address offset of 24h. This address must be 4 bytes aligned and should not lie in HSE reserved area.

The following table shows the valid values for advancement in the next LCs. For all other values at the given address, LC advancement is not allowed.

Table 167. Valid values for LC advancement

LC	Valid values for LC advancement
OEM_PROD	DADA_DADAh
IN_FIELD	BABA_BABAh

NOTE

Even if LC advancement is not planned the value programmed should be a valid address accessible by HSE.

Depending on the HSE firmware feature flag, the application password on the location must program before LC advancement; otherwise, SBAF does not attempt LC advancement.

The chip provides an LC mechanism for an irreversible progression of restrictions to access the chip's security-related content. You cannot reverse the chip's LC, so it is only possible to mature the chip. SBAF advances the chip through the LC:

- CUST_DEL → OEM_PROD or IN_FIELD

- OEM_PROD → IN_FIELD

To advance the LC through SBAF involves inserting the LC configuration word address in the IVT. SBAF issues a destructive reset on successful advancement. If the chip is found in the same LC as the IVT indicated, you can ignore LC advancement.

32.5.3 Structure definition of image vector table

Application can use the following structure to configure the IVT. See the *HSE Firmware Reference Manual* for more information.

```
typedef const struct image_vector_table
{
uint32_t Header; /*Header of IVT Structure */
uint32_t BootConfig; /*Boot Configuration Word */
const uint32_t Reserved1; /* Reserved */
const uint32_t * CM7_0_StartAddress; /*Start Address of Application on CM7_0 Core */
const uint32_t Reserved2; /* Reserved */
const uint32_t * CM7_1_StartAddress; /*Start Address of Application on CM7_1 Core */
const uint32_t Reserved3; /* Reserved */
const uint32_t * CM7_2_StartAddress; /*Start Address of Application on CM7_1 Core */
const uint32_t * Reserved4; /* Reserved */
const uint32_t * LCConfig; /*Address of LC configuration Word */
uint8_t Reserved5[216];    /* Reserved */
}ivt_t;
```

NOTE

You must reserve the fields that are not valid for a specific configuration.

32.6 Boot flow

Below diagram explains boot sequence flow of SBAF.

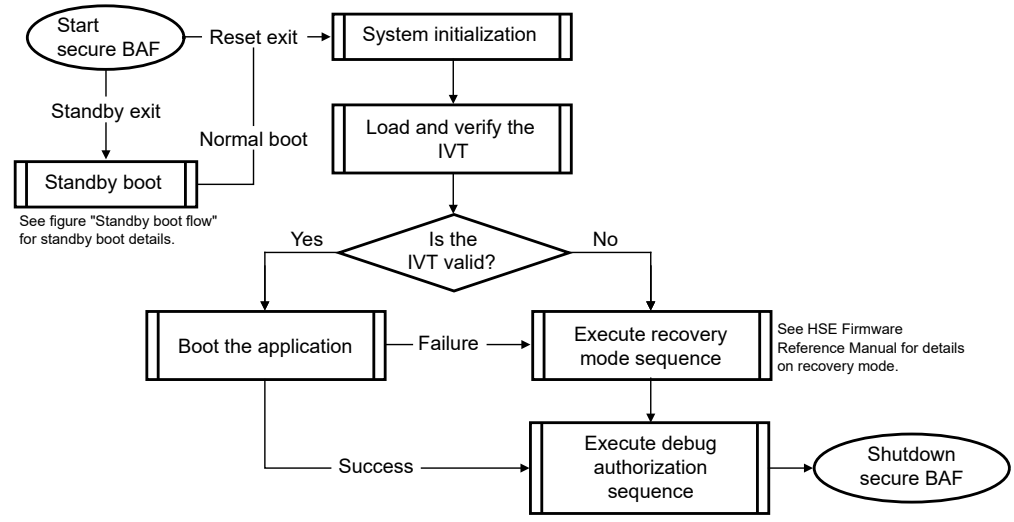


Figure 140. Boot flow

32.7 Standby boot

SBAF supports boot from standby exit. Chip register DCM.DCMRWF5 (address 402AC610h) supports boot after exit from Standby mode. This register clears after POR. See the "Device Configuration Module (DCM)" chapter in the S32K396 reference manual for more information.

You must program this register before entering Standby mode.

There are two types of boot mode after exit from Standby mode:

- Fast Standby
- Normal Boot after exit from Standby mode

In Fast Standby mode, the SBAF boots the Cortex-M7_0 core and halts the HSE CPU.

The flow of Standby Boot is explained below:

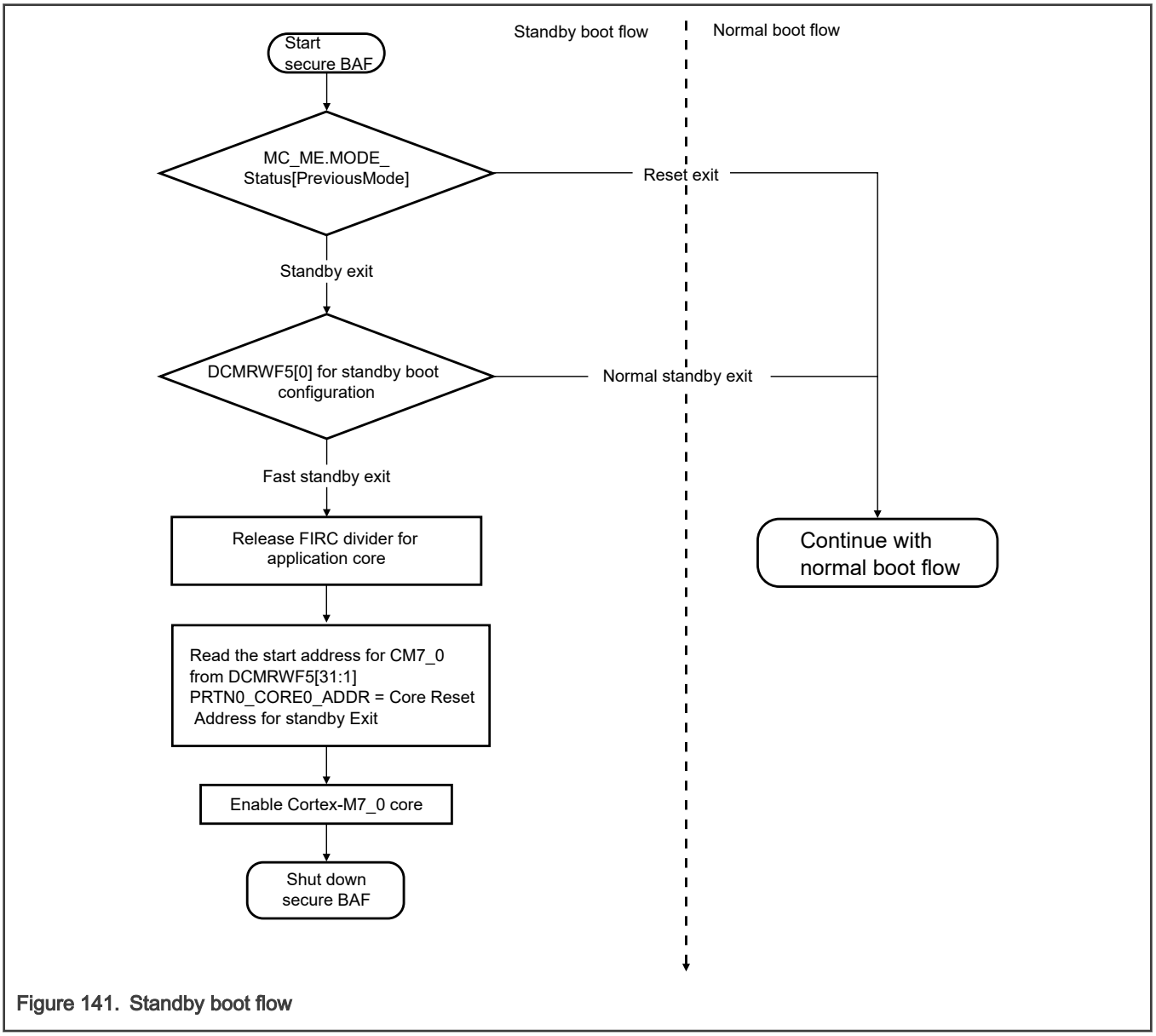


Figure 141. Standby boot flow

32.8 Reduced Clock mode configuration

If you use clocking option B (Reduced clock mode configuration), the application sets the “dcf_client_utest_misc” DCF record to enable Reduced Clock mode. See the DCF clients file attached to the S32K396 reference manual for more information on DCF records.

After reset, SBAF checks for DCMROF21[HSE_CLK_MODE_OPTION]. If you configure this field for clocking option B, the SBAF configures the MUX_0_DC_2 divider in MC_CGM.

Below figure explains steps for reduced clock mode configuration steps by SBAF.

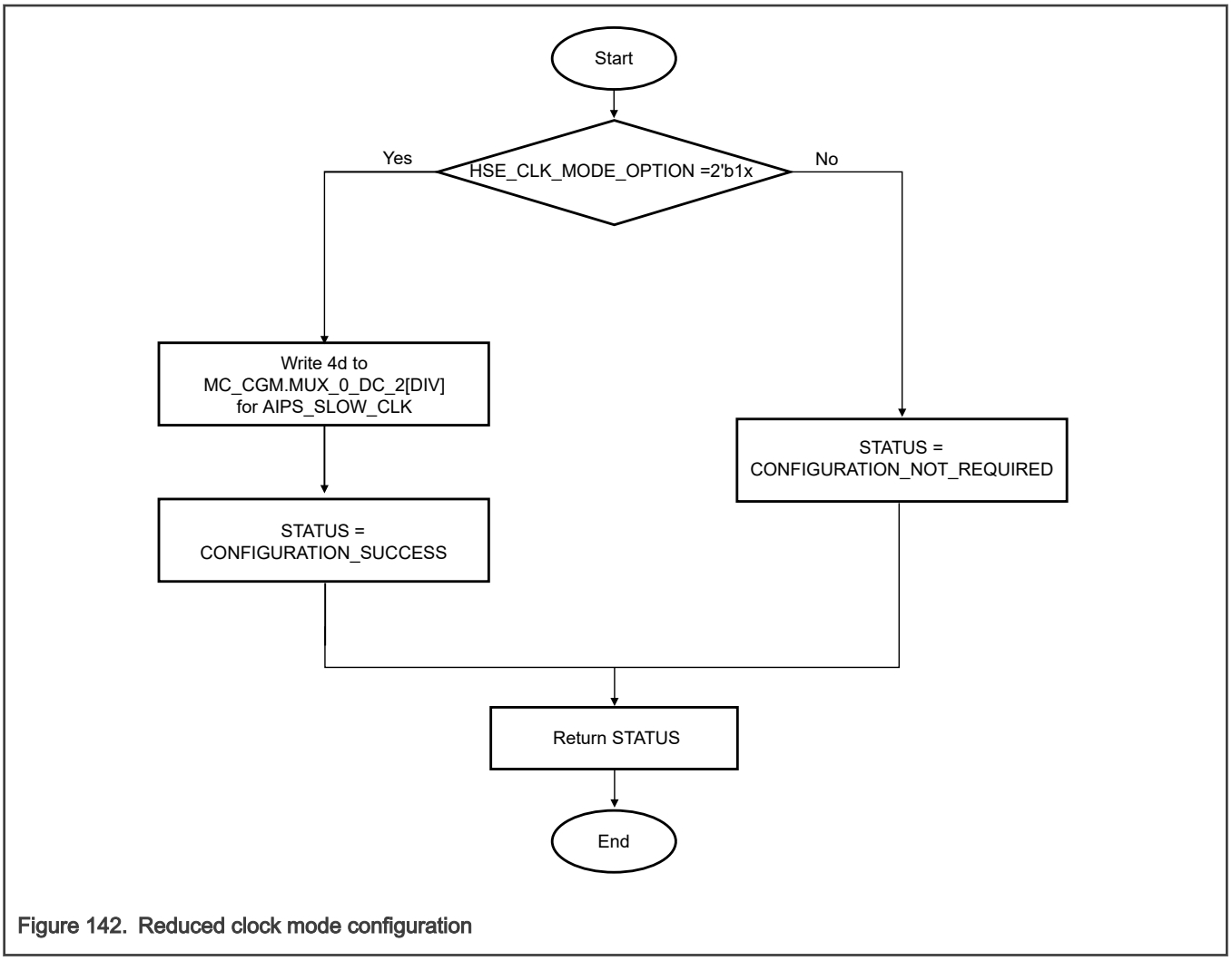


Figure 142. Reduced clock mode configuration

32.9 Debug authorization

You must program CUST_DB_PSWD_A at location 1B00_0080h. The application core debug is always password-based if the HSE firmware usage feature flag is cleared. See UTEST memory location usage by SBAF for more information.

32.10 FIRC divider register control

HSE.CONFIG_REG_GPR, at register address 4039_C064h, controls the FIRC divider.

After SBAF executes WFI, it provides write access to HSE.CONFIG_REG_GPR[FIRC_DIV_SEL], and you can configure this register. Before accessing this register, you must wait for the SBAF to enter WFI by reading core status register of HSE CPU.

32.11 Application boot

The HSE firmware is responsible for securely booting the application image and not the SBAF. If secure boot is not requested (by writing 0 to the BOOT_SEQ field in Boot configuration word in IVT structure), SBAF always loads the application image, without authentication, in all chips, LC. SBAF enables the clock of every core that is enable in the IVT.

Following flow chart explains the steps of application boot performed by SBAF.

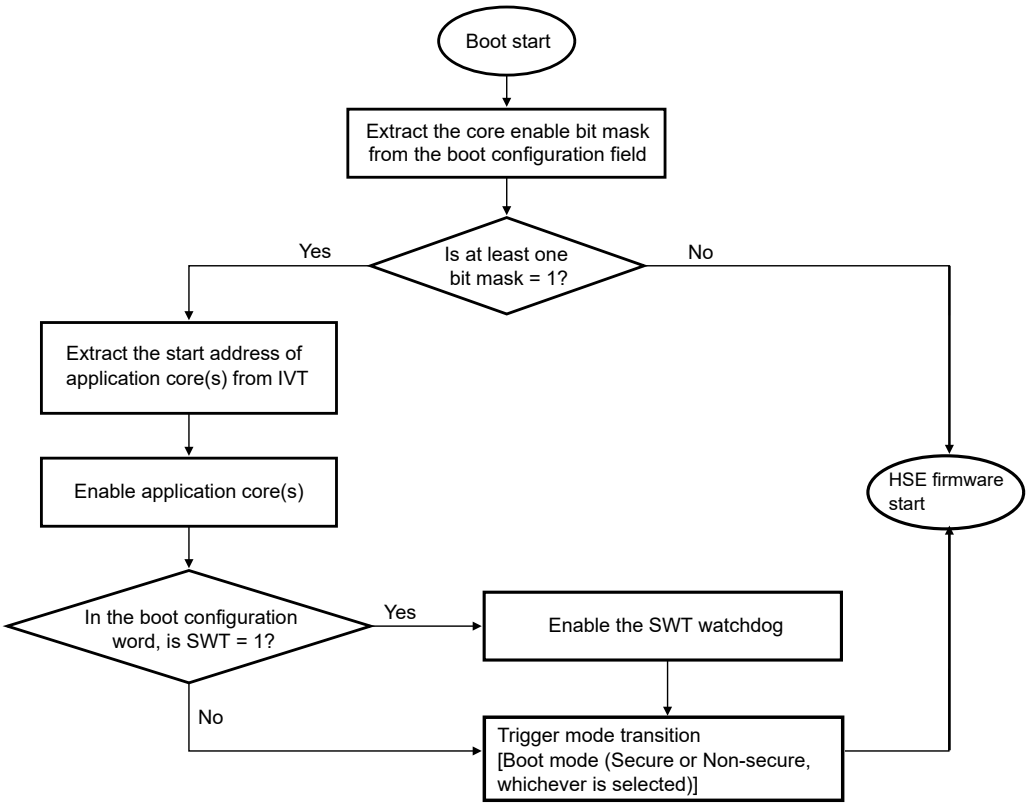


Figure 143. Application boot sequence

Before configuring HSE_CLK, you must wait for the SBAF to enter WFI by reading core status register of HSE CPU.

32.12 Recovery mode sequence

This feature allows you to program the application image in LC = MCU_PROD and LC = CUST_DEL and debug the reason of corruption of IVT and re-program the IVT in other LC.

The following scenarios take place when SBAF executes the recovery mode sequence.

- A valid IVT is not found (corrupted or not programmed).
- SBAF does not boot the application.
- Boot configuration word in IVT does not program the application enablement field.
- The application issued more than eight functional resets and Disable Recovery mode on functional reset field is not set in DCM.DCMRWP1.
- The application issued more than eight destructive resets and Disable Recovery mode on destructive reset field is not set in DCM.DCMRWP1.

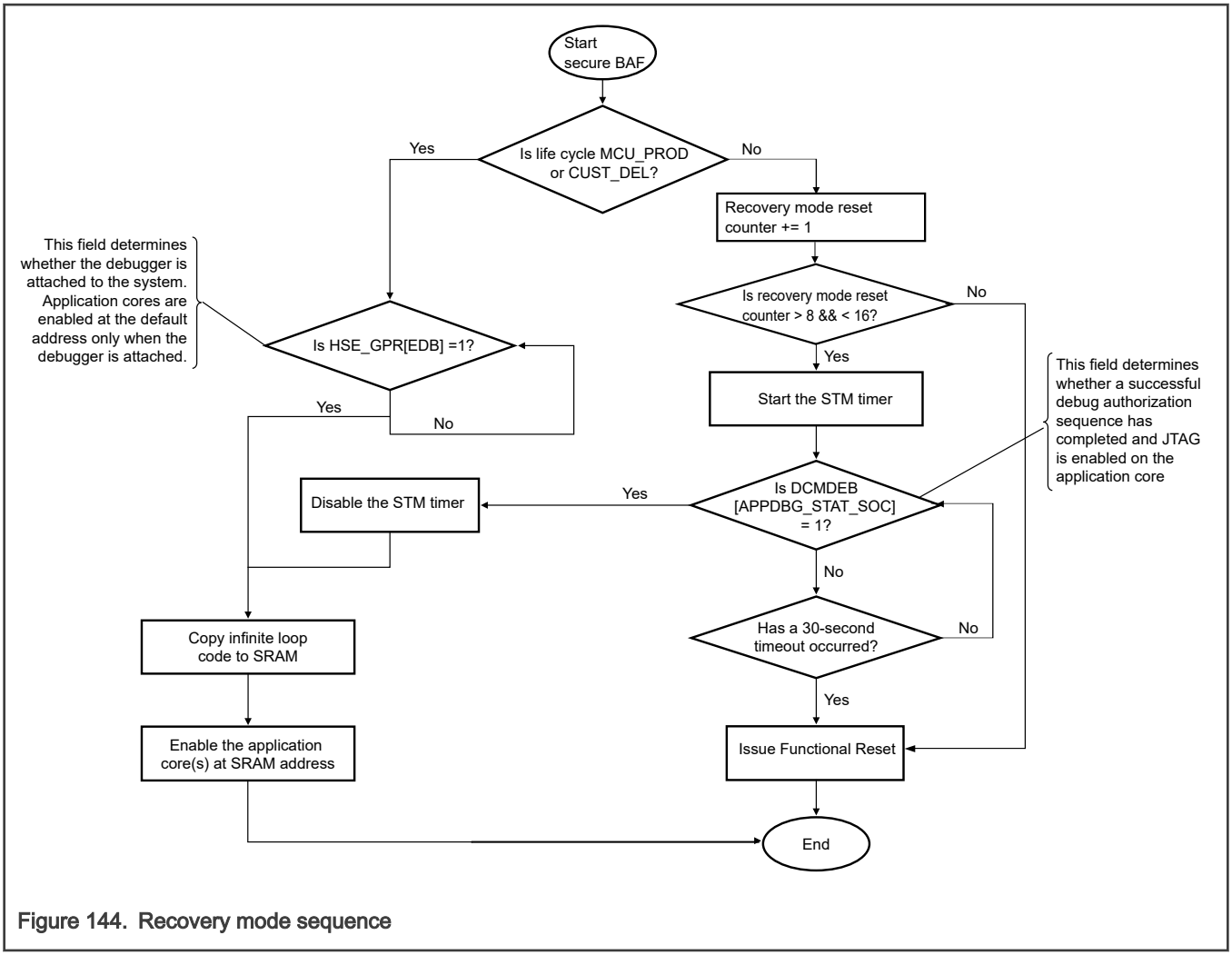


Figure 144. Recovery mode sequence

The infinite loop with the WFI code copies to SRAM1 that is 2040_0100h, and the code size is 16 bytes.

32.13 XRDC configuration

SBAF ensures that it has access to its resources and the application does not have access to area reserved for SBAF.
The following sections describe the XRDC default configuration values when you clear the HSE firmware usage feature flag. Application should configure its XRDC and enable the XRDC by itself as SBAF does not enable the XRDC.

When the HSE_B firmware feature flag is enabled, the application can provide XRDC configuration via IVT. For this scenario, see the *HSE-B Firmware Reference Manual* for more information on XRDC configuration.

32.13.1 XRDC configuration of MDAC

Following table list down the default configuration of MDAC by SBAF.

Table 168. XRDC configuration of MDAC

MDAC register HSE CPU	Value	Domain number assigned to HSE CPU
MDA_W0_3_DFMT0	C000_0003h	3

32.13.2 XRDC configuration of MRC

Following table list down the MRC used by SBAF.

Table 169. XRDC configuration of MRC

MRC number	Region descriptor number	Remarks
0	14	Reserved for Application
0	15	Reserved for Application

32.13.3 XRDC configuration of PDAC

SBAF configures and lock the following peripherals for its use. SBAF provides all Permissions to all domains.

Table 170. XRDC configuration of PDAC

Peripheral name	Peripheral PDAC number
Flash Controller alternate	155
Flash Memory alternate	188
HSE_GPR	231

32.14 BAF flash programming controls

The platform flash controller generates an exception of read-while-write if you simultaneously perform read and write on the same block. HSE CPU uses the Configuration PE Lock Register (CONFIG_PE_LOCK) in the HSE space to control the block program and erase for application.

BAF locks the high addressing code flash memory block during its execution, and it is cleared when the HSE CPU enters WFI. See the "Chip Configuration" chapter for the address of the high addressing code flash memory area.

Before programming, erasing, or executing from this address space, the application core polls for HSE.CONFIG_GPR3 relevant bits to ensure that the HSE CPU is in the WFI state. See section "HSE GPR Register 3" in the *HSE Firmware Reference Manual*.

For boot sequence 1 (secure boot) or flash synchronization with the HSE firmware, see the *HSE Firmware Reference Manual*.

32.15 Status registers for application usage

This section explains various status registers to provide status information to the application.

32.15.1 SBAF version information

The SBAF version is a 64-bit field. The application can read the SBAF from address 4039_C020h. The information of this register is stored in the HSE.CONFIG_GPR1 (4039_C020h) and HSE.CONFIG_GPR2 (4039_C024h) registers. See the HSE.CONFIG_GPR1 and HSE.CONFIG_GPR2 registers in the HSE_B chapter for details.

32.15.2 DCM.DCMRWP1

The application can disable Recovery mode entry by SBAF after programming bits 23 and 22 of DCM.DCMRWP1.

Table 171. DCM.DCMRWP1

Bits	Number of bits	R/W access by application	Description
24-31	8		Reserved
23	1	R/W	Disable Recovery Mode On Destructive Reset Indicates that this field resets by default, and SBAF allows Recovery mode sequence if the application issues more than eight destructive resets. The application can set this field to disable Recovery mode when the application issues > 8 destructive resets.
22	1	R/W	Disable Recovery Mode On Functional Reset Indicates that this field resets by default, and SBAF allows Recovery mode sequence if the application issues > 8 functional resets. The application can set this field to disable Recovery mode when the application issues > 8 functional resets.
21	1	R	Reserved
16-20	5	R	Recovery Mode Reset Counter Indicates that to enable Recovery mode functionality for the OEM_PROD and IN_FIELD LC stages, SBAF increments this counter when a functional or destructive reset is issued.
15	1	R	Reserved
11-14	4	R	Destructive Reset Counter Indicates that SBAF increments this counter when a destructive reset is issued.
0-10	11	R	Reserved

32.15.3 SBAF status information bits (HSE.CONFIG_GPR3)

SBAF writes HSE.CONFIG_GPR3 at address 4039_C028h to show the status information. See the HSE.CONFIG_GPR3 register in the HSE_B chapter for details.

32.16 Interrupt and exception handling

- **Interrupt handling:** No special interrupt handling routines are required during the boot process. Interrupts are disabled during SBAF execution.
- **Exception handling:** SBAF enters the recoverable mode sequence -
  - after enabling debug authorization
  - after eight consecutive functional resets from Application Firmware
  - after eight consecutive destructive resets from Application Firmware
- **Boot target watchdog:** SBAF enables/disables SWT0 watchdog with default timeout, that is according to the boot configuration word (by default 25 ms), before enabling the application core(s). It is expected that the application services this watchdog before expiration.

32.17 Hardware modules used by SBAF

- **MC_ME:** SBAF uses MC_ME to enable the application cores, mode switch, and other operations during its execution.
- **FXOSC:** SBAF configures FXOSC according to the crystal oscillator configuration flag in UTEST.
- **Clock Generation Module (MC_CGM):** SBAF configures MC_CGM in Reduced Clock mode configuration.
- **DCM:** SBAF uses the DCM to identify the Life Cycle, standby boot mode configuration, lockstep, and clock mode configuration.
- **HSE_GPR:** SBAF configures hardware protection, program erase lock, FIRC divider control, and SBAF version number.
- **XRDC:** SBAF configures the XRDC module.
- **Flash Module:** SBAF always perform the write and erase operation on alternate interface. See Chip configuration for details of flash memory usage by SBAF.

32.17.1 Hardware module configured by SBAF from their reset value

Below are the list of registers modified by SBAF from their reset values and visible to App cores.

1. Read Write GPR On POR 1 (DCMRWP1) 0x402AC400U /* use to read and update reset counter */
2. Read Write GPR On POR 7 (DCMRWP7) 0x402AC618U /* Publishing silicon ID */
3. Read Write GPR On Functional Reset 4 (DCMRWF4) 0x402AC60CU /* This configures the App core operation in Wait mode for Phantom Core */
4. Configuration REG_GPR (CONFIG_REG_GPR) 0x4039C064U /* configuring FIRC configuration control to APP/HSE */
5. Read Write GPR On Destructive Reset 4 (DCMRWD4) 0x402AC50CUL /* DCMRWD4 bits 2-7 only cleared on every reset*/
6. Read Write GPR On Destructive Reset 5 (DCMRWD5) 0x402AC510UL /* DCMRWD5 bits 29-31 only cleared on every reset*/
7. Read-Only GPR On Destructive Reset 1 (DCMROD1) 0x402AC200UL /* DCMROD1 bit 1 only cleared on every reset*/
8. Read-Only GPR On Functional Reset 2 (DCMROF2) 0x402AC304UL /* DCMROF2 to DCMROF17 All 0-31 bits are cleared on every reset*/
9. Read-Only GPR On Functional Reset 19 (DCMROF19) 0x402AC348UL /* DCMROF19 bits 29,31 cleared on every reset*/
10. Read-Only GPR On Functional Reset 20 (DCMROF20) 0x402AC34CUL /* Clearing required bits DCMROF20 register on every reset*/

32.18 Hardware IP registers details modified by SBAF

Below table summarizes the registers which are modified by SBAF.

Table 172. Hardware IP registers modified by SBAF

IP	Register name	Default value (hex)	Modified value (hex)
XRDC	XRDC.MDA_W0_3_DFMT0	0000_0000h	It can be C000_0001h - C000_0003h, see XRDC configuration of MDAC.
	XRDC.MRGD_W0_14	0000_0001h	HSE UTEST start[1]
	XRDC.MRGD_W1_14	0000_001Fh	HSE UTEST end[1]

Table continues on the next page...

Table 172. Hardware IP registers modified by SBAF (continued)

IP	Register name	Default value (hex)	Modified value (hex)
	XRDC.MRGD_W2_14	0000_0000h	0000_0FFFh
	XRDC.MRGD_W3_14	0000_0000h	E000_0000h
	XRDC.MRGD_W0_15	0000_0001h	HSE code flash memory start[1]
	XRDC.MRGD_W1_15	0000_001Fh	HSE code flash memory end[1]
	XRDC.MRGD_W2_15	0000_0000h	0000_0FFFh
	XRDC.MRGD_W3_15	0000_0000h	E000_0000h
	XRDC.PDAC_W0_155	0000_0000h	0000_0FFFh
	XRDC.PDAC_W1_155	0000_0000h	E000_0000h
	XRDC.PDAC_W0_188	0000_0000h	0000_0FFFh
	XRDC.PDAC_W1_188	0000_0000h	E000_0000h
	XRDC.PDAC_W0_231	0000_0000h	0000_0FFFh
	XRDC.PDAC_W1_231	0000_0000h	E000_0000h
General purpose registers with write access by HSE CPU	HSE.CONFIG_PE_LOCK	0000_0000h	Protects only the HSE area[1]
	HSE.CONFIG_RAMPR	See the HSE chapter.	4000_0000h (Releases full memory)
	HSE.CONFIG_RAMPR_ALT		BFFF_FFFFh
	HSE.CONFIG_CFPRL		4000_0000h (Releases full memory)
	HSE.CONFIG_CFPRL_ALT		BFFF_FFFFh
	HSE.CONFIG_CFPRH		4000_C000h
	HSE.CONFIG_CFPRH_ALT		BFFF_3FFFh
	HSE.CONFIG_DFPR		4002_0000h
	HSE.CONFIG_DFPR_ALT		BFFD_FFFFh
	HSE.CONFIG_REG_GPR	A000_0003h	See FIRC divider register control.

Table continues on the next page...

Table 172. Hardware IP registers modified by SBAF (continued)

IP	Register name	Default value (hex)	Modified value (hex)
MC_ME	MC_ME.PRTN1_COFB1_STAT	1CFE_2FFCh	FXOSC and MC_CGM clocks are enabled by default.
	MC_ME.PRTN0_COREx_ADDR	0040_0000h 0041_0000h 009F_FC00h	SBAF updates this address if you request the application core 0,1,2 boot during the normal boot sequence in IVT or Recovery mode (0x20400100).
	MC_ME.PRTN0_COREx_PCONF	0000_0000h	The core clock is enabled when the recovery mode sequence is executed or when the clock is enabled in Boot configuration word.
	MC_ME.PRTN0_COREx_PUPD	0000_0000h	
	MC_ME.CTL_KEY	0000_5AF0h	SBAF updates this register if SBAF boots any one of the application core. 0000_5AF0h and then 0000_A50Fh
FXOSC	FXOSC.CTRL	019D_00C0h	See Crystal oscillator configuration flag.
MC_RGM	MC_RGM.DRET	0000_0000h	0000_000Fh
SWT_0	SWT_0.CR	FF00_010Ah	FF00_000Bh, when SWT_0 is enabled in the boot configuration word and FF00_000Ah when the SWT_0 is disabled in the boot configuration word.
	SWT_0.IR	0000_0000h	0000_0001h

1. See Chip configuration for more information on the HSE area addressing.

32.19 Glossary

BAF Boot assist flash

CUST_DEL Chip's life cycle stage, customer delivery

IN_FIELD Chip's life cycle stage, in field

IVT Image vector table

LC Chip's life cycle—limits by design the configuration and debug/test possibilities of the chip for in-field usage

MCU_PROD Chip's life cycle stage, MCU production

OEM_PROD Chip's life cycle stage, OEM production

OTA Over the air

SBAF Secure boot assist flash

WFI	Wait for interrupt

Chapter 33
Security Overview

33.1 Introduction

This chip has a comprehensive set of customer-configurable security features designed to protect code and data from unauthorized access. This section delivers only the high level security overview. The chip security feature details are published in the HSE firmware reference manual and HSE service interface manual. Contact your NXP representative for details if you need secure operation.

33.2 Security features

- Exceeds the EVITA- full functionality and offers high performance for edge nodes applications.

  EVITA was a European research project existing from 2008 to 2011. There is no standard or a specification to test compliance. However, HSE_B meets the common expectations often described in the automotive industry as EVITA Full and exceeds them in these cases:

  - HSE_B supports up to AES-256 instead of AES-128
  - HSE_B supports up to ECC-521 instead of ECC-256
  - HSE_B supports SHA-2/Miyaguchi-Preneel instead of Whirlpool
- Bases its chip censorship on the life cycle model. Access to chip code and data becomes progressively more restricted as the chip moves forward a defined set of life cycle steps.
- Offers these memory security features:
  - NVM censorship support
  - Debug password protection
  - OTP flash memory areas
- Supports a unique ID—The chip has a unique ID stored in an OTP flash memory area. Any core on the chip can read this unique ID.
- Includes HSE_B, which is a dedicated security system providing:
  - A processor core
  - Dedicated SRAM
  - Symmetric Hardware Accelerator
  - Asymmetric Hardware Accelerator
  - True Random Number Generator (TRNG)
  - Pseudo Random Number Generator (PRNG)
  - Exclusive access to secure areas of the chip's flash memory
  - OTA: In Field Secure Code/Data updates

  NOTE

  Refer Security Reference Manual and Firmware Reference Manual for the details on OTA.

  Also, HSE_B runs NXP firmware independently from the main chip processor cores and can implement advanced security and monitoring functions.
- Supports a secure debugger interface.
- Provides boot modes:

  - Trusted and secure boot support
  - Handshake that supports BAF
- Monitors operating conditions to maximize tampering resistance.
- Includes basic debugger restrictions based on debug authentication.

When HSE_B detects a security failure, it moves the chip to a secure state.

In case if the security errors are critical and severe, the chip moves to reset state, else, the chip stays in the RUN mode and the device lifecycle automatically transitions to a more secured IN_FIELD phase. In non-critical security error condition, the application might continue to run without any impact.

33.3 Glossary

AES	Advanced encryption standard
BAF	Boot assist flash
ECC	Elliptic curve cryptography
EVITA	E-safety vehicle intrusion protected applications
NVM	Nonvolatile memory
OTP	One-time programmable
OTA	Over the air firmware

Chapter 34
Hardware Security Engine (HSE_B)

34.1 HSE subsystem

HSE is a security subsystem. It runs security functions for applications having stringent confidentiality and authenticity requirements. HSE has the following objectives:

- Isolating security-sensitive information (for example, secret keys) from the application (the host)
- Transferring the cryptographic operations from application cores and processing them
- Accelerating cryptographic operations with dedicated coprocessors
- Enforcing security measures on the application, during runtime and system startup

The HSE subsystem is the only master that is unconditionally released from reset after POR. It then releases the CPU subsystems in the host from reset, with the opportunity to apply certain checks beforehand (secure system startup). Based on certain conditions, HSE can also trigger interrupts and reset signals to the host during runtime.

34.1.1 CPU subsystem

The HSE CPU subsystems process the security functions and control system resources to provide security services to the application domain (the host).

34.1.2 Cryptographic accelerators

The HSE subsystem supports the following cryptographic accelerators:

- An AES engine supporting all standard key sizes (128, 192, 256 bits) and various complex ciphering modes (ECB, CBC, CTR, OFB, CFB, CCM, CMAC)
- A hash engine that supports standard several primitives: MD5, SHA-1, SHA-224, SHA-256
- PKC which accelerates RSA and ECC operations (key generation, signature generation, signature verification, ciphering)
  - RSA (1024, 2048, 3072, 4096-bit)
  - ECC over prime numbers
    - BN P256, P638
    - ANSI X9P192 to X9P512
    - Brainpool P160 to P512
    - Sec P128 to P521
    - TU Darmstadt prime Curve 1 to 35
    - Ed25519

The HSE subsystem supports several other cryptographic primitives through the software. See HSE firmware for more information.

34.1.3 Random number generator (RNG)

The RNG in this chip consists of a TRNG and a DRBG. Both are designed to be compliant to the highest strength in security as specified in

- BSI AIS20/31
- NIST SP800-90a,b,c

The TRNG function provides a seed for the DRBG, while the DRBG is available to the host via dedicated random number generation services.

34.1.4 Timers

The HSE subsystem features:

- An independent dedicated system timer
- HSE_STM (apart from chip timer resources), that allows recurring autonomous functions such as runtime memory verification checks
- A watchdog timer to reset the HSE subsystem in case of unexpected runtime failure

34.1.5 Memory resources

See Configuration_GPR memory map for more information on configuration controls related to HSE memory resources.

34.1.5.1 Secure RAM

Secure RAM refers to RAM area that the HSE subsystem access exclusively.

34.1.5.2 Secure flash

Secure flash refers to nonvolatile memory that the HSE subsystem accesses exclusively.

34.2 HSE interface

34.2.1 Messaging unit (MU)

The HSE subsystem has two messaging units:

- HSE_MU0
- HSE_MU1

See the "Messaging Unit (MU)" chapter for more information.

34.2.1.1 Overview

MU is the communication interface between the host and the HSE subsystem. The host uses MU to trigger service requests and to receive service responses. The HSE firmware uses MU to receive service requests, return service responses, and provide a general status of the HSE subsystem.

Each of the two MU instances available in the HSE subsystem has:

- Two sides:
  - MUA: Only the HSE subsystem accesses it.
  - MUB: The host accesses it.

    The registers on one side have corresponding registers on the other side.
- A set of 32-bit readable and writable transmit registers (MUB_TRn), which the host uses to transfer the address of the service descriptor to the HSE firmware. The HSE firmware retrieves the address of the service descriptor in the corresponding registers MUA_RRn.
- A set of 32-bit read-only receive registers (MUB_RRn), which the host uses to retrieve the response to the service requests. The HSE firmware provides the response to service requests in the corresponding registers MUA_TRn.
- Control and status registers to manage MU and the access to transmit and receive registers.

The advantages of using the MU to manage the HSE service requests and responses are:

- Hardware mechanisms are in place on the transmit registers to avoid service request overrun.

- Interrupt signals are available to allow asynchronous management of the requests (avoiding active waiting loops).
- Freedom from interference between different application cores. You can configure each MU instance with specific access restrictions that can be used, for example, to isolate the requests that different masters make (in different MU instances). You configure such access controls using XRDC.

34.3 Debug

34.3.1 HSE subsystem debug

The debugging of the HSE subsystem and associated firmware is restricted to NXP engineering teams.

34.3.2 Host debug

The host debug is either open or protected, depending on the device Lifecycle state. See the 'Life cycle' section in the ‘Device Configuration Module’ chapter of the Reference Manual for details on device lifecycle advancement and decoding. See the Debug Subsystem chapter in the Reference Manual for details on host/application core debug.

The debug protection consists of locking the debugger access through the JTAG interface until the HSE firmware authenticates the debugger. This authentication is based on ADK/P, a 16-byte region within UTEST used for application core debug. This location will be used by SBAF to run the debug authorization feature. SBAF will use this value to derive the application expected response register and HSE expected response register. See UTEST memory map in the DCF clients file attached to this document.

The authentication method can be:

- Static: In this case, ADK/P is a password which the debugger provides in plain form.
- Dynamic: In this case, ADK/P is a cryptographic key which the debugger uses to calculate a cryptographic response to a random challenge.

34.4 HSE firmware

Factory supplied firmware that runs in the HSE subsystem controls HSE functionality. It essentially serves the host with a set of security services as described in Table 173.

Table 173. Summary of firmware security services

Service	Summary
Administration	Install, configure, update, and test the HSE firmware
Key management	Available for the application to manage different sets of keys that the HSE firmware manages, for example, cryptographic services
Cryptographic	Provide the application with cryptographic primitives that high level security tasks use in the application
Random number	Generate random streams that can be used in various security protocols
Memory verification	Allow the application to verify different memory areas at startup (after reset) and during runtime
Monotonic counter	Provide the application with a set of monotonic counters that can be read and only incremented
Secure time	Allow the configuration of a secure tick to be signaled to the application

Table 174 provides an overview of services and features that the HSE firmware supports.

Table 174. HSE firmware features

Service	Category	Feature
Cryptography	Ciphers	AES: ECB, CBC, CFB, OFB, CTR, XTS[1] RSAES: PKCS1-v1_5, OAEP
	Message Authentication Code (MAC)	AES: CMAC, XCBC-MAC[1], HMAC[1], and GMAC[1]
	Hashing	SHA1 SHA224, SHA256, SHA384, SHA512 SHA3_224[1], SHA3_256[1], SHA3_384[1], SHA3_512[1] MD5 Miyaguchi-Preneel Compression
	Authenticated ciphers	AES: CCM, GCM[1]
	Digital signature generation and verification	RSASSA_PSS RSASSA_PKCS1-v1_5 ECDSA – ECC over GF(P) with all prime standard curve supported EdDSA - Ed25519 pre-hashed curve
Key management	Max key sizes	AES: 256 bits RSA: 4096 bits ECC: 521 bits DH: 4096 bits
	Key generation	Permanent and ephemeral RSA and ECC key pair generation
	Key import or export	Plain or encrypted form, with optional authentication tag. SHE key update protocol
	Key derivation	NIST 800-108, PBKDF2, and so on
	Key exchange	ECDH and Classic DH
	Certificate handling	Key Installation from X.509 and CVC certificates Certificate installation for Root of Trust establishment.
Boot and memory verification	Authentication schema	AES CMAC, XCBC-MAC RSA & ECC signatures
	Verification flow	Before application startup (strict secure boot) In parallel to the application startup On the application demand
	Sanctions	No startup (strict secure boot)

Table continues on the next page...

Table 174. HSE firmware features (continued)

Service	Category	Feature
		Chip reset Key usage restrictions
Monotonic counter	Counter management	Incrementing and reading volatile and non-volatile counters
Random number	Deterministic random bit generation	Based on a True Random Number AIS31 Class P2 high and FIPS 140-2 compliant
Secure time	Secure tick	Application interrupts at configurable frequency
Administration services	HSE administration	Firmware installation and update Subsystem configuration and testing

1. Software implementation of cryptographic primitives.

See documents in Table 175 for more information about how to install, configure, and use the HSE firmware that NXP provides.

Table 175. References

Document number	Document title	Description
HSEFWRM	HSE Firmware Reference Manual	Contains details about how to install, configure, and use the HSE firmware.
HSESIRM	HSE Service Interface Reference Manual	Security firmware API reference for non-AUTOSAR users.

34.5 Configuration_GPR register descriptions

34.5.1 Configuration_GPR memory map

This section describes the chip configurations that only the HSE core manages. These constitute control of peripherals, secure size configurations for SRAM and flash memory, flash memory program or erase control, and so on.

NOTE

Write accesses to configuration registers apart from 32-bit accesses might result in unpredictable chip behavior, therefore must not be done.

Configuration_GPR base address: 4039_C000h

Offset	Register	Width (In bits)	Access	Reset value
1Ch	General Purpose Configuration 0 (CONFIG_REG0)	32	R	0000_0000h
20h	SBAF Version Information Low Word (CONFIG_GPR1)	32	RW	See section
24h	SBAF Version Information High Word (CONFIG_GPR2)	32	RW	See section
28h	SBAF Status Information (CONFIG_GPR3)	32	RW	0000_0000h
34h	General Purpose Configuration 6 (CONFIG_REG6)	32	R	0000_0035h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
64h	Configuration REG_GPR (CONFIG_REG_GPR)	32	RW	A000_0003h

34.5.2 General Purpose Configuration 0 (CONFIG_REG0)

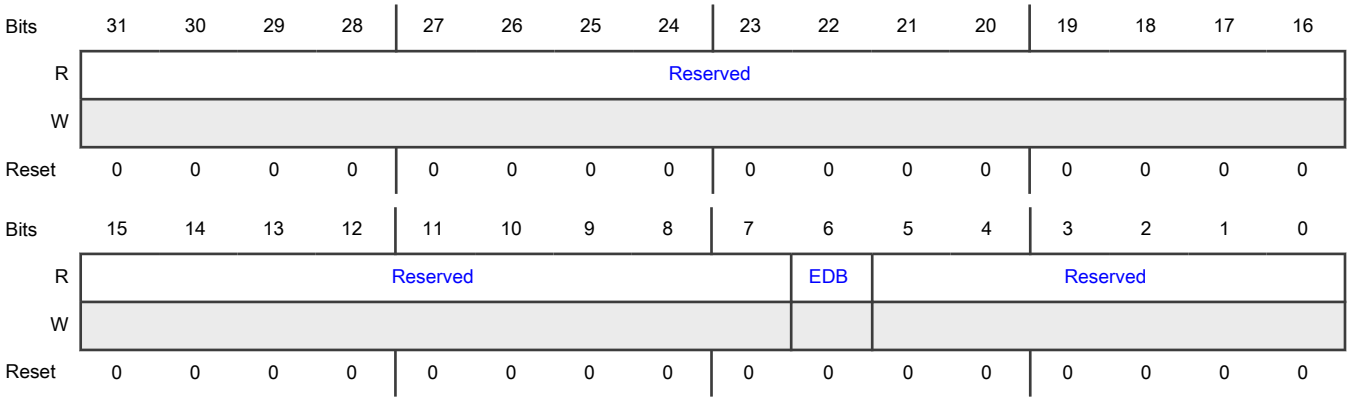
Offset

Register	Offset
CONFIG_REG0	1Ch

Function

The EDB field resets on destructive or POR reset events and functional reset has no impact on it.

Diagram



Fields

Field	Function
31-7 —	Reserved
6 EDB	Hardware Debugger Attached This is a sticky field that clears on destructive reset or POR. 0b - Debugger not connected 1b - Debugger connected
5-0 —	Reserved

34.5.3 SBAF Version Information Low Word (CONFIG_GPR1)

Offset

Register	Offset
CONFIG_GPR1	20h

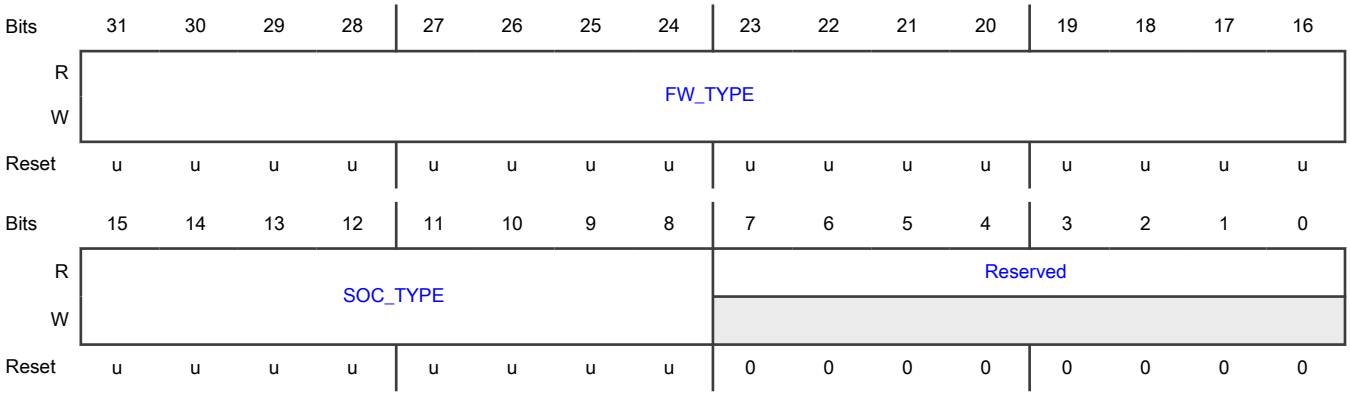
Function

The SBAF version is a 64-bit field. The application can read the SBAF by reading two 32-bit registers; SBAF version information Low Word and SBAF version information High Word.

NOTE

Reset values for unreserved bits change according to SBAF version.

Diagram



Fields

Field	Function
31-16 FW_TYPE	FW_TYPE This field represents the SBAF firmware type. The values of this field are: • 0 – used for standard generic firmware targeting all customers • 1-7 – Reserved • ≥ 8 – used for Custom 1, Custom 2 (for example: Custom 1 = customer X's project A, Custom 2 = customer Y's project B)
15-8 SOC_TYPE	SOC_TYPE_ID This field represents the SBAF firmware, which is targeted for the S32K3XX chip variant. The values of this field are: • 0x5 – used for HSE-B S32K3x4 • 0xB – used for HSE-B S32K3x0

Table continues on the next page...

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Field	Function
	• 0xC – used for HSE-B S32K3x1 • 0xD – used for HSE-B S32K3x2 • 0xE – used for HSE-B S32K3x8 • 0xF – used for HSE-B S32K3x6
7-0 —	Reserved

34.5.4 SBAF Version Information High Word (CONFIG_GPR2)

Offset

Register	Offset
CONFIG_GPR2	24h

Function

The SBAF version is a 64-bit field. The application can read the SBAF by reading two 32-bit registers; SBAF version information Low Word and SBAF version information High Word.

NOTE

Reset values for unreserved bits change according to SBAF version.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RC_NUMBER								INCREMENTAL_NUMBER							
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BASELINE_NUMBER								Reserved							
W																
Reset	u	u	u	u	u	u	u	u	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24	RC_NUMBER

Table continues on the next page...

Table continued from the previous page...

Field	Function
RC_NUMBER	Release Candidate Number.
23-16 INCREMENTAL_NUMBER	INCREMENTAL_NUMBER Incremented when new features are added but compatibility kept.
15-8 BASELINE_NUMBER	BASELINE_NUMBER Incremented when the compatibility with the previous version is broken.
7-0 —	Reserved

34.5.5 SBAF Status Information (CONFIG_GPR3)

Offset

Register	Offset
CONFIG_GPR3	28h

Function

This register provides the status information about SBAF. Refer to the latest *HSE-B Firmware Reference Manual* for more information.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved				B2ARA	B1ARA	B0ARA	UTARA	Reserved				B2AWA	B1AWA	B0AWA	UTAWA
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved								IVTVS	Reserved	ACB	HFW_P	HFW_DFE	HFW_CFE	MU_E	HSE_FW
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 B2ARA	Flash block 2 application read access 0b - Application can read or execute from flash block 2 1b - Application should not read or execute from flash block 2 as HSE firmware is performing flash write operation on this block
26 B1ARA	Flash block 1 application read access 0b - Application can read or execute from flash block 1 1b - Application should not read or execute from flash block 1 as HSE firmware is performing flash write operation on this block
25 B0ARA	Flash block 0 application read access 0b - Application can read or execute from flash block 0 1b - Application should not read or execute from flash block 0 as HSE firmware is performing flash write operation on this block
24 UTARA	UTEST Flash application read access 0b - Application can read or execute from UTEST flash block 1b - Application should not read or execute from UTEST area as HSE firmware is performing flash write operation on this block
23-20 —	Reserved
19 B2AWA	Flash block 2 application write access 0b - Block 2 is available for program and erase for application 1b - Application program and erase is blocked for block 2 as HSE firmware is reading or executing on this block
18 B1AWA	Flash block 1 application write access 0b - Block 1 is available for program and erase for application 1b - Application program and erase is blocked for block 1 as HSE firmware is reading or executing on this block
17 B0AWA	Flash block 0 application write access 0b - Block 0 is available for program and erase for application 1b - Application program and erase is blocked for block 0 as HSE firmware is reading or executing on this block
16 UTAWA	UTEST Flash application write access

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Block 4 is available for program and erase for application 1b - Application program and erase is blocked for UTEST block as HSE firmware is reading or executing on this block
15-8 —	Reserved
7 IVTVS	Indicates the IVT verification selection 0b - SBAF verifies the IVT and secure recovery image with a fixed IV 1b - SBAF verifies the IVT and secure recovery image with random IV
6 —	Reserved
5 ACB	Indicates that SBAF boots the application cores. 0b - Normally 1b - In recovery mode sequence
4 HFW_P	Indicates HSE firmware presence in code Flash. 0b - HSE firmware is present 1b - HSE firmware is erased from code Flash by SBAF handshake logic in current reset cycle
3 HFW_DFE	HSE firmware from data flash area is erased by SBAF handshake logic in current reset cycle. 0b - Not erased 1b - Erased
2 HFW_CFE	HSE firmware from code flash area is erased by SBAF handshake logic in current reset cycle. 0b - Not erased 1b - Erased
1 MU_E	Represents the MU interface for installation of HSE firmware. 0b - Disabled 1b - Enabled
0 HSE_FW	Indicates that HSE firmware is present and SBAF boots the HSE firmware. 0b - No 1b - Yes

34.5.6 General Purpose Configuration 6 (CONFIG_REG6)

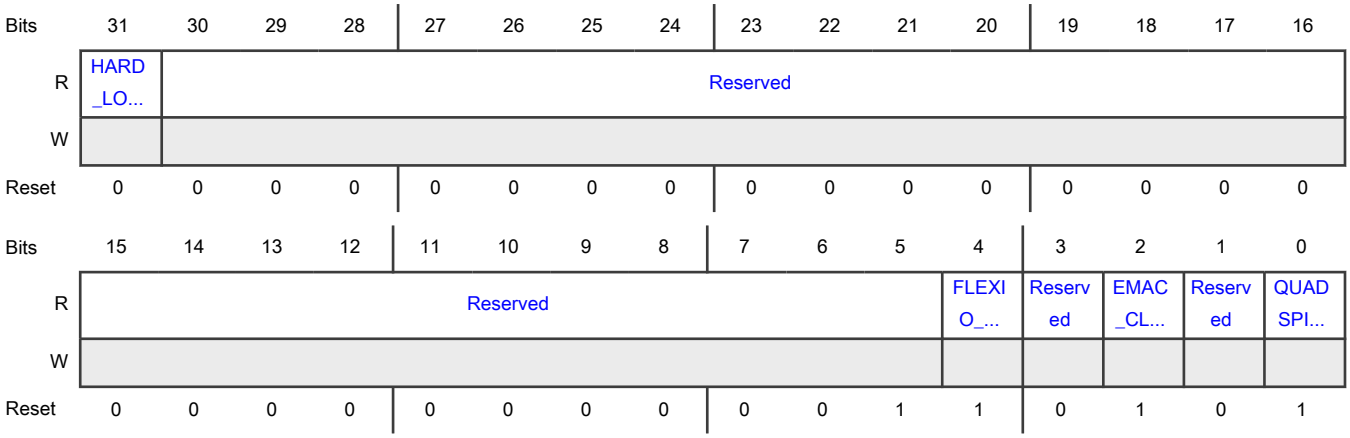
Offset

Register	Offset
CONFIG_REG6	34h

Function

Resets on functional reset.

Diagram



Fields

Field	Function
31 HARD_LOCK	Hard Lock This is a sticky field. If you write 1 to it, it remains 1 until next reset. 0b - Write access to this register is allowed 1b - Write access to this register is not allowed
30-5 —	Reserved
4 FLEXIO_CLOCK_GATE	FlexIO Clock Gating Clock to FlexIO peripheral is on or off. 0b - Clock is off (gated) 1b - Clock is on
3 —	Reserved
2	Ethernet Clock Gating

Table continues on the next page...

Table continued from the previous page...

Field	Function
EMAC_CLOCK_GATE	Clock to Ethernet peripheral is on or off. 0b - Clock is off (gated) 1b - Clock is on
1 —	Reserved
0 QUADSPI_SDID_PCTL	QuadSPI Clock Gating Clock to QuadSPI peripheral is on or off. 0b - Clock is off (gated) 1b - Clock is on

34.5.7 Configuration REG_GPR (CONFIG_REG_GPR)

Offset

Register	Offset
CONFIG_REG_GPR	64h

Function

Resets on functional reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	APP_CORE_ACC				Reserved											
W																
Reset	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved														FIRC_DIV_SEL	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-29	APP_CORE_ACC

Table continues on the next page...

Table continued from the previous page...

Field	Function
APP_CORE_ACC	**NOTE** While writing to this register, APP_CORE_ACC is RO and should not be changed from 0b101. 101b - Application core can write the FIRC_DIV_SEL field. The APP_CORE_ACC must be 101b to have access to the FIRC_DIV_SEL field. All other values - No access to application core
28-2 —	Reserved
1-0 FIRC_DIV_SEL	FIRC Divider Indicates this chip's FIRC clock division factor. 00b - Divided by 2 01b - Divided by 2 10b - Divided by 16 11b - Undivided

34.6 Glossary

ADK/P	Application debug key/password
AES	Advanced encryption standard
CBC	Cipher block chaining
CCM	Counter with CBC MAC (Cipher block chaining message authentication code)
CFB	Cipher feedback mode
CMAC	Cipher-based message authentication code
CTR	Counter-based block cipher mode
CVC	Card verifiable certificates
Classic DH	Classical Diffie–Hellman, a key exchange method
DRBG	Deterministic random bit generator
ECB	Electronic code book
ECC	Elliptic curve cryptography
ECDH	Elliptic-curve Diffie–Hellman, a key exchange method
ECDSA	Elliptic curve digital signature algorithm
EdDSA	Edwards-curve digital signature algorithm
FIPS	Federal information processing standards
GCM	Galois/counter mode
GMAC	Galois message authentication code

HMAC	Keyed-hash message authentication code
MD5	Message-digest algorithm 5
MUA	Messaging unit A interface
MUB	Messaging unit B interface
NIST	National institute of standards and technology
OAEP	Optimal asymmetric encryption padding
OFB	Output feedback based block cipher mode
PKC	Public key cryptographic engine
PKCS1	Public-key cryptography standards. PKCS provides the basic definitions of, and recommendations for implementing the RSA algorithm.
POR	Power-on reset
RNG	Random number generator
RSA	Rivest shamir adleman (a public key cryptosystem)
RSASSA_PSS	RSA signature scheme with appendix - probabilistic signature scheme
SHA	Secure hash algorithm
SHE	Secure hardware extension
TRNG	True random number generator
XCBC-MAC	Extended ciphertext block chaining MAC
XTS	XEX (XOR encrypt XOR) based tweaked-codebook mode with ciphertext stealing

Chapter 35
Device Configuration Format (DCF) records

35.1 Overview

DCF configures certain registers of this chip during system boot while the reset signal asserts. An individual DCF record points to an internal register in the chip and the data to be written to that register.

UTEST DCF—The UTEST DCF clients are present within the UTEST region of the flash and programmed during production testing. You may write the other records and program them at the same time the application code is programmed in the flash memory. See the DCF client file attached to this document for the description on the UTEST DCF records.

System boot is a complex process that requires you to initialize the chip properly before releasing reset. Before using the chip, the user writes the application specific code into the flash memory. The user can also update the DCF records from their initial settings as per application requirements, in case if needed.

After power is supplied to an appropriately configured chip, PMC controls the chip, and after the system power supplies reach predefined levels, PMC signals MC_RGM to start the boot sequence. During this sequence, MC_RGM enables DCM to read the chip configuration records and then write the configuration information to the specified registers.

35.2 DCF clients

These are 32-bit wide hardware registers inside a module that receive and store data from a DCF record. This stored data is used to initialize registers and configure features.

DCF clients:

- Are assigned a default value before any DCF records are written.
- May have special writing constraints, such as:
  - Write once.
  - Change from 1 to 0 only.
  - Change from 0 to 1 only.
- May not implement all 32 bits.

35.2.1 Safety features of DCF clients

Depending on the DCF client's role in the chip, the client may be equipped with a safety feature or a combination of these features.

35.2.1.1 Parity

If a DCF client implements parity checking, the client receives a parity bit in addition to its data in the DCF record. During chip operation, the client continuously monitors whether the data it stores matches the parity. The parity scheme used is even parity. So, the number of 1s in the WDATA and parity field needs to be even. For example, if the WDATA field has the value 0000_0001h, the value of the parity field needs to be 1 so that the total number of 1s is even. It also reports errors to DCM in case of discrepancies.

35.2.1.2 Triple voting

DCF clients that use triple voting have three copies of the register. DCM writes to all the three registers in a single write cycle. During chip operation, the DCF client continuously monitors whether all these three copies match. In case of discrepancies, the client reports errors to DCM. The chip uses the majority result, so single errors do not affect the chip's operation. If case of single error, since the chip uses the majority result, there will be no impact to the chip's behavior.

35.2.2 DCF client modification rules

Depending on its role in the chip, a DCF client may implement one or a combination of modification rules. If a modification rule is in effect, the order in which DCF records are placed in the record list may be important.

35.2.2.1 Write once

A DCF client using the write once rule can only be written with a single DCF record. The records that are appended later in the list are ignored and do not change the value of the client.

35.2.2.2 Write 0 only

A field in a DCF client can only be changed from 1 to 0. Therefore, if the value of a field in the previous DCF record is 0, an attempt by a later record to write 1 to it is ignored.

35.2.2.3 Write 1 only

A field in a DCF client can only be changed from 0 to 1. Therefore, if the value of a field in the previous DCF record is 1, an attempt by a later record to write 0 to the field is ignored.

35.3 DCF record structure

A DCF record is a double-word (64-bit) entry that consists of the following:

- Control word—This provides information to locate the corresponding DCF client internal to the chip (pointer to the location of a register internal to the chip).
- Data word—This contains the data to be written to the DCF client.

DCF records select the target DCF client using a 30-bit field in the DCF record that consists of a 15-bit chip select field and a 15-bit address field. All modules that include DCF clients are assigned a chip select during chip definition. The address field is only relevant for address decoding within that module and may not necessarily relate to the address of a register that is visible to you.

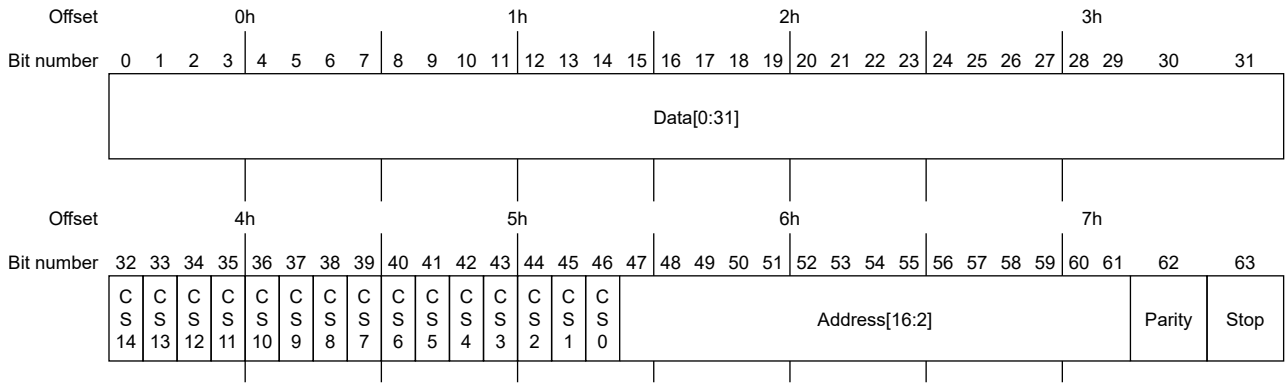


Figure 145. DCF record structure

Table 176. DCF record field descriptions

Field	Name	Description
0-31	Data[0:31]	Provides the data that is to be written to the DCF client.
32-46	CS*n*	Indicates chip select *n*. The value 1 is written to a chip select per DCF record to select the target module for the DCF client. The value 0 must be written to all other chip selects.

Table continues on the next page...

Table 176. DCF record field descriptions (continued)

Field	Name	Description
47-61	Address[16:2]	Contains the address of the DCF client within the selected module. Address decoding for DCF clients may not match the standard software address map decoding. For details, see the DCF client addresses provided with each module.
62	Parity	Indicates parity for the DCF record.
63	Stop	Indicates the end of the list for DCF records. 0 – Not the end 1 – End The erased state of flash memory is FFFF_FFFF_FFFF_FFFFh. Therefore, the list ends with the first unprogrammed double word. This location can be programmed with a new record to extend the list.

35.4 DCF records sequence

An individual DCF record contains information to locate the corresponding DCF client internal to the chip (control word) and the data to be written to that client (data word).

DCF records appear as contiguous series of entries programmed at a specific address within UTEST flash memory, and must present the following pattern:

- The first DCF record must be a start record. This record must be placed at the beginning of a DCF area in UTEST flash memory to indicate to the chip that the specified records must be processed.
- DCF records containing configuration data must immediately follow the start record with no blank records in between. An unprogrammed record is interpreted as a stop record and no DCF records following that are processed. This allows you to program the records in several sessions, appending new records at the end of the list each time.
- DCF stop record with bit set indicates the end of configuration records. It is not recommended to set STOP bit in last DCF record programmed during production because that prevents appending additional DCFs records. The UTEST flash memory location following the last DCF record programmed at the factory is an unprogrammed location, which has FFFF_FFFFh as its content. Thus, the stop bit location in this unprogrammed flash memory location is logic 1, signifying that this is the last DCF record and it is not to be acted upon.

Table 177 shows the record that DCM recognizes as a start record.

Table 177. DCF start record

0h (0:31)	4h (32:63)
05AA_55AFh	0000_0000h

The factory sets the DCF start record at the beginning of the UTEST flash memory area.

Table 178 shows the record that DCM recognizes as a stop record.

Table 178. DCF stop record

0:31	32:62	63
Ignored	Ignored	1

The DCF records that you supply must be added in a contiguous manner immediately following the factory-written DCF records. You must never have an unprogrammed record in the series of DCF records because that is interpreted as a stop record.

Table 179 shows the series of DCF records when *n* data records are stored in the UTEST flash memory.

Table 179. Series of DCF records in UTEST flash memory

Record type	Address offset	Data			
Start	0h	05AA_55AFh			
	4h	0000_0000h			STOP = 0
Data	8h	WDATA[31:0]			
	Ch	CS[14:0]	ADDR[16:2]	Parity	STOP = 0
	10h	WDATA[31:0]			
	14h	CS[14:0]	ADDR[16:2]	Parity	STOP = 0
	...	...			
Stop	8(*n*-1) + 0h	Reserved			
	8(*n*-1) + 4h	Reserved			1
Ignored	8*n* + 0h				
	8*n* + 4h				

More than one DCF records can write to the same DCF client. In this case, the later record usually overrides a DCF client value defined by a previous record. However, not all DCF clients allow overwrites; this depends on individual implementation of DCF clients.

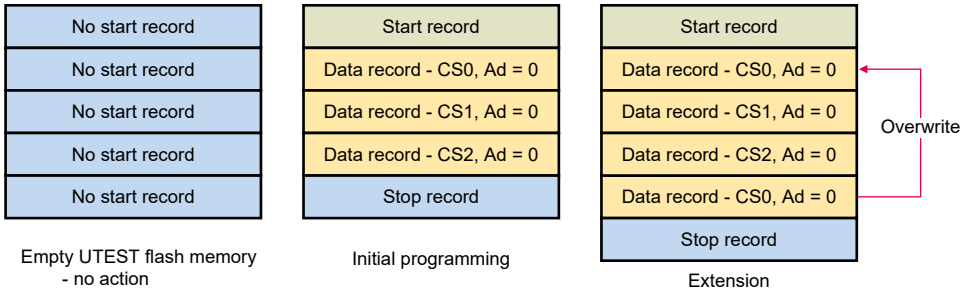


Figure 146. Appending DCF records

35.5 Chip configuration records

The DCF clients table contains information on DCF clients available in the chip. See the DCF clients file attached to this document.

The next table shows an example of how the information in this chapter is integrated with the attached DCF clients file.

Table 180. Integration of DCF information

Type	Data(n) assuming Quad page program	Data	Comment
Reset pad dedicated control DCF client (dcf_client_reset_pad_dedicated - column D in the "Utest DCF Clients" sheet)	Data word (determined base on the DCF record description in the "Utest DCF Client Register Bits" sheet)	0000_0001h	Data to enable pad as dedicated reset pad
	Control word (without parity) (selected from column C in the "Utest DCF Clients" sheet)	0010_0008h	Chip Select is 3 and address is 8, 0010_0000h+ 8h

35.6 Glossary

UTEST User test. Refers to UTEST region of the flash.

Chapter 36
Device Configuration Module General-Purpose Registers (DCM_GPR)

36.1 Chip-specific DCM information

36.1.1 DCM register fields availability in product family

The following table summarizes the DCM register fields which are not available in S32K36x. Other DCM register fields are available in all the products.

Table 181. DCM register fields availability in product family

Register field	Register field abbreviation	Register field description
DCMROD3[31]	CM7_1_ICDATA_ECC_ERR	See Register section for details
DCMROD3[29]	CM7_1_DCTAG_ECC_ERR	See Register section for details
DCMROD3[27]	CM7_1_DCDATA_ECC_ERR	See Register section for details
DCMROD3[1]	CM7_1_LOCKUP	See Register section for details
DCMROD4[7]	CM7_1_DTCM1_ECC_ERR	See Register section for details
DCMROD4[6]	CM7_1_DTCM0_ECC_ERR	See Register section for details
DCMROD4[5]	CM7_1_ITCM_ECC_ERR	See Register section for details
DCMROD4[1]	CM7_1_ICTAG_ECC_ERR	See Register section for details
DCMROD5[19]	CM7_1_AHBM_RDATA_EDC_ERR	See Register section for details
DCMROD5[18]	CM7_1_AHBP_RDATA_EDC_ERR	See Register section for details
DCMROD7[4]	CM7_1_AHBP_ALARM	See Register section for details
DCMROD7[1]	CM7_1_AHBM_ALARM	See Register section for details
DCMRWD3[31]	CM7_1_ICDATA_ECC_ERR_EN	See Register section for details
DCMRWD3[29]	CM7_1_DCTAG_ECC_ERR_EN	See Register section for details
DCMRWD3[27]	CM7_1_DCDATA_ECC_ERR_EN	See Register section for details
DCMRWD3[1]	CM7_1_LOCKUP_EN	See Register section for details
DCMRWD4[7]	CM7_1_DTCM1_ECC_ERR_EN	See Register section for details
DCMRWD4[6]	CM7_1_DTCM0_ECC_ERR_EN	See Register section for details
DCMRWD4[5]	CM7_1_ITCM_ECC_ERR_EN	See Register section for details
DCMRWD4[1]	CM7_1_ICTAG_ECC_ERR_EN	See Register section for details
DCMRWD5[19]	CM7_1_AHBM_RDATA_EDC_ERR_EN	See Register section for details
DCMRWD5[18]	CM7_1_AHBP_RDATA_EDC_ERR_EN	See Register section for details
DCMRWD8[29]	FLEXCAN5_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[28]	FLEXCAN4_DBG_DIS_CM7_1	See Register section for details

Table continues on the next page...

Table 181. DCM register fields availability in product family (continued)

Register field	Register field abbreviation	Register field description
DCMRWD8[27]	FLEXCAN3_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[26]	FLEXCAN2_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[25]	FLEXCAN1_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[24]	FLEXCAN0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[23]	FLEXIO_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[22]	LPI2C1_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[21]	LPI2C0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[20]	LPSPI5_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[19]	LPSPI4_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[18]	LPSPI3_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[17]	LPSPI2_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[16]	LPSPI1_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[15]	LPSPI0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[14]	PIT2_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[13]	PIT1_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[12]	PIT0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[11]	STM1_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[10]	STM0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[9]	SWT1_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[8]	SWT0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[7]	RTC_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[4]	eMIOS0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[3]	LCU1_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[2]	LCU0_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[1]	FCCU_DBG_DIS_CM7_1	See Register section for details
DCMRWD8[0]	EDMA_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[20]	SD_ADC3_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[19]	SD_ADC2_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[18]	SD_ADC1_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[17]	SD_ADC0_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[14]	EDMA1_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[12]	IGF0_DBG_DIS_CM7_1	See Register section for details

Table continues on the next page...

Table 181. DCM register fields availability in product family (continued)

Register field	Register field abbreviation	Register field description
DCMRWD9[11]	ETPU_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[10]	SIPI_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[9]	eFlexPWM1_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[8]	eFlexPWM0_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[7]	DSPI_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[6]	DIGRF_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[4]	SWT2_DBG_DIS_CM7_1	See Register section for details
DCMRWD9[3]	STM2_DBG_DIS_CM7_1	See Register section for details
DCMRWD15[29]	CM7_1_AHBS_ALARM_EN	See Register section for details
DCMRWD15[4]	CM7_1_AHBP_ALARM_EN	See Register section for details
DCMRWD15[1]	CM7_1_AHBM_ALARM_EN	See Register section for details
DCMRWF4[18]	CM7_1_CPUWAIT	See Register section for details

36.2 DCM_GPR register descriptions

Before you start to work with the GPR register take care about the following:

- Do not modify the reserved locations, registers, or reserved bits with respect to their default configurations. Chip behavior is not guaranteed in case of such writes.
- The writes to the DCM Read Write registers (DCMRWPx, DCMRWDx, and DCMRWFx) are synchronized and take up to 4 cycles of CORE_CLK, which means that the register configuration is effective at least 4 CORE_CLK after its write.
- The DCMROXn registers are sticky in nature. These registers latch the previous state and retain values across standby mode. Therefore, reading these registers might indicate a previously latched value. To read these sticky status registers after a reset event, a standby mode exit or any update in the signals which they latch, it is recommended to first clear the corresponding fields by writing 1 to the fields. This operation clears the previously latched status, and the fields get updated with the new status correctly.
- You must access DCM after at least 9 AIPS_SLOW_CLK cycles of writing to MC_RGM.ERCTRL because the configuration of MC_RGM.ERCTRL takes several cycles to be effective.

36.2.1 DCM_GPR memory map

DCM_GPR base address: 402A_C000h

Offset	Register	Width (In bits)	Access	Reset value
200h	Read-Only GPR On Destructive Reset 1 (DCMROD1)	32	RW	0000_0000h
208h	Read-Only GPR On Destructive Reset 3 (DCMROD3)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
20Ch	Read-Only GPR On Destructive Reset 4 (DCMROD4)	32	RW	0000_0000h
210h	Read-Only GPR On Destructive Reset 5 (DCMROD5)	32	RW	0000_0000h
214h	Read-Only GPR On Destructive Reset 6 (DCMROD6)	32	RW	0000_0000h
218h	Read-Only GPR On Destructive Reset 7 (DCMROD7)	32	RW	0000_0000h
300h	Read-Only GPR On Functional Reset 1 (DCMROF1)	32	RW	0000_0000h
304h	Read-Only GPR On Functional Reset 2 (DCMROF2)	32	RW	0000_0000h
308h	Read-Only GPR On Functional Reset 3 (DCMROF3)	32	RW	0000_0000h
30Ch	Read-Only GPR On Functional Reset 4 (DCMROF4)	32	RW	0000_0000h
310h	Read-Only GPR On Functional Reset 5 (DCMROF5)	32	RW	0000_0000h
314h	Read-Only GPR On Functional Reset 6 (DCMROF6)	32	RW	0000_0000h
318h	Read-Only GPR On Functional Reset 7 (DCMROF7)	32	RW	0000_0000h
31Ch	Read-Only GPR On Functional Reset 8 (DCMROF8)	32	RW	0000_0000h
320h	Read-Only GPR On Functional Reset 9 (DCMROF9)	32	RW	0000_0000h
324h	Read-Only GPR On Functional Reset 10 (DCMROF10)	32	RW	0000_0000h
328h	Read-Only GPR On Functional Reset 11 (DCMROF11)	32	RW	0000_0000h
32Ch	Read-Only GPR On Functional Reset 12 (DCMROF12)	32	RW	0000_0000h
330h	Read-Only GPR On Functional Reset 13 (DCMROF13)	32	RW	0000_0000h
334h	Read-Only GPR On Functional Reset 14 (DCMROF14)	32	RW	0000_0000h
338h	Read-Only GPR On Functional Reset 15 (DCMROF15)	32	RW	0000_0000h
33Ch	Read-Only GPR On Functional Reset 16 (DCMROF16)	32	RW	0000_0000h
340h	Read-Only GPR On Functional Reset 17 (DCMROF17)	32	RW	0000_0000h
348h	Read-Only GPR On Functional Reset 19 (DCMROF19)	32	R	4000_0000h
34Ch	Read-Only GPR On Functional Reset 20 (DCMROF20)	32	R	See section
350h	Read-Only GPR On Functional Reset 21 (DCMROF21)	32	R	0000_0000h
400h	Read Write GPR On POR 1 (DCMRWP1)	32	RW	0000_0400h
408h	Read Write GPR On POR 3 (DCMRWP3)	32	RW	0000_0000h
504h	Read Write GPR On Destructive Reset 2 (DCMRWD2)	32	RW	0000_0000h
508h	Read Write GPR On Destructive Reset 3 (DCMRWD3)	32	RW	FF7F_9BFFh
50Ch	Read Write GPR On Destructive Reset 4 (DCMRWD4)	32	RW	EF7F_FFFFh
510h	Read Write GPR On Destructive Reset 5 (DCMRWD5)	32	RW	FFFF_FFFFh
514h	Read Write GPR On Destructive Reset 6 (DCMRWD6)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
518h	Read Write GPR On Destructive Reset 7 (DCMRWD7)	32	RW	0000_0000h
51Ch	Read Write GPR On Destructive Reset 8 (DCMRWD8)	32	RW	0000_0000h
520h	Read Write GPR On Destructive Reset 9 (DCMRWD9)	32	RW	0000_0000h
52Ch	Read Write GPR On Destructive Reset 12 (DCMRWD12)	32	RW	0000_0000h
530h	Read Write GPR On Destructive Reset 13 (DCMRWD13)	32	RW	0000_0000h
534h	Read Write GPR On Destructive Reset 14 (DCMRWD14)	32	RW	BBFF_FFFFh
538h	Read Write GPR On Destructive Reset 15 (DCMRWD15)	32	RW	7FFF_FFFFh
600h	Read Write GPR On Functional Reset 1 (DCMRWF1)	32	RW	0000_0000h
604h	Read Write GPR On Functional Reset 2 (DCMRWF2)	32	RW	0000_0000h
608h	Read Write GPR On Functional Reset 3 (DCMRWF3)	32	RW	0000_0000h
60Ch	Read Write GPR On Functional Reset 4 (DCMRWF4)	32	RW	0000_0000h
610h	Read Write GPR On Functional Reset 5 (DCMRWF5)	32	RW	See section
700h	Read-Only GPR On PMCPOR Reset 1 (DCMROPP1)	32	RW	0000_0000h
704h	Read-Only GPR On PMCPOR Reset 2 (DCMROPP2)	32	RW	0000_0000h
708h	Read-Only GPR On PMCPOR Reset 3 (DCMROPP3)	32	RW	0000_0000h
70Ch	Read-Only GPR On PMCPOR Reset 4 (DCMROPP4)	32	RW	0000_0000h

36.2.2 Read-Only GPR On Destructive Reset 1 (DCMROD1)

Offset

Register	Offset
DCMROD1	200h

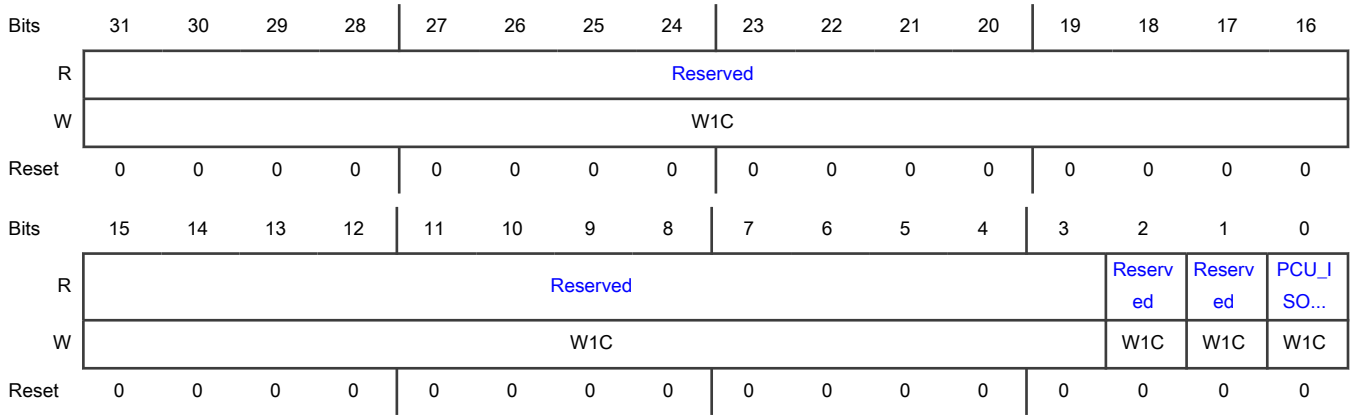
Function

Contains information related to:

- Key response ready status.
- DCF violation from HSE_B.
- PCU input isolation status.

This register resets after destructive reset 1.

Diagram



Fields

Field	Function
31-3 —	Reserved
2 —	Reserved
1 —	Reserved
0 PCU_ISO_STATUS	PCU Input Isolation Status On Previous Standby Entry Specifies whether input isolation was enabled in the previous standby entry. 0b - No 1b - Yes

36.2.3 Read-Only GPR On Destructive Reset 3 (DCMROD3)

Offset

Register	Offset
DCMROD3	208h

Function

Contains information related to:

- ECC and life cycle errors.
- AXBS, RCCU, and gasket alarms.

This register resets after destructive reset 3.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CM7_1_I...	CM7_0_I...	CM7_1_D...	CM7_0_D...	CM7_1_D...	CM7_0_D...	PRAM0_E...	PRAM1_E...	Reserved	LC_ERR	PF3_DAT...	PF3_COD...	PERIPH_...	MAC_GSK...	TCM_AXB...	DATA_ED...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ADDR_ED...	Reserved	Reserved	QSPI_GS...	HSE_GSK...	Reserved	DMA_AXB...	SYS_AXB...	DMA_PER...	DMA_SYS...	TCM_GSK...	CM7_RCC...	CM7_RCC...	HSE_LOC...	CM7_1_L...	CM7_0_L...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 CM7_1_ICDATA_ECC_ERR	Cortex-M7_1 I-cache Multi-Bit ECC Error Specifies whether the Cortex-M7_1 core's I-cache data memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU noncritical fault (NCF) 2. 0b - No 1b - Yes
30 CM7_0_ICDATA_ECC_ERR	Cortex-M7_0 I-cache Data ECC Error Specifies whether the Cortex-M7_0 core's I-cache data memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
29 CM7_1_DCTAG_ECC_ERR	Cortex-M7_1 D-cache Tag ECC Error Specifies whether the Cortex-M7_1 core's D-cache tag memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
28 CM7_0_DCTAG_ECC_ERR	Cortex-M7_0 D-cache Tag ECC Error Specifies whether the Cortex-M7_0 core's D-cache tag memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
27	Cortex-M7_1 D-cache Data Memory ECC Error

Table continues on the next page...

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Field	Function
CM7_1_DCDATA_ECC_ERR	Specifies whether the Cortex-M7_1 core's D-cache data memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
26 CM7_0_DCDATA_ECC_ERR	Cortex-M7_0 D-cache Data Memory ECC Error Specifies whether the Cortex-M7_0 core's D-cache data memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
25 PRAM0_ECC_ERR	Multi-Bit ECC Error From PRAM0 Specifies whether a multi-bit ECC error occurred from PRAM0. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
24 PRAM1_ECC_ERR	Multi-Bit ECC Error From PRAM1 Specifies whether a multi-bit ECC error occurred from PRAM1. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
23 —	Reserved
22 LC_ERR	Error In Life Cycle Scanning Specifies whether an error occurred during life-cycle scanning. Read this bit to identify the reason of fault in case of FCCU NCF 3. 0b - No error while lifecycle scanning. 1b - Error while lifecycle scanning
21 PF3_DATA_ECC_ERR	Program Flash Memory 3 Data ECC Uncorrectable Error Specifies whether FMU reported an uncorrectable error in the flash memory controller port 3 data memory. Read this field to identify the reason for a fault in case of FCCU NCF 3. The errors are reported from FMU and are connected to FCCU NCFs. These are also connected to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels. The path is from FMU to PFLASH controller, and then from ERM to FCCU.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No 1b - Yes
20 PF3_CODE_ECC_ERR	Flash Memory 3 Code ECC Uncorrectable Error Specifies whether FMU reported uncorrectable errors in the flash memory controller port 3 code memory. Read this field to identify the reason for a fault in case of FCCU NCF 3. The errors are reported from FMU and are connected to FCCU NCFs. These are also connected to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels. The path is from FMU to PFLASH controller, and then from ERM to FCCU. 0b - No 1b - Yes
19 PERIPH_AXBS_ALARM	Peripheral AXBS_Lite Safety Alarm Status Specifies whether peripheral AXBS_Lite reported a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
18 MAC_GSKT_ALARM	MAC IAHB Gasket Alarm Status Specifies whether the MAC IAHB gasket reported an alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
17 TCM_AXBS_ALARM	TCM AHB Splitter Safety Alarm Status Specifies whether the TCM AHB splitter reported a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
16 DATA_EDC_ERR	Data EDC Error Specifies whether an integrity error occurred on address for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
15	Address EDC Error Status Specifies whether an integrity error occurred on address for safety.

Table continues on the next page...

Table continued from the previous page...

Field	Function
ADDR_EDC_ERR	Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
14 —	Reserved
13 —	Reserved
12 QSPI_GSKT_ALARM	QuadSPI IAHB Gasket Alarm Status Specifies whether the QuadSPI IAHB gasket reported an alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
11 HSE_GSKT_ALARM	HSE IAHB Gasket Alarm Status Specifies whether the HSE_B IAHB gasket reported an alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
10 —	Reserved
9 DMA_AXBS_ALARM	eDMA AXBS_Lite Safety Alarm Status Specifies whether eDMA AXBS_Lite reported a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
8 SYS_AXBS_ALARM	System AXBS Safety Alarm Status Specifies whether the system AXBS indicated a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
7	eDMA Peripheral Gasket Alarm Status Specifies whether the eDMA peripheral AXBS IAHB gasket reported a safety alarm.

Table continues on the next page...

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Field	Function
DMA_PERIPH_GSKT_ALARM	Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
6 DMA_SYS_GSKT_ALARM	eDMA System Gasket Alarm Status Specifies whether the IAHB gasket safety alarm, from the eDMA system AXBS IAHB gasket, reported a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
5 TCM_GSKT_ALARM	TCM IAHB Gasket Monitor Alarm Status Specifies whether the TCM IAHB gasket reported an alarm. If the value of this field is 1, the gasket reports a monitor alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
4 CM7_RCCU2_ALARM	Cortex-M7 Core Redundant Lockstep Error Status Specifies whether RCCU reported a lockstep alarm. Read this field to identify the reason for a fault in case of FCCU NCF 0. 0b - No 1b - Yes
3 CM7_RCCU1_ALARM	Cortex-M7 Core Lockstep Error Status Specifies whether RCCU reported a lockstep alarm. Read this field to identify the reason for a fault in case of FCCU NCF 0. 0b - No 1b - Yes
2 HSE_LOCKUP	HSE_B Core Lockup Status Specifies whether the HSE_B core is in the Lockup state. Read this field to identify the reason for a fault in case of FCCU NCF 0. 0b - No 1b - Yes
1	Cortex-M7_1 Core Lockup Status Specifies whether the Cortex_M7_1 core is in the Lockup state.

Table continues on the next page...

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Field	Function
CM7_1_LOCKUP	Read this field to identify the reason for a fault in case of FCCU NCF 0. 0b - No 1b - Yes
0 CM7_0_LOCKUP	Cortex-M7_0 Core Lockup Status Specifies whether the Cortex-M7_0 core is in the Lockup state. Read this field to identify the reason for a fault in case of FCCU NCF 0. 0b - No 1b - Yes

36.2.4 Read-Only GPR On Destructive Reset 4 (DCMROD4)

Offset

Register	Offset
DCMROD4	20Ch

Function

Contains information related to:

- Accidental partial test activation errors.
- Go/No-go indicator supply statuses.
- Flash memory errors.
- Alarm statuses.

This register resets after destructive reset 4.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CM7_2_L...	TEST_AC...	TEST_AC...	Reserved	VDD2P5_...	VDD1P1_...	FLASH_E...	Reserved	Reserved	FLASH_S...	FLASH_R...	FLASH_R...	FLASH_A...	FLASH_E...	PF2_DAT...	PF2_COD...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PF1_DAT...	PF1_COD...	PF0_DAT...	PF0_COD...	HSE_RAM...	PRAM1_F...	PRAM0_F...	DMA_TCD...	CM7_1_D...	CM7_1_D...	CM7_1_I...	CM7_0_D...	CM7_0_D...	CM7_0_I...	CM7_1_I...	CM7_0_I...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 CM7_2_LOCKUP	CM7_2 Core Lockup Status Read this bit to identify the reason of fault in case of FCCU NCF 0. 0b - CM7_2 core not in lockup state. 1b - CM7_2 core in lockup state.
30 TEST_ACTIVATION_1_ERR	Accidental Partial Test Activation 1 Error Specifies whether partial test 1 is activated accidentally. Read this field to identify the reason for a fault in case of FCCU NCF 5. 0b - No 1b - Yes
29 TEST_ACTIVATION_0_ERR	Accidental Partial Test Activation 0 Error Specifies whether partial test 0 is activated accidentally. Read this field to identify the reason for a fault in case of FCCU NCF 5. 0b - No 1b - Yes
28 —	Reserved
27 VDD2P5_GNG_ERR	Go/No-go Indicator For VDD_HV_FLA Specifies whether the VDD_HV_FLA (double-bond) supply going to XOSC and PLL is clean. Read this field to identify the reason for a fault in case of FCCU NCF 4. If this field = 1, the "go" indication specifies a clean supply, and if this field = 0, the "no-go" indication specifies an unclean supply with a fault in the double-bond connection or its routing within the chip. 0b - Yes 1b - No
26 VDD1P1_GNG_ERR	Go/No-go Indicator For VDD1PD1 Specifies whether the VDD1PD1 (double-bond) supply going to PLL is clean. Read this field to identify the reason for a fault in case of FCCU NCF 4. If this field = 1, the "go" indication specifies a clean supply, and if this field = 0, the "no-go" indication specifies an unclean supply with a fault in the double-bond connection or its routing within the chip. 0b - Yes 1b - No
25	ECC Error From Flash Controller This alarm Specifies that the flash controller detected an error in the address ECC manipulation logic through EDC. Read this bit to identify the reason for a fault in case of FCCU NCF 3.

Table continues on the next page...

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Field	Function
FLASH_ECC_ERR	0b - No ECC error from flash controller. 1b - ECC error from flash controller.
24 —	Reserved
23 —	Reserved
22 FLASH_SCAN_ERR	Flash Memory Scan Error Status Specifies whether the flash memory encountered an error during the DCM flash scanning process because of invalid data. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
21 FLASH_RST_ERR	Flash Reset Error Status Specifies whether the flash memory encountered a flash memory reset error during its reset reads. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
20 FLASH_REF_ERR	Flash Memory Reference Error Status Specifies whether the flash memory encountered a reference current loss or read voltage error during previous read(s). Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
19 FLASH_ADDR_ENC_ERR	Flash Memory Address Encode Error Status Specifies whether FMU reported an address encode error in the flash memory. During address decoding, if multiple or no address line is selected, FMU reports an address encode error. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
18 FLASH_EDC_ERR	Flash Memory EDC Error Status Specifies whether FMU reported an integrity error after an ECC correction error in the flash memory. Read this field to identify the reason for a fault in case of FCCU NCF 3.

Table continues on the next page...

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Field	Function
	0b - No 1b - Yes
17 PF2_DATA_ECC_ERR	Program Flash Memory 2 Data ECC Error Status Specifies whether FMU reported uncorrectable errors in the flash memory controller port 2 data memory. These errors are connected to FCCU NCFs and to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
16 PF2_CODE_ECC_ERR	Program Flash Memory 2 Code ECC Error Status Specifies whether FMU reported uncorrectable errors in the flash memory controller port 2 code memory. These errors are connected to FCCU NCFs and to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
15 PF1_DATA_ECC_ERR	Program Flash Memory 1 Data ECC Error Status Specifies whether FMU reported uncorrectable errors in the flash memory controller port 1 data memory. These errors are connected to FCCU NCFs and to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
14 PF1_CODE_ECC_ERR	Program Flash Memory 1 Code ECC Error Status Specifies whether FMU reported uncorrectable errors in the flash memory controller port 1 code memory. These errors are connected to FCCU NCFs and to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
13 PF0_DATA_ECC_ERR	Program Flash Memory 0 Data ECC Error Status Specifies whether FMU reported uncorrectable errors in the flash memory controller port 0 data memory. These errors are connected to FCCU NCFs and to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels.

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Table continued from the previous page...

Field	Function
	Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
12 PF0_CODE_ECC_ERR	Program Flash Memory 0 Code ECC Error Status Specifies whether FMU reported uncorrectable errors in the flash memory controller port 0 code memory. These errors are connected to FCCU NCFs and to ERM. See the "Error Reporting Module (ERM)" chapter for memory errors and mapping onto ERM channels. Read this field to identify the reason for a fault in case of FCCU NCF 3. 0b - No 1b - Yes
11 HSE_RAM_ECC_ERR	HSE_B RAM Uncorrectable ECC Status Specifies whether HSE_B RAM reported an uncorrectable ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
10 PRAM1_FCCU_ALARM	PRAM1 FCCU Alarm Status Specifies whether PRAM1 reported a safety alarm. This field specifies the status of the PRAM1 safety alarm, whether the alarm is set on faulty PRAM1 read or read-modify error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
9 PRAM0_FCCU_ALARM	PRAM0 FCCU Alarm Status Specifies whether PRAM0 reported a safety alarm. This field specifies the status of the PRAM0 safety alarm, whether the alarm is set on faulty PRAM0 read or read-modify error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
8 DMA_TCD_RAM_ECC_ERR	eDMA TCD RAM ECC Error Specifies whether the eDMA_TCD memory detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes

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Field	Function
7 CM7_1_DTCM1_ECC_ERR	Cortex-M7_1 DTCM 1 ECC Error Specifies whether the Cortex-M7_1 core's DTCM block 1 detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_1 core's DTCM consists of two physical blocks. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
6 CM7_1_DTCM0_ECC_ERR	Cortex-M7_1 DTCM 0 ECC Error Specifies whether the Cortex-M7_1 core's DTCM block 0 detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_1 core's DTCM consists of two physical blocks. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
5 CM7_1_ITCM_ECC_ERR	Cortex-M7_1 ITCM ECC Error Specifies whether the Cortex-M7_1 core's ITCM detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
4 CM7_0_DTCM1_ECC_ERR	Cortex-M7_0 DTCM 1 ECC Error Specifies whether the Cortex-M7_0 core's DTCM block 1 detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_0 core's DTCM consists of two physical blocks. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
3 CM7_0_DTCM0_ECC_ERR	Cortex-M7_0 DTCM 0 ECC Error Specifies whether the Cortex-M7_0 core's DTCM block 0 detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_0 core's DTCM consists of two physical blocks. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
2	Cortex-M7_0 ITCM ECC Error

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Field	Function
CM7_0_ITCM_ECC_ERR	Specifies whether the Cortex-M7_0 core's ITCM detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. Read this field to identify the reason of fault in case of FCCU NCF 2. 0b - No 1b - Yes
1 CM7_1_ICTAG_ECC_ERR	Cortex-M7_1 I-cache Tag ECC Error Specifies whether the Cortex-M7_1 core's I-cache tag memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
0 CM7_0_ICTAG_ECC_ERR	Cortex-M7_0 I-cache Tag ECC Error Specifies whether the Cortex-M7_0 core's I-cache tag memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes

36.2.5 Read-Only GPR On Destructive Reset 5 (DCMROD5)

Offset

Register	Offset
DCMROD5	210h

Function

Contains information related to:

- ECC and EDC errors.
- Activation and bus errors.

This register resets after destructive reset 5.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CM7_2_D...	CM7_2_D...	CM7_2_I...	CM7_2_I...	CM7_2_I...	CM7_2_D...	CM7_2_D...	CM7_2_A...	CM7_2_A...	HSE_RDA...	CM7_0_A...	CM7_0_A...	CM7_1_A...	CM7_1_A...	DMA_RDA...	Reserved
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MAC_RDA...	TCM_RDA...	DEBUG_A...	MCT_BUS...	STCU_BI...	MBIST_A...	STCU_NCF	SW_NCF_3	SW_NCF_2	SW_NCF_1	SW_NCF_0	INTM_3_...	INTM_2_...	INTM_1_...	INTM_0_...	Reserved
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 CM7_2_DTCM1_ECC_ERR	Cortex-M7_2 DTCM 1 ECC Error Specifies whether the Cortex-M7_2 core's DTCM block 1 detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_2 core's DTCM consists of two physical blocks. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
30 CM7_2_DTCM0_ECC_ERR	Cortex-M7_2 DTCM 0 ECC Error Specifies whether the Cortex-M7_2 core's DTCM block 0 detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_2 core's DTCM consists of two physical blocks. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
29 CM7_2_ITCM_ECC_ERR	Cortex-M7_2 ITCM ECC Error Specifies whether the Cortex-M7_2 core's ITCM detected an uncorrectable ECC error. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
28 CM7_2_ICTAG_ECC_ERR	Cortex-M7_2 I-cache Tag ECC Error Specifies whether the Cortex-M7_2 core's I-cache tag memory reported a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2.

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Field	Function
	0b - No 1b - Yes
27 CM7_2_ICDATA_ECC_ERR	Cortex-M7_2 I-cache Data ECC Error Specifies whether the Cortex-M7_2 core's I-cache data memory reported a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
26 CM7_2_DCTAG_ECC_ERR	Cortex-M7_2 D-cache Tag ECC Error Specifies whether the Cortex-M7_2 core's D-cache tag memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
25 CM7_2_DCDATA_ECC_ERR	Cortex-M7_2 D-cache Data ECC Error Specifies whether the Cortex-M7_2 core's D-cache data memory detected a multi-bit ECC error. Read this field to identify the reason for a fault in case of FCCU NCF 2. 0b - No 1b - Yes
24 CM7_2_AHBM_RDATA_EDC_ERR	Cortex-M7_2 AHBM Read Data EDC Error Specifies whether an integrity error is reported on the Cortex-M7_2 core's main read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
23 CM7_2_AHBP_RDATA_EDC_ERR	Cortex-M7_2 AHBP Read Data EDC Error Specifies whether an integrity error is reported on the Cortex-M7_2 core's peripheral read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
22 HSE_RDATA_EDC_ERR	HSE_B Read Data EDC Error Specifies whether an integrity error is reported on the HSE_B read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No

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Field	Function
	1b - Yes
21 CM7_0_AHBM_RDATA_EDC_ERR	Cortex-M7_0 AHBM Read Data EDC Error Specifies whether an integrity error is reported on the Cortex-M7_0 core's main read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
20 CM7_0_AHBP_RDATA_EDC_ERR	Cortex-M7_0 AHBP Read Data EDC Error Specifies whether an integrity error is reported on the Cortex-M7_0 core's peripheral read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
19 CM7_1_AHBM_RDATA_EDC_ERR	Cortex-M7_1 AHBM Read Data EDC Error Specifies whether an integrity error is reported on the Cortex-M7_1 core's main read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
18 CM7_1_AHBP_RDATA_EDC_ERR	Cortex-M7_1 AHBP Read Data EDC Error Specifies whether an integrity error is reported on the Cortex-M7_1 core's peripheral read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
17 DMA_RDATA_EDC_ERR	eDMA Read Data EDC Error Specifies whether an integrity error is reported on the eDMA read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
16 —	Reserved
15 MAC_RDATA_EDC_ERR	MAC Read Data EDC Error Specifies whether an integrity error is reported on the MAC read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No 1b - Yes
14 TCM_RDATA_EDC_ERR	TCM Read Data EDC Error Specifies whether an integrity error is reported on the TCM read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
13 DEBUG_ACTIVATION_ERR	Debug Activation Error Specifies whether an unintended debug is activated. This field monitors unintended debug activation. It displays 1 as its value when the core is in halted state with the application debug or debugger request not enabled. Read this field to identify the reason for a fault in case of FCCU NCF 5. 0b - No 1b - Yes
12 MCT_BUS_ERR	MCT Bus Error Fault reported due to illegal access on MBIST Master Controller (MCT). This fault is reported via a transfer error indication to the system. Read this bit to identify the reason of fault in case of FCCU NCF 5. 0b - No transfer error indicated from MCT. 1b - Transfer error indicated from MCT.
11 STCU_BIST_USER_CF	STCU2 BIST User Critical Fault (CF) Specifies whether LBIST or MBIST is enabled accidentally when the fault condition is detected in Run mode. Read this field to identify the reason for a fault in case of FCCU NCF 5. 0b - No 1b - Yes
10 MBIST_ACTIVATION_ERR	MBIST Activation Error Specifies whether an accidental backdoor access is enabled on memories. DCMRWD5[MBIST_ACTIVATION_ERR_EN] needs to be disabled on FCCU when performing a fault injection. Read this field to identify the reason for a fault in case of FCCU NCF 5. 0b - No 1b - Yes
9	STCU2 NCF Result Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
STCU_NCF	Specifies whether STCU2 NCF, which is a BIST result error, is reported. Read this field to identify the reason for a fault in case of FCCU NCF 5. 0b - No 1b - Yes
8 SW_NCF_3	Software NCF3 Status Specifies whether DCMRWF1[FCCU_SW_NCF3] is enabled. Read this field to identify the reason for a fault in case of FCCU NCF 7. 0b - No 1b - Yes
7 SW_NCF_2	Software NCF2 Status Specifies whether DCMRWF1[FCCU_SW_NCF2] is enabled. Read this field to identify the reason for a fault in case of FCCU NCF 7. 0b - No 1b - Yes
6 SW_NCF_1	Software NCF1 Status Specifies whether DCMRWF1[FCCU_SW_NCF1] is enabled. Read this field to identify the reason for a fault in case of FCCU NCF 7. 0b - No 1b - Yes
5 SW_NCF_0	Software NCF 0 Status Specifies whether DCMRWF1[FCCU_SW_NCF0] is enabled. Read this field to identify the reason for a fault in case of FCCU NCF 7. 0b - No 1b - Yes
4 INTM_3_ERR	INTM_3 Error Specifies whether INTM_3 reported an error. The reported error is recorded in INTM.INTM_STATUS3. See the "Functional description" section of the "Interrupt Monitor (INTM)" chapter for details. Read this field to identify the reason for a fault in case of FCCU NCF 6. 0b - No 1b - Yes
3	INTM_2 Error

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Field	Function
INTM_2_ERR	Specifies whether INTM_2 reported an error. The reported error is recorded in INTM.INTM_STATUS2. See the "Functional description" section of the "Interrupt Monitor (INTM)" chapter for details. Read this field to identify the reason for a fault in case of FCCU NCF 6. 0b - No 1b - Yes
2 INTM_1_ERR	INTM_1 Error Specifies whether INTM_1 reported an error. The reported error is recorded in INTM.INTM_STATUS1. See the "Functional description" section of the "Interrupt Monitor (INTM)" chapter for details. Read this field to identify the reason for a fault in case of FCCU NCF 6. 0b - No 1b - Yes
1 INTM_0_ERR	INTM_0 Error Specifies whether INTM_0 reported an error. The reported error is recorded in INTM.INTM_STATUS0. See the "Functional description" section of the "Interrupt Monitor (INTM)" chapter for details. Read this field to identify the reason for a fault in case of FCCU NCF 6. 0b - No 1b - Yes
0 —	Reserved

36.2.6 Read-Only GPR On Destructive Reset 6 (DCMROD6)

Offset

Register	Offset
DCMROD6	214h

Function

Contains information related to:

- Safety, RCCU, and AXI alarm statuses.
- Core memory errors.
- CF and NCF errors.
- ECC and EDC errors.

This register resets after destructive reset 6.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DMA1_AX...	Reserved	ZIPWIRE...	DMA1_PE...	DMA1_SY...	Reserved	eDMA1_R...	eDMA1_R...	CM7_2_R...	CM7_2_R...	OMU_2_A...	OMU_1_A...	OMU_0_A...	ETPU_GL...	SAR_ADC...	SAR_ADC...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	QSPI_FL...	DMA1_TC...	ZIPWIRE...	DMA1_RD...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DMA1_AXBS_ALARM	eDMA_1 AXBS Safety Alarm Status Specifies whether eDMA_1 AXBS_Lite indicated a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
30 —	Reserved
29 ZIPWIRE_GSKT_ALARM	ZIPWIRE Gasket Alarm Specifies status of IAHB gasket safety alarm from Zipwire IAHB gasket. Read this bit to identify the reason of fault in case of FCCU NCF 1. 0b - No 1b - Yes
28 DMA1_PERIPH_GSKT_ALARM	DMA1 Peripheral Gasket Alarm Specifies status of IAHB gasket safety alarm from DMA1 periph AXBS IAHB gasket. Read this bit to identify the reason of fault in case of FCCU NCF 1. 0b - No 1b - Yes
27 DMA1_SYS_GSKT_ALARM	DMA1 System Gasket Alarm Specifies status of IAHB gasket safety alarm from DMA1 system AXBS IHAB gasket. Read this bit to identify the reason of fault in case of FCCU NCF 1.

Table continues on the next page...

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Field	Function
	0b - No 1b - Yes
26 —	Reserved
25 eDMA1_RCCU2_ALARM	eDMA_1 RCCU_2 Alarm Specifies whether RCCU_2 reported a lockstep alarm. This field specifies the eDMA_1 and checker eDMA_1 redundant lockstep error status. Read it to identify the reason for a fault in case of FCCU NCF 13. 0b - No 1b - Yes
24 eDMA1_RCCU1_ALARM	eDMA_1 RCCU_1 Alarm Status Specifies whether RCCU_1 reported a lockstep alarm. This field specifies the eDMA_1 and checker eDMA_1 lockstep error status. Read it to identify the reason for a fault in case of FCCU NCF 13. 0b - No 1b - Yes
23 CM7_2_RCCU2_ALARM	Cortex-M7_2 RCCU_2 Alarm Status Specifies whether RCCU_2 reported a lockstep alarm. This field specifies the redundant lockstep error status of the Cortex M7_2 and checker Cortex M7_2 cores. Read it to identify the reason for a fault in case of FCCU NCF 12. 0b - No 1b - Yes
22 CM7_2_RCCU1_ALARM	Cortex-M7_2 RCCU_1 Alarm Status Specifies whether RCCU_1 reported a lockstep alarm. This field specifies the lockstep error status of the Cortex-M7_2 and checker Cortex-M7_2 cores. Read it to identify the reason for a fault in case of FCCU NCF 12. 0b - No 1b - Yes
21 OMU_2_ALARM	OMU_2 Alarm Specifies whether FCCU reported the OMU_2 Alarm through OMU. Read this field to identify the reason for a fault in case of FCCU NCF 10. 0b - No 1b - Yes

Table continues on the next page...

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Field	Function
20 OMU_1_ALARM	OMU_1 Alarm Specifies whether FCCU reported the OMU_1 Alarm through OMU. Read this field to identify the reason for a fault in case of FCCU NCF 10. 0b - No 1b - Yes
19 OMU_0_ALARM	OMU_0 Alarm Specifies whether FCCU reported the OMU_0 Alarm through OMU. Read this field to identify the reason for a fault in case of FCCU NCF 10. 0b - No 1b - Yes
18 ETPU_GLEX_ERR	ETPU Global Exception detected at FCCU. Read this bit to identify the reason of fault in case of FCCU NCF 14. 0b - ETPU global exception not detected at FCCU. 1b - ETPU global exception detected at FCCU.
17 SAR_ADC6_CF_ERR	SAR_ADC_6 CF Error Specifies whether FCCU detected a SAR_ADC_6 CF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
16 SAR_ADC5_CF_ERR	SAR_ADC_5 CF Error Specifies whether FCCU detected a SAR_ADC_5 CF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
15 SAR_ADC4_CF_ERR	SAR_ADC_4 CF Error Specifies whether FCCU detected a SAR_ADC_4 CF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
14 SAR_ADC3_CF_ERR	SAR_ADC_3 CF Error Specifies whether FCCU detected a SAR_ADC_3 CF. Read this field to identify the reason for a fault in case of FCCU NCF 9.

Table continues on the next page...

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Field	Function
	0b - No 1b - Yes
13 SAR_ADC2_CF_ERR	SAR_ADC_2 CF Error Specifies whether FCCU detected a SAR_ADC_2 CF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
12 SAR_ADC1_CF_ERR	SAR_ADC_1 CF Error Specifies whether FCCU detected a SAR_ADC_1 CF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
11 SAR_ADC0_CF_ERR	SAR_ADC_0 CF Error Specifies whether FCCU detected a SAR_ADC_0 CF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
10 SAR_ADC6_NCF_ERR	SAR_ADC_6 NCF Error Specifies whether FCCU detected a SAR_ADC_6 NCF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
9 SAR_ADC5_NCF_ERR	SAR_ADC_5 NCF Error Specifies whether FCCU detected a SAR_ADC_5 NCF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
8 SAR_ADC4_NCF_ERR	SAR_ADC_4 NCF Error Specifies whether FCCU detected a SAR_ADC_4 NCF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No

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Field	Function
	1b - Yes
7 SAR_ADC3_NCF_ERR	SAR_ADC_3 NCF Error Specifies whether FCCU detected a SAR_ADC_3 NCF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
6 SAR_ADC2_NCF_ERR	SAR_ADC_2 NCF Error Specifies whether FCCU detected a SAR_ADC_2 NCF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
5 SAR_ADC1_NCF_ERR	SAR_ADC_1 NCF Error Specifies whether FCCU detected a SAR_ADC_1 NCF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
4 SAR_ADC0_NCF_ERR	SAR_ADC_0 NCF Error Specifies whether FCCU detected a SAR_ADC_0 NCF. Read this field to identify the reason for a fault in case of FCCU NCF 9. 0b - No 1b - Yes
3 QSPI_FLASHA_ECC_ERR	Uncorrectable ECC error status from flashA interface of QuadSPI. Read this bit to identify the reason of fault in case of FCCU NCF 2. 0b - Uncorrectable ECC error from flashA disabled/not detected. 1b - Uncorrectable ECC error detected from flashA.
2 DMA1_TCD_RAM_ECC_ERR	eDMA_1 TCD RAM ECC Error Specifies whether the eDMA_1_TCD memory detected an uncorrectable ECC error. The uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. Read this field to identify the reason for a fault in case of FCCU NCF2. 0b - No 1b - Yes
1	Zipwire Read Data EDC Error

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Field	Function
ZIPWIRE_RDATA_EDC_ERR	Specifies whether an integrity error is reported on the Zipwire read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF1. 0b - No 1b - Yes
0 DMA1_RDATA_EDC_ERR	eDMA 1 Read Data EDC Error Specifies whether an integrity error is reported on the eDMA1 read data for safety. Read this field to identify the reason for a fault in case of FCCU NCF1. 0b - No 1b - Yes

36.2.7 Read-Only GPR On Destructive Reset 7 (DCMROD7)

Offset

Register	Offset
DCMROD7	218h

Function

Contains information related to:

- LVDS pad receiver fault statuses.
- AXBS, AHBP, and AHBM alarm statuses.

This field resets after destructive reset 7.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	CM7_2_A...	CM7_1_A...	CM7_0_A...	XMEM_OD...	PMEM_EC...	PMEM_EC...	PMEM_EC...	PMEM_EC...	XMEM_EV...	XMEM_EV...	XMEM_EV...	XMEM_EV...	XMEM_OD...	XMEM_OD...	XMEM_OD...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	XMEM_OD...	PMEM_EC...	XMEM_EV...	VDD2P5_...	VDD1P1_...	VDDA_SW...	VDDA_SD...	VDDA_SD...	LVDS_3P...	ZIPWIRE...	CM7_2_A...	CM7_1_A...	CM7_0_A...	CM7_2_A...	CM7_1_A...	CM7_0_A...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 — Reserved	Reserved
30 CM7_2_AHBS_ALARM	CM7_2 AHBS interface IAHB Gasket monitor alarm status. Read this bit to identify the reason of fault in case of FCCU NCF 1. 0b - No alarm reported from CM7_0 AHBS interface IAHB gasket. 1b - Monitor alarm reported from CM7_0 AHBS interface IAHB gasket.
29 CM7_1_AHBS_ALARM	CM7_1 AHBS interface IAHB Gasket monitor alarm status. Read this bit to identify the reason of fault in case of FCCU NCF 1. 0b - No alarm reported from CM7_0 AHBS interface IAHB gasket. 1b - Monitor alarm reported from CM7_0 AHBS interface IAHB gasket.
28 CM7_0_AHBS_ALARM	CM7_0 AHBS interface IAHB Gasket monitor alarm status. Read this bit to identify the reason of fault in case of FCCU NCF 1. 0b - No alarm reported from CM7_0 AHBS interface IAHB gasket. 1b - Monitor alarm reported from CM7_0 AHBS interface IAHB gasket.
27 XMEM_ODD_ECC_CORE_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during core access. 0b - Multi-bit error on odd xmem memory per thread during core access not detected. 1b - Multi-bit error on odd xmem memory per thread during core access detected.
26 PMEM_ECC3_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access. 0b - Multi-bit error on pmem memory per thread during DSP access not detected. 1b - Multi-bit error on pmem memory per thread during DSP access detected.
25 PMEM_ECC2_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access. 0b - Multi-bit error on pmem memory per thread during DSP access not detected. 1b - Multi-bit error on pmem memory per thread during DSP access detected.
24 PMEM_ECC1_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access. 0b - Multi-bit error on pmem memory per thread during DSP access not detected. 1b - Multi-bit error on pmem memory per thread during DSP access detected.
23 PMEM_ECC0_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access. 0b - Multi-bit error on pmem memory per thread during DSP access not detected. 1b - Multi-bit error on pmem memory per thread during DSP access detected.

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Field	Function
22 XMEM_EVEN_ECC3_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Multi-bit error on even xmem memory per thread during DSP access not detected. 1b - Multi-bit error on even xmem memory per thread during DSP access detected.
21 XMEM_EVEN_ECC2_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Multi-bit error on even xmem memory per thread during DSP access not detected. 1b - Multi-bit error on even xmem memory per thread during DSP access detected.
20 XMEM_EVEN_ECC1_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Multi-bit error on even xmem memory per thread during DSP access not detected. 1b - Multi-bit error on even xmem memory per thread during DSP access detected.
19 XMEM_EVEN_ECC0_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Multi-bit error on even xmem memory per thread during DSP access not detected. 1b - Multi-bit error on even xmem memory per thread during DSP access detected.
18 XMEM_ODD_ECC3_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Multi-bit error on odd xmem memory per thread during DSP access not detected. 1b - Multi-bit error on odd xmem memory per thread during DSP access detected.
17 XMEM_ODD_ECC2_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Multi-bit error on odd xmem memory per thread during DSP access not detected. 1b - Multi-bit error on odd xmem memory per thread during DSP access detected.
16 XMEM_ODD_ECC1_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Multi-bit error on odd xmem memory per thread during DSP access not detected. 1b - Multi-bit error on odd xmem memory per thread during DSP access detected.
15 XMEM_ODD_ECC0_DSP_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Multi-bit error on odd xmem memory per thread during DSP access not detected. 1b - Multi-bit error on odd xmem memory per thread during DSP access detected.
14 PMEM_ECC_CORE_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during core access.

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Field	Function
	0b - Multi-bit error on pmem memory per thread during core access not detected. 1b - Multi-bit error on pmem memory per thread during core access detected.
13 XMEM_EVEN_ECC_CORE_ERR	Status of the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during core access. 0b - Multi-bit error on even xmem memory per thread during core access not detected. 1b - Multi-bit error on even xmem memory per thread during core access detected.
12 VDD2P5_GNG2_ERR	Go/Nogo indicator status for VDD_HV_FLA (triple bond) going to FXOSC and PLL. Read this bit to identify the reason of fault in case of FCCU NCF4. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
11 VDD1P1_GNG2_ERR	Go/Nogo indicator status for VDD_HV_FLA (triple bond) going to FXOSC and PLL. Read this bit to identify the reason of fault in case of FCCU NCF4. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
10 VDDA_SWG_GNG_ERR	Go/Nogo indicator status for VDDA_SWG supply going to SWG0/1. Read this bit to identify the reason of fault in case of FCCU NCF 4. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
9 VDDA_SDADC1_GNG_ERR	Go/Nogo indicator status for VDDA_SDADC supply going to SDADC1. Read this bit to identify the reason of fault in case of FCCU NCF 4. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
8 VDDA_SDADC0_GNG_ERR	Go/Nogo indicator status for VDDA_SDADC supply going to SDADC0. Read this bit to identify the reason of fault in case of FCCU NCF 4. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
7 LVDS_3P3V_RX_FAULT	LVDS 3P3V RX Fault Status Specifies the 3.3 V pad receiver fault status, showing whether or not the pad reported a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 13. 0b - No

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Field	Function
	1b - Yes
6 ZIPWIRE_AXBS_ALARM	Zipwire AXBS Alarm Status Specifies the Zipwire AXBS_Lite safety alarm status, showing whether or not Zipwire AXBS_Lite reported a safety alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
5 CM7_2_AHBP_ALARM	Cortex-M7_2 AHBP Alarm Status Specifies the Cortex-M7_2 AHBP interface IAHB gasket monitor alarm status, showing whether or not the gasket reported a monitor alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
4 CM7_1_AHBP_ALARM	Cortex-M7_1 AHBP Alarm Status Specifies the Cortex-M7_1 AHBP interface IAHB gasket monitor alarm status, showing whether or not the gasket reported a monitor alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
3 CM7_0_AHBP_ALARM	Cortex-M7_0 AHBP Alarm Status Specifies the Cortex-M7_0 AHBP interface IAHB gasket monitor alarm status, showing whether or not the gasket reported a monitor alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
2 CM7_2_AHBM_ALARM	Cortex-M7_2 AHBM Alarm Status Specifies the Cortex-M7_2 AHBM interface IAHB gasket monitor alarm status, showing whether or not the gasket reported a monitor alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
1	Cortex-M7_1 AHBM Alarm Status Specifies the Cortex-M7_1 AHBM interface IAHB gasket monitor alarm status, showing whether or not the gasket reported a monitor alarm.

Table continues on the next page...

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Field	Function
CM7_1_AHBM_ALARM	Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes
0 CM7_0_AHBM_ALARM	Cortex-M7_0 AHBM Alarm Status Specifies the Cortex-M7_0 AHBM interface IAHB gasket monitor alarm status, showing whether or not the gasket reported a monitor alarm. Read this field to identify the reason for a fault in case of FCCU NCF 1. 0b - No 1b - Yes

36.2.8 Read-Only GPR On Functional Reset 1 (DCMROF1)

Offset

Register	Offset
DCMROF1	300h

Function

Specifies current transfer channel ID.

This register resets after functional reset 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved		Reserved				Reserved	Reserved	Reserved		Reserved				Reserved	Reserved
W	W1C		W1C				W1C	W1C	W1C		W1C				W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved		Reserved				Reserved	Reserved	Reserved		Reserved	Reserved	Reserved	Reserved	MAC_MDC...	MAC_MDC...
W	W1C		W1C				W1C	W1C	W1C		W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-26 —	Reserved
25 —	Reserved
24 —	Reserved
23-22 —	Reserved
21-18 —	Reserved
17 —	Reserved
16 —	Reserved
15-14 —	Reserved
13-10 —	Reserved
9 —	Reserved
8 —	Reserved
7-6 —	Reserved
5 —	Reserved
4	Reserved

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Field	Function
—	
3 —	Reserved
2 —	Reserved
1 MAC_MDC_CHID_1	MAC eDMA Channel ID1 Status Specifies whether channel ID1 is the current transfer channel ID. 0b - No 1b - Yes
0 MAC_MDC_CHID_0	MAC eDMA Channel ID0 Status Specifies whether channel ID0 is the current transfer channel ID. 0b - No 1b - Yes

36.2.9 Read-Only GPR On Functional Reset 2 (DCMROF2)

Offset

Register	Offset
DCMROF2	304h

Function

Specifies the SDID0 contents that DCM scans from the flash memory.

This register resets after functional reset 2.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DCF_SDID0															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCF_SDID0															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DCF_SDID0	DCF Client SDID 0 Configuration

36.2.10 Read-Only GPR On Functional Reset 3 (DCMROF3)

Offset

Register	Offset
DCMROF3	308h

Function

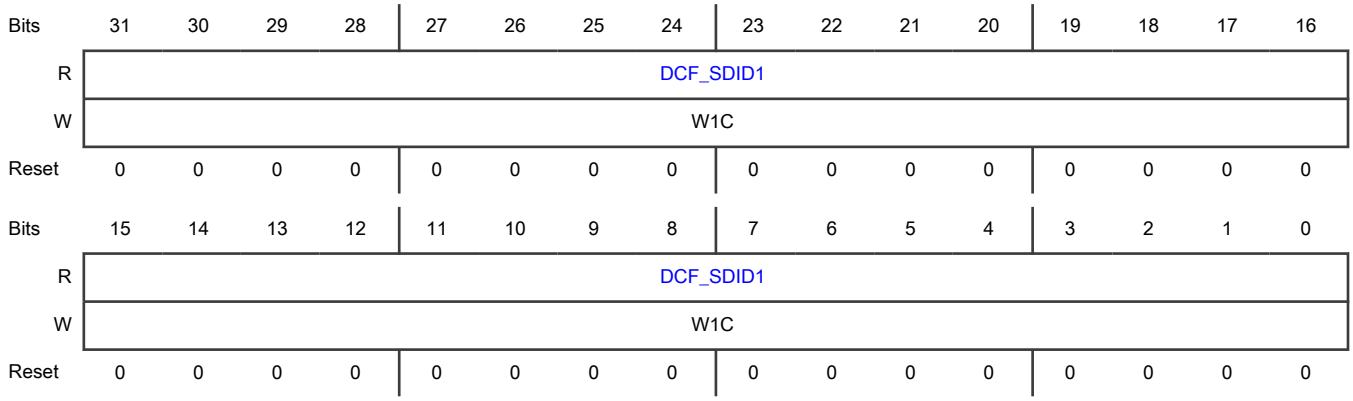
Specifies the SDID1 contents that DCM scans from the flash memory.

This register resets after functional reset 3.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID1	DCF Client SDID 1 Configuration

36.2.11 Read-Only GPR On Functional Reset 4 (DCMROF4)

Offset

Register	Offset
DCMROF4	30Ch

Function

Specifies the SDID2 contents that DCM scans from the flash memory.

This register resets after functional reset 4.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DCF_SDID2															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCF_SDID2															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DCF_SDID2	DCF Client SDID 2 Configuration

36.2.12 Read-Only GPR On Functional Reset 5 (DCMROF5)

Offset

Register	Offset
DCMROF5	310h

Function

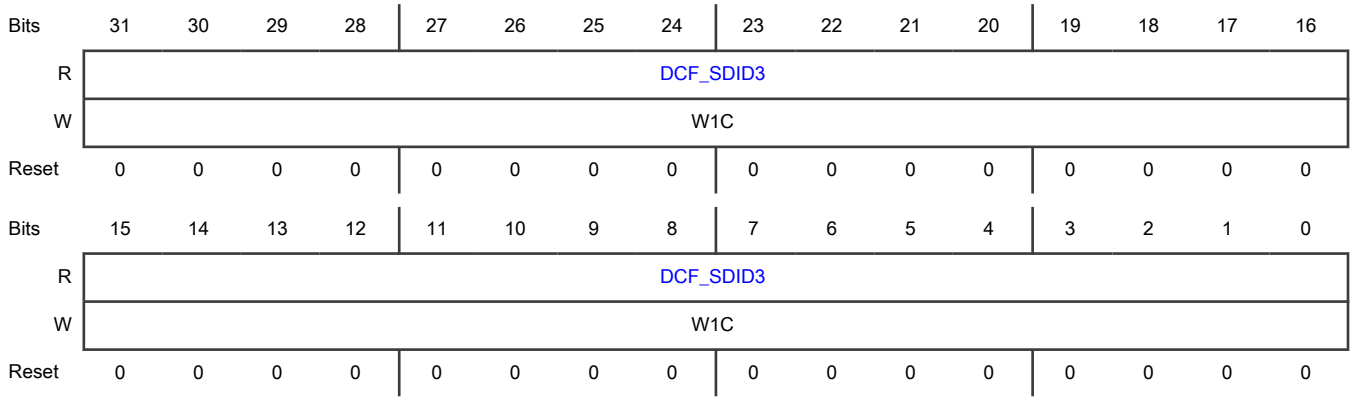
Specifies the SDID3 contents that DCM scans from the flash memory.

This register resets after functional reset 5.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID3	DCF Client SDID 3 Configuration

36.2.13 Read-Only GPR On Functional Reset 6 (DCMROF6)

Offset

Register	Offset
DCMROF6	314h

Function

Specifies the SDID4 contents that DCM scans from the flash memory.

This register resets after functional reset 6.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DCF_SDID4															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCF_SDID4															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DCF_SDID4	DCF Client SDID 4 Configuration

36.2.14 Read-Only GPR On Functional Reset 7 (DCMROF7)

Offset

Register	Offset
DCMROF7	318h

Function

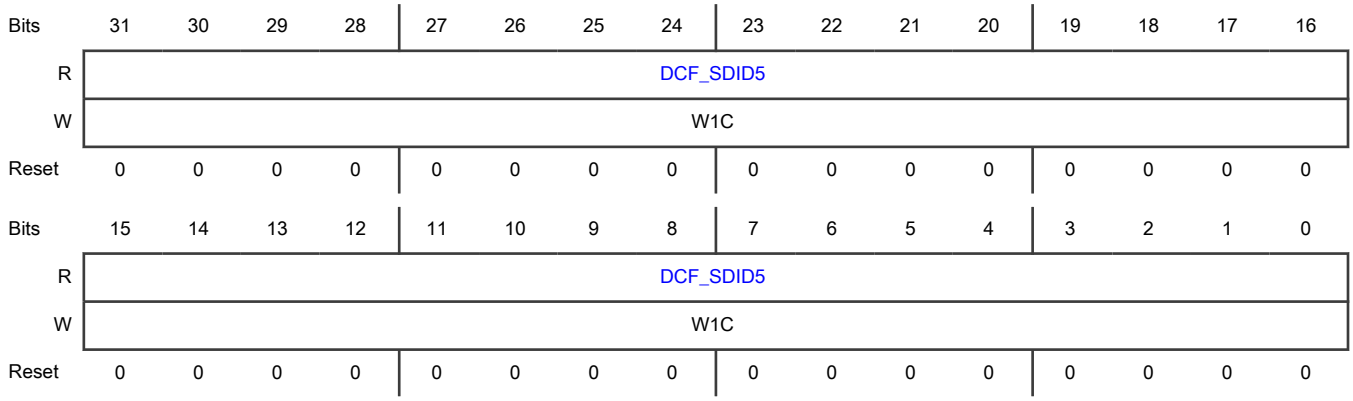
Specifies the SDID5 contents that DCM scans from the flash memory.

This register resets after functional reset 7.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID5	DCF Client SDID 5 Configuration

36.2.15 Read-Only GPR On Functional Reset 8 (DCMROF8)

Offset

Register	Offset
DCMROF8	31Ch

Function

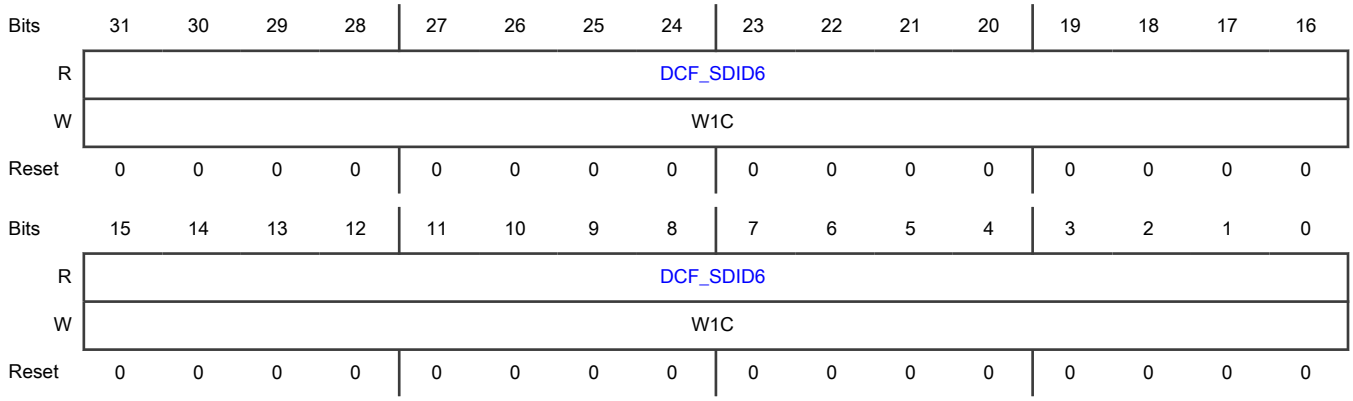
Specifies the SDID6 contents that DCM scans from the flash memory.

This register resets after functional reset 8.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID6	DCF Client SDID 6 Configuration

36.2.16 Read-Only GPR On Functional Reset 9 (DCMROF9)

Offset

Register	Offset
DCMROF9	320h

Function

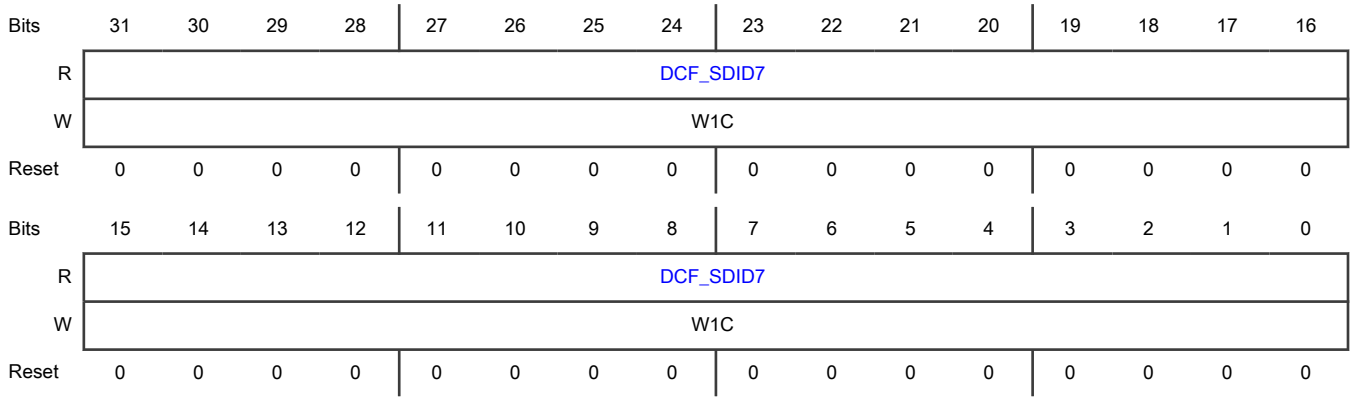
Specifies the SDID7 contents that DCM scans from the flash memory.

This register resets after functional reset 9.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID7	DCF Client SDID 7 Configuration

36.2.17 Read-Only GPR On Functional Reset 10 (DCMROF10)

Offset

Register	Offset
DCMROF10	324h

Function

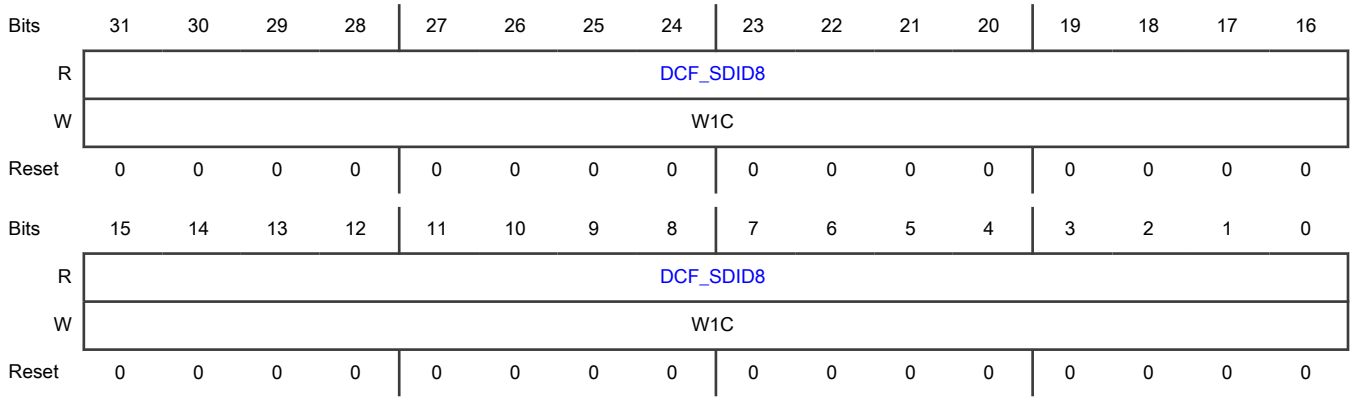
Specifies the SDID8 contents that DCM scans from the flash memory.

This register resets after functional reset 10.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID8	DCF Client SDID 8 Configuration

36.2.18 Read-Only GPR On Functional Reset 11 (DCMROF11)

Offset

Register	Offset
DCMROF11	328h

Function

Specifies the SDID9 contents that DCM scans from the flash memory.

This register resets after functional reset 11.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DCF_SDID9															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCF_SDID9															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DCF_SDID9	DCF Client SDID 9 Configuration

36.2.19 Read-Only GPR On Functional Reset 12 (DCMROF12)

Offset

Register	Offset
DCMROF12	32Ch

Function

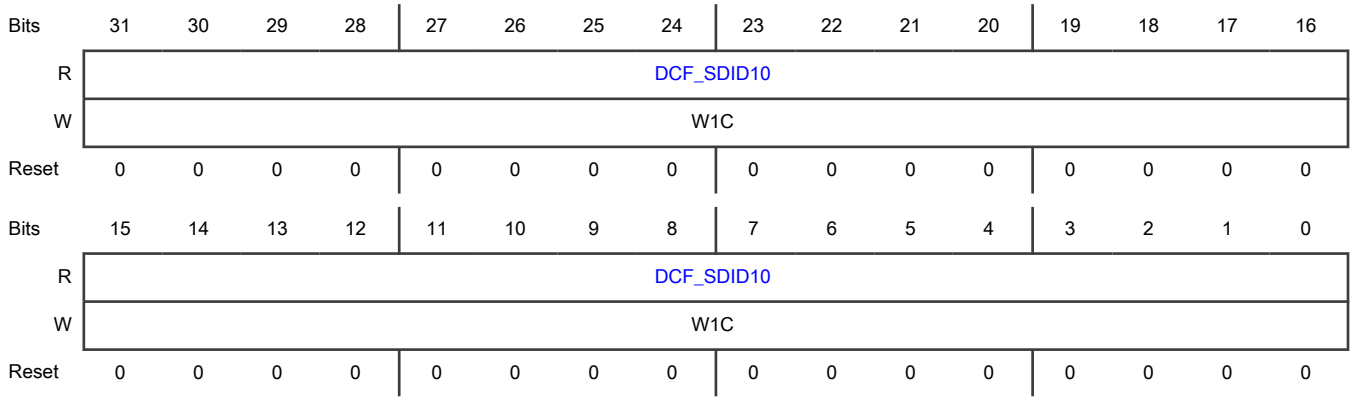
Specifies the SDID10 contents that DCM scans from the flash memory.

This register resets after functional reset 12.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID10	DCF Client SDID 10 Configuration

36.2.20 Read-Only GPR On Functional Reset 13 (DCMROF13)

Offset

Register	Offset
DCMROF13	330h

Function

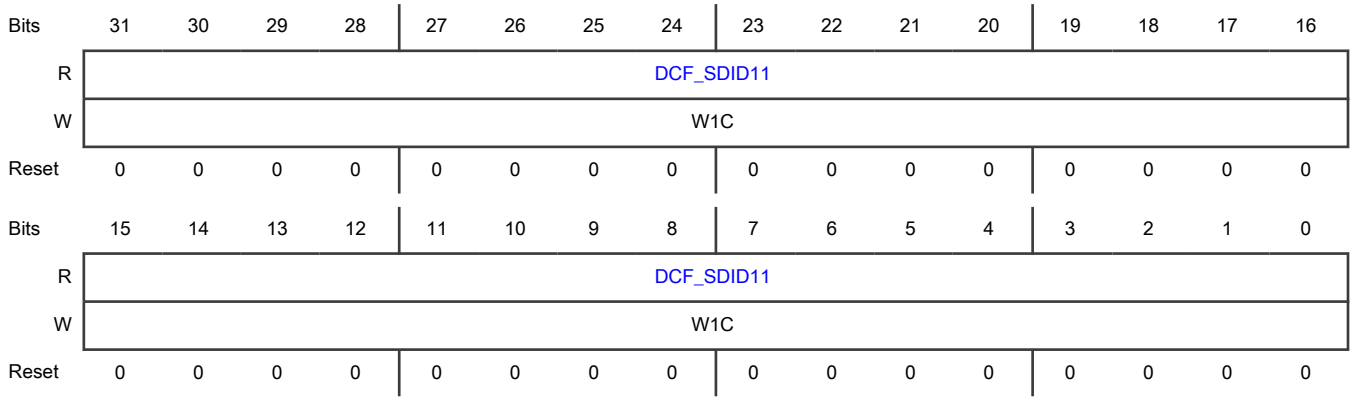
Specifies the SDID11 contents that DCM scans from the flash memory.

This register resets after functional reset 13.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID11	DCF Client SDID 11 Configuration

36.2.21 Read-Only GPR On Functional Reset 14 (DCMROF14)

Offset

Register	Offset
DCMROF14	334h

Function

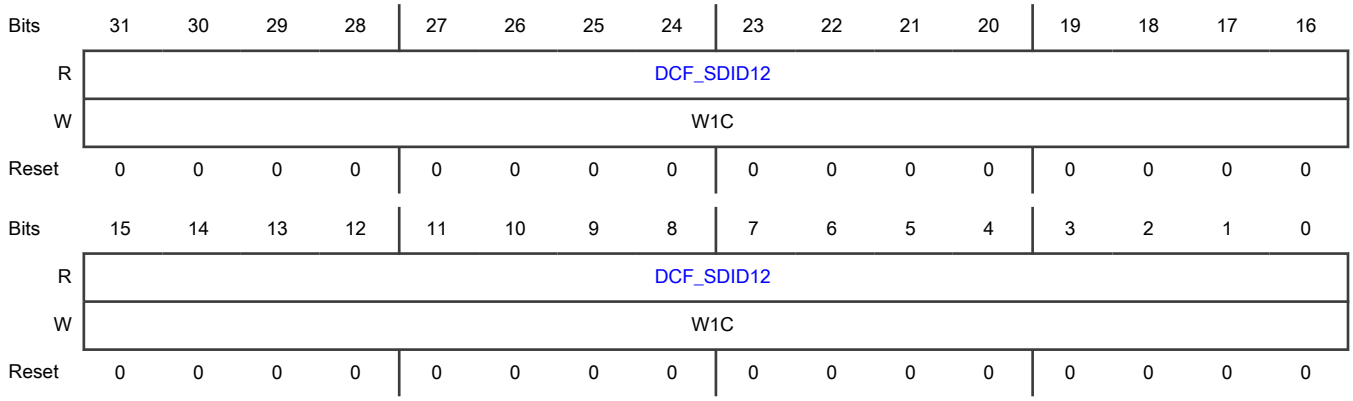
Specifies the SDID12 contents that DCM scans from flash memory.

This register resets after functional reset 14.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID12	DCF Client SDID 12 Configuration

36.2.22 Read-Only GPR On Functional Reset 15 (DCMROF15)

Offset

Register	Offset
DCMROF15	338h

Function

Specifies the SDID13 contents that DCM scans from the flash memory.

This register resets after functional reset 15.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DCF_SDID13															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCF_SDID13															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DCF_SDID13	DCF Client SDID 13 Configuration

36.2.23 Read-Only GPR On Functional Reset 16 (DCMROF16)

Offset

Register	Offset
DCMROF16	33Ch

Function

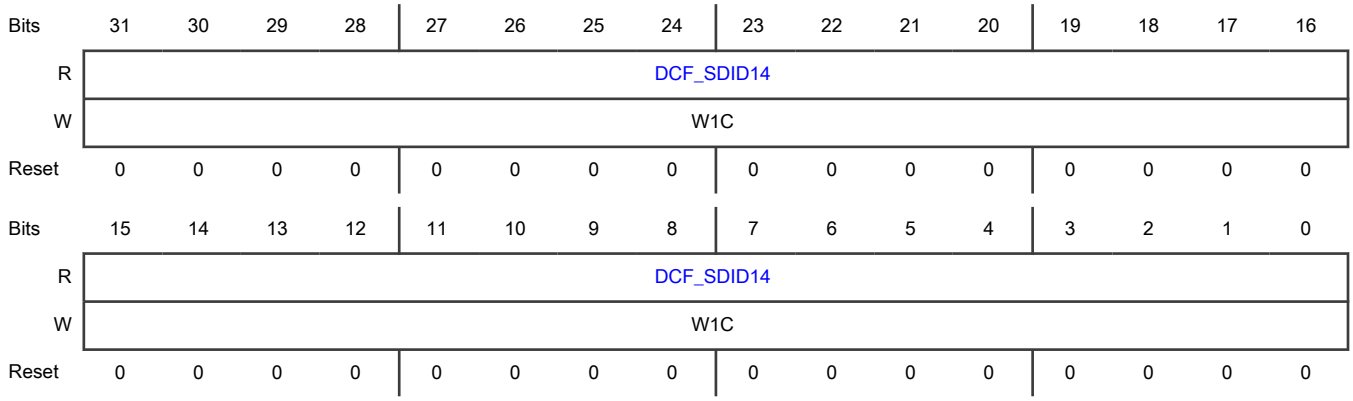
Specifies the SDID14 contents that DCM scans from the flash memory.

This register resets after functional reset 16.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID14	DCF Client SDID 14 Configuration

36.2.24 Read-Only GPR On Functional Reset 17 (DCMROF17)

Offset

Register	Offset
DCMROF17	340h

Function

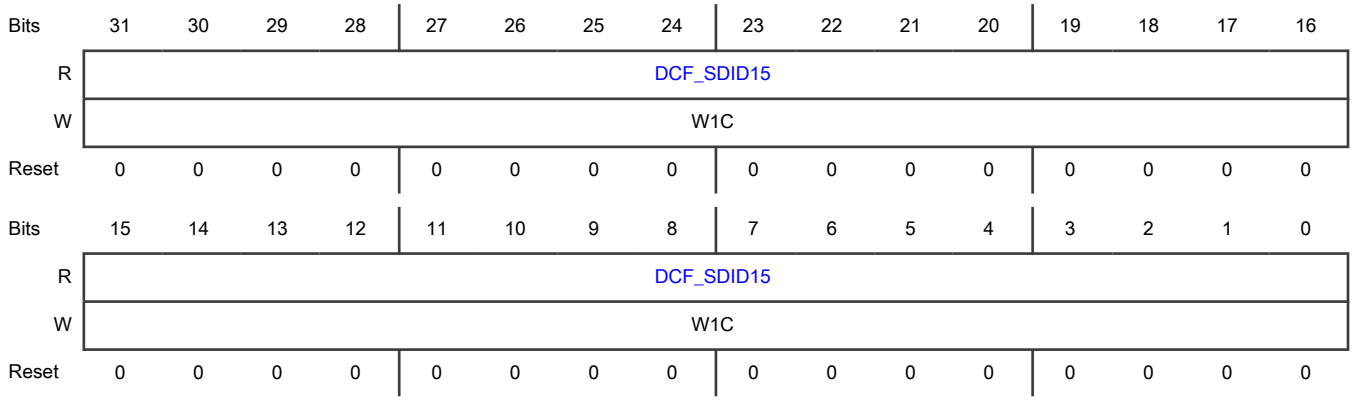
Specifies the SDID15 contents that DCM scans from the flash memory.

This register resets after functional reset 17.

NOTE

See the DCF clients file attached to this document for more information. The Utest section contains chip-configurable ID information, captured as status on read-only GPR in functional reset.

Diagram



Fields

Field	Function
31-0 DCF_SDID15	DCF Client SDID 15 Configuration

36.2.25 Read-Only GPR On Functional Reset 19 (DCMROF19)

Offset

Register	Offset
DCMROF19	348h

Function

Contains information related to:

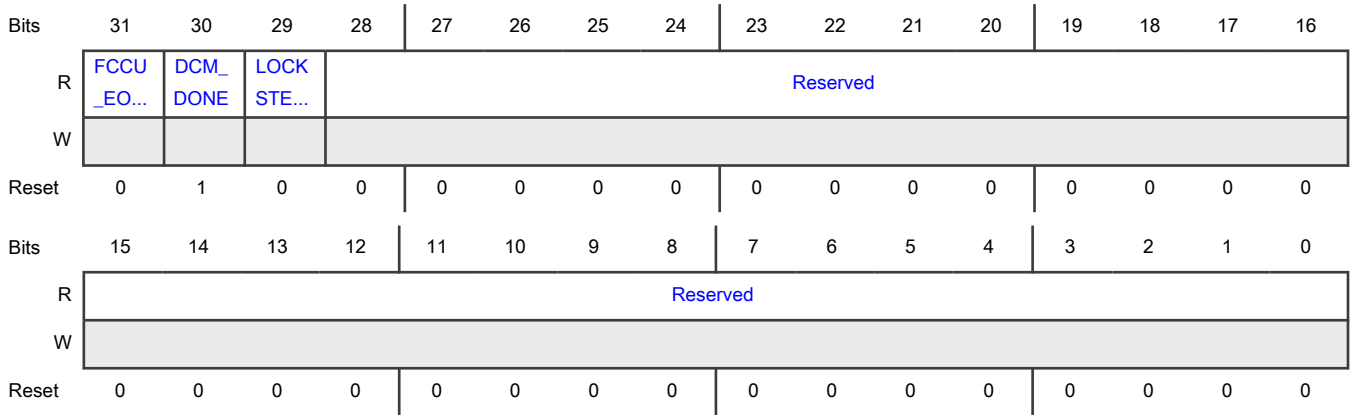
- FCCU EOUT status.
- Flash memory scanning status.
- Lockstep enable.

This register resets after functional reset 19.

NOTE

The reset value is undefined on reset and is loaded from the flash memory contents at the end of the reset sequence.

Diagram



Fields

Field	Function
31 FCCU_EOUT_DEDICATED	FCCU EOUT Status Specifies the status of FCCU_EOUT pins on GPIO_2 and GPIO_3 as configured in the DCF record, UTEST_MISC[FCCU_EOUT_DEDICATED]. See the DCF clients file attached to this document for more information. **NOTE** If the pads are dedicated to FCCU error output, these must not be programmed as input. 0b - General purpose, supporting all functions 1b - Dedicated EOUT pins
30 DCM_DONE	Flash Memory Scanning Status Specifies the status of flash memory scanning by DCM. 0b - Incomplete 1b - Complete
29 LOCKSTEP_EN	Lockstep Enable Specifies the current chip operation mode as configured in the DCF record, UTEST_MISC[LOCKSTEP_EN]. See the DCF clients file attached to this document for more information. 0b - Decoupled operation of Cortex-M7_0 and Cortex-M7_1 1b - Lockstep operation of Cortex-M7_0 and Cortex-M7_1
28-0 —	Reserved

36.2.26 Read-Only GPR On Functional Reset 20 (DCMROF20)

Offset

Register	Offset
DCMROF20	34Ch

Function

Specifies the information of chip destructive reset escalation support for destructive reset sources as configured in the DCF record, DEST_RST_ESC[13:0]. See the DCF clients file attached to this document for the mapping of corresponding destructive reset events.

This register resets after functional reset 20.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DCF_DEST_RST_ESC														Reserved	Reserved
W																
Reset	u[1]	u	u	u	u	u	u	u	u	u	u	u	u	u	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved				Reserved				Reserved	QSPI_IA...	Reserved	Reserved	Reserved	Reserved	Reserved	POR_WDG...
W																
Reset	0	0	0	0	0	0	0	0	0	0	u[1]	0	0	0	0	u[1]

1. The reset value of this register is dependent on the DCF client's default value.

Fields

Field	Function
31-18 DCF_DEST_RST_ESC	DCF Destructive Reset Escalation Enables the destructive reset escalation feature for the corresponding destructive reset event. 00_0000_0000_0000b - Disables 00_0000_0000_0001b - Enables
17 —	Reserved
16 —	Reserved
15-12	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
11-7 —	Reserved
6 —	Reserved
5 QSPI_IAHB_BYP	QuadSPI IAHB Bypass Status Specifies the status of the QuadSPI IAHB gasket as configured in the DCF record, UTEST_MISC[QSPI_IAHB_BYP]. See the DCF clients file attached to this document for more information. 0b - Register wall enabled 1b - Register wall bypassed
4 —	Reserved
3 —	Reserved
2 —	Reserved
1 —	Reserved
0 POR_WDG_EN	POR Watchdog (POR_WDG) Status Specifies the status of POR_WDG as configured in the DCF record, UTEST_MISC[POR_WDG_EN]. The POR_WDG is enabled by default. See the DCF clients file attached to this document for more information. 0b - Disabled 1b - Enabled

36.2.27 Read-Only GPR On Functional Reset 21 (DCMROF21)

Offset

Register	Offset
DCMROF21	350h

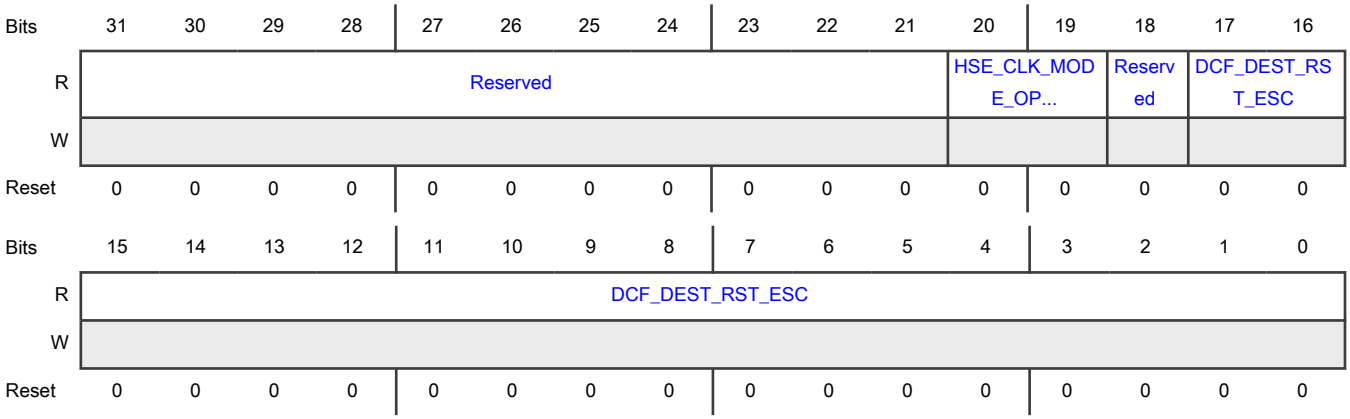
Function

Specifies the information of chip destructive reset escalation support for destructive reset sources as configured in the DCF record, DEST_RST_ESC[31:14].

This register resets after functional reset 21.

See the DCF clients file attached to this document for the mapping of corresponding destructive reset events.

Diagram



Fields

Field	Function
31-21 —	Reserved
20-19 HSE_CLK_MODE_OPTION	HSE_B Clock Mode Option Specifies the applicable clocking options. • If the value of this field is 0b, the ratio of 1:2 between the HSE_B IPS interface clock (AIPS_SLOW_CLK), HSE_B module clock (HSE_CLK), and HSE_IAHB gasket is enabled. • If the value of this field is 1b, the ratio of 1:2 between the HSE_B IPS interface clock (AIPS_SLOW_CLK), HSE_B module clock (HSE_CLK), and HSE_IAHB gasket is bypassed. • If the value of this field is 10b or 11b, the ratio of 1:4 between the HSE_B IPS interface clock (AIPS_SLOW_CLK), HSE_B module clock (HSE_CLK), and HSE_IAHB gasket is enabled. 00b - Option A 01b - Options C, D, E, E2, and F 10b - Option B 11b - Option B
18 —	Reserved
17-0	DCF Destructive Reset Escalation Enables the destructive reset escalation feature for the corresponding destructive reset event.

Table continues on the next page...

Table continued from the previous page...

Field	Function
DCF_DEST_RST_ESC	00_0000_0000_0000_0000b - Disables 00_0000_0000_0000_0001b - Enables

36.2.28 Read Write GPR On POR 1 (DCMRWP1)

Offset

Register	Offset
DCMRWP1	400h

Function

Contains information related to:

- Voltage dividers.
- Supply voltage monitoring.
- Ethernet modes.
- Software NCFs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved								SBAF_RE...	SBAF_RE...	Reserved		SYS_REC_COUNTER			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	DEST_RESET_COUNT				POR_WDOG_TRIM		STANBDY...	Reserved	Reserved	Reserved		CLKOUT_...	Reserved		Reserved
Reset	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23 SBAF_REC_DIS_DRST	Disable Recovery Mode On Destructive Reset

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This bit is reset by default and Secure BAF allows recovery mode sequence if Application issues > 8 destructive reset. Application can set this bit to disable recovery mode when Application issues > 8 destructive reset. 0 - Recovery mode is enabled on greater than 8 destructive resets. 1 - Recovery mode is disabled on greater than 8 destructive resets.
22 SBAF_REC_DIS_FRST	Disable Recovery Mode On Functional Reset This bit is reset by default and Secure BAF allows recovery mode sequence if Application issues > 8 functional reset. Application can set this bit to disable recovery mode when Application issues > 8 functional reset. 0 - Recovery mode is enabled on greater than 8 functional resets. 1 - Recovery mode is disabled on greater than 8 functional resets.
21 —	Reserved
20-16 SYS_REC_COUNTER	System Recovery Counter System recovery counter stored by sBAF and HSE FW
15 —	Reserved
14-11 DEST_RESET_COUNT	Destructive Reset Counts This bit is used by sBAF internally to preserve destructive reset counts.
10-9 POR_WDOG_TRIM	POR_WDG Trim Specifies the trims for the POR_WDG timeout value. 00b - POR_WDG timeout = 06.25 ms 01b - POR_WDG timeout = 12.50 ms 10b - POR_WDG timeout = 25.00 ms 11b - POR_WDG timeout = 50.00 ms
8 STANBDY_PWDOG_DIS	Standby POR_WDG Disable Disables the standby entry and exit monitoring window of POR_WDG. 0b - Enables 1b - Disables
7 —	Reserved

Table continues on the next page...

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Field	Function
6 —	Reserved
5-4 —	Reserved
3 CLKOUT_STANDBY	Clockout Standby Expose Over Functional And Destructive Reset Specifies whether the CLKOUT_STANDBY function is available during functional or destructive reset on PTA22. 0b - No 1b - Yes
2-1 —	Reserved
0 —	Reserved

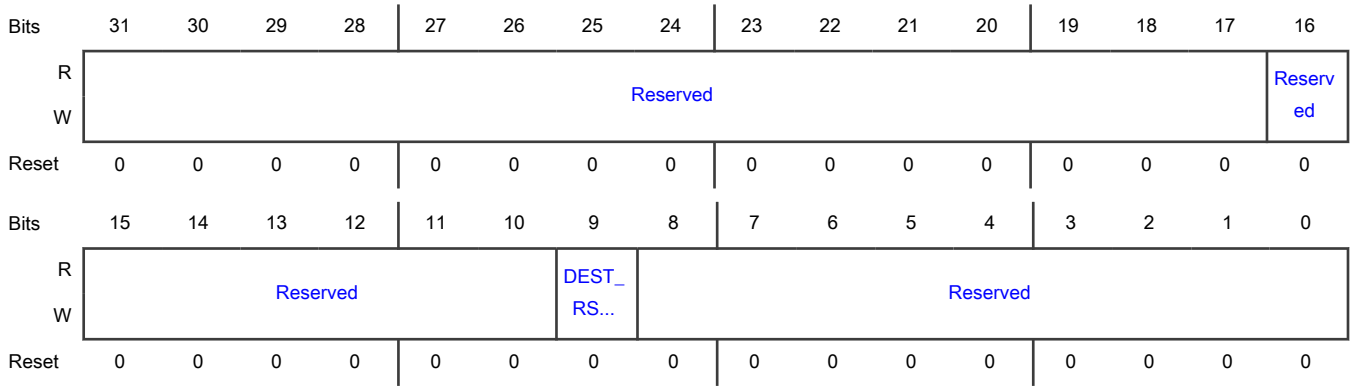
36.2.29 Read Write GPR On POR 3 (DCMRWP3)

Offset

Register	Offset
DCMRWP3	408h

Function
Resets after POR 3.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 —	Reserved
15-10 —	Reserved
9 DEST_RST9_AS_IPI	Destructive Reset 9 Configures a destructive reset to interrupt. 0b - Destructive reset 1b - PLL LOL interrupt
8-0 —	Reserved

36.2.30 Read Write GPR On Destructive Reset 2 (DCMRWD2)

Offset

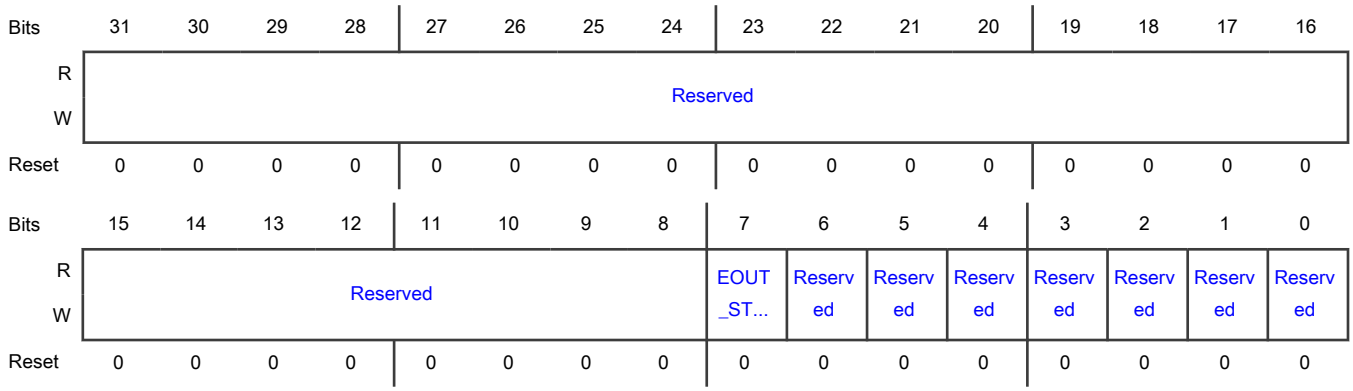
Register	Offset
DCMRWD2	504h

Function

Controls the EOUT state during self-test.

This register resets after destructive reset 2.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 EOUT_STAT_DUR_STEST	Controls the EOUT state during self-test If this field = 0, the EOUT state changes to high impedance post self-test when the chip is under reset, and if this field = 1, the EOUT state remains in Fault state until this field becomes 0. DCMROF19[FCCU_EOUT_DEDICATED] is required for the feature. DCMROF19[FCCU_EOUT_DEDICATED] = 1 when you are using this feature. 0b - High impedance 1b - Fault state
6 —	Reserved
5 —	Reserved
4 —	Reserved
3 —	Reserved
2 —	Reserved
1 —	Reserved
0 —	Reserved

36.2.31 Read Write GPR On Destructive Reset 3 (DCMRWD3)

Offset

Register	Offset
DCMRWD3	508h

Function
Includes fault disable fields and resets after destructive reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CM7_1_I...	CM7_0_I...	CM7_1_D...	CM7_0_D...	CM7_1_D...	CM7_0_D...	PRAM0_E...	PRAM1_E...	Reserved	LC_ERR_...	PF3_DAT...	PF3_COD...	PERIPH_...	MAC_GSK...	TCM_AXB...	DATA_ED...
W																
Reset	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ADDR_ED...	Reserved	Reserved	QSPI_GS...	HSE_GSK...	Reserved	DMA_AXB...	SYS_AXB...	DMA_PER...	DMA_SYS...	TCM_GSK...	CM7_RCC...	CM7_RCC...	Reserved	CM7_1_L...	CM7_0_L...
W																
Reset	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31 CM7_1_ICDATA_ECC_ERR_EN	Cortex-M7_1 I-cache ECC Error Enable Specifies whether the Cortex-M7_1 core's I-cache data memory detected a multi-bit ECC error. This field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_1 core's I-cache data memory. 0b - No 1b - Yes
30 CM7_0_ICDATA_ECC_ERR_EN	Cortex-M7_0 I-cache ECC Error Enable Specifies whether the Cortex-M7_0 core's I-cache data memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_0 core's I-cache data memory. 0b - No 1b - Yes
29 CM7_1_DCTAG_ECC_ERR_EN	Cortex-M7_1 D-cache Tag ECC Error Enable Specifies whether the Cortex-M7_1 core's D-cache tag memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_1 core's D-cache tag memory. 0b - No 1b - Yes
28 CM7_0_DCTAG_ECC_ERR_EN	Cortex-M7_0 D-cache Tag ECC Error Enable Specifies whether the Cortex-M7_0 core's D-cache tag memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_0 core's D-cache tag memory. 0b - No 1b - Yes

Table continues on the next page...

Table continued from the previous page...

Field	Function
27 CM7_1_DCDATA_ECC_ERR_EN	Cortex-M7_1 D-cache Data ECC Error Enable Specifies whether the Cortex-M7_1 core's D-cache data memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_1 core's D-cache data memory. 0b - No 1b - Yes
26 CM7_0_DCDATA_ECC_ERR_EN	Cortex-M7_0 D-cache Data ECC Error Enable Specifies whether the Cortex-M7_0 core's D-cache data memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_0 core's D-cache data memory. 0b - No 1b - Yes
25 PRAM0_ECC_ERR_EN	PRAM0 ECC Error Enable Specifies whether a multi-bit ECC error occurred from PRAM0. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from PRAM0. 0b - No 1b - Yes
24 PRAM1_ECC_ERR_EN	PRAM1 ECC Error Enable Specifies whether a multi-bit ECC error occurred from PRAM1. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from PRAM1. 0b - No 1b - Yes
23 —	Reserved
22 LC_ERR_EN	Life Cycle Scanning Error Enable Specifies whether an error is encountered during life-cycle scanning. The field enables fault monitoring at FCCU NCF 3 if there is an error in life-cycle scanning. **NOTE** On any POR or destructive reset event, because this field becomes 0, the field has no effect. A life-cycle error (in case it is present) is not disabled. 0b - No 1b - Yes

Table continues on the next page...

Table continued from the previous page...

Field	Function
21 PF3_DATA_ECC_ERR_EN	Program Flash Memory 3 Data ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 3 data memory. The field enables fault monitoring at FCCU NCF 3 in case of a program flash memory 3 data ECC uncorrectable error. The path is from FMU to PFLASH controller and then ERM to FCCU. 0b - No 1b - Yes
20 PF3_CODE_ECC_ERR_EN	Program Flash Memory 3 Code ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 3 code memory. The field enables fault monitoring at FCCU NCF 3 in case of a program flash memory 3 code ECC uncorrectable error. The path is from FMU to PFLASH controller and then ERM to FCCU. 0b - No 1b - Yes
19 PERIPH_AXBS_ALARM_EN	Peripheral AXBS Alarm Enable Specifies whether peripheral AXBS_Lite reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of a peripheral AXBS_Lite safety alarm. 0b - No 1b - Yes
18 MAC_GSKT_ALARM_EN	MAC Gasket Alarm Enable Specifies whether the MAC IAHB gasket reported an alarm. The field enables fault monitoring at FCCU NCF 1 in case of an MAC IAHB gasket alarm. 0b - No 1b - Yes
17 TCM_AXBS_ALARM_EN	TCM AXBS Alarm Enable Specifies whether the TCM AHB splitter reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of a TCM AHB splitter safety alarm. 0b - No 1b - Yes
16 DATA_EDC_ERR_EN	Data EDC Error Enable Specifies whether a data EDC error occurred. The field enables fault monitoring at FCCU NCF 1, in case of an integrity error on data, for safety. 0b - No 1b - Yes

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Field	Function
15 ADDR_EDC_ERR_EN	Address EDC Error Enable Specifies whether an address integrity (EDC) error occurred. The field enables fault monitoring at FCCU NCF 1, in case of an integrity error on address, for safety. 0b - No 1b - Yes
14 —	Reserved
13 —	Reserved
12 QSPI_GSKT_ALARM_EN	QuadSPI Gasket Alarm Enable Specifies whether the QuadSPI IAHB gasket reported an alarm. The field enables fault monitoring at FCCU NCF 1 in case of QuadSPI IAHB gasket alarm. 0b - No 1b - Yes
11 HSE_GSKT_ALARM_EN	HSE_B Gasket Alarm Enable Specifies whether the HSE_B IAHB gasket reported an alarm. The field enables fault monitoring at FCCU NCF 1 in case of HSE_B IAHB gasket alarm. 0b - No 1b - Yes
10 —	Reserved
9 DMA_AXBS_ALARM_EN	DMA AXBS Alarm Enable Specifies whether eDMA AXBS_Lite reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of an eDMA AXBS_Lite safety alarm. 0b - No 1b - Yes
8 SYS_AXBS_ALARM_EN	System AXBS Alarm Enable Specifies whether the system AXBS reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of a system AXBS safety alarm. 0b - No 1b - Yes

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Field	Function
7 DMA_PERIPH_GSKT_ALARM_EN	TCM Gasket Alarm Enable Specifies whether the eDMA-peripheral AXBS IAHB gasket reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of IAHB gasket safety alarm from the eDMA peripheral AXBS IAHB gasket. 0b - No 1b - Yes
6 DMA_SYS_GSKT_ALARM_EN	DMA System Gasket Alarm Enable Specifies whether the eDMA-system AXBS IAHB gasket reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of IAHB gasket safety alarm from the eDMA-system AXBS IAHB gasket. 0b - No 1b - Yes
5 TCM_GSKT_ALARM_EN	TCM Gasket Alarm Enable Specifies whether the TCM IAHB gasket reported an alarm. If this field = 1, the gasket reports a monitor alarm. The field enables fault monitoring at FCCU NCF 1 in case of TCM IAHB gasket monitor alarm. 0b - No 1b - Yes
4 CM7_RCCU2_ALARM_EN	Cortex-M7 RCCU2 Alarm Enable Specifies whether a redundant RCCU reported a lockstep alarm. The field enables fault monitoring at FCCU NCF 0 in case of the Cortex-M7 core redundant lockstep. 0b - No 1b - Yes
3 CM7_RCCU1_ALARM_EN	Cortex-M7 RCCU1 Alarm Enable Specifies whether RCCU reported a lockstep alarm. The field enables fault monitoring at FCCU NCF 0 in case of the Cortex-M7 core lockstep. 0b - No 1b - Yes
2 —	Reserved
1 CM7_1_LOCKUP_EN	Cortex-M7_1 Lockup Enable Specifies whether the Cortex-M7_1 core is in the Lockup state. The field enables fault monitoring at FCCU NCF 0 in case of the Cortex-M7_1 core lockup.

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Field	Function
	0b - No 1b - Yes
0 CM7_0_LOCKUP_EN	Cortex-M7 Lockup Enable Specifies whether the Cortex-M7_0 core is in the Lockup state. The field enables fault monitoring at FCCU NCF 0 in case of the Cortex-M7_0 core lockup. 0b - No 1b - Yes

36.2.32 Read Write GPR On Destructive Reset 4 (DCMRWD4)

Offset

Register	Offset
DCMRWD4	50Ch

Function

Contains information related to:

- Test activation errors.
- Fault monitoring.
- DCM flash memory scanning.
- ECC errors.

This register resets after destructive reset 4.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CM7_2_L...	TEST_AC...	TEST_AC...	Reserved	VDD2P5_...	VDD1P1_...	Reserved	FLASH_A...	Reserved	FLASH_S...	FLASH_R...	FLASH_R...	FLASH_A...	FLASH_E...	PF2_DAT...	PF2_COD...
Reset	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PF1_DAT...	PF1_COD...	PF0_DAT...	PF0_COD...	Reserved	PRAM1_F...	PRAM0_F...	DMA_TCD...	CM7_1_D...	CM7_1_D...	CM7_1_I...	CM7_0_D...	CM7_0_D...	CM7_0_I...	CM7_1_I...	CM7_0_I...
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31 CM7_2_LOCKUP_EN	Enable bit for enabling the fault monitoring at FCCU NCF 0 for the fault: CM7_2 core lockup. 0b - CM7_2 core not in lockup state. 1b - CM7_2 core in lockup state.
30 TEST_ACTIVATION_1_ERR_EN	Test Activation 1 Error Enable Specifies whether a partial test is activated accidentally. The field enables fault monitoring at FCCU NCF 5 in case of an accidental partial test activation 1. 0b - No 1b - Yes
29 TEST_ACTIVATION_0_ERR_EN	Test Activation 0 Error Enable Specifies whether a partial test is activated accidentally. The field enables fault monitoring at FCCU NCF 5 in case of an accidental partial test activation 0. 0b - No 1b - Yes
28 —	Reserved
27 VDD2P5_GNG_ERR_EN	VDD2P5 Go/No-go Error Enable Specifies whether the VDD2P5 (double bond) supply is clean. The field enables fault monitoring at FCCU NCF 4 if there is a "go/no-go" indicator for VDD_HV_FLA (double bond) going to FXOSC and PLL. If the value of this field = 0, there is a "go" indication that the supply if clean; if it = 1, there is a "no-go" indication that the supply is unclean and there is a fault in double-bond connection or its routing within the chip. 0b - Clean 1b - Unclean
26 VDD1P1_GNG_ERR_EN	VDD1PD1 Go/No-go Error Enable Specifies whether the VDD1PD1 (double bond) supply is clean. The field enables fault monitoring at FCCU NCF 4 if there is a "go/no-go" indicator for VDD1PD1 (double bond) supply going to PLL. If the value of this field = 0, there is a "go" indication that the supply if clean; if it = 1, there is a "no-go" indication that the supply is unclean and there is a fault in double-bond connection or its routing within the chip. 0b - Clean 1b - Unclean
25 —	Reserved

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Field	Function
24 FLASH_ACCESS_ERR_EN	Flash Memory Access Error Enable Specifies whether a transaction monitor mismatch error occurred from the flash memory controller. The field enables fault monitoring at FCCU NCF 3 in case of a transaction monitor mismatch error from the flash memory controller. The alarm indicates that the flash memory controller detected a transaction monitor mismatch when compared to the flash memory safety feedback output. The flash memory specifies where the reconstructed address is compared with the address that invoked the flash memory access. 0b - No 1b - Yes
23 —	Reserved
22 FLASH_SCAN_ERR_EN	Flash Memory Scanning Error Enable Specifies whether an error occurred during DCM flash memory scanning. The field enables fault monitoring at FCCU NCF 3 in case of an error during the DCM flash memory scanning process because of invalid data. **NOTE** On a POR or destructive reset event, because this field becomes 0, the field has no effect. A life-cycle error (in case it is present) is not disabled. 0b - No 1b - Yes
21 FLASH_RST_ERR_EN	Flash Memory Reset Error Enable Specifies whether a flash memory reset error occurred. The field enables fault monitoring at FCCU NCF 3 in case of a flash memory reset error. This error indication is set when the flash memory encounters errors during its reset reads. 0b - No 1b - Yes
20 FLASH_REF_ERR_EN	Flash Memory Reference Error Encode Specifies whether a reference current loss or read voltage error occurred during previous read(s). The field enables fault monitoring at FCCU NCF 3 if there is a flash memory reference current loss or read voltage error during previous read(s). 0b - No 1b - Yes
19 FLASH_ADDR_ENC_ERR_EN	Flash Memory Address Encode Error Enable Specifies whether an address encode error occurred in the flash memory.

Table continues on the next page...

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Field	Function
	The field enables fault monitoring at FCCU NCF 3 if there is a flash memory address encode error. During address decoding, if multiple or no address line is selected, FMU reports an address encode error. 0b - No 1b - Yes
18 FLASH_EDC_ERR_EN	Flash Memory EDC Error Enable Specifies whether EDC after ECC error is reported in the flash memory. The field enables fault monitoring at FCCU NCF 3 in case of a flash memory ECC correction error via EDC, reported by FMU. 0b - No 1b - Yes
17 PF2_DATA_ECC_ERR_EN	PF2 Data ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 2 data memory. The field enables fault monitoring at FCCU NCF 3 in case of Flash2 data ECC uncorrectable error. 0b - No 1b - Yes
16 PF2_CODE_ECC_ERR_EN	PF2 Code ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 2 code memory. The field enables fault monitoring at FCCU NCF 3 in case of Flash2 code ECC uncorrectable error. 0b - No 1b - Yes
15 PF1_DATA_ECC_ERR_EN	PF1 Data ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 1 data memory. The field enables fault monitoring at FCCU NCF 3 in case of Flash1 data ECC uncorrectable error. 0b - No 1b - Yes
14 PF1_CODE_ECC_ERR_EN	PF1 Code ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 1 code memory. The field enables fault monitoring at FCCU NCF 3 in case of Flash1 code ECC uncorrectable error. 0b - No 1b - Yes
13	PF0 Data ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 0 data memory.

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Field	Function
PF0_DATA_ECC_ERR_EN	The field enables fault monitoring at FCCU NCF 3 in case of Flash0 data ECC uncorrectable error. 0b - No 1b - Yes
12 PF0_CODE_ECC_ERR_EN	PF0 Code ECC Error Enable Specifies whether FMU reported an uncorrectable error in the flash memory controller port 0 code memory. The field enables fault monitoring at FCCU NCF 3 in case of Flash0 code ECC uncorrectable error. 0b - No 1b - Yes
11 —	Reserved
10 PRAM1_FCCU_ALARM_EN	PRAM1 FCCU Alarm Enable Specifies whether PRAM1 reported a safety alarm. The field enables fault monitoring at FCCU NCF 2 in case of PRAM1 safety alarm. This alarm is set on faulty SRAM1 read or read-modify error. 0b - No 1b - Yes
9 PRAM0_FCCU_ALARM_EN	PRAM0 FCCU Alarm Enable Specifies whether PRAM0 reported a safety alarm. The field enables fault monitoring at FCCU NCF 2 in case of PRAM0 safety alarm. This alarm is set to faulty SRAM0 read or read-modify error. 0b - No 1b - Yes
8 DMA_TCD_RAM_ECC_ERR_EN	eDMA TCD RAM ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error reported from the eDMA_TCD memory. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. 0b - No 1b - Yes
7 CM7_1_DTCM1_ECC_ERR_EN	Cortex-M7_1 DTCM 1 ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_1 core's DTCM block 1. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error.

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Field	Function
	The Cortex-M7_1 core's DTCM 1 consists of two physical blocks. 0b - No 1b - Yes
6 CM7_1_DTCM0_ECC_ERR_EN	Cortex-M7_1 DTCM 0 ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_1 core's DTCM consists of two physical blocks. This field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_1 core's DTCM block 0. 0b - No 1b - Yes
5 CM7_1_ITCM_ECC_ERR_EN	Cortex-M7_1 ITCM ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_1 core's ITCM. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. 0b - No 1b - Yes
4 CM7_0_DTCM1_ECC_ERR_EN	Cortex-M7_0 DTCM 1 ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_0 core's DTCM block 1. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_0 core's DTCM consists of two physical blocks. 0b - No 1b - Yes
3 CM7_0_DTCM0_ECC_ERR_EN	Cortex-M7_0 DTCM 0 ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_0 core's DTCM block 0. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_0 core's DTCM consists of two physical blocks. 0b - No 1b - Yes
2 CM7_0_ITCM_ECC_ERR_EN	Cortex-M7 ITCM ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU.

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Field	Function
	The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_0 core's ITCM. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. 0b - No 1b - Yes
1 CM7_1_ICTAG_ECC_ERR_EN	Cortex-M7_1 I-cache Tag ECC Error Enable Specifies whether the Cortex-M7_1 core's I-cache tag memory detected a multi-bit ECC error. This field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_1 core's I-cache tag memory. 0b - No 1b - Yes
0 CM7_0_ICTAG_ECC_ERR_EN	Cortex-M7_0 I-cache Tag ECC Error Enable Specifies whether the Cortex-M7_0 core's I-cache tag memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_0 core's I-cache tag memory. 0b - No 1b - Yes

36.2.33 Read Write GPR On Destructive Reset 5 (DCMRWD5)

Offset

Register	Offset
DCMRWD5	510h

Function

Contains information related to:

- Uncorrectable ECC error detection.
- I-cache and D-cache ECC errors.
- Fault monitoring.

This register resets after destructive reset 5.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CM7_2_D...	CM7_2_D...	CM7_2_I...	CM7_2_I...	CM7_2_I...	CM7_2_D...	CM7_2_D...	CM7_2_A...	CM7_2_A...	Reserved	CM7_0_A...	CM7_0_A...	CM7_1_A...	CM7_1_A...	DMA_RDA...	Reserved
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MAC_RDA...	TCM_RDA...	DEBUG_A...	MCT_BUS...	STCU_BI...	MBIST_A...	STCU_NC...	SW_NCF_...	SW_NCF_...	SW_NCF_...	SW_NCF_...	INTM_3_...	INTM_2_...	INTM_1_...	INTM_0_...	Reserved
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31 CM7_2_DTCM1_ECC_ERR_EN	Cortex-M7_2 DTCM 1 ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU from the Cortex-M7_2 core's DTCM block 1. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_2 core's DTCM block 1. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_2 core's DTCM consists of two physical blocks. 0b - No 1b - Yes
30 CM7_2_DTCM0_ECC_ERR_EN	Cortex-M7_2 DTCM 0 ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU from the Cortex-M7_2 core's DTCM block 0. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_2 core's DTCM block 0. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. The Cortex-M7_2 core's DTCM consists of two physical blocks. 0b - No 1b - Yes
29 CM7_2_ITCM_ECC_ERR_EN	Cortex-M7_2 ITCM ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU from the Cortex-M7_2 core's ITCM. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error from the Cortex-M7_2 core's ITCM. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. 0b - No 1b - Yes
28	Cortex-M7_2 I-cache Tag ECC Error Enable

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Field	Function
CM7_2_ICTAG_ECC_ERR_EN	Specifies whether the Cortex-M7_2 core's I-cache tag memory detected a multi-bit error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_2 core's I-cache tag memory. 0b - No 1b - Yes
27 CM7_2_ICDATA_ECC_ERR_EN	Cortex-M7_2 I-cache Data ECC Error Enable Specifies whether the Cortex-M7_2 core's I-cache data memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_2 core's I-cache data memory. 0b - No 1b - Yes
26 CM7_2_DCTAG_ECC_ERR_EN	Cortex-M7_2 D-cache Tag ECC Error Enable Specifies whether the Cortex-M7_2 core's D-cache tag memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_2 core's D-cache tag memory. 0b - No 1b - Yes
25 CM7_2_DCDATA_ECC_ERR_EN	Cortex-M7_2 D-cache Data ECC Error Enable Specifies whether the Cortex-M7_2 core's D-cache data memory detected a multi-bit ECC error. The field enables fault monitoring at FCCU NCF 2 if there is a multi-bit ECC error from the Cortex-M7_2 core's D-cache data memory. 0b - No 1b - Yes
24 CM7_2_AHBM_RDATA_EDC_ERR_EN	Cortex-M7_2 AHBM Read Data EDC Error Enable Specifies whether an integrity error is reported on the Cortex-M7_2 core's main read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the Cortex-M7_2 core's main read data, for safety. 0b - No 1b - Yes
23 CM7_2_AHBP_RDATA_EDC_ERR_EN	Cortex-M7_2 AHBP Read Data EDC Error Enable Specifies whether an integrity error is reported on the Cortex-M7_2 core's peripheral read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the Cortex-M7_2 core's peripheral read data, for safety.

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Field	Function
	0b - No 1b - Yes
22 —	Reserved
21 CM7_0_AHBM_RDATA_EDC_ERR_EN	Cortex-M7_0 AHBM Read Data EDC Error Enable Specifies whether an integrity error is reported on the Cortex-M7_0 core's main read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the Cortex-M7_0 core's main read data, for safety. 0b - No 1b - Yes
20 CM7_0_AHBP_RDATA_EDC_ERR_EN	Cortex-M7_0 AHBP Read Data EDC Error Enable Specifies whether an integrity error is reported on the Cortex-M7_0 core's peripheral read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the Cortex-M7_0 core's peripheral read data, for safety. 0b - No 1b - Yes
19 CM7_1_AHBM_RDATA_EDC_ERR_EN	Cortex-M7_1 AHBM Read Data EDC Error Enable Specifies whether an integrity error is reported on the Cortex-M7_1 core's main read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the Cortex-M7_1 core's main read data, for safety. 0b - No 1b - Yes
18 CM7_1_AHBP_RDATA_EDC_ERR_EN	Cortex-M7_1 AHBP Read Data EDC Error Enable Specifies whether an integrity error is reported on the Cortex-M7_1 core's peripheral read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the Cortex-M7_1 core's peripheral read data, for safety. 0b - No 1b - Yes
17 DMA_RDATA_EDC_ERR_EN	eDMA Read Data EDC Error Enable Specifies whether an integrity error is reported on the eDMA read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the eDMA read data, for safety. 0b - No

Table continues on the next page...

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Field	Function
	1b - Yes
16 — —	Reserved
15 MAC_RDATA_EDC_ERR_EN	MAC Read Data EDC Error Enable Specifies whether an integrity error is reported on the MAC read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the MAC read data, for safety. 0b - No 1b - Yes
14 TCM_RDATA_EDC_ERR_EN	TCM Read Data EDC Error Enable Specifies whether an integrity error is reported on the TCM read data. The field enables fault monitoring at FCCU NCF 1, if there is an integrity error on the TCM read data, for safety. 0b - No 1b - Yes
13 DEBUG_ACTIVATION_ERR_EN	Debug Activation Error Enable Specifies whether unintended debug is activated. The field enables fault monitoring at FCCU NCF 5 for monitoring of unintended debug activation. The value of this field is 1 when the core is in the Halted state with application debug not enabled or debugger request not enabled. **NOTE** While the debugger is connected, DEBUG_ACTIVATION_ERR_EN must be 0 to disable debug activation error monitoring because the debugger is intentionally connected to the chip. 0b - No 1b - Yes
12 MCT_BUS_ERR_EN	MCT Bus Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 5 for the fault: Fault reported due to illegal access on MBIST Master Controller (MCT). This fault is reported via a transfer error indication to the system. 0b - No transfer error indicated from MCT. 1b - Transfer error indicated from MCT.
11 STCU_BIST_USER_CF_EN	STCU2 BIST User CF Enable Specifies whether LBIST or MBIST is enabled accidentally (a fault condition is detected in Run mode). The field enables fault monitoring at FCCU NCF 5 if LBIST or MBIST is enabled accidentally.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No 1b - Yes
10 MBIST_ACTIVATION_ERR_EN	MBIST Activation Error Enable Specifies whether accidental backdoor is enabled on memories. The field enables fault monitoring at FCCU NCF 5 in case of an accidental backdoor access on memories. This monitor needs to be disabled on FCCU when performing a fault injection. 0b - No 1b - Yes
9 STCU_NCF_EN	STCU2 NCF Enable Enables fault monitoring at FCCU NCF 5 for STCU2 NCF, that is, BIST result error. 0b - Disables 1b - Enables
8 SW_NCF_3_EN	Software NCF 3 Enable Enables fault monitoring at FCCU NCF 7 for software NCF3 (DCMRWF1[FCCU_SW_NCF3]). 0b - Disables 1b - Enables
7 SW_NCF_2_EN	Software NCF 2 Enable Enables fault monitoring at FCCU NCF 7 for software NCF2 (DCMRWF1[FCCU_SW_NCF2]). 0b - Disables 1b - Enables
6 SW_NCF_1_EN	Software NCF 1 Enable Enables fault monitoring at FCCU NCF 7 for software NCF1 (DCMRWF1[FCCU_SW_NCF1]). 0b - Disables 1b - Enables
5 SW_NCF_0_EN	Software NCF 0 Enable Enables fault monitoring at FCCU NCF 7 for software NCF0 (DCMRWF1[FCCU_SW_NCF0]). 0b - Disables 1b - Enables
4 INTM_3_ERR_EN	INTM 3 Error Enable Specifies whether interrupt monitor 3 reported an error.

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Field	Function
	The field enables fault monitoring at FCCU NCF 6 if INTM reports an interrupt monitor 3 error. This error is also reported in INTM.INTM_STATUS3. See the "Functional description" section in the INTM chapter for details. 0b - No 1b - Yes
3 INTM_2_ERR_EN	INTM 2 Error Enable Specifies whether interrupt monitor 2 reported an error. The field enables fault monitoring at FCCU NCF 6 if INTM reports an interrupt monitor 2 error. This error is also reported in INTM.INTM_STATUS2. See the "Functional description" section in the INTM chapter for details. 0b - No 1b - Yes
2 INTM_1_ERR_EN	INTM 1 Error Enable Specifies whether interrupt monitor 1 reported an error. The field enables fault monitoring at FCCU NCF 6 if INTM reports an interrupt monitor 1 error. This error is also reported in INTM.INTM_STATUS1. See the "Functional description" section in the INTM chapter for details. 0b - No 1b - Yes
1 INTM_0_ERR_EN	INTM 0 Error Enable Specifies whether interrupt monitor 0 reported an error. The field enables fault monitoring at FCCU NCF 6 if INTM reports an interrupt monitor 0 error. This error is also reported in INTM.INTM_STATUS0. See the "Functional description" section in the INTM chapter for details. 0b - No 1b - Yes
0 —	Reserved

36.2.34 Read Write GPR On Destructive Reset 6 (DCMRWD6)

Offset

Register	Offset
DCMRWD6	514h

Function

Contains information related to module debug disable.

This register resets after destructive reset 6.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	Reserved	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXIO_...	LPI2C1_...	LPI2C0_...	LPSPI5_...	LPSPI4_...	LPSPI3_...	LPSPI2_...	LPSPI1_...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LPSPI0_...	PIT2_DB...	PIT1_DB...	PIT0_DB...	STM1_DB...	STM0_DB...	SWT1_DB...	SWT0_DB...	RTC_DBG...	Reserved	Reserved	EMIOS0_...	LCU1_DB...	LCU0_DB...	FCCU_DB...	EDMA_DB...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29 FLEXCAN5_DBG_DIS_CM7_0	FlexCAN_5 Debug Disable Cortex-M7_0 Specifies whether FlexCAN_5 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
28 FLEXCAN4_DBG_DIS_CM7_0	FlexCAN_4 Debug Disable Cortex-M7_0 Specifies whether FlexCAN_4 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
27 FLEXCAN3_DBG_DIS_CM7_0	FlexCAN_3 Debug Disable Cortex-M7_0 Specifies whether FlexCAN_3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
26 FLEXCAN2_DBG_DIS_CM7_0	FlexCAN_2 Debug Disable Cortex-M7_0 Specifies whether FlexCAN_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
25 FLEXCAN1_DBG_DIS_CM7_0	FlexCAN_1 Debug Disable Cortex-M7_0 Specifies whether FlexCAN_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
24 FLEXCAN0_DBG_DIS_CM7_0	FlexCAN_0 Debug Disable Cortex-M7_0 Specifies whether FlexCAN_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
23 FLEXIO_DBG_DIS_CM7_0	FlexIO Debug Disable Cortex-M7_0 Specifies whether FlexIO enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
22 LPI2C1_DBG_DIS_CM7_0	LPI2C_1 Debug Disable Cortex-M7_0 Specifies whether LPI2C_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
21	LPI2C_0 Debug Disable Cortex-M7_0

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Field	Function
LPI2C0_DBG_DIS_CM7_0	Specifies whether LPI2C_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
20 LPSPI5_DBG_DIS_CM7_0	LPSPI_5 Debug Disable Cortex-M7_0 Specifies whether LPSPI_5 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
19 LPSPI4_DBG_DIS_CM7_0	LPSPI_4 Debug Disable Cortex-M7_0 Specifies whether LPSPI_4 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
18 LPSPI3_DBG_DIS_CM7_0	LPSPI_3 Debug Disable Cortex-M7_0 Specifies whether LPSPI_3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
17 LPSPI2_DBG_DIS_CM7_0	LPSPI_2 Debug Disable Cortex-M7_0 Specifies whether LPSPI_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
16 LPSPI1_DBG_DIS_CM7_0	LPSPI_1 Debug Disable Cortex-M7_0 Specifies whether LPSPI_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
15 LPSPI0_DBG_DIS_CM7_0	LPSPI_0 Debug Disable Cortex-M7_0 Specifies whether LPSPI_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
14 PIT2_DBG_DIS_CM7_0	PIT_2 Debug Disable Cortex-M7_0 Specifies whether PIT_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
13 PIT1_DBG_DIS_CM7_0	PIT_1 Debug Disable Cortex-M7_0 Specifies whether PIT_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
12 PIT0_DBG_DIS_CM7_0	PIT_0 Debug Disable Cortex-M7_0 Specifies whether PIT_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
11 STM1_DBG_DIS_CM7_0	STM_1 Debug Disable Cortex-M7_0 Specifies whether STM_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
10	STM_0 Debug Disable Cortex-M7_0

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Field	Function
STM0_DBG_DIS_CM7_0	Specifies whether STM_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
9 SWT1_DBG_DIS_CM7_0	SWT_1 Debug Disable Cortex-M7_0 Specifies whether SWT_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
8 SWT0_DBG_DIS_CM7_0	SWT_0 Debug Disable Cortex-M7_0 Specifies whether SWT_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
7 RTC_DBG_DIS_CM7_0	RTC Debug Disable Cortex-M7_0 Specifies whether RTC enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
6 —	Reserved
5 —	Reserved
4 EMIOS0_DBG_DIS_CM7_0	eMIOS_0 Debug Disable Cortex-M7_0 Specifies whether eMIOS_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted

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Field	Function
3 LCU1_DBG_DIS_CM7_0	LCU_1 Debug Disable Cortex-M7_0 Specifies whether LCU_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
2 LCU0_DBG_DIS_CM7_0	LCU_0 Debug Disable Cortex-M7_0 Specifies whether LCU_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
1 FCCU_DBG_DIS_CM7_0	FCCU Debug Disable Cortex-M7_0 Specifies whether FCCU enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
0 EDMA_DBG_DIS_CM7_0	eDMA Debug Disable Cortex-M7_0 Specifies whether eDMA enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted

36.2.35 Read Write GPR On Destructive Reset 7 (DCMRWD7)

Offset

Register	Offset
DCMRWD7	518h

Function

Contains information related to module debug disable.

This register resets after destructive reset 7.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved				Reserved				Reserved			SD_ADC3...	SD_ADC2...	SD_ADC1...	SD_ADC0...	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	EDMA1_D...	Reserved	IGF0_DB...	ETPU_DB...	SIPI_DB...	eFlexPW...	eFlexPW...	DSPI_DB...	DIGRF_D...	Reserved	SWT2_DB...	STM2_DB...	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27-24 —	Reserved
23-21 —	Reserved
20 SD_ADC3_DBG_DIS_CM7_0	SD_ADC3 Debug Disable Cortex-M7_0 Specifies whether SD_ADC3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
19 SD_ADC2_DBG_DIS_CM7_0	SD_ADC2 Debug Disable Cortex-M7_0 Specifies whether SD_ADC2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
18 SD_ADC1_DBG_DIS_CM7_0	SD_ADC1 Debug Disable Cortex-M7_0 Specifies whether SD_ADC1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
17 SD_ADC0_DBG_DIS_CM7_0	SD_ADC0 Debug Disable Cortex-M7_0 Specifies whether SD_ADC0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
16-15 —	Reserved
14 EDMA1_DBG_DIS_CM7_0	eDMA_1 Debug Disable Cortex-M7_0 Specifies whether eDMA_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
13 —	Reserved
12 IGF0_DBG_DIS_CM7_0	IGF_0 Debug Disable Cortex-M7_0 Specifies whether IGF_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
11 ETPU_DBG_DIS_CM7_0	eTPU Debug Disable Cortex-M7_0 Specifies whether eTPU enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
10 SIPI_DBG_DIS_CM7_0	SIPI Debug Disable Cortex-M7_0 Specifies whether SIPI enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode.

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Field	Function
	Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
9 eFlexPWM1_DBG_DIS_CM7_0	eFlexPWM_1 Debug Disable Cortex-M7_0 Specifies whether eFlexPWM_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
8 eFlexPWM0_DBG_DIS_CM7_0	eFlexPWM_0 Debug Disable Cortex-M7_0 Specifies whether eFlexPWM_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
7 DSPI_DBG_DIS_CM7_0	DSPI Debug Disable Cortex-M7_0 Specifies whether DSPI enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
6 DIGRF_DBG_DIS_CM7_0	LFAST Debug Disable Cortex-M7_0 Specifies whether LFAST enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
5 —	Reserved
4 SWT2_DBG_DIS_CM7_0	SWT_2 Debug Disable Cortex-M7_0 Specifies whether SWT_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
3 STM2_DBG_DIS_CM7_0	STM_2 Debug Disable Cortex-M7_0 Specifies whether STM_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_0 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
2 —	Reserved
1 —	Reserved
0 —	Reserved

36.2.36 Read Write GPR On Destructive Reset 8 (DCMRWD8)

Offset

Register	Offset
DCMRWD8	51Ch

Function

Provides module debug disable information.

This register resets after destructive reset 8.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	Reserved	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXIO_...	LPI2C1_...	LPI2C0_...	LPSPI5_...	LPSPI4_...	LPSPI3_...	LPSPI2_...	LPSPI1_...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LPSPI0_...	PIT2_DB...	PIT1_DB...	PIT0_DB...	STM1_DB...	STM0_DB...	SWT1_DB...	SWT0_DB...	RTC_DBG...	Reserved	Reserved	EMIOS0_...	LCU1_DB...	LCU0_DB...	FCCU_DB...	EDMA_DB...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29 FLEXCAN5_DBG_DIS_CM7_1	FlexCAN_5 Debug Disable Cortex-M7_1 Specifies whether FlexCAN_5 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
28 FLEXCAN4_DBG_DIS_CM7_1	FlexCAN_4 Debug Disable Cortex-M7_1 Specifies whether FlexCAN_4 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
27 FLEXCAN3_DBG_DIS_CM7_1	FlexCAN_3 Debug Disable Cortex-M7_1 Specifies whether FlexCAN_3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
26	FlexCAN_2 Debug Disable Cortex-M7_1

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Field	Function
FLEXCAN2_DBG_DIS_CM7_1	Specifies whether FlexCAN_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
25 FLEXCAN1_DBG_DIS_CM7_1	FlexCAN_1 Debug Disable Cortex-M7_1 Specifies whether FlexCAN_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
24 FLEXCAN0_DBG_DIS_CM7_1	FlexCAN_0 Debug Disable Cortex-M7_1 Specifies whether FlexCAN_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
23 FLEXIO_DBG_DIS_CM7_1	FlexIO Debug Disable Cortex-M7_1 Specifies whether FlexIO enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
22 LPI2C1_DBG_DIS_CM7_1	LPI2C_1 Debug Disable Cortex-M7_1 Specifies whether LPI2C_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
21 LPI2C0_DBG_DIS_CM7_1	LPI2C_0 Debug Disable Cortex-M7_1 Specifies whether LPI2C_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
20 LPSPI5_DBG_DIS_CM7_1	LPSPI_5 Debug Disable Cortex-M7_1 Specifies whether LPSPI_5 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
19 LPSPI4_DBG_DIS_CM7_1	LPSPI_4 Debug Disable Cortex-M7_1 Specifies whether LPSPI_4 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
18 LPSPI3_DBG_DIS_CM7_1	LPSPI_3 Debug Disable Cortex-M7_1 Specifies whether LPSPI_3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
17 LPSPI2_DBG_DIS_CM7_1	LPSPI_2 Debug Disable Cortex-M7_1 Specifies whether LPSPI_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
16 LPSPI1_DBG_DIS_CM7_1	LPSPI_1 Debug Disable Cortex-M7_1 Specifies whether LPSPI_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
15	LPSPI_0 Debug Disable Cortex-M7_1

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Field	Function
LPSPI0_DBG_DIS_CM7_1	Specifies whether LPSPI_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
14 PIT2_DBG_DIS_CM7_1	PIT_2 Debug Disable Cortex-M7_1 Specifies whether PIT_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
13 PIT1_DBG_DIS_CM7_1	PIT_1 Debug Disable Cortex-M7_1 Specifies whether PIT_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
12 PIT0_DBG_DIS_CM7_1	PIT_0 Debug Disable Cortex-M7_1 Specifies whether PIT_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
11 STM1_DBG_DIS_CM7_1	STM_1 Debug Disable Cortex-M7_1 Specifies whether STM_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
10 STM0_DBG_DIS_CM7_1	STM_0 Debug Disable Cortex-M7_1 Specifies whether STM_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
9 SWT1_DBG_DIS_CM7_1	SWT_1 Debug Disable Cortex-M7_1 Specifies whether SWT_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
8 SWT0_DBG_DIS_CM7_1	SWT_0 Debug Disable Cortex-M7_1 Specifies whether SWT_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
7 RTC_DBG_DIS_CM7_1	RTC Debug Disable Cortex-M7_1 Specifies whether RTC enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
6 —	Reserved
5 —	Reserved
4 EMIOS0_DBG_DIS_CM7_1	eMIOS_0 Debug Disable Cortex-M7_1 Specifies whether eMIOS_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
3 LCU1_DBG_DIS_CM7_1	LCU_1 Debug Disable Cortex-M7_1 Specifies whether LCU_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode.

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Field	Function
	Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
2 LCU0_DBG_DIS_CM7_1	LCU_0 Debug Disable Cortex-M7_1 Specifies whether LCU_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
1 FCCU_DBG_DIS_CM7_1	FCCU Debug Disable Cortex-M7_1 Specifies whether FCCU enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
0 EDMA_DBG_DIS_CM7_1	eDMA Debug Disable Cortex-M7_1 Specifies whether eDMA enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted

36.2.37 Read Write GPR On Destructive Reset 9 (DCMRWD9)

Offset

Register	Offset
DCMRWD9	520h

Function

Provides module debug disable information.

This register resets after destructive reset 9.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved				Reserved				Reserved			SD_ADC3...	SD_ADC2...	SD_ADC1...	SD_ADC0...	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	EDMA1_D...	Reserved	IGF0_DB...	ETPU_DB...	SIPI_DB...	eFlexPW...	eFlexPW...	DSPI_DB...	DIGRF_D...	Reserved	SWT2_DB...	STM2_DB...	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27-24 —	Reserved
23-21 —	Reserved
20 SD_ADC3_DBG_DIS_CM7_1	SD_ADC3 Debug Disable Cortex-M7_1 Specifies whether SD_ADC3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
19 SD_ADC2_DBG_DIS_CM7_1	SD_ADC2 Debug Disable Cortex-M7_1 Specifies whether SD_ADC2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
18 SD_ADC1_DBG_DIS_CM7_1	SD_ADC1 Debug Disable Cortex-M7_1 Specifies whether SD_ADC1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
17 SD_ADC0_DBG_DIS_CM7_1	SD_ADC0 Debug Disable Cortex-M7_1 Specifies whether SD_ADC0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
16-15 —	Reserved
14 EDMA1_DBG_DIS_CM7_1	eDMA Debug Disable Cortex-M7_1 Specifies whether eDMA enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
13 —	Reserved
12 IGF0_DBG_DIS_CM7_1	IGF_0 Debug Disable Cortex-M7_1 Specifies whether IGF_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
11 ETPU_DBG_DIS_CM7_1	eTPU Debug Disable Cortex-M7_1 Specifies whether eTPU enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
10 SIPI_DBG_DIS_CM7_1	SIPI Debug Disable Cortex-M7_1 Specifies whether SIPI enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode.

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Field	Function
	Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
9 eFlexPWM1_DBG_DIS_CM7_1	eFlexPWM_1 Debug Disable Cortex-M7_1 Specifies whether eFlexPWM_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
8 eFlexPWM0_DBG_DIS_CM7_1	eFlexPWM_0 Debug Disable Cortex-M7_1 Specifies whether eFlexPWM_0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
7 DSPI_DBG_DIS_CM7_1	DSPI Debug Disable Cortex-M7_1 Specifies whether DSPI enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
6 DIGRF_DBG_DIS_CM7_1	LFAST Debug Disable Cortex-M7_1 Specifies whether LFAST enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
5 —	Reserved
4 SWT2_DBG_DIS_CM7_1	SWT_2 Debug Disable Cortex-M7_1 Specifies whether SWT_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug.

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Field	Function
	0b - Enters Debug mode 1b - Remains functional and unimpacted
3 STM2_DBG_DIS_CM7_1	STM_2 Debug Disable Cortex-M7_1 Specifies whether STM_2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_1 core enters Debug mode. Write 1 to this field to disable debug. 0b - Enters Debug mode 1b - Remains functional and unimpacted
2 —	Reserved
1 —	Reserved
0 —	Reserved

36.2.38 Read Write GPR On Destructive Reset 12 (DCMRWD12)

Offset

Register	Offset
DCMRWD12	52Ch

Function

Provides module debug disable information.

This register resets after destructive reset 12.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	Reserved	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXCAN...	FLEXIO_...	LPI2C1_...	LPI2C0_...	LPSPI5_...	LPSPI4_...	LPSPI3_...	LPSPI2_...	LPSPI1_...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LPSPI0_...	PIT2_DB...	PIT1_DB...	PIT0_DB...	STM1_DB...	STM0_DB...	SWT1_DB...	SWT0_DB...	RTC_DBG...	Reserved	Reserved	eMIOS0_...	LCU1_DB...	LCU0_DB...	FCCU_DB...	EDMA_DB...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29 FLEXCAN5_DBG_DIS_CM7_2	FlexCAN5 Debug Disable For Cortex M7_2 Specifies whether FlexCAN5 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FlexCAN5 enters Debug mode, and if this field = 1, FlexCAN5 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
28 FLEXCAN4_DBG_DIS_CM7_2	FlexCAN4 Debug Disable For Cortex M7_2 Specifies whether FlexCAN4 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FlexCAN4 enters Debug mode, and if this field = 1, FlexCAN4 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
27 FLEXCAN3_DBG_DIS_CM7_2	FlexCAN3 Debug Disable For Cortex M7_2 Specifies whether FlexCAN3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FlexCAN3 enters Debug mode, and if this field = 1, FlexCAN3 remains functional. Write 1 to this field to disable debug.

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Field	Function
	0b - Enables Debug mode 1b - Disables Debug mode
26 FLEXCAN2_DBG_DIS_CM7_2	FlexCAN2 Debug Disable For Cortex M7_2 Specifies whether FlexCAN2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FlexCAN2 enters Debug mode, and if this field = 1, FlexCAN2 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
25 FLEXCAN1_DBG_DIS_CM7_2	FlexCAN1 Debug Disable For Cortex M7_2 Specifies whether FlexCAN1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FlexCAN1 enters Debug mode, and if this field = 1, FlexCAN1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
24 FLEXCAN0_DBG_DIS_CM7_2	FlexCAN0 Debug Disable For Cortex M7_2 Specifies whether FlexCAN0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FlexCAN0 enters Debug mode, and if this field = 1, FlexCAN0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
23 FLEXIO_DBG_DIS_CM7_2	FlexIO Debug Disable For Cortex M7_2 Specifies whether FlexIO enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FlexIO enters Debug mode, and if this field = 1, FlexIO remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
22 LPI2C1_DBG_DIS_CM7_2	LPI2C1 Debug Disable For Cortex M7_2 Specifies whether LPI2C1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPI2C1 enters Debug mode, and if this field = 1, LPI2C1 remains functional. Write 1 to this field to disable debug.

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Field	Function
	0b - Enables Debug mode 1b - Disables Debug mode
21 LPI2C0_DBG_DIS_CM7_2	LPI2C0 Debug Disable For Cortex M7_2 Specifies whether LPI2C0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPI2C0 enters Debug mode, and if this field = 1, LPI2C0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
20 LPSPI5_DBG_DIS_CM7_2	LPSPI5 Debug Disable For Cortex M7_2 Specifies whether LPSPI5 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPSPI5 enters Debug mode, and if this field = 1, LPSPI5 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
19 LPSPI4_DBG_DIS_CM7_2	LPSPI4 Debug Disable For Cortex M7_2 Specifies whether LPSPI4 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPSPI4 enters Debug mode, and if this field = 1, LPSPI4 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
18 LPSPI3_DBG_DIS_CM7_2	LPSPI3 Debug Disable For Cortex M7_2 Specifies whether LPSPI3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPSPI3 enters Debug mode, and if this field = 1, LPSPI3 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
17 LPSPI2_DBG_DIS_CM7_2	LPSPI2 Debug Disable For Cortex M7_2 Specifies whether LPSPI2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPSPI2 enters Debug mode, and if this field = 1, LPSPI2 remains functional. Write 1 to this field to disable debug.

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Field	Function
	0b - Enables Debug mode 1b - Disables Debug mode
16 LPSPI1_DBG_DIS_CM7_2	LPSPI1 Debug Disable For Cortex M7_2 Specifies whether LPSPI1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPSPI1 enters Debug mode, and if this field = 1, LPSPI1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
15 LPSPI0_DBG_DIS_CM7_2	LPSPI0 Debug Disable For Cortex M7_2 Specifies whether LPSPI0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LPSPI0 enters Debug mode, and if this field = 1, LPSPI0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
14 PIT2_DBG_DIS_CM7_2	PIT2 Debug Disable For Cortex M7_2 Specifies whether PIT2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, PIT2 enters Debug mode, and if this field = 1, PIT2 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
13 PIT1_DBG_DIS_CM7_2	PIT1 Debug Disable For Cortex M7_2 Specifies whether PIT1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, PIT1 enters Debug mode, and if this field = 1, PIT1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
12 PIT0_DBG_DIS_CM7_2	PIT0 Debug Disable For Cortex M7_2 Specifies whether PIT0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, PIT0 enters Debug mode, and if this field = 1, PIT0 remains functional. Write 1 to this field to disable debug.

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Field	Function
	0b - Enables Debug mode 1b - Disables Debug mode
11 STM1_DBG_DIS_CM7_2	STM1 Debug Disable For Cortex M7_2 Specifies whether STM1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, STM1 enters Debug mode, and if this field = 1, STM1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
10 STM0_DBG_DIS_CM7_2	STM0 Debug Disable For Cortex M7_2 Specifies whether STM0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, STM0 enters Debug mode, and if this field = 1, STM0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
9 SWT1_DBG_DIS_CM7_2	SWT1 Debug Disable For Cortex M7_2 Specifies whether SWT1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SWT1 enters Debug mode, and if this field = 1, SWT1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
8 SWT0_DBG_DIS_CM7_2	SWT0 Debug Disable For Cortex M7_2 Specifies whether SWT0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SWT0 enters Debug mode, and if this field = 1, SWT0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
7 RTC_DBG_DIS_CM7_2	RTC Debug Disable For Cortex M7_2 Specifies whether RTC enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, RTC enters Debug mode, and if this field = 1, RTC remains functional. Write 1 to this field to disable debug.

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Field	Function
	0b - Enables Debug mode 1b - Disables Debug mode
6 —	Reserved
5 —	Reserved
4 eMIOS0_DBG_DIS_CM7_2	eMIOS0 Debug Disable For Cortex M7_2 Specifies whether eMIOS0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, eMIOS0 enters Debug mode, and if this field = 1, eMIOS0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
3 LCU1_DBG_DIS_CM7_2	LCU1 Debug Disable For Cortex M7_2 Specifies whether LCU1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LCU1 enters Debug mode, and if this field = 1, LCU1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
2 LCU0_DBG_DIS_CM7_2	LCU0 Debug Disable For Cortex M7_2 Specifies whether LCU0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LCU0 enters Debug mode, and if this field = 1, LCU0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
1 FCCU_DBG_DIS_CM7_2	FCCU Debug Disable For Cortex M7_2 Specifies whether FCCU enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, FCCU enters Debug mode, and if this field = 1, FCCU remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode

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Field	Function
0 EDMA_DBG_DIS_CM7_2	eDMA Debug Disable For Cortex M7_2 Specifies whether eDMA enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, eDMA enters Debug mode, and if this field = 1, eDMA remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode

36.2.39 Read Write GPR On Destructive Reset 13 (DCMRWD13)

Offset

Register	Offset
DCMRWD13	530h

Function

Provides module debug disable information.

This register resets after destructive reset 13.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved				Reserved				Reserved			SD_ADC3...	SD_ADC2...	SD_ADC1...	SD_ADC0...	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	EDMA1_D...	Reserved	IGF0_DB...	ETPU_DB...	SIPI_DB...	eFlexPW...	eFlexPW...	DSPI_DB...	DIGRF_D...	Reserved	SWT2_DB...	STM2_DB...	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27-24	Reserved

Table continues on the next page...

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Field	Function
—	
23-21 —	Reserved
20 SD_ADC3_DBG_DIS_CM7_2	SD_ADC3 Debug Disable For Cortex-M7_2 Specifies whether SD_ADC3 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SD_ADC3 enters Debug mode, and if this field = 1, SD_ADC3 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
19 SD_ADC2_DBG_DIS_CM7_2	SD_ADC2 Debug Disable For Cortex-M7_2 Specifies whether SD_ADC2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SD_ADC2 enters Debug mode, and if this field = 1, SD_ADC2 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
18 SD_ADC1_DBG_DIS_CM7_2	SD_ADC1 Debug Disable For Cortex-M7_2 Specifies whether SD_ADC1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SD_ADC1 enters Debug mode, and if this field = 1, SD_ADC1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
17 SD_ADC0_DBG_DIS_CM7_2	SD_ADC0 Debug Disable For Cortex-M7_2 Specifies whether SD_ADC0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SD_ADC0 enters Debug mode, and if this field = 1, SD_ADC0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
16-15 —	Reserved
14	eDMA_1 Debug Disable For Cortex-M7_2

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Field	Function
EDMA1_DBG_DIS_CM7_2	Specifies whether eDMA_1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, eDMA_1 enters Debug mode, and if this field = 1, eDMA_1 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
13 —	Reserved
12 IGF0_DBG_DIS_CM7_2	IGF0 Debug Disable For Cortex-M7_2 Specifies whether IGF0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, IGF0 enters Debug mode, and if this field = 1, IGF0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
11 ETPU_DBG_DIS_CM7_2	eTPU Debug Disable For Cortex-M7_2 Specifies whether eTPU enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, eTPU enters Debug mode, and if this field = 1, eTPU remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
10 SIPI_DBG_DIS_CM7_2	SIPI Debug Disable For Cortex-M7_2 Specifies whether SIPI enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SIPI enters Debug mode, and if this field = 1, SIPI remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
9 eFlexPWM1_DBG_DIS_CM7_2	eFlexPWM1 Debug Disable For Cortex-M7_2 Specifies whether eFlexPWM1 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, eFlexPWM1 enters Debug mode, and if this field = 1, eFlexPWM1 remains functional. Write 1 to this field to disable debug.

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Field	Function
	0b - Enables Debug mode 1b - Disables Debug mode
8 eFlexPWM0_DBG_DIS_CM7_2	eFlexPWM0 Debug Disable For Cortex-M7_2 Specifies whether eFlexPWM0 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, eFlexPWM0 enters Debug mode, and if this field = 1, eFlexPWM0 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
7 DSPI_DBG_DIS_CM7_2	DSPI Debug Disable For Cortex-M7_2 Specifies whether DSPI enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, DSPI enters Debug mode, and if this field = 1, DSPI remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
6 DIGRF_DBG_DIS_CM7_2	LFAST Debug Disable For Cortex-M7_2 Specifies whether LFAST enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, LFAST enters Debug mode, and if this field = 1, LFAST remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
5 —	Reserved
4 SWT2_DBG_DIS_CM7_2	SWT2 Debug Disable For Cortex-M7_2 Specifies whether SWT2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, SWT2 enters Debug mode, and if this field = 1, SWT2 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
3	STM2 Debug Disable For Cortex-M7_2

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Field	Function
STM2_DBG_DIS_CM7_2	Specifies whether STM2 enters Debug mode or remains functional and unimpacted when the Cortex-M7_2 core enters Debug mode. If this field = 0, STM2 enters Debug mode, and if this field = 1, STM2 remains functional. Write 1 to this field to disable debug. 0b - Enables Debug mode 1b - Disables Debug mode
2 —	Reserved
1 —	Reserved
0 —	Reserved

36.2.40 Read Write GPR On Destructive Reset 14 (DCMRWD14)

Offset

Register	Offset
DCMRWD14	534h

Function

Provides module debug disable information.

This register resets after destructive reset 14.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	DMA1_AX...	Reserved	ZIPWIRE...	DMA1_PE...	DMA1_SY...	Reserved	eDMA1_R...	eDMA1_R...	CM7_2_R...	CM7_2_R...	OMU_2_A...	OMU_1_A...	OMU_0_A...	ETPU_GL...	SAR_ADC...	SAR_ADC...
Reset	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	SAR_ADC...	QSPI_FL...	DMA1_TC...	ZIPWIRE...	DMA1_RD...
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31 DMA1_AXBS_ALARM_EN	eDMA_1 AXBS Alarm Enable Specifies whether eDMA_1 AXBS_Lite reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of an eDMA AXBS_Lite safety alarm. 0b - No 1b - Yes
30 —	Reserved
29 ZIPWIRE_GSKT_ALARM_EN	ZIPWIRE Gasket Alarm Enable Specifies whether ZIPWIRE gasket reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 for ZIPWIRE gasket safety alarm. 0b - No 1b - Yes
28 DMA1_PERIPH_GSKT_ALARM_EN	DMA1 Peripheral Gasket Alarm Enable Specifies whether DMA1 peripheral gasket reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 for DMA1 peripheral gasket safety alarm. 0b - No 1b - Yes
27 DMA1_SYS_GSKT_ALARM_EN	DMA1 System Gasket Alarm Enable Specifies whether DMA1 system gasket reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 for DMA1 system gasket safety alarm. 0b - No 1b - Yes
26 —	Reserved
25 eDMA1_RCCU2_ALARM_EN	eDMA_1 RCCU_2 Alarm Enable Specifies whether RCCU reported a lockstep alarm. The field enables fault monitoring at FCCU NCF 12 in case of eDMA_1 and eDMA_1 checker redundant lockstep error. 0b - No 1b - Yes
24	eDMA_1 RCCU_1 Alarm Enable Specifies whether RCCU reported a lockstep alarm.

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Field	Function
eDMA1_RCCU1_ALARM_EN	The field enables fault monitoring at FCCU NCF 12 in case of eDMA_1 and eDMA_1 checker lockstep error. 0b - No 1b - Yes
23 CM7_2_RCCU2_ALARM_EN	Cortex-M7_2 RCCU_2 Alarm Enable Specifies whether RCCU_2 reported a lockstep alarm. The field enables fault monitoring at FCCU NCF 11 in case of Cortex-M7_2 and Cortex-M7_2 checker cores redundant lockstep error. 0b - No 1b - Yes
22 CM7_2_RCCU1_ALARM_EN	Cortex-M7_2 RCCU_1 Alarm Enable Specifies whether RCCU reported a lockstep alarm. The field enables fault monitoring at FCCU NCF 11 in case of Cortex-M7_2 and Cortex-M7_2 checker cores lockstep error. 0b - No 1b - Yes
21 OMU_2_ALARM_EN	OMU_2 Alarm Enable Specifies whether OMU_2 alarm detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 10 for OMU_2. 0b - No 1b - Yes
20 OMU_1_ALARM_EN	OMU_1 Alarm Enable Specifies whether OMU_1 alarm detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 10 for OMU_1. 0b - No 1b - Yes
19 OMU_0_ALARM_EN	OMU_0 Alarm Enable Specifies whether OMU_0 alarm detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 10 for OMU_0. 0b - No 1b - Yes
18	ETPU Global Exception Error Enable Specifies whether ETPU Global exception detection is enabled at FCCU.

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Field	Function
ETPU_GLEX_ERR_EN	The field enables fault monitoring at FCCU NCF 14 for ETPU Global exception. 0b - No 1b - Yes
17 SAR_ADC6_CF_ERR_EN	SAR_ADC_6 CF Error Enable Specifies whether SAR_ADC_6 CF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_6 CF. 0b - No 1b - Yes
16 SAR_ADC5_CF_ERR_EN	SAR_ADC_5 CF Error Enable Specifies whether SAR_ADC_5 CF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_5 CF. 0b - No 1b - Yes
15 SAR_ADC4_CF_ERR_EN	SAR_ADC_4 CF Error Enable Specifies whether SAR_ADC_4 CF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_4 CF. 0b - No 1b - Yes
14 SAR_ADC3_CF_ERR_EN	SAR_ADC_3 CF Error Enable Specifies whether SAR_ADC_3 CF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_3 CF. 0b - No 1b - Yes
13 SAR_ADC2_CF_ERR_EN	SAR_ADC_2 CF Error Enable Specifies whether SAR_ADC_2 CF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_2 CF. 0b - No 1b - Yes
12 SAR_ADC1_CF_ERR_EN	SAR_ADC_1 CF Error Enable Specifies whether SAR_ADC_1 CF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_1 CF.

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Field	Function
	0b - No 1b - Yes
11 SAR_ADC0_CF_ERR_EN	SAR_ADC_0 CF Error Enable Specifies whether SAR_ADC_0 CF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_0 CF. 0b - No 1b - Yes
10 SAR_ADC6_NCF_ERR_EN	SAR_ADC_6 NCF Error Enable Specifies whether SAR_ADC_6 NCF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_6 NCF. 0b - No 1b - Yes
9 SAR_ADC5_NCF_ERR_EN	SAR_ADC_5 NCF Error Enable Specifies whether SAR_ADC_5 NCF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_5 NCF. 0b - No 1b - Yes
8 SAR_ADC4_NCF_ERR_EN	SAR_ADC_4 NCF Error Enable Specifies whether SAR_ADC_4 NCF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_4 NCF. 0b - No 1b - Yes
7 SAR_ADC3_NCF_ERR_EN	SAR_ADC_3 NCF Error Enable Specifies whether SAR_ADC_3 NCF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_3 NCF. 0b - No 1b - Yes
6 SAR_ADC2_NCF_ERR_EN	SAR_ADC_2 NCF Error Enable Specifies whether SAR_ADC_2 NCF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_2 NCF. 0b - No

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Field	Function
	1b - Yes
5 SAR_ADC1_NCF_ERR_EN	SAR_ADC_1 NCF Error Enable Specifies whether SAR_ADC_1 NCF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_1 NCF. 0b - No 1b - Yes
4 SAR_ADC0_NCF_ERR_EN	SAR_ADC_0 NCF Error Enable Specifies whether SAR_ADC_0 NCF detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 9 for SAR_ADC_0 NCF. 0b - No 1b - Yes
3 QSPI_FLASHA_ECC_ERR_EN	QSPI FLASHA ECC Error Enable Specifies whether QSPI FLASHA ECC detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 2 for QSPI FLASHA ECC. 0b - No 1b - Yes
2 DMA1_TCD_RAM_ECC_ERR_EN	eDMA_1 TCD RAM ECC Error Enable Specifies whether uncorrectable ECC error detection is enabled at FCCU. The field enables fault monitoring at FCCU NCF 2 in case of an uncorrectable ECC error reported from the eDMA_1 TCD memory. This uncorrectable ECC error consists of a multi-bit data ECC error and an address ECC error. 0b - No 1b - Yes
1 ZIPWIRE_RDATA_EDC_ERR_EN	Zipwire Read Data EDC Error Enable Specifies whether an integrity error is reported on the Zipwire read data. The field enables fault monitoring at FCCU NCF 1, in case of an integrity error on the Zipwire read data, for safety. 0b - No 1b - Yes
0 DMA1_RDATA_EDC_ERR_EN	eDMA_1 Read Data EDC Error Enable Specifies whether an integrity error is reported on the eDMA_1 read data. The field enables fault monitoring at FCCU NCF 1, in case of an integrity error on the eDMA_1 read data, for safety.

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Field	Function
	0b - No 1b - Yes

36.2.41 Read Write GPR On Destructive Reset 15 (DCMRWD15)

Offset

Register	Offset
DCMRWD15	538h

Function

Provides module debug disable information.

This register resets after destructive reset 15.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	CM7_2_A...	CM7_1_A...	CM7_0_A...	XMEM_OD...	PMEM_EC...	PMEM_EC...	PMEM_EC...	PMEM_EC...	XMEM_EV...	XMEM_EV...	XMEM_EV...	XMEM_EV...	XMEM_OD...	XMEM_OD...	XMEM_OD...
W																
Reset	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	XMEM_OD...	PMEM_EC...	XMEM_EV...	VDD2P5_...	VDD1P1_...	VDDA_SW...	VDDA_SD...	VDDA_SD...	LVDS_3P...	ZIPWIRE...	CM7_2_A...	CM7_1_A...	CM7_0_A...	CM7_2_A...	CM7_1_A...	CM7_0_A...
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31 —	Reserved
30 CM7_2_AHBS_ALARM_EN	Cortex-M7_2 AHBS Alarm Enable Specifies whether the Cortex-M7_2 AHBS interface IAHB gasket reported an alarm. Enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_2 AHBS interface IAHB Gasket monitor alarm. 0b - No 1b - Yes

Table continues on the next page...

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Field	Function
29 CM7_1_AHBS_ALARM_EN	Cortex-M7_1 AHBS Alarm Enable Specifies whether the Cortex-M7_1 AHBS interface IAHB gasket reported an alarm. Enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_1 AHBS interface IAHB Gasket monitor alarm. 0b - No 1b - Yes
28 CM7_0_AHBS_ALARM_EN	Cortex-M7_0 AHBS Alarm Enable Specifies whether the Cortex-M7_0 AHBS interface IAHB gasket reported an alarm. Enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_0 AHBS interface IAHB Gasket monitor alarm. 0b - No 1b - Yes
27 XMEM_ODD_ECC_CORE_ERR_EN	XMEM Odd ECC Core Error Enable Enables bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during core access. 0b - Disabled 1b - Enabled
26 PMEM_ECC3_DSP_ERR_EN	PMEM ECC3 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
25 PMEM_ECC2_DSP_ERR_EN	PMEM ECC2 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
24 PMEM_ECC1_DSP_ERR_EN	PMEM ECC1 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
23 PMEM_ECC0_DSP_ERR_EN	PMEM ECC0 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during DSP access.

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Field	Function
	0b - Disabled 1b - Enabled
22 XMEM_EVEN_ECC3_DSP_ERR_EN	XMEM Even ECC3 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
21 XMEM_EVEN_ECC2_DSP_ERR_EN	XMEM Even ECC2 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
20 XMEM_EVEN_ECC1_DSP_ERR_EN	XMEM Even ECC1 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
19 XMEM_EVEN_ECC0_DSP_ERR_EN	XMEM Even ECC0 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
18 XMEM_ODD_ECC3_DSP_ERR_EN	XMEM Odd ECC3 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
17 XMEM_ODD_ECC2_DSP_ERR_EN	XMEM Odd ECC2 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
16	XMEM Odd ECC1 DSP Error Enable

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Field	Function
XMEM_ODD_ECC1_DSP_ERR_EN	Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
15 XMEM_ODD_ECC0_DSP_ERR_EN	XMEM Odd ECC0 DSP Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on odd xmem memory per thread during DSP access. 0b - Disabled 1b - Enabled
14 PMEM_ECC_CORE_ERR_EN	PMEM ECC Core Error Enable Enables bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on pmem memory per thread during core access. 0b - Disabled 1b - Enabled
13 XMEM_EVEN_ECC_CORE_ERR_EN	XMEM Even ECC Core Error Enable Enables bit for enabling the fault monitoring at FCCU NCF 8 for the fault: Multi-bit error on even xmem memory per thread during core access. 0b - Disabled 1b - Enabled
12 VDD2P5_GNG2_ERR_EN	VDD2P5 Go Nogo Error Enable Enables bit for enabling the fault monitoring at FCCU NCF 4 for the fault: Go/Nogo for VDD_HV_FLA (triple bond) going to FXOSC and PLL. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
11 VDD1P1_GNG2_ERR_EN	VDD1P1 Go Nogo Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 4 for the fault: Go/Nogo indicator for VDD1PD1 (triple bond) supply going to PLL. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
10 VDDA_SWG_GNG_ERR_EN	VDDA SWG Go Nogo Error Enable Enable bit for enabling the fault monitoring at FCCU NCF 4 for the fault: Go/Nogo indicator for VDDA_SWG supply going to SWG0/1.

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Field	Function
	0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
9 VDDA_SDADC1_GNG_ERR_EN	VDDA SDADC Go Nogo Error Enable Enables bit for enabling the fault monitoring at FCCU NCF 4 for the fault: Go/Nogo indicator for VDDA_SDADC supply going to SDADC1. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
8 VDDA_SDADC0_GNG_ERR_EN	VDDA SDADC Go Nogo Error Enable Enables bit for enabling the fault monitoring at FCCU NCF 4 for the fault: Go/Nogo indicator for VDDA_SDADC supply going to SDADC0. 0b - Go indication referring to the supply being clean. 1b - No go indication referring to the supply being unclean and a fault in double bond connection or its routing within the chip.
7 LVDS_3P3V_RX_FAULT_EN	LVDS 3P3V RX Fault Enable Specifies whether the 3.3 V LVDS RX pad reported a safety alarm. The field enables fault monitoring at FCCU NCF 13 for 3.3 V LVDS pad receiver. 0b - No 1b - Yes
6 ZIPWIRE_AXBS_ALARM_EN	Zipwire AXBS Alarm Enable Specifies whether Zipwire AXBS_Lite reported a safety alarm. The field enables fault monitoring at FCCU NCF 1 in case of a Zipwire AXBS_Lite safety alarm. 0b - No 1b - Yes
5 CM7_2_AHBP_ALARM_EN	Cortex-M7_2 AHBP Alarm Enable Specifies whether the Cortex-M7_2 AHBP interface IAHB gasket reported an alarm. If this field = 1, the gasket reports a monitor alarm. The field enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_2 AHBP interface IAHB gasket monitor alarm. 0b - No 1b - Yes
4	Cortex-M7_1 AHBP Alarm Enable

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Field	Function
CM7_1_AHBP_ALARM_EN	Specifies whether the Cortex-M7_1 AHBP interface IAHB gasket reported an alarm. If this field = 1, the gasket reports a monitor alarm. The field enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_1 AHBP interface IAHB gasket monitor alarm. 0b - No 1b - Yes
3 CM7_0_AHBP_ALARM_EN	Cortex-M7_0 AHBP Alarm Enable Specifies whether the Cortex-M7_0 AHBP interface IAHB gasket reported an alarm. If this field = 1, the gasket reports a monitor alarm. The field enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_0 AHBP interface IAHB gasket monitor alarm. 0b - No 1b - Yes
2 CM7_2_AHBM_ALARM_EN	Cortex-M7_2 AHBM Alarm Enable Specifies whether the Cortex-M7_2 AHBM interface IAHB gasket reported an alarm. If this field = 1, the gasket reports a monitor alarm. The field enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_2 AHBM interface IAHB gasket monitor alarm. 0b - No 1b - Yes
1 CM7_1_AHBM_ALARM_EN	Cortex-M7_1 AHBM Alarm Enable Specifies whether the Cortex-M7_1 AHBM interface IAHB gasket reported an alarm. If this field = 1, the gasket reports a monitor alarm. The field enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_1 AHBM interface IAHB gasket monitor alarm. 0b - No 1b - Yes
0 CM7_0_AHBM_ALARM_EN	Cortex-M7_0 AHBM Alarm Enable Specifies whether the Cortex-M7_0 AHBM interface IAHB gasket reported an alarm. If this field = 1, the gasket reports a monitor alarm. The field enables fault monitoring at FCCU NCF 1 in case of a Cortex-M7_0 AHBM interface IAHB gasket monitor alarm. 0b - No 1b - Yes

36.2.42 Read Write GPR On Functional Reset 1 (DCMRWF1)

Offset

Register	Offset
DCMRWF1	600h

Function

Contains information related to:

- Voltage dividers, LFAST clocks, and supply voltage monitoring.
- I/O configurations.

This field resets after functional reset 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	Reserved			VDD_1_5...	VDD_HV_...	VDD_HV_...	VSS_LV_...	SUPPLY_MON_SEL			SUPPLY_...	Reserved	PMIC_PG...	Reserved	STANDBY...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	VDD_HV_...	Reserved	Reserved	Reserved	Reserved	LFAST_R...	LFAST_P...	LFAST_P...	MAC_CON...	Reserved	FCCU_SW...	FCCU_SW...	FCCU_SW...	FCCU_SW...	CAN_TIM...	CAN_TIM...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30-28 —	Reserved
27 VDD_1_5_VLT_DVDR_EN	VDD1P5 Voltage Divider Enable Enables the VDD1P5 2:1 divider for voltage measurement using the supply voltage that ADC monitors. 0b - Disables 1b - Enables
26 VDD_HV_B_VLT_DVDR_EN	VDD_HV_B Voltage Divider Enable Enables the VDD_HV_B 2:1 divider for voltage measurement by using the supply voltage that ADC monitors.

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Field	Function
	0b - Disables 1b - Enables
25 VDD_HV_A_VLT_DVDR_EN	VDD_HV_A Voltage Divider Enable Enables the VDD_HV_A 2:1 divider for voltage measurement by using supply voltage that ADC monitors. 0b - Disables 1b - Enables
24 VSS_LV_ANMUX_EN	VSS_LV Monitoring Enable Enables VSS_LV monitoring. **NOTE** You must write 1 to this field (with DCMRWF1[SUPPLY_MON_EN] = 1b0 for VSS_LV monitoring by ADC0). 0b - Disables 1b - Enables
23-21 SUPPLY_MON_SEL	Supply Monitoring Select Selects the source of voltage that ADC uses for supply monitoring. **NOTE** • The SUPPLY_MON_SEL configurations are effective only when SUPPLY_MON_EN is 1. • When SUPPLY_MON_EN is 0 and VSS_LV_ANMUX_EN is 1, VSS_LV is monitored. 000b - VDD_HV_A_DIV 001b - VDD_HV_B_DIV 010b - VDD_1.5_DIV 011b - VDD_2.5_OSC 100b - VDD1.1_PD1_HOT_POINT 101b - VDD1.1_PD1_COLD_POINT 110b - VDD1.1_PLL 111b - VDD1.1_PD0
20 SUPPLY_MON_EN	Supply Monitoring Enable Enables the ADC supply voltage monitoring. 0b - Disables 1b - Enables
19	Reserved

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Field	Function
—	
18 PMIC_PGOOD_HNDSHK_BYP	Controls the PMIC_PGOOD handshake with the external Power Management IC (PMIC) while standby exit. 0b - The standby exit proceeds only when the active edge (as per DCMRWF2[PGOOD_POLARITY] configuration) is detected on the PGOOD signal. 1b - The PMIC_PGOOD handshake with the PMIC is bypassed.
17 —	Reserved
16 STANDBY_IO_CONFIG	Standby I/O Configuration Controls the IO state in the standby mode. This bit needs to be written both at the standby entry as well as standby exit as per the below description. 0b - Must be written as 0 before IO configurations are done in standby entry sequence. 1b - Must be written as 1 after IO configurations are done on standby exit.
15 VDD_HV_B_IO_CTRL_LATCH	VDD_HV_B I/O Control Latch Controls the IO controls (SRC, DSE, PKE, PUS, PUE, IBE and OBE) latching in low frequency RUN mode to reduce power consumption on VDD_HV_B domain pins. The pad output path is functional as usual. **NOTE** This field must remain 0, except in FIRC 3 MHz and FIRC 187.5 kHz operation modes. 0b - VDD_HV_B domain pins function as normal. 1b - The IO controls of VDD_HV_B domain pins are latched.
14 —	Reserved
13 —	Reserved
12 —	Reserved
11 —	Reserved
10 LFAST_RX_MM_EN	Enables the LFAST_RX LVDS pad mismatch for reduced VOD variations on V33 supply line. 0b - The LFAST_RX LVDS pad mismatch for reduced VOD variations not enabled. 1b - The LFAST_RX LVDS pad mismatch for reduced VOD variations is enabled.

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Field	Function
9 LFAST_PLL_VCO_CLK_EN	LFAST PLL VCO Clock Enable Enables the LFAST PLL VCO clocks. 0b - Disables 1b - Enables
8 LFAST_PLL_BANKA_CLK_EN	LFAST PLL Bank_A Clock Enable Enables the LFAST PLL BANK_A clocks. 0b - Disables 1b - Enables
7 MAC_CONF_SEL	Selects between MII and RMII mode of ethernet. 0b - MII mode 1b - RMII mode
6 —	Reserved
5 FCCU_SW_NCF3	FCCU Software NCF 3 Specifies whether NCF 3 to FCCU is generated. For the exact FCCU slot, see the "Fault Collection and Control Unit (FCCU)" chapter. 0b - Not generated 1b - Generated
4 FCCU_SW_NCF2	FCCU Software NCF 2 Specifies whether NCF 2 to FCCU is generated. For the exact FCCU slot, see the "Fault Collection and Control Unit (FCCU)" chapter. 0b - Not generated 1b - Generated
3 FCCU_SW_NCF1	FCCU Software NCF 1 Specifies whether NCF 1 to FCCU is generated. For the exact FCCU slot, see the "Fault Collection and Control Unit (FCCU)" chapter. 0b - Not generated 1b - Generated
2 FCCU_SW_NCF0	FCCU Software NCF 0 Specifies whether NCF0 to FCCU is generated. For the exact FCCU slot, see the "Fault Collection and Control Unit (FCCU)" chapter. 0b - Not generated 1b - Generated

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Field	Function
1 CAN_TIMESTAMP_EN	FlexCAN Timestamp Enable Enables the FlexCAN timestamping feature. 0b - Disables 1b - Enables
0 CAN_TIMESTAMP_SEL	FlexCAN Timestamp Select Selects either EMAC or STM for FlexCAN timestamping. 0b - EMAC 1b - STM0

36.2.43 Read Write GPR On Functional Reset 2 (DCMRWF2)

Offset

Register	Offset
DCMRWF2	604h

Function

Contains information related to:

- WKPU source select.
- PGOOD polarity.
- HSE_B gasket bypass.
- Bypass standby exit.

This register resets after functional reset 2.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	WKPU8_S...	WKPU45_...	WKPU27_...	WKPU18_...	Reserved	Reserved	Reserved	Reserved	Reserved		PGOOD_P...	Reserved	Reserved	Reserved	Reserved	HSE_GSK...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SUPPLY2_MON_SEL			SUPPLY2...	Reserved	Reserved		PMOS_CT...	Reserved		PMC_TRI...	FIRC_TR...	DCM_SCA...	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 WKPU8_SRC_SELECT	WKPU[8] Source Select Controls and specifies the source of WKPU[8]. 0b - GPIO[34] 1b - GPIO[231]
30 WKPU45_SRC_SELECT	WKPU[45] Source Select Controls and specifies the source of WKPU[45]. 0b - GPIO[89] 1b - GPIO[217]
29 WKPU27_SRC_SELECT	WKPU[27] Source Select Controls and specifies the source of WKPU[27]. 0b - GPIO[130] 1b - GPIO[233]
28 WKPU18_SRC_SELECT	WKPU[18] Source Select Controls and specifies the source of WKPU[18]. 0b - GPIO[75] 1b - GPIO[235]
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23-22 —	Reserved
21 PGOOD_POLARITY	PGOOD Signal Edge Polarity See the PMIC documentation before performing this configuration. **NOTE** PGOOD_POLARITY configuration is valid only if PMIC_PGOOD_HNDSHK_BYP is set as 1'0b.

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Field	Function
	0b - Rising egde. PGOOD signal is considered active while it sees a transitioning edge from active low state to active high state. 1b - Falling egde. PGOOD signal is considered active while it sees a transitioning edge from active high state to active low state.
20 —	Reserved
19 —	Reserved
18 —	Reserved
17 —	Reserved
16 HSE_GSKT_BYPASS	HSE_B Gasket Bypass Enables the HSE_B IAHB gasket behavior out of Standby mode. • If you write 0 to this field, the DCF client controls the HSE_B IAHB gasket bypass configuration. The system must continue to run on FIRC, and if intended to run on PLL, a functional reset must be asserted. • If you write 1 to this field, the HSE_B IAHB gasket is bypassed out of standby. 0b - Not bypassed 1b - Bypassed
15-13 SUPPLY2_MON_SEL	Supply 2 Monitoring Select Selects the source of voltage that ADC uses for supply monitoring. **NOTE** The SUPPLY2_MON_SEL configurations are effective only when SUPPLY2_MON_EN is 1. 000b - VDD2P5_PLL2 001b - VDD1P1_PLL2 010b - VDD_LVDS 011b - Reserved
12 SUPPLY2_MON_EN	Supply 2 Monitoring Enable Enables supply voltage that ADC monitors to makes use of another ANAMUX. 0b - Disables 1b - Enables

Table continues on the next page...

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Field	Function
11 —	Reserved
10-9 —	Reserved
8 PMOS_CTRL_GPIO_DATA	PMOS Control GPIO Data Controls the data-out from the PMOS_CTRL pad when PMC.CONFIG[LMSMPSEN] is 0. PMOS_CTRL_GPIO_DATA is not impacted if PMC.CONFIG[LMSMPSEN] is 1. 0b - Data is 0 1b - Data is 1
7-6 —	Reserved
5 PMC_TRIM_RGM_DCF_BYP_STDBY_EXT	PMC Trim MC_RGM DCF Bypass Standby Exit Controls the bypassing of PMC trimming and MC_RGM loading on standby exit. 0b - Not bypassed 1b - Bypassed
4 FIRC_TRIM_BYP_STDBY_EXT	FIRC Trim Bypass Standby Exit Controls the bypassing of FIRC trimming on standby exit. 0b - Not bypassed 1b - Bypassed
3 DCM_SCAN_BYP_STDBY_EXT	DCM Scan Bypass Standby Exit Controls the bypassing of DCM scanning on standby exit. 0b - Not bypassed 1b - Bypassed
2 —	Reserved
1 —	Reserved
0 —	Reserved

36.2.44 Read Write GPR On Functional Reset 3 (DCMRWF3)

Offset

Register	Offset
DCMRWF3	608h

Function

Controls and specifies sources of WKPU.

This register resets after functional reset 3.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved				LFAST_R...	Reserved			Reserved				Reserved			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	Reserved		WKPU54_...	WKPU57_...	WKPU55_...	WKPU52_...	WKPU51_...	WKPU5_S...	WKPU31_...	WKPU3_S...	WKPU29_...	WKPU25_...	WKPU20_...	WKPU2_S...	WKPU17_...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 LFAST_RX_TERM_EN	LFAST TX Term Enable Enables the LFAST_RX LVDS pad 100 ohm internal termination at pad. 0b - The LFAST_RX LVDS pad termination disabled 1b - The LFAST_RX LVDS pad termination enabled
26-24 —	Reserved
23-22 —	Reserved
21-16 —	Reserved

Table continues on the next page...

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Field	Function
15 —	Reserved
14-13 —	Reserved
12 WKPU54_SRC_SELECT	WKPU[54] Source Select Controls and specifies the source of WKPU[54]. 0b - GPIO[116] 1b - GPIO[184]
11 WKPU57_SRC_SELECT	WKPU[57] Source Select Controls and specifies the source of WKPU[57]. 0b - GPIO[151] 1b - GPIO[186]
10 WKPU55_SRC_SELECT	WKPU[55] Source Select Controls and specifies the source of WKPU[55]. 0b - GPIO[146] 1b - GPIO[201]
9 WKPU52_SRC_SELECT	WKPU[52] Source Select Controls and specifies the source of WKPU[52]. 0b - GPIO[125] 1b - GPIO[206]
8 WKPU51_SRC_SELECT	WKPU[51] Source Select Controls and specifies the source of WKPU[51]. 0b - GPIO[123] 1b - GPIO[163]
7 WKPU5_SRC_SELECT	WKPU[5] Source Select Controls and specifies the source of WKPU[5]. 0b - GPIO[1] 1b - GPIO[65]
6 WKPU31_SRC_SELECT	WKPU[31] Source Select Controls and specifies the source of WKPU[31].

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Field	Function
	0b - GPIO[16] 1b - GPIO[179]
5 WKPU3_SRC_SELECT	WKPU[3] Source Select Controls and specifies the source of WKPU[3]. 0b - GPIO[70] 1b - GPIO[80]
4 WKPU29_SRC_SELECT	WKPU[29] Source Select Controls and specifies the source of WKPU[29]. 0b - GPIO[134] 1b - GPIO[173]
3 WKPU25_SRC_SELECT	WKPU[25] Source Select Controls and specifies the source of WKPU[25]. 0b - GPIO[40] 1b - GPIO[138]
2 WKPU20_SRC_SELECT	WKPU[20] Source Select Controls and specifies the source of WKPU[20]. 0b - GPIO[15] 1b - GPIO[161]
1 WKPU2_SRC_SELECT	WKPU[2] Source Select Controls and specifies the source of WKPU[2]. 0b - GPIO[71] 1b - GPIO[61]
0 WKPU17_SRC_SELECT	WKPU[17] Source Select Controls and specifies the source of WKPU[17]. 0b - GPIO[41] 1b - GPIO[181]

36.2.45 Read Write GPR On Functional Reset 4 (DCMRWF4)

Offset

Register	Offset
DCMRWF4	60Ch

Function

Contains information related to:

- Mux mode enable.
- Input bypass.

This field resets after functional reset 4.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved	Reserved		Reserved	Reserved					Reserved		Reserved	CM7_2_C...	CM7_1_C...	CM7_0_C...	GLITCH_...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	GLITCH_...	GLITCH_...	GLITCH_...	Reserved		Reserved	Reserved		Reserved		Reserved	MUX_MOD...	Reserved	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30-29 —	Reserved
28 —	Reserved
27-23 —	Reserved
22-21 —	Reserved
20 —	Reserved
19 CM7_2_CPUWAIT	Cortex-M7_2 CPU Wait Enables the configuration to place the Cortex-M7_2 core into CPU wait mode. 0b - Disables CPUWAIT 1b - Enables CPUWAIT

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Field	Function
18 CM7_1_CPUWAIT	Cortex-M7_1 CPU Wait Enables the configuration to place the Cortex-M7_1 core into CPU wait mode. 0b - Disables CPUWAIT 1b - Enables CPUWAIT
17 CM7_0_CPUWAIT	Cortex-M7_0 CPU Wait Enables the configuration to place the Cortex-M7_0 core in CPU wait mode. 0b - Disables CPUWAIT 1b - Enables CPUWAIT
16 GLITCH_FIL_TRG_IN3_BYP	Glitch Filter TRGMUX Input 3 Bypass Selects whether to bypass or filter out the pulse. If this field = 0, it enables glitch filter on TRGMUX input 60, and if the field = 1, it bypasses glitch filter on TRGMUX input 60. 0b - Enables 1b - Bypasses
15 GLITCH_FIL_TRG_IN2_BYP	Glitch Filter TRGMUX Input 2 Bypass Selects whether to bypass or filter out the pulse. If this field = 0, it enables glitch filter on TRGMUX input 61, and if the field = 1, it bypasses glitch filter on TRGMUX input 61. 0b - Enables 1b - Bypasses
14 GLITCH_FIL_TRG_IN1_BYP	Glitch Filter TRGMUX Input 1 Bypass Selects whether to bypass or filter out the pulse. If this field = 0, it enables glitch filter on TRGMUX input 62, and if the field = 1, it bypasses glitch filter on TRGMUX input 62. 0b - Enables 1b - Bypasses
13 GLITCH_FIL_TRG_IN0_BYP	Glitch Filter TRGMUX Input 0 Bypass Selects whether to bypass or filter out the pulse. If this field = 0, it enables glitch filter on TRGMUX input 63, and if the field = 1, it bypasses glitch filter on TRGMUX input 63. 0b - Enables 1b - Bypasses
12-11 —	Reserved
10 —	Reserved

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Field	Function
9 —	Reserved
8-7 —	Reserved
6-5 —	Reserved
4 MUX_MODE_EN_ADC1_S15	Mux Mode Enable ADC_1 Standard Channel 15 Controls the selection of GPIOs to drive ADC_1 standard channel 15. 0b - GPIO_4 1b - GPIO_3
3 —	Reserved
2 —	Reserved
1 —	Reserved
0 —	Reserved

36.2.46 Read Write GPR On Functional Reset 5 (DCMRWF5)

Offset

Register	Offset
DCMRWF5	610h

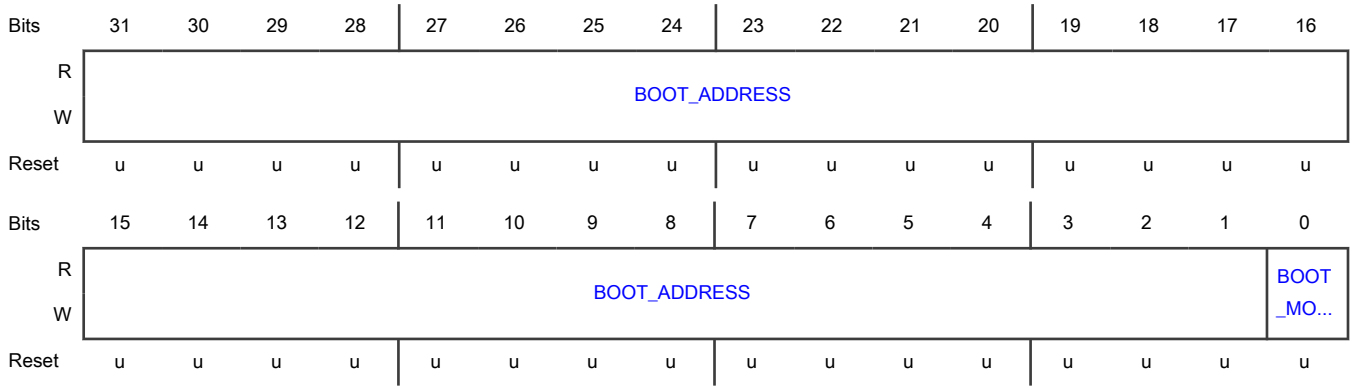
Function

Contains boot address and boot mode.

This register resets after functional reset 5.

The reset value of this register is undefined on reset and is loaded from the flash memory contents at the end of the reset sequence.

Diagram



Fields

Field	Function
31-1 BOOT_ADDRESS	Boot Address Specifies the Cortex-M7_0 base address of the vector table to be used after exiting Standby mode (only to be considered in Fast Standby mode).
0 BOOT_MODE	Boot Mode Selects the type of Boot mode after exiting Standby mode. 0b - Normal 1b - Fast Standby

36.2.47 Read-Only GPR On PMCPOR Reset 1 (DCMROPP1)

Offset

Register	Offset
DCMROPP1	700h

Function

Resets after PMCPOR reset 1 and captures the status of the functional reset sequence process when POR_WDG overflows.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	POR_WDG...	POR_WDG...	POR_WDG...	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	POR_WDG...	Reserved	Reserved	POR_WDG...	Reserved
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	POR_WDG...	Reserved	Reserved	POR_WDG...	POR_WDG...	Reserved	Reserved	Reserved	POR_WDG...	POR_WDG...	POR_WDG...	POR_WDG...	POR_WDG...	POR_WDG...	POR_WDG...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 POR_WDG_STAT31	POR_WDG Status 31 Captures the status of the MC_RGM reset event (if occurred) while the chip is in Standby mode. **NOTE** This field is used only for standby sequence monitoring. 0b - Not detected 1b - Detected
30 POR_WDG_STAT30	POR_WDG Status 30 Captures the status of standby exit acknowledgement by MC_PCU when POR_WDG overflows. **NOTE** This field is used only for standby sequence monitoring. 0b - Not acknowledged 1b - Acknowledged
29 POR_WDG_STAT29	POR_WDG Status 29 Captures the status of the MC_ME standby entry request that MC_ME initiates when POR_WDG overflows. **NOTE** This field is used only for standby sequence monitoring. 0b - Active 1b - Inactive
28	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 —	Reserved
22 —	Reserved
21 —	Reserved
20 POR_WDG_STAT20	POR_WDG Status 20 Specifies the status of the functional reset sequence process, DEST0, when POR_WDG overflows. 0b - Inactive 1b - Active
19 —	Reserved
18 —	Reserved
17 POR_WDG_STAT17	POR_WDG Status 17 Specifies the status of the functional reset sequence process, FUNC10, when POR_WDG overflows. 0b - Inactive 1b - Active
16 —	Reserved

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Field	Function
15 —	Reserved
14 POR_WDG_STAT14	POR_WDG Status 14 Specifies the status of the functional reset sequence process, FUNC9, when POR_WDG overflows. 0b - Inactive 1b - Active
13 —	Reserved
12 —	Reserved
11 POR_WDG_STAT11	POR_WDG Status 11 Specifies the status of the functional reset sequence process, FUNC8, when POR_WDG overflows. 0b - Inactive 1b - Active
10 POR_WDG_STAT10	POR_WDG Status 10 Specifies the status of the functional reset sequence process, FUNC7, when POR_WDG overflows. 0b - Inactive 1b - Active
9 —	Reserved
8 —	Reserved
7 —	Reserved
6 POR_WDG_STAT6	POR_WDG Status 6 Specifies the status of the functional reset sequence process, FUNC6, when POR_WDG overflows. 0b - Inactive 1b - Active
5	POR_WDG Status 5 Specifies the status of the functional reset sequence process, FUNC5, when POR_WDG overflows.

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Field	Function
POR_WDG_STAT5	0b - Inactive 1b - Active
4 POR_WDG_STAT4	POR_WDG Status 4 Specifies the status of the functional reset sequence process, FUNC4, when POR_WDG overflows. 0b - Inactive 1b - Active
3 POR_WDG_STAT3	POR_WDG Status 3 Specifies the status of the functional reset sequence process, FUNC3, when POR_WDG overflows. 0b - Inactive 1b - Active
2 POR_WDG_STAT2	POR_WDG Status 2 Specifies the status of the functional reset sequence process, FUNC2, when POR_WDG overflows. 0b - Inactive 1b - Active
1 POR_WDG_STAT1	POR_WDG Status 1 Specifies the status of the functional reset sequence process, FUNC1, when POR_WDG overflows. 0b - Inactive 1b - Active
0 POR_WDG_STAT0	POR_WDG Status 0 Specifies the status of the functional reset sequence process, FUNC0, when POR_WDG overflows. 0b - Inactive 1b - Active

36.2.48 Read-Only GPR On PMCPOR Reset 2 (DCMROPP2)

Offset

Register	Offset
DCMROPP2	704h

Function

Resets after PMCPOR reset 2 and captures the MC_RGM functional or external event status when POR_WDG overflows.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	POR_WDG...	POR_WDG...	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	POR_WDG...	Reserved	Reserved	Reserved	POR_WDG...
W		W1C	W1C									W1C				W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	Reserved	Reserved	POR_WDG...	Reserved	Reserved	POR_WDG...	POR_WDG...	POR_WDG...	POR_WDG...	Reserved	POR_WDG...	POR_WDG...	Reserved	Reserved	POR_WDG...
W				W1C			W1C	W1C	W1C	W1C		W1C	W1C			W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 POR_WDG_STAT62	POR_WDG Status 62 Specifies the value of MC_RGM.FES[DEBUG_FUNC] when POR_WDG overflows. 0b - 0 1b - 1
29 POR_WDG_STAT61	POR_WDG Status 61 Specifies the value of MC_RGM.FES[SW_FUNC] when POR_WDG overflows. 0b - 0 1b - 1
28 —	Reserved
27 —	Reserved
26 —	Reserved
25 —	Reserved
24	Reserved

Table continues on the next page...

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Field	Function
—	
23 —	Reserved
22 —	Reserved
21 —	Reserved
20 POR_WDG_STAT52	POR_WDG Status 52 Specifies the value of MC_RGM.FES[HSE_BOOT_RST] when POR_WDG overflows. 0b - 0 1b - 1
19 —	Reserved
18 —	Reserved
17 —	Reserved
16 POR_WDG_STAT48	POR_WDG Status 48 Specifies the value of MC_RGM.FES[HSE_SWT_RST] when POR_WDG overflows. 0b - 0 1b - 1
15 —	Reserved
14 —	Reserved
13 —	Reserved
12 POR_WDG_STAT44	POR_WDG Status 44 Specifies the value of MC_RGM.FES[PLL_AUX] when POR_WDG overflows.

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Field	Function
	0b - 0 1b - 1
11 —	Reserved
10 —	Reserved
9 POR_WDG_STAT41	POR_WDG Status 41 Specifies the value of MC_RGM.FES[JTAG_RST] when POR_WDG overflows. 0b - 0 1b - 1
8 POR_WDG_STAT40	POR_WDG Status 40 Specifies the value of MC_RGM.FES[Reserved] when POR_WDG overflows. 0b - 0 1b - 1
7 POR_WDG_STAT39	POR_WDG Status 39 Specifies the value of MC_RGM.FES[SWT1_RST] when POR_WDG overflows. 0b - 0 1b - 1
6 POR_WDG_STAT38	POR_WDG Status 38 Specifies the value of MC_RGM.FES[SWT0_RST] when POR_WDG overflows. 0b - 0 1b - 1
5 —	Reserved
4 POR_WDG_STAT36	POR_WDG Status 36 Specifies the value of MC_RGM.FES[ST_DONE] when POR_WDG overflows. 0b - 0 1b - 1
3 POR_WDG_STAT35	POR_WDG Status 35 Specifies the value of MC_RGM.FES[FCCU_RST] when POR_WDG overflows.

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Field	Function
	0b - 0 1b - 1
2 —	Reserved
1 —	Reserved
0 POR_WDG_STAT32	POR_WDG Status 32 Specifies the value of MC_RGM.FES[F_EXR] when POR_WDG overflows. 0b - 0 1b - 1

36.2.49 Read-Only GPR On PMCPOR Reset 3 (DCMROPP3)

Offset

Register	Offset
DCMROPP3	708h

Function

Resets after PMCPOR reset 3 and captures the MC_RGM destructive event status when POR_WDG overflows.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	POR_WDG...	POR_WDG...	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	POR_WDG...	POR_WDG...	POR_WDG...
W		W1C	W1C											W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	POR_WDG...	POR_WDG...	Reserved	POR_WDG...	Reserved	POR_WDG...	POR_WDG...	POR_WDG...	Reserved	POR_WDG...	Reserved	POR_WDG...	POR_WDG...	Reserved	Reserved	POR_WDG...
W	W1C	W1C		W1C		W1C	W1C	W1C		W1C		W1C	W1C			W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 POR_WDG_STAT94	POR_WDG Status 94 Specifies the value of MC_RGM.DES[DEBUG_DEST] when POR_WDG overflows. 0b - 0 1b - 1
29 POR_WDG_STAT93	POR_WDG Status 93 Specifies the value of MC_RGM.DES[SW_DEST] when POR_WDG overflows. 0b - 0 1b - 1
28 —	Reserved
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 —	Reserved
22 —	Reserved
21 —	Reserved
20 —	Reserved
19	Reserved

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Field	Function
—	
18 POR_WDG_STAT82	POR_WDG Status 82 Specifies the value of MC_RGM.DES[HSE_SNVS_RST] when POR_WDG overflows. 0b - 0 1b - 1
17 POR_WDG_STAT81	POR_WDG Status 81 Specifies the value of MC_RGM.DES[HSE_TMPR_RST] when POR_WDG overflows. 0b - 0 1b - 1
16 POR_WDG_STAT80	POR_WDG Status 80 Specifies the value of MC_RGM.DES[CM7_CORE_CLK_FAIL] when POR_WDG overflows. 0b - 0 1b - 1
15 POR_WDG_STAT79	POR_WDG Status 79 Specifies the value of MC_RGM.DES[SYS_DIV_FAIL] when POR_WDG overflows. 0b - 0 1b - 1
14 POR_WDG_STAT78	POR_WDG Status 78 Specifies the value of MC_RGM.DES[HSE_CLK_FAIL] when POR_WDG overflows. 0b - 0 1b - 1
13 —	Reserved
12 POR_WDG_STAT76	POR_WDG Status 76 Specifies the value of MC_RGM.DES[AIPS_PLAT_CLK_FAIL] when POR_WDG overflows. 0b - 0 1b - 1
11 —	Reserved
10	POR_WDG Status 74 Specifies the value of MC_RGM.DES[CORE_CLK_FAIL] when POR_WDG overflows.

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Field	Function
POR_WDG_STAT74	0b - 0 1b - 1
9 POR_WDG_STAT73	POR_WDG Status 73 Specifies the value of MC_RGM.DES[PLL_LOL] when POR_WDG overflows. 0b - 0 1b - 1
8 POR_WDG_STAT72	POR_WDG Status 72 Specifies the value of MC_RGM.DES[SWT2_RST] when POR_WDG overflows. 0b - 0 1b - 1
7 —	Reserved
6 POR_WDG_STAT70	POR_WDG Status 70 Specifies the value of MC_RGM.DES[MC_RGM_FRE] when POR_WDG overflows. 0b - 0 1b - 1
5 —	Reserved
4 POR_WDG_STAT68	POR_WDG Status 68 Specifies the value of MC_RGM.DES[STCU_URF] when POR_WDG overflows. 0b - 0 1b - 1
3 POR_WDG_STAT67	POR_WDG Status 67 Specifies the value of MC_RGM.DES[FCCU_FTR] when POR_WDG overflows. 0b - 0 1b - 1
2 —	Reserved
1 —	Reserved

Table continues on the next page...

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Field	Function
0 POR_WDG_STAT64	POR_WDG Status 64 Specifies the value of MC_RGM.DES[F_POR] when POR_WDG overflows. 0b - 0 1b - 1

36.2.50 Read-Only GPR On PMCPOR Reset 4 (DCMROPP4)

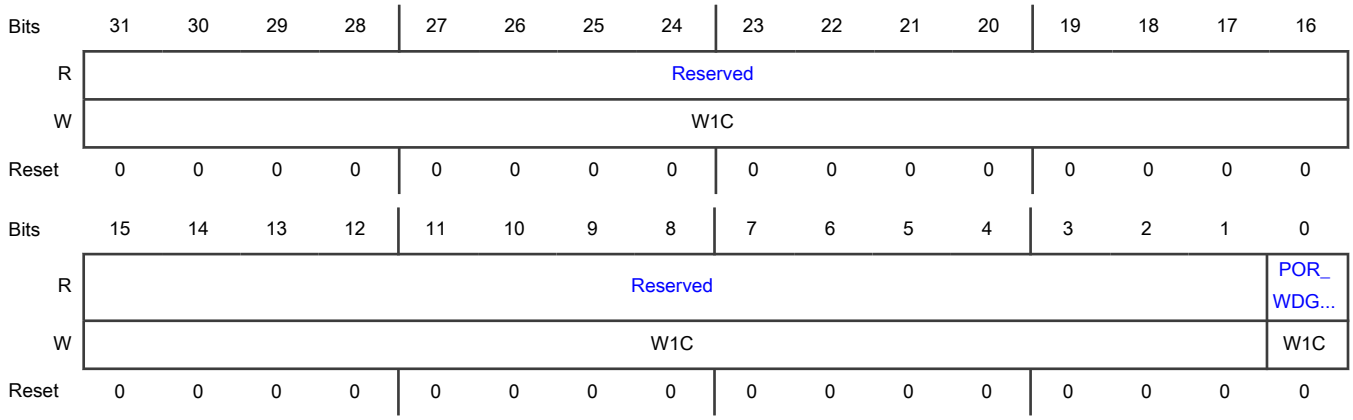
Offset

Register	Offset
DCMROPP4	70Ch

Function

Resets after PMCPOR reset 4 and captures the POR_WDG reset event if POR_WDG initiates a POR sequence.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 POR_WDG_STAT96	POR_WDG Status 96 Specifies the status of POR_WDG. If this field = 1, it indicates that a stuck scenario is detected and the chip POR event is raised. See POR_WDG_STAT[95:0] for the chip status when POR_WDG overflows.

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Field	Function
	0b - Inactive 1b - Active

Chapter 37
Device Configuration Module (DCM)

37.1 Overview

37.1.1 Block diagram

This figure is a block representation of DCM

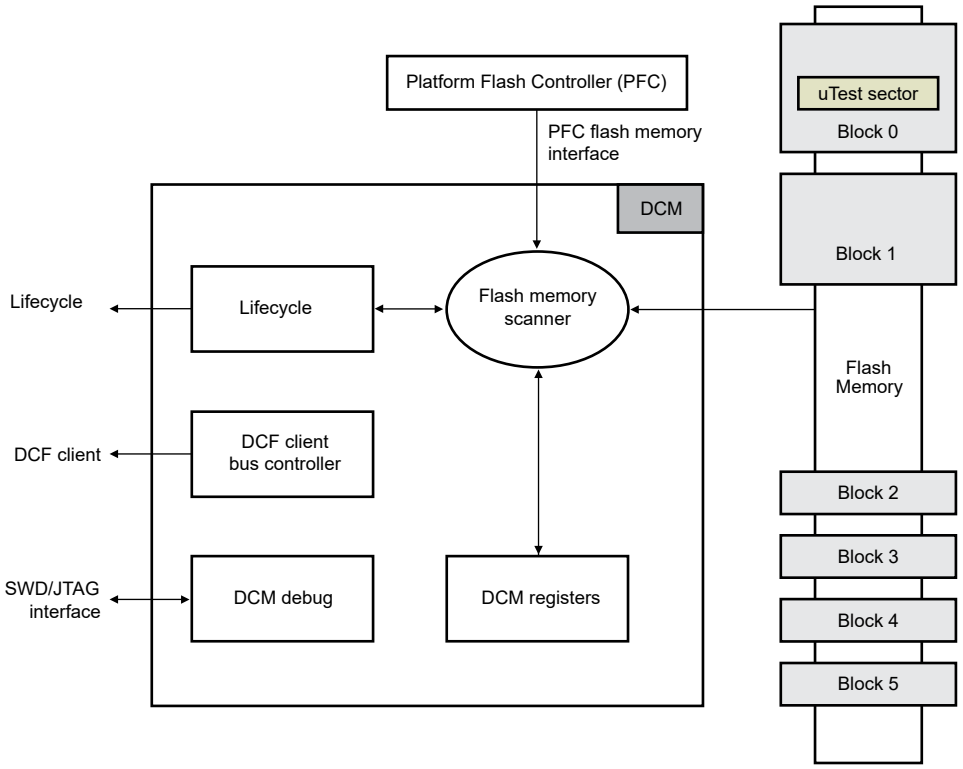


Figure 147. DCM block diagram

DCM controls:

- LC
- DCF client population
- Debug authorization (Export Control mode)

The module also establishes a RoT for the chip by parsing the master root key and other security records.

37.1.2 Features

- Scans flash memory and configures the system for:
  - LC detection
  - DCF records configuration using flash memory
- Provides a valid boot address detection

- Enables the DCF client to be writable via the IPS bus
- Parametrizes control to mask a set of DCF client chip select
- Supports temporary advancement of the LC
- Manages debug features for flash memory content and the chip like debug enable control and debug authorization.

37.2 Functional description

DCM provides information about the current state and configuration of the system that you could use to:

- Configure the application software.
- Debug the system.

37.2.1 Modes of operation

DCM operates identically in all system modes of operation.

37.2.2 DCF mechanism

The DCF mechanism handles chip parameter settings via the OTP flash memory.

You can store a series of DCF records in UTEST flash memory, and each record is 64 bits in length. The chip processes these records during the system reset sequence before the CPU leaves reset.

37.2.3 DCF error recording

DCF errors are recorded in DCM for both types of clients—spread spectrum safe and normal. See DCF client error mechanism for details on spread spectrum safe clients.

37.2.4 DCF client error mechanism

The DCM consists of DCMMISC[DCMCERS] for detecting faulty DCF records. The DCMSRRn registers capture the details up to 16 faulty records. The DCMCERS bit can be cleared by writing 1 to it.

While scanning the flash, in case if a faulty record is encountered, the DCMMISC[DCMCERS] gets set indicating that there is atleast one faulty record. In such a case, the user can identify the details about the faulty record in the DCMSRRn registers and should update the flash memory with a new record, provided the record is not write-once.

For example, in the image below, if the faulty DCF record is DCF2, then the correct DCF record must also be DCF2. Even in case if the faulty record is updated, the DCM stores the faulty record via the DCMMISC[DCMCERS] and DCMSRRn registers.

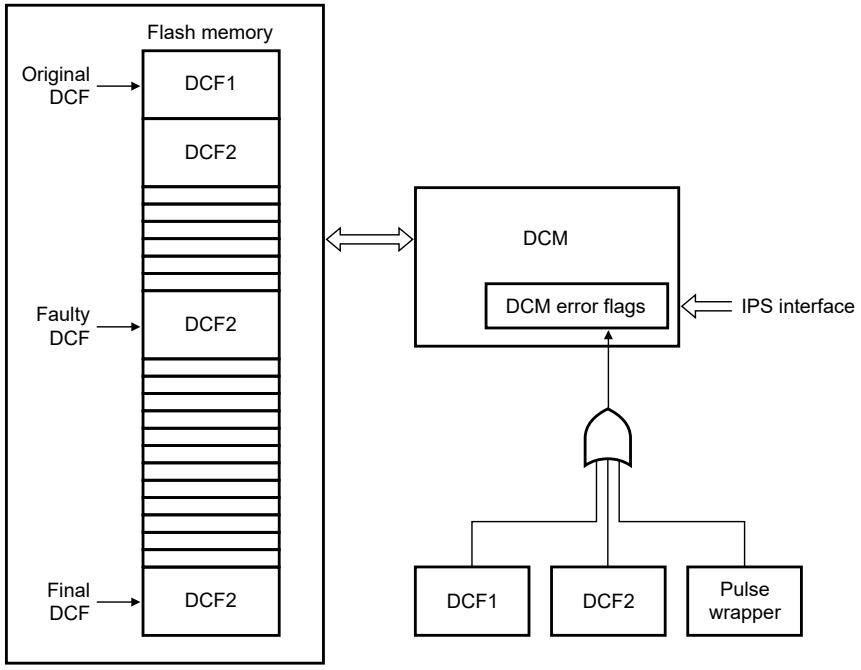


Figure 148. DCF error and DCMCERS handling

37.2.5 DCF error detection mechanism

This figure shows that a faulty DCF record is loaded between the original and final DCF record sets.

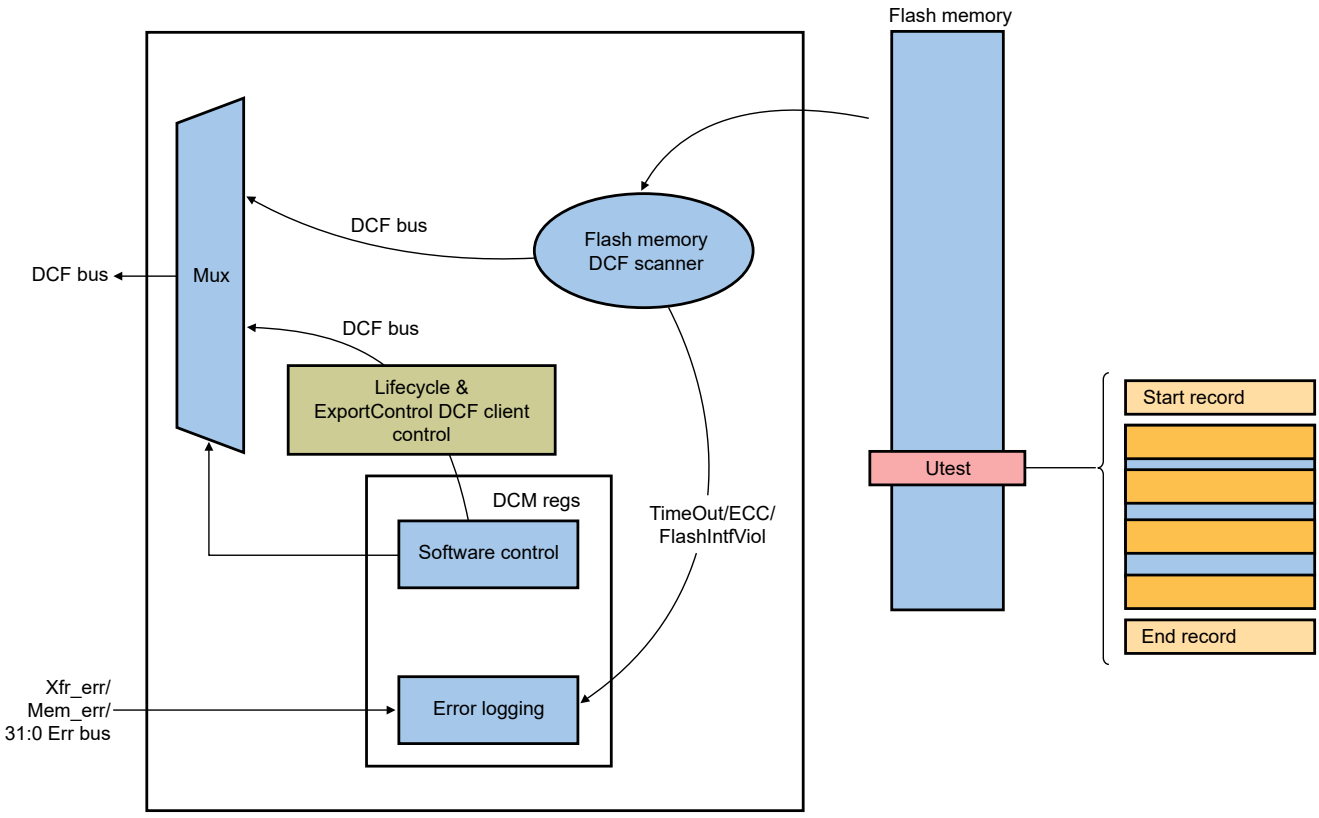


Figure 149. DCF error detection mechanism

37.2.6 LC

DCM determines the LC of the chip by reading the LC slots from the Utest flash memory. This read operation is performed during the reset phase, with normal timings. The operating monitors and an ECC check protect the operation. Additionally, a set of sanity checks executed over the LC read data guarantee the integrity of the final LC value.

At the end of the reset phase, the LC contains one of the following values:

- OEM production (OEM_PROD)
- In field (IN_FIELD)
- Pre-FA
- FA

The DCM LC progresses in the direction shown in this figure:

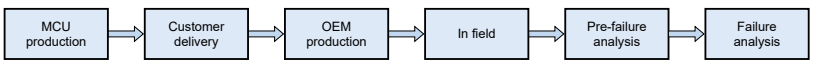


Figure 150. LC sequence

The LC is written into six slots, 128 bits each, and at fixed locations in the Utest flash memory block. Each LC slot is read in a single atomic operation and is organized in two types of fields:

- Valid (lower 64b of LC slot)
- Invalid (higher 64b of LC slot)

Depending on the possible combinations of data programmed into these fields, each LC slot indicates one of the four possible statuses as shown in Table 182. To know more about LC slots, see Table 183.

Table 182. LC slot status

LC slots		LC slot value
Valid field (64 bits)	Invalid field (64 bits)	
Erased	Erased	Erased
Marked	Erased	Active
Marked	Marked	Inactive
Other values		Illegal

In this case, "Marked" refers to a value that is configured based on the bit pattern 55AA_50AF_55AA_50AFh, and "Erased" is detected using the bit pattern FFFF_FFFF_FFFF_FFFFh.

Table 183. LC slots

LC slot 2 OEM_PROD	LC slot 3 IN_FIELD	LC slot 4 Pre-FA	LC slot 5 FA	Resulting LC
Active	Erased	Erased	Erased	OEM_PROD
Inactive	Active	Erased	Erased	IN_FIELD
Inactive	Inactive	Active	Erased	PFA
Inactive	Inactive	Inactive	Active	FA
Erased	Erased	Erased	Erased	System reset
Illegal	Illegal	Erased	Erased	IN_FIELD

NOTE

When triggering DCM for rescanning the software, you must ensure that the flash memory program and erase fields are not set. Otherwise, DCM does not configure the chip and ignores all data returned from the UTEST flash memory. This results in LC becoming IN_FIELD. All DCF clients indicate their default values in this case.

37.3 DCM register descriptions

37.3.1 DCM memory map

DCM base address: 402A_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	DCM Status (DCMSTAT)	32	R	0000_0371h
4h	LC and LC Control (DCMLCC)	32	RW	See section
8h	LC Scan Status (DCMLCS)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
1Ch	DCM Miscellaneous (DCMMISC)	32	RW	0000_0001h
20h	Debug Status and Configuration (DCMDEB)	32	RW	0000_0000h
2Ch	DCF Error Count (DCMEC)	32	R	0000_0000h
30h	DCF Scan Report (DCMSRR1)	32	RW	0000_0000h
34h	DCF Scan Report (DCMSRR2)	32	RW	0000_0000h
38h	DCF Scan Report (DCMSRR3)	32	RW	0000_0000h
3Ch	DCF Scan Report (DCMSRR4)	32	RW	0000_0000h
40h	DCF Scan Report (DCMSRR5)	32	RW	0000_0000h
44h	DCF Scan Report (DCMSRR6)	32	RW	0000_0000h
48h	DCF Scan Report (DCMSRR7)	32	RW	0000_0000h
4Ch	DCF Scan Report (DCMSRR8)	32	RW	0000_0000h
50h	DCF Scan Report (DCMSRR9)	32	RW	0000_0000h
54h	DCF Scan Report (DCMSRR10)	32	RW	0000_0000h
58h	DCF Scan Report (DCMSRR11)	32	RW	0000_0000h
5Ch	DCF Scan Report (DCMSRR12)	32	RW	0000_0000h
60h	DCF Scan Report (DCMSRR13)	32	RW	0000_0000h
64h	DCF Scan Report (DCMSRR14)	32	RW	0000_0000h
68h	DCF Scan Report (DCMSRR15)	32	RW	0000_0000h
6Ch	DCF Scan Report (DCMSRR16)	32	RW	0000_0000h
80h	LC Scan Status 2 (DCMLCS_2)	32	RW	0000_0000h

37.3.2 DCM Status (DCMSTAT)

Offset

Register	Offset
DCMSTAT	0h

Function

Indicates the status of DCM at different stages.

NOTE

This register resets on functional reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0													0		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				0	DCMDBGPS	0	DCMUTS	0			DCMLCST	0		DCMERR	DCMDONE
W																
Reset	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	1

Fields

Field	Function
31-19 —	Reserved
18-16 —	Reserved
15-12 —	Reserved
11 —	Reserved
10 DCMDBGPS	Debug Password Scanning Status Indicates the DCM debug password scanning status. 0b - Completed with errors 1b - Completed successfully
9 —	Reserved
8 DCMUTS	DCM Utest DCF Scanning Status (valid only if DCMDONE bit is set) **NOTE** This bit always returns 0 in In Field LC. 0b - Completed with errors. 1b - Completed successfully.
7-5	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
4 DCMLCST	LC Scanning Status (valid only if DCMDONE bit is set) Indicates the DCM LC scanning status. **NOTE** This bit always returns 0 in INFIELD lifecycle. 0b - Completed with errors 1b - Completed successfully
3-2 —	Reserved
1 DCMERR	DCM Completion of Flash Scan with Error Status (valid only if DCMDONE bit is set) 0b - Completed with success. 1b - Completed with error.
0 DCMDONE	DCM Flash Scanning Status Indicates whether the DCM scanning is in progress or complete. 0b - Running 1b - Completed

37.3.3 LC and LC Control (DCMLCC)

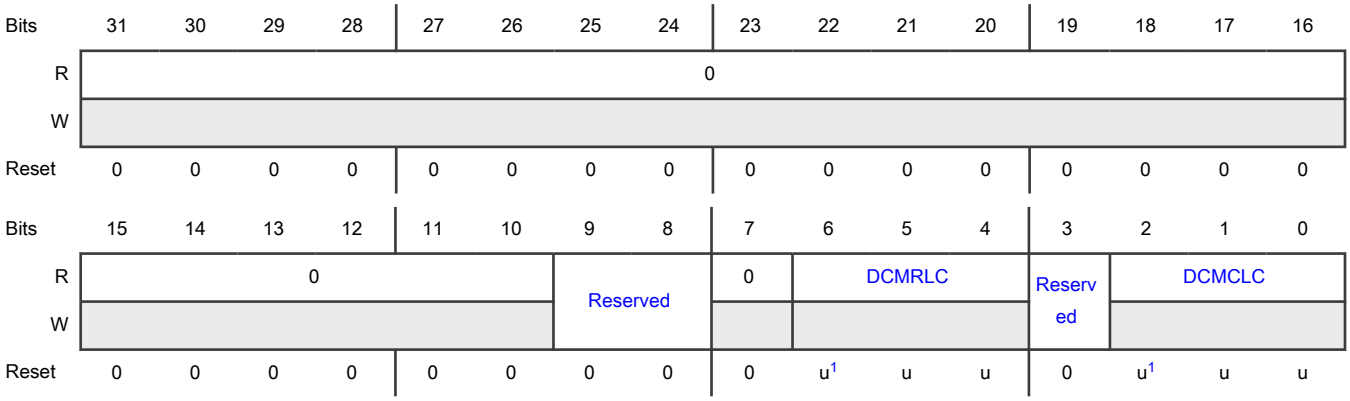
Offset

Register	Offset
DCMLCC	4h

Function

Resets on the functional reset besides the DCMLCFN and DCMFLC fileds which are reset only on destructive reset.

Diagram



1. Post reset, the reset value of this register is 0000_0077h, and after scanning, it changes according to the programmed value.

Fields

Field	Function
31-10 —	Reserved
9-8 —	Reserved
7 —	Reserved
6-4 DCMRLC	Real LC Projects the real LC of the chip. The LC can move in this sequence: (010 : OEM_PROD) > (111 : IN_FIELD) > (001 : Pre-FA) > (000 : FA) 000b - FA 001b - Pre-FA 010b - OEM_PROD 100b - Reserved 101b - Reserved 111b - IN_FIELD
3 —	Reserved
2-0 DCMCLC	Current LC Projects the current LC of the chip. The LC can move in this sequence: (010 : OEM_PROD) > (111 : IN_FIELD) > (001 : Pre-FA) > (000 : FA)

Table continues on the next page...

Table continued from the previous page...

Field	Function
	000b - FA 001b - Pre-FA 010b - OEM_PROD 100b - Reserved 101b - Reserved 111b - IN_FIELD

37.3.4 LC Scan Status (DCMLCS)

Offset

Register	Offset
DCMLCS	8h

Function

Stores the status of LC scanning. By default, the status of each LC is "not yet scanned."

This register:

- Resets on destructive reset.
- Always returns 0 in a valid IN_FIELD LC (in LC without an error).

This register captures the errors related to LC scanning on each of these resets: POR, destructive, and functional. If an error is captured, its status in this register is cleared by writing 1 to the corresponding field or to any of the destructive or POR events.

All LC slot errors are captured and cleared independently.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		DCMLCFE5	DCMLCE5	DCMLCC5			DCMLCSS5	DCMLCFE4	DCMLCE4	DCMLCC4			DCMLCSS4	DCMLCFE3	DCMLCE3
W			W1C	W1C	W1C			W1C	W1C	W1C	W1C			W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCMLCC3			DCMLCSS3	Reserved											
W	W1C			W1C	W1C											
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29 DCMLCFE5	Pre-FA Flash Memory Error Check Indicates the status of the Pre-FA flash memory error check. 0b - No errors 1b - Errors exist
28 DCMLCE5	Pre-FA ECC Errors Indicates if Pre-FA is successful or has ECC errors. 0b - No errors 1b - Error
27-25 DCMLCC5	Pre-FA Marking Status Indicates the Pre-FA marking status. These errors may cause this field to indicate the "not scanned yet" status: • If the reading completes too early and DCM has not yet scanned the LC. • If there is an error in the flash memory after completion of the reading. 000b - Not scanned yet 001b - Marked as active 010b - Marked as inactive 011b - Region is erased/virgin 101b - Marked as inactive by an unknown pattern 110b - Scanning timed out
24 DCMLCSS5	Pre-FA Scan Status Indicates the status of the Pre-FA scan. 0b - No errors 1b - Errors exist
23 DCMLCFE4	IN_FIELD Flash Memory Error Check Indicates the status of IN_FIELD flash memory error check. 0b - No errors 1b - Errors exist
22 DCMLCE4	IN_FIELD ECC Errors Indicates if IN_FIELD has ECC errors.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No errors 1b - Errors exist
21-19 DCMLCC4	IN_FIELD Marking Status Indicates the IN_FIELD marking status. These errors may cause this field to indicate the "not scanned yet" status: • If the reading completes too early and DCM has not yet scanned the LC. • If there is an error in the flash memory after completion of the reading. 000b - Not scanned yet 001b - Marked as active 010b - Marked as inactive 011b - Region is erased/virgin 101b - Marked as inactive by an unknown pattern 110b - Scanning timed out
18 DCMLCSS4	IN_FIELD Scan Status Indicates the status of the IN_FIELD scan. 0b - No errors 1b - Errors exist
17 DCMLCFE3	OEM_PROD Flash Memory Error Check Indicates the status of the OEM_PROD flash memory error check. 0b - No errors 1b - Errors exist
16 DCMLCE3	OEM_PROD ECC Errors Indicates if OEM_PROD has ECC errors. 0b - No errors 1b - Errors exist
15-13 DCMLCC3	OEM_PROD Marking Indicates the OEM_PROD marking status. These errors may cause this field to indicate the "not scanned yet" status: • If the reading completes too early and DCM has not yet scanned the LC. • If there is an error in the flash memory after completion of the reading. 000b - Not scanned yet

Table continues on the next page...

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Field	Function
	001b - Marked as active 010b - Marked as inactive 011b - Region is erased/virgin 101b - Marked as inactive by an unknown pattern 110b - Scanning timed out
12 DCMLCSS3	OEM_PROD Scan Status Indicates the status of OEM_PROD scan. 0b - No errors 1b - Errors exist
11-0 —	Reserved

37.3.5 DCM Miscellaneous (DCMMISC)

Offset

Register	Offset
DCMMISC	1Ch

Function

Resets on destructive reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	DCMCERS	0				0							
W				W1C												
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		0		DCMDBGE	DCMDBGT	0									
W					W1C	W1C										
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29 —	Reserved
28 DCMCERS	DCF Client Errors Records the status of errors from DCF clients. 0b - No errors on any of the DCF clients 1b - Atleast one safety DCF client has an error
27-24 —	Reserved
23-14 —	Reserved
13-12 —	Reserved
11 DCMDBGE	DCM ECC error on DBG sections This bit is set if there is any ECC error during scanning of CUST_PWD, or UID. 0b - No ECC error 1b - ECC error
10 DCMDBGT	DBG Section Timeout Error Indicates if there is a DCM UTEST flash memory timeout error in DBG sections. The value of this field is 1 in case a timeout error occurs when scanning CUST_PWD, or UID. 0b - No error 1b - Error exists
9-0 —	Reserved

37.3.6 Debug Status and Configuration (DCMDEB)

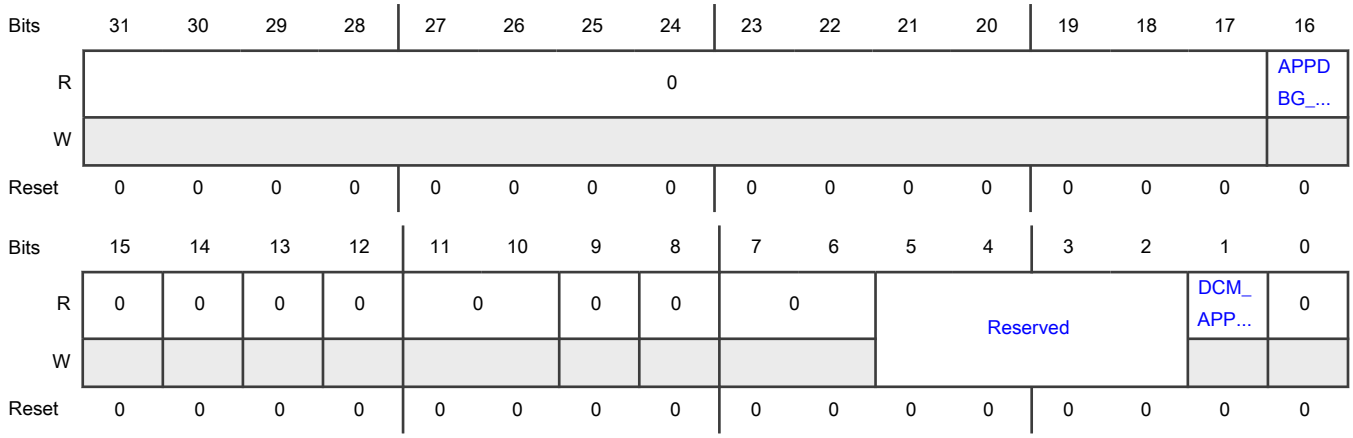
Offset

Register	Offset
DCMDEB	20h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 APPDBG_STAT_SOC	Application Debug Status Indicates the application debug status of the chip. 0b - Disabled 1b - Enabled
15 —	Reserved
14 —	Reserved
13 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
12 —	Reserved
11-10 —	Reserved
9 —	Reserved
8 —	Reserved
7-6 —	Reserved
5-2 —	Reserved
1 DCM_APPDBG_STAT	DCM Authentication Engine Status Indicates the DCM authentication engine status for the application core. **NOTE** This value of this field is 0 in Non-Export Control mode. 0b - Disabled 1b - Enabled
0 —	Reserved

37.3.7 DCF Error Count (DCMEC)

Offset

Register	Offset
DCMEC	2Ch

Function

Indicates number of faulty DCF records.

This register resets on destructive reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCMECT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-0 DCMECT	DCF Error Count Indicates number of faulty DCF records.

37.3.8 DCF Scan Report (DCMSRR1)

Offset

Register	Offset
DCMSRR1	30h

Function

Resets on destructive reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		DCMDCFT1	DCMESD1	DCMESF1	DCMDCFF1			0				DCMDCFE1			
W			W1C	W1C	W1C	W1C							W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DCMDCFE1															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT1	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD1	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF1	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF1	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE1	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

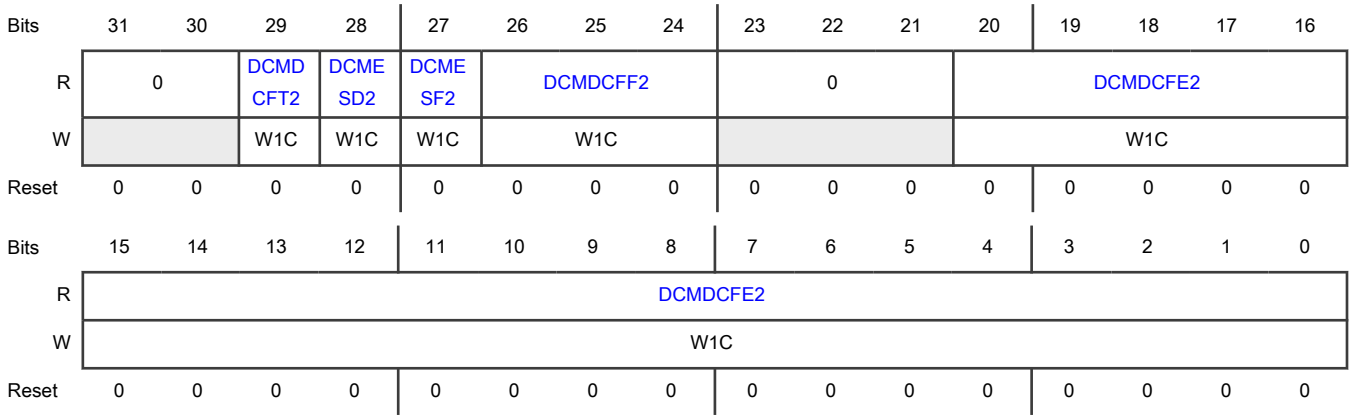
37.3.9 DCF Scan Report (DCMSRR2)

Offset

Register	Offset
DCMSRR2	34h

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT2	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD2	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF2	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF2	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE2	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.10 DCF Scan Report (DCMSRR3)

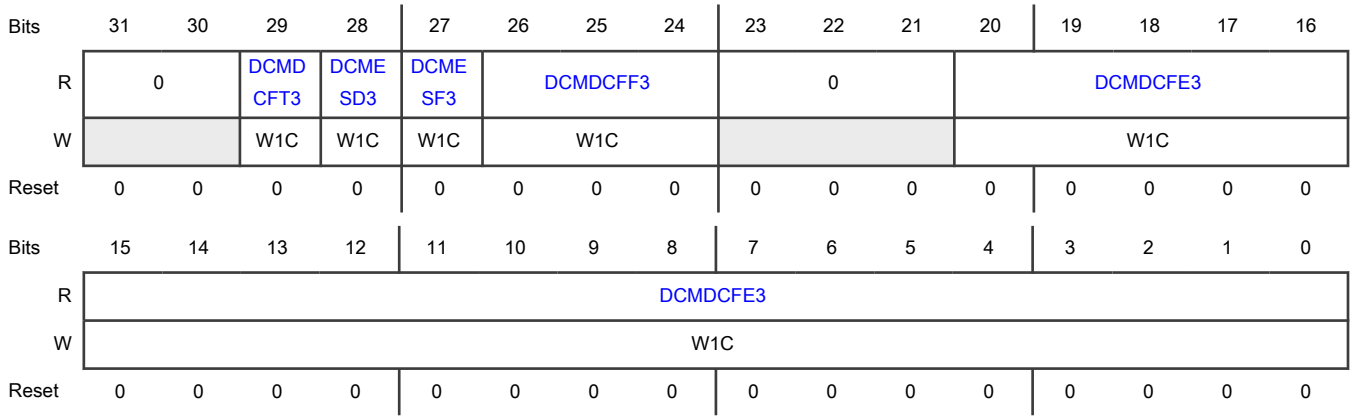
Offset

Register	Offset
DCMSRR3	38h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT3	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD3	Chip Side Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF3	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF3	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE3	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

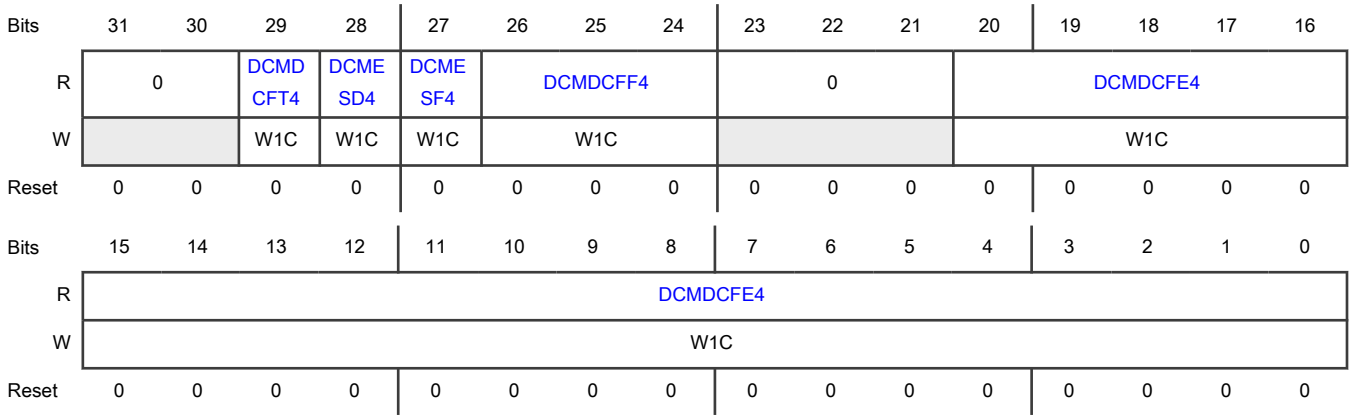
37.3.11 DCF Scan Report (DCMSRR4)

Offset

Register	Offset
DCMSRR4	3Ch

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT4	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD4	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF4	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF4	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE4	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.12 DCF Scan Report (DCMSRR5)

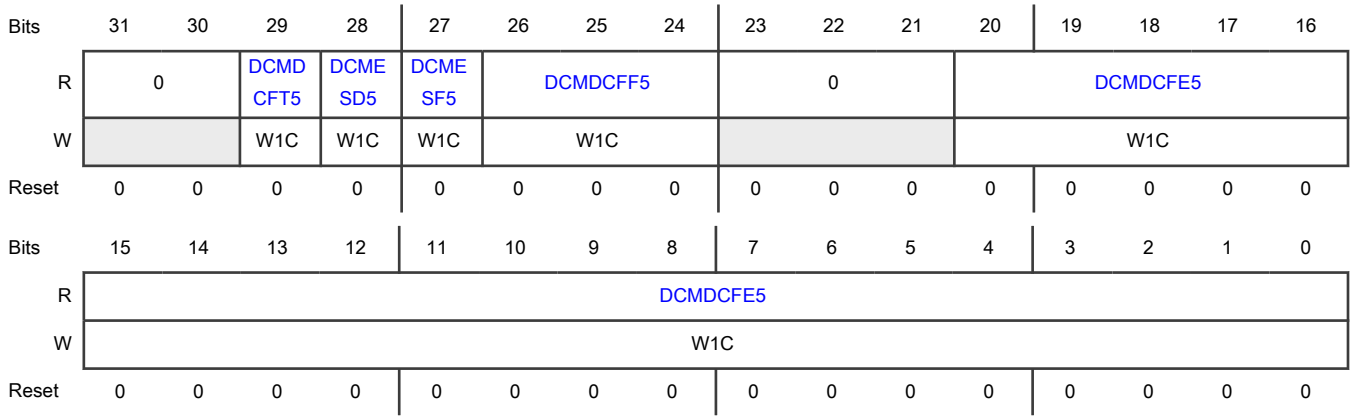
Offset

Register	Offset
DCMSRR5	40h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT5	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD5	Chip Side Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF5	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF5	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE5	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

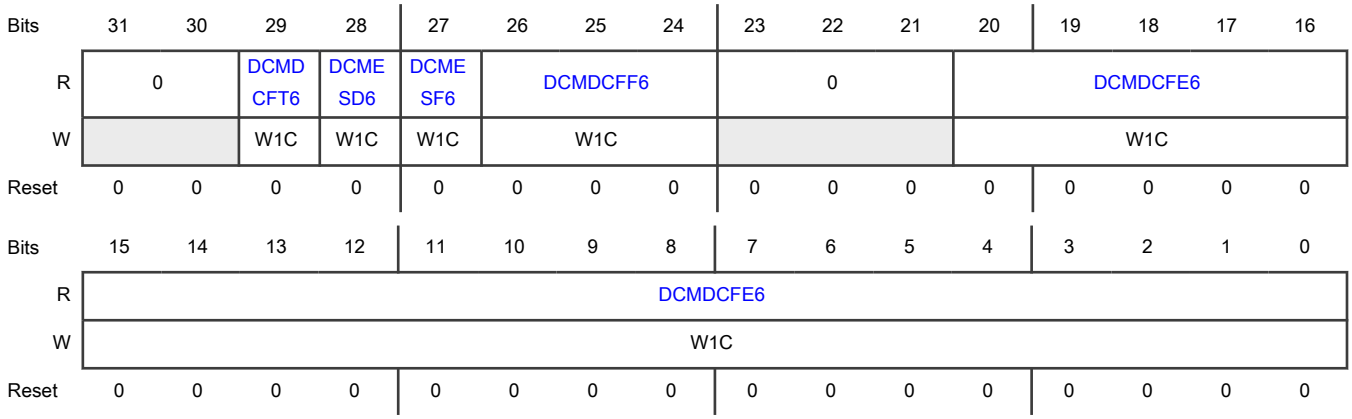
37.3.13 DCF Scan Report (DCMSRR6)

Offset

Register	Offset
DCMSRR6	44h

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT6	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD6	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF6	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF6	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE6	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.14 DCF Scan Report (DCMSRR7)

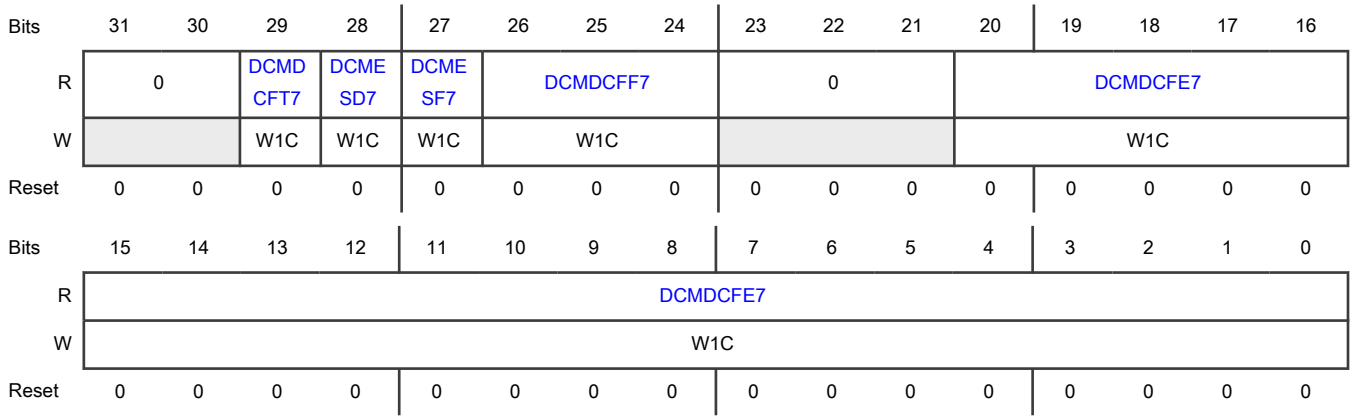
Offset

Register	Offset
DCMSRR7	48h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT7	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD7	Chip Side Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF7	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF7	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE7	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

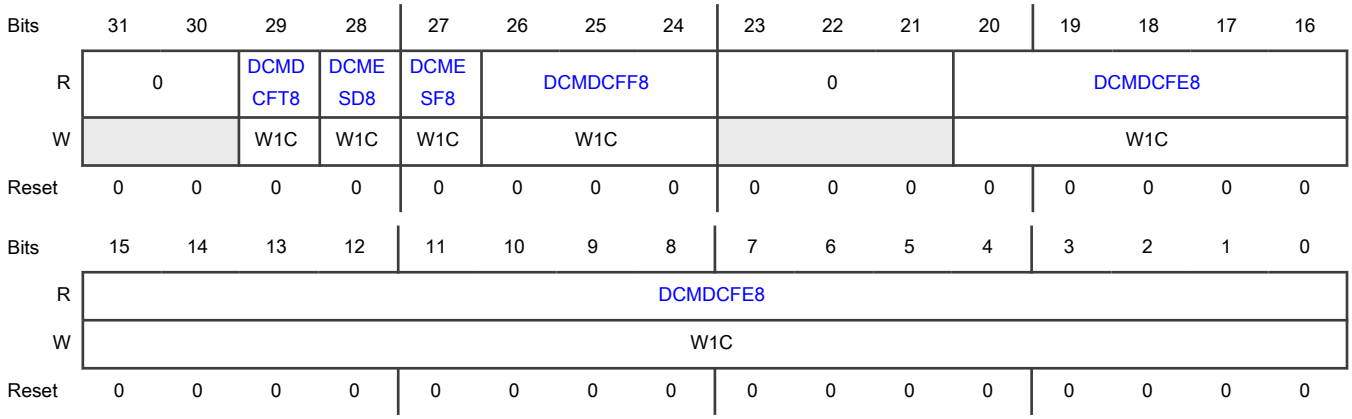
37.3.15 DCF Scan Report (DCMSRR8)

Offset

Register	Offset
DCMSRR8	4Ch

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT8	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD8	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF8	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF8	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE8	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.16 DCF Scan Report (DCMSRR9)

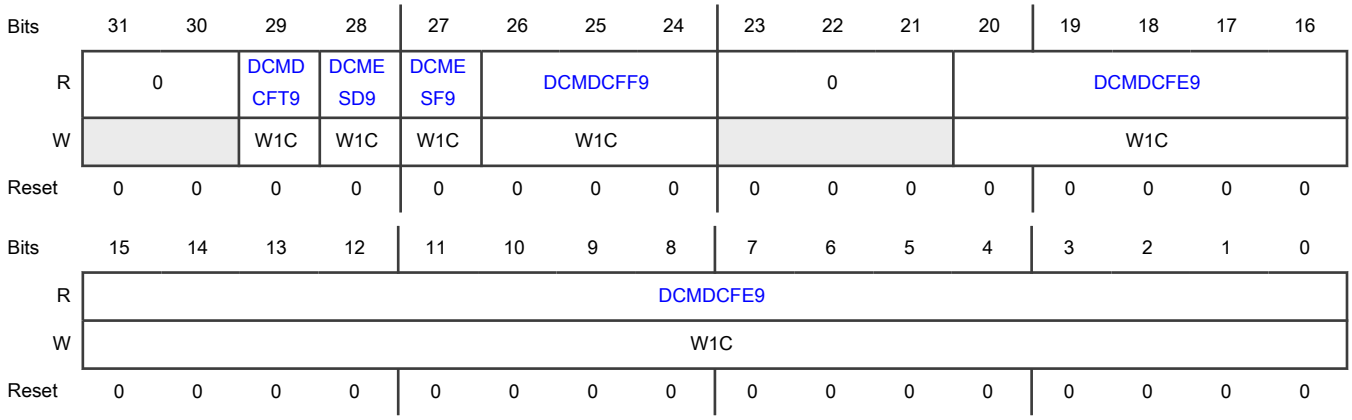
Offset

Register	Offset
DCMSRR9	50h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT9	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD9	Chip Side Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF9	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF9	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE9	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

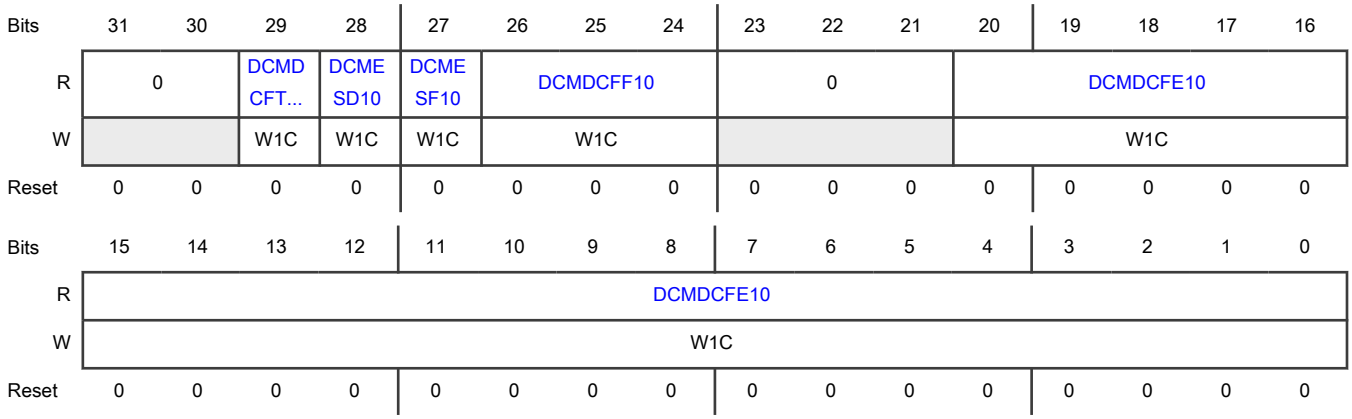
37.3.17 DCF Scan Report (DCMSRR10)

Offset

Register	Offset
DCMSRR10	54h

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT10	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD10	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF10	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF10	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE10	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.18 DCF Scan Report (DCMSRR11)

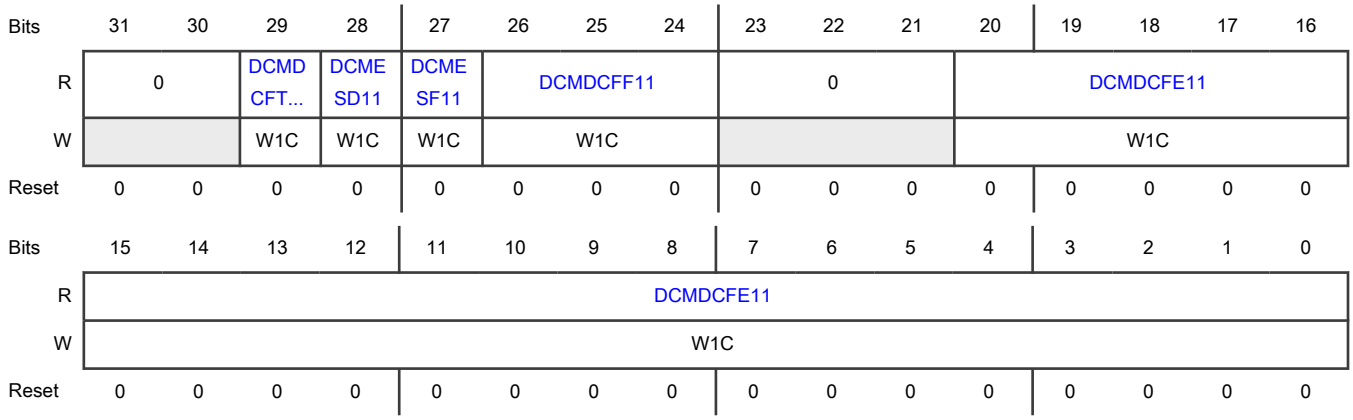
Offset

Register	Offset
DCMSRR11	58h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT11	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD11	Chip Side Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF11	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF11	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE11	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

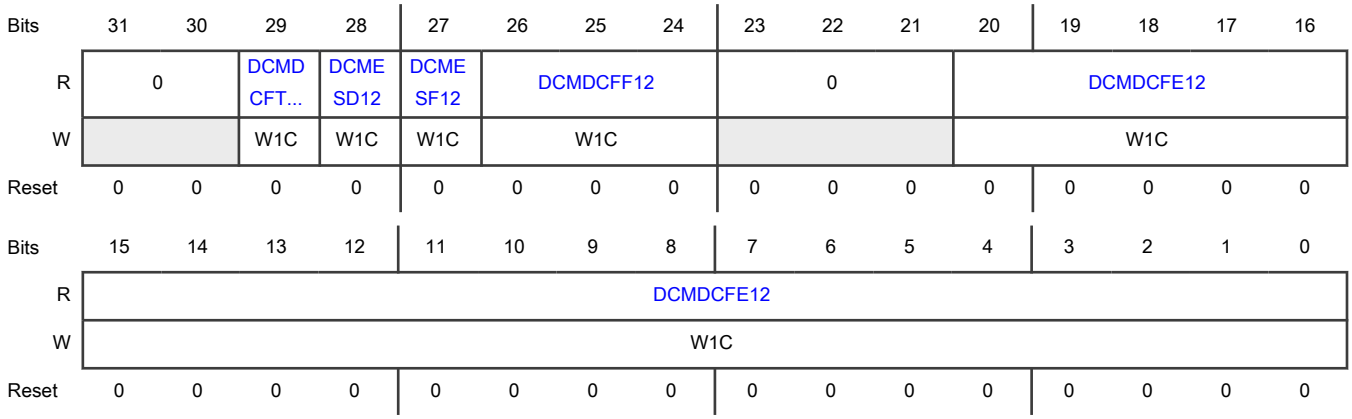
37.3.19 DCF Scan Report (DCMSRR12)

Offset

Register	Offset
DCMSRR12	5Ch

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT12	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD12	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF12	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF12	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE12	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.20 DCF Scan Report (DCMSRR13)

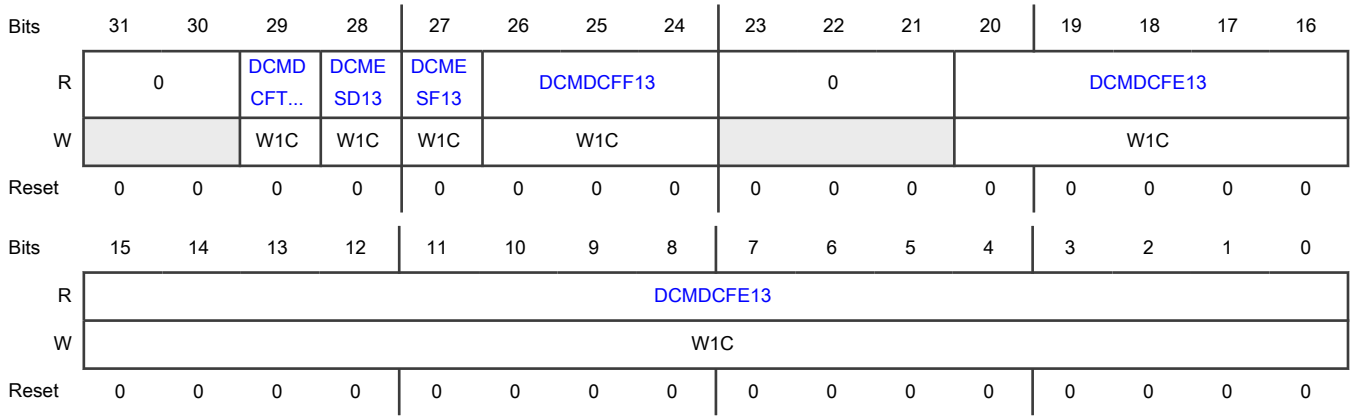
Offset

Register	Offset
DCMSRR13	60h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT13	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD13	Chip Side Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF13	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF13	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE13	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

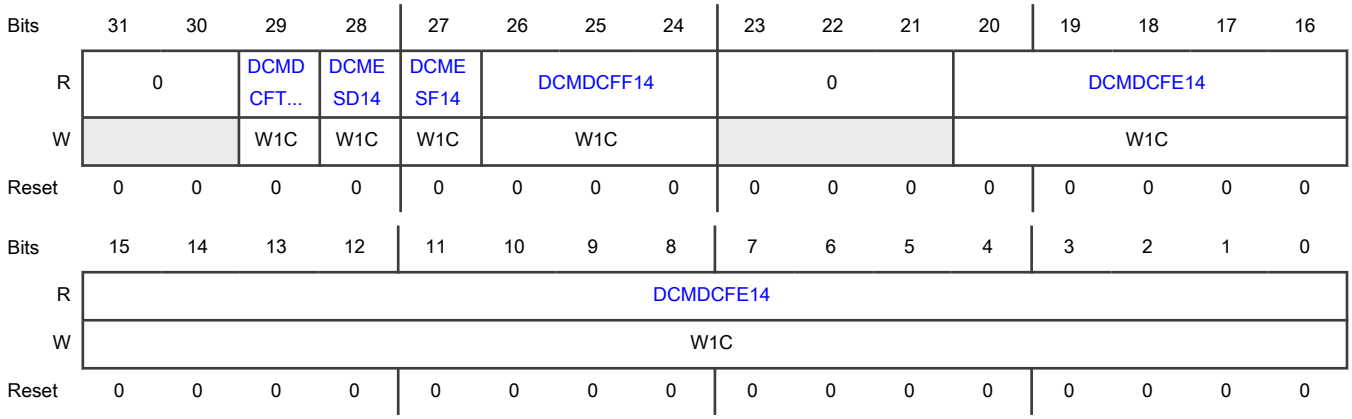
37.3.21 DCF Scan Report (DCMSRR14)

Offset

Register	Offset
DCMSRR14	64h

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT14	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD14	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF14	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF14	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE14	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.22 DCF Scan Report (DCMSRR15)

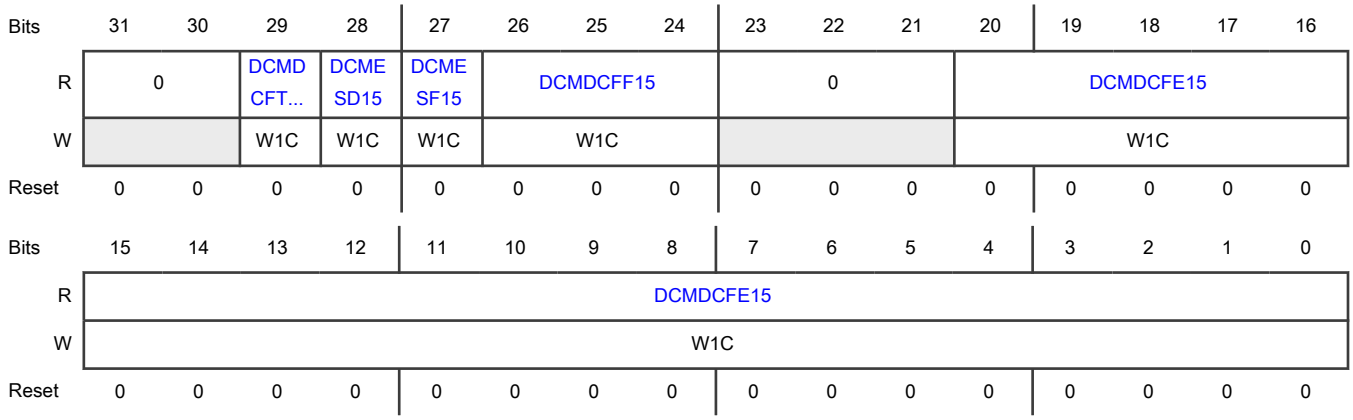
Offset

Register	Offset
DCMSRR15	68h

Function

Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT15	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD15	Chip Side Error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF15	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF15	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved
20-0 DCMDCFE15	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

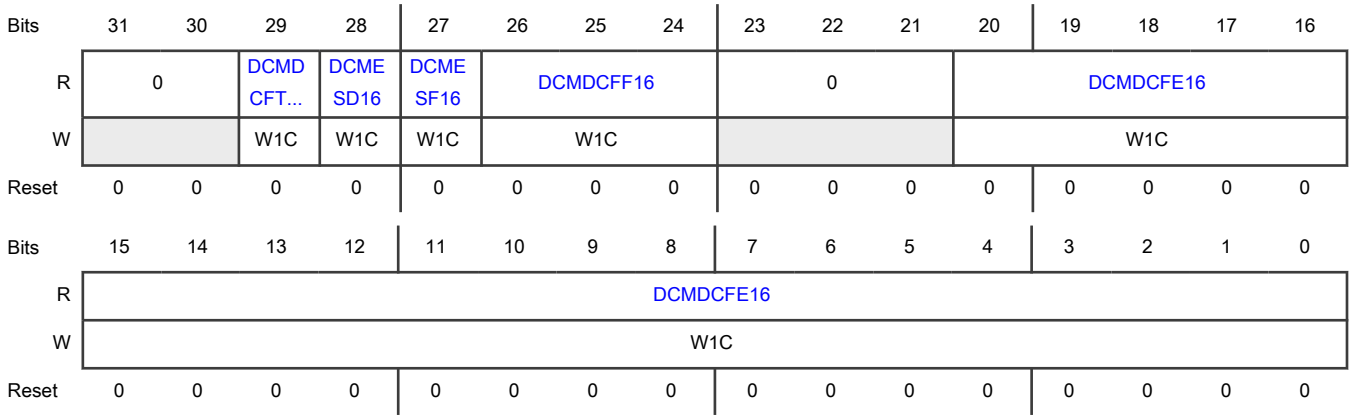
37.3.23 DCF Scan Report (DCMSRR16)

Offset

Register	Offset
DCMSRR16	6Ch

Function
Resets on destructive reset.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 DCMDCFT16	Scanning Timeout On Flash Memory Indicates if scanning timeout exists on flash memory address. 0b - Does not exist 1b - Exists
28 DCMESD16	Chip Side Error Indicates if an error exists on chip side. These errors could be parity errors or the ones reported by the DCF client, such as write-once error. 0b - No errors 1b - Errors exist
27 DCMESF16	Flash Memory Error Indicates if a UTEST flash memory ECC error exists. 0b - No errors 1b - Errors exist
26-24 DCMDCFF16	DCF Record Location Indicates the DCF record location in flash memory. 010b - Utest flash memory 101b - Others: Reserved
23-21 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
20-0 DCMDCFE16	Flash Memory Address Indicates the flash memory address of the DCF client having an error.

37.3.24 LC Scan Status 2 (DCMLCS_2)

Offset

Register	Offset
DCMLCS_2	80h

Function

Stores the status of LC scanning. By default, the status of each LC is "not yet scanned."

This register:

- Resets on destructive reset.
- Always returns 0 in a valid IN_FIELD LC (in LC without an error).

This register captures the errors related to LC scanning on each of these resets: POR, destructive, and functional. If an error is captured, its status in this register is cleared by writing 1 to the corresponding field or to any of the destructive or POR events.

All LC slot errors are captured and cleared independently.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0										DCMLCFE6	DCMLCE6	DCMLCC6			DCMLCSS6
W											W1C	W1C	W1C			W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-6 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
5 DCMLCFE6	Flash Memory Error Check Indicates the status of flash memory check. 0b - No errors 1b - Errors exist
4 DCMLCE6	FA ECC Errors Indicates if ECC errors exist in FA. 0b - No errors 1b - Errors exist
3-1 DCMLCC6	FA Marking Indicates the FA marking status. These errors may cause this field to indicate the "not scanned yet" status: • If the reading completes too early and DCM has not yet scanned the LC. • If there is an error in the flash memory after completion of the reading. 000b - Not scanned yet 001b - Marked as active 010b - Marked as inactive 011b - Region is erased/virgin 101b - Marked as inactive by an unknown pattern 110b - Scanning timed out
0 DCMLCSS6	FA Scan Status Indicates if errors exist in the FA scan. 0b - No errors 1b - Errors exist

37.4 Glossary

FA	Failure analysis
LC	Life cycle
Pre-FA	Pre-failure analysis
RoT	Root of trust
OTP	One Time Programmable
DCF	Device Configuration Format

Chapter 38
Messaging Unit (MU)

38.1 Chip-specific MU information

38.1.1 MU instances and configuration

This chip includes MUs for communication across the different cores. Each MU includes two interfaces, MUA and MUB. Two different processors control them for communication.

Table 184 indicates the MUs and their interfaces present in the device.

NOTE

The HSE_B core controls the MUA interface of MU_0 and MU_1. Therefore, the application core cannot control the interface.

Table 184. MU instances

Instance	Use case
MU_0	Communication between HSE_B and application cores
MU_1	Communication between HSE_B and application cores
MU_2	Communication between application cores

38.2 Overview

MU enables two processors on a chip to communicate and coordinate by passing messages (for example, data, status, and control) through the MU interface. MU also allows one processor to signal the other processor using interrupts.

MU must synchronize the accesses from one side to the other because MU can manage messaging between processors using different clocks. MU accomplishes synchronization using two sets of matching registers: processor A-facing and processor B-facing.

38.2.1 Block diagram

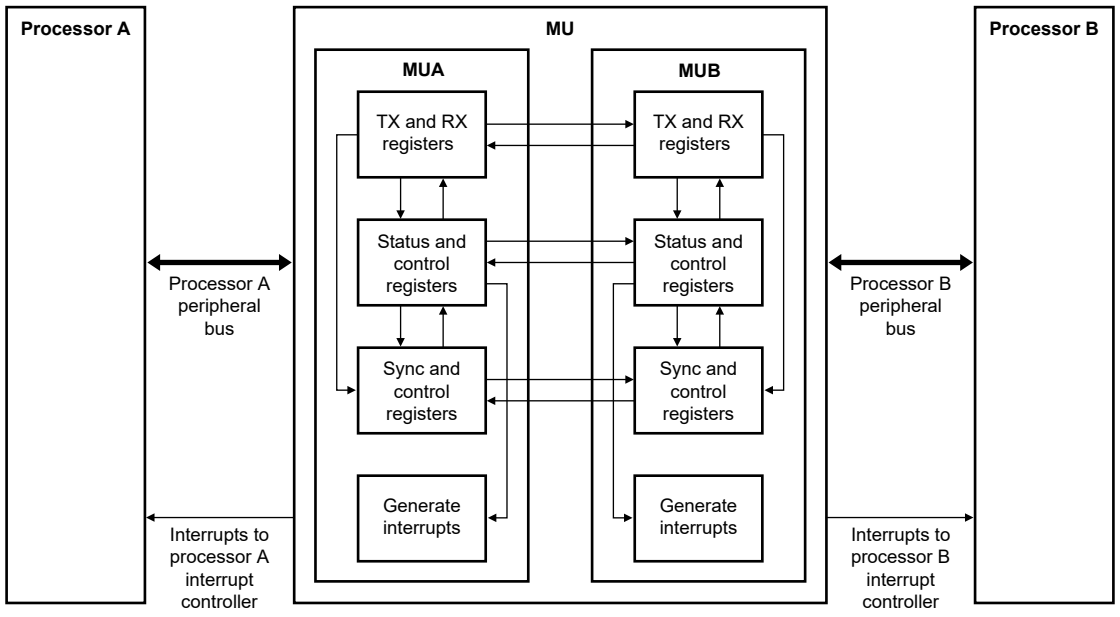


Figure 151. Block diagram

38.2.2 Features

- Memory-mapped registers (MU is connected as a peripheral under the peripheral bus on the processor A-side and processor B-side)
- Synchronized message transfers between cores
  - To send data or messages from one side to the other, MUA provides 4 transmit registers and 4 receive registers. MUB provides 4 transmit registers and 4 receive registers.
  - Transmit empty flags (TSR[TEn]) and receive full flags (RSR[RFn]) facilitate the transfer of data or messages between cores on both sides of MU.
  - A synchronization mechanism updates the transmit and the receive flags. There is an inherent latency between updating the flag on one side and reflecting its status on the other side. See Event update timing.
  - MU has a 3-bit flag data register, which you can use to send flag data between the two MU sides.
- Interprocessor interrupts
  - MU has 9 interrupt sources on each side (processor A-side, processor B-side) for signaling the other processor. You can use the interrupts for notification of receive and transmit events and for general-purpose signaling between processors. There are 1 general-purpose interrupt requests available and 8 receive and transmit interrupt sources.
- Reset (Each processor can issue a reset to MU via CR[MUR], which is a self-clearing field).

38.3 Functional description

MU enables two cores (processor A and processor B) to communicate with each other:

- By sharing messages and data.
- By enabling one core to wake the other core by using interrupts.

The messaging, control, and status registers of the two cores are mapped to processor A memory and processor B memory as a regular peripheral. The peripheral data bus is 32 bits wide inside MU.

Messaging logic is used with shared memory. Various messaging methods can implement a messaging protocol. For example, a message could mean one of the following:

- A message of *n* words has been written starting at offset *x* in the memory.
- The previous data block that was sent has been read.

The ability to keep messaging logic independent of the shared memory is not restricted to a predefined hardware protocol. The software required to manage the messaging is short and straightforward.

Most of the messaging mechanisms are symmetric. They are duplicated and are available on both the processor A side and processor B side. The messaging mechanisms are:

- 4 32-bit transmit registers, which are each reflected in 4 read-only receive registers on the side of the other processor. These registers can transfer 32-bit word messages or the frame information of the messages written to the shared memory. For example, they can transfer the number of words, initial address, and message type code.
- Writing to a transmitter-side transmit register (TR*n*) clears the Transmitter Empty flag in the transmitter-side Status register (TS*n*[TE*n*]), and sets the Receiver Full flag in the receiver-side Status register (RS*n*[RF*n*]). Setting the flag on the receiver side can trigger an interrupt on the receiver side (a maskable receive interrupt).
- Reading a receiver-side receive register (RR*n*) clears the Receiver Full flag in the receiver-side Status register (RS*n*[RF*n*]), and sets the Transmitter Empty flag in the transmitter-side Status register (TS*n*[TE*n*]). Setting the Transmitter Empty flag can trigger an interrupt on the transmitter side (a maskable transmit interrupt).
- 1 general-purpose interrupt request flags are reflected in General-purpose Status (GSR) on the receiver side.
- 3-bit flag data is transmitted from Flag Control (FCR) to Flag Status (FSR) on the side receiving the flag data. SR[FUP] sets when the flag data is transmitted and clears when the receiving side acknowledges the flag data (the flag is updated).

Writing to a transmit register signals to the receiver side that data is ready for retrieval.

Do not write to the transmit register again without verifying that the data is retrieved. The transmitter side cannot determine the exact time that the receiver attempts to retrieve the data. Before attempting to write to the transmit register again, the transmitter side must wait for the Transmitter Empty interrupt or it must poll TSR[TE*n*].

Reading a receive register signals to the transmitter side that data can be written to that register.

Do not read the receive register again without verifying that the data is written. The receiver side cannot determine the exact time that the transmitter attempts to write the data. Before attempting to read the receive register again, the receiver side must wait for the Receiver Full interrupt or it must poll RSR[RF*n*].

38.3.1 Submodules

38.3.1.1 MUA side

MUA receives its register configuration via the processor A peripheral bus. It sends or receives messages to or from MUB. Processor A can receive messages by reading MUA registers, and MUA can send interrupts to processor A when interrupts are enabled.

NOTE

Processor B should not access MUA registers. Processor C, if exist, should also not access MUA registers. TRDC might be needed to prevent such illegal access of Processor B or C to MUA registers.

38.3.1.2 MUB side

MUB receives its register configuration via the processor B peripheral bus. It sends or receives messages to or from MUA. Processor B can receive messages by reading MUB registers, and MUB can send interrupts to processor B when interrupts are enabled.

NOTE

Processor A should not access MUB registers. Processor C, if exist, should also not access MUB registers. TRDC might be needed to prevent such illegal access of Processor A or C to MUB registers.

38.3.2 Event update timing

The messaging side of each processor has a hardware mechanism to send event update requests to the other processor. An event occurs when the status register of the receiving processor must reflect any information change. The event update latency is the delay between the event being ready at one processor and the resulting update at the status register of the other processor:

- The minimum event latency is (1 clock cycle of the sending side) + (2.5 clock cycles of the receiving side). This minimum case happens when no event is pending when the new event occurs.
- The maximum event latency is (6 clock cycles of the sending side) + (6.5 clock cycles of the receiving side). The maximum case happens when the event occurs just after a previous event is sent to the other side.

The event update latency varies depending on the time at which the subsequent event is triggered.

38.3.3 Clocking

Table 185. MU clocks

Clock name	Description
Bus clock MUA	Used only for bus accesses to MUA control and configuration registers
Bus clock MUB	Used only for bus accesses to MUB control and configuration registers

38.3.4 Resets

The following sections list the reset sources included in MU. Each reset performs a different function for the MU module compared to the function it performs for the system.

38.3.4.1 Asynchronous system reset

When the asynchronous system reset on either side of MU is asserted, SR[MURS] becomes 1 until the asynchronous system reset sequence on both the MUA and MUB sides ends. Verify that SR[MURS] becomes 0 before accessing MU.

The asynchronous system reset on one side of MU resets the other side of MU. The reset forces all control and status registers to return to their default values and clears all internal states. The following table shows the exceptions to this behavior.

Table 186. Exceptions to asynchronous system reset

MUA-side exceptions	MUB-side exceptions
MUB_CR[MURIE]	MUA_CR[MURIE]
MUB_SR[MURIP]	MUA_SR[MURIP]
MUB_SR[MURS]	MUA_SR[MURS]

38.3.4.2 MU software reset

Writing 1 to CR[MUR] causes most control and status registers to return to their default values and clears all internal states.

The instruction immediately following the assertion of CR[MUR] must not write to the MU registers. The reset sequence may overwrite such a write, with the register retaining the reset value. To know the end of the reset sequence for both processors, monitor the value of SR[MURS]. After the reset sequence on both processors has ended, a write to the MU registers can be attempted.

NOTE

The process of CR[MUR] becoming 1 is delicate because it asynchronously affects the registers on the other side. CR[MUR] becoming 1 may cause unpredictable behavior if, for example, the other processor is concurrently testing an MU register field (TSR[TE*n*] in the other processor). Before writing 1 to CR[MUR], verify that the other processor is not engaged in an MU signaling activity.

38.3.5 Interrupts

MU controls interrupt requests that one processor makes to the other processor. This section describes all the interrupts that the module generates.

MU can generate these interrupt sources individually to send to the processors:

- 4 receive interrupts (asserted when the Receive Full flags are set in Receive Status (RSR) and enabled in Receive Control (RCR)) for each receive register
- 4 transmit interrupts (asserted when the Transmit Empty flags are set in Transmit Status (TSR) and enabled in Transmit Control (TCR)) for each transmit register
- 1 general-purpose interrupt (asserted when the GIP flag is set in General-Purpose Interrupt Enable (GIER) and enabled in General-Purpose Interrupt Enable (GIER))

All interrupts are maskable in the processor control registers: TCR, RCR, GIER, and CR. MU does not assume any internal priority of these interrupts. Multiple interrupts (for example, receive 0 and receive 1, or any transmit or general-purpose interrupt) can be asserted simultaneously. The interrupt controller must resolve the priority of these interrupts at the chip level.

Triggering any enabled interrupt wakes the processor from below mode before servicing the interrupt

The software (as part of the interrupt handler) must clear the general-purpose interrupt pending flag (GSR[GIP0]) to deassert the request to the interrupt controller.

When a processor writes to the general-purpose interrupt flag (GCR[GIR0]), MU synchronizes the write event to the other processor to set the general-interrupt request pending flag (GSR[GIP0]). When GSR[GIP0] is set, if the general-purpose interrupt is enabled on the receiving processor side (GIER[GIE0] is 1), the transmitting-side general-purpose interrupt is issued to the receiving processor, which clears this interrupt by writing 1 to GSR[GIP0]. The interrupt is deasserted as soon as the write to GSR[GIP0] occurs. MU synchronizes the write event of GSR[GIP0] to the other processor. The synchronized signal clears the GIR0 flag.

Before writing 1 to GCR[GIR0], verify that this field is 0, which means that a general interrupt is not pending. Generally, MU ignores writing 1 to this field while the field is already 1, but in some cases it may issue a second interrupt.

38.4 External signals

This module has no external signals.

38.5 Initialization

MU does not require initialization.

38.6 Application information

MU facilitates messages between processors. For example, MU passes:

- Short messages. Transmit registers can pass short messages from 1 to 4 words in length for processor A and from 1 to 4 words for processor B. For example, for a four-word message, only one register must have its corresponding interrupt enabled on the receiving side. The first three words of the message are written to the registers with masked interrupts. The fourth word is written to the last register, triggering an interrupt on the receiving side.
- Frame information. Transmit registers can pass frame information for long messages written to the shared system memory. Such frame information normally includes a start address and a number of words. It can include a message type code.

- Event notices and requests. MU can signal events and requests that do not include data words between processors using general-purpose interrupts. For example, one such event is acknowledging that a long message is read from the shared system memory.
- Fixed-length data. Formatted data with a fixed length can be written to predetermined locations in the shared memory. A processor can use general-purpose interrupts to signal to the other processor that the data is ready.
- Announcements. A processor can use the 3 flags to announce its current program state or other billboard messages to the other processor.

38.6.1 Messaging protocols using interrupts

The example below describes a four-word messaging sequence sent between the processor A and processor B.

The transmitting processor writes to the transmit registers sequentially. When *n* = 0, 1, and 2, the interrupts are disabled, so no interrupt goes to the processor (although interrupt conditions occur). For *n* = 3, the interrupt is enabled, and MU generates the last receive interrupt request.

1. Write sequence:
    a. The transmitting processor writes the message information sequentially to its Transmit registers 0, 1, 2.
    b. When the write to Transmit register 3 occurs, RSR[RF3] is set after synchronization. It immediately triggers the receive full 3 interrupt on the receiving processor.
2. Read sequence:
    a. The receiving processor receives the receive full 3 interrupt and starts reading the message transferred from the receive registers.
    b. After the receiving processor reads Receive register 3, MU clears RSR[RF3].

Table 187 and Figure 152 describe the messaging model, using transmit and receive registers and the interrupt messaging protocol.

Table 187. Interrupt messaging protocol (generalized)

Step	Action	Description
1	Processor A writes data.	RR*n* on processor B's side reflects a data write to TR*n* by processor A.
2	Clear the transmitter empty flag and set the receiver full flag.	The data write to TR*n*: • Clears TSR[TE*n*] on the processor A side. • Sets RSR[RF*n*] on the processor B side.
3	Generate the receive interrupt request.	Setting RSR[RF*n*] generates a receive interrupt request to processor B.
4	Processor B reads the data.	After receiving the receive interrupt request, processor B performs a data read of RR*n*.
5	Clear the receiver full flag and set the transmitter empty flag.	Reading the data from the RR*n* register: • Clears RSR[RF*n*] on the processor B side. • Sets TSR[TE*n*] on the processor A side.
6	Generate the transmit interrupt request.	Setting TSR[TE*n*] generates a transmit interrupt request to processor A.

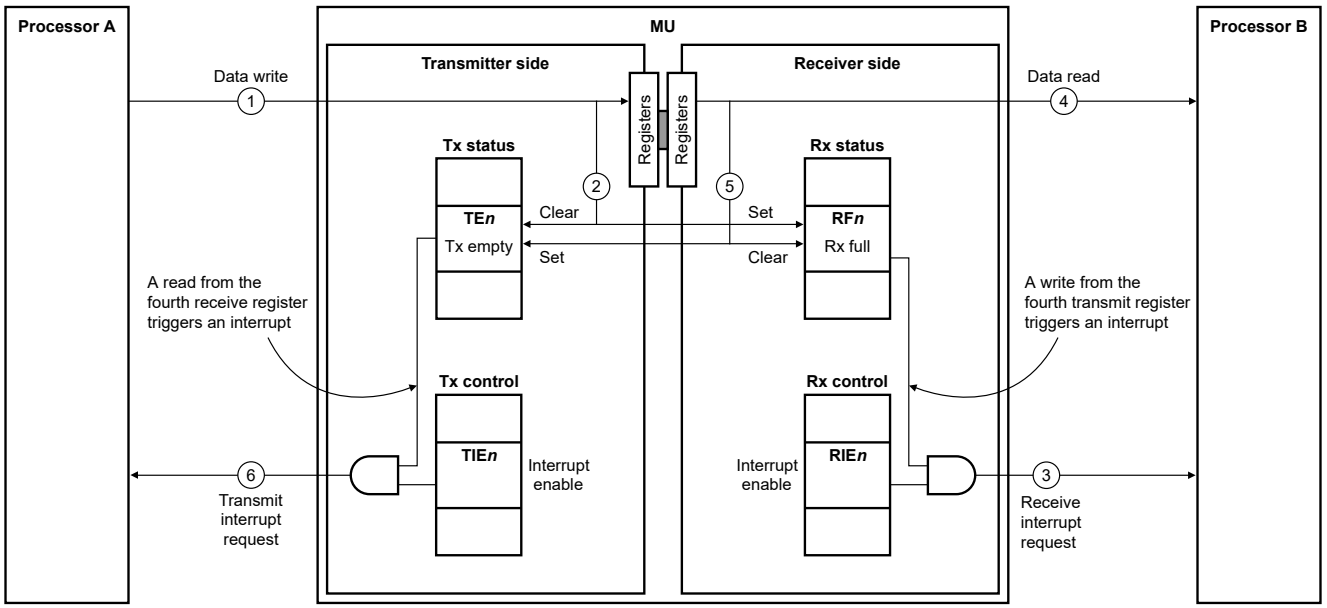


Figure 152. Messaging model using transmit and receive registers

You can use the messaging hardware to implement messaging protocols for an array of message types. MU provides full support for interrupt and polling management schemes.

38.6.2 Messaging protocols using event interrupts

MU can signal events and requests that do not include data words between processors using general-purpose interrupts.

Formatted data with a fixed length can be written to predetermined locations in the shared memory. A processor can use a general-purpose interrupt to signal to the other processor that the data is ready.

A processor can use the 3 flags to announce its current program state (or similar messages) to the other processor.

Table 188 and Figure 153 describe the event steps when the processor triggers a general-purpose interrupt.

Table 188. General-purpose interrupt messaging protocol (generalized)

Step	Action	Description
1	Processor A sets its associated general-purpose interrupt request flag.	Processor A sets GCR[GIR0].
2	The general-purpose interrupt request pending status flag is set.	GSR[GIP0] is set.
3	MU generates the general-purpose interrupt request to processor B.	Setting GSR[GIP0] generates the general-purpose interrupt request to processor B. GIER[GIE0] must be set for processor B.
4	Processor B reads the status register.	Processor B reads GSR[GIP0].
5	Processor B services the interrupt.	—

Table continues on the next page...

Table 188. General-purpose interrupt messaging protocol (generalized) (continued)

Step	Action	Description
6	Processor B sets GSR[GIP0] to clear the interrupt.	Processor B writes 1 to the corresponding GSR[GIP0] flag to clear the interrupt.
7	GCR[GIR0] is cleared.	Setting GSR[GIP0] clears GCR[GIR0] on the processor A side.

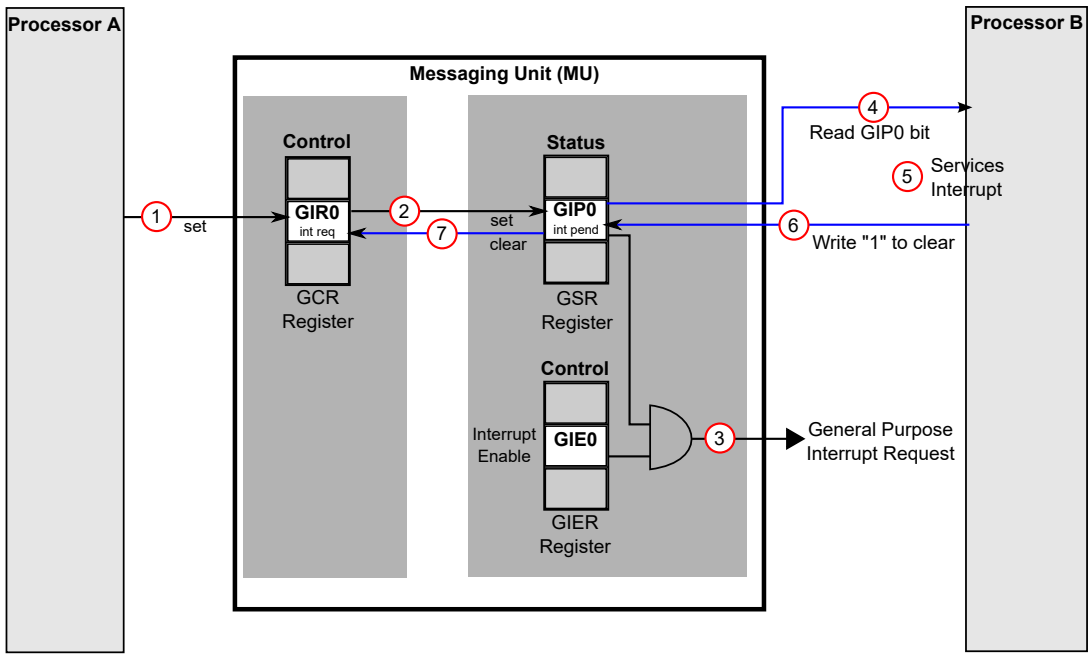


Figure 153. Messaging model using a general-purpose interrupt

38.6.3 Exclusive access to shared memory

MU can signal one processor about its current access to shared memory. This signaling prevents the other processor from overwriting data during the exclusive memory access period.

The following tables describe the signaling protocol that processor A uses to inform processor B about its current access (write) to shared memory:

- Table 189 shows processor A performing an exclusive access to shared memory.
- Table 190 shows processor B scanning for transaction information.
- Table 191 shows processor B accepting exclusive access from processor A.
- Table 192 shows processor B rejecting exclusive access from processor A.

According to the examples shown in the following tables, GCR[GIR0], RR*n*, and TR*n* are reserved to support exclusive access to the shared memory protocol.

Table 189. Processor A performs an exclusive access to shared memory

Step	Action	Description
1	Processor A sends the GIR0 request to processor B using the processor A control register.	Before processor A performs an exclusive access to the shared memory, it sends a GIR0 request to processor B.
2	Processor A sends an exclusive-access request using a transmit data register (TR*n*).	Processor A sends an exclusive-access request (command, location, and length of target access) to processor B using a selected transmit data register (TR0).
3	Processor A waits for a dedicated interrupt from processor B.	Processor A waits for a dedicated interrupt (as an acknowledgment) triggered by processor B before proceeding.
4	Processor A accesses the shared memory.	After receiving a dedicated interrupt from processor B, processor A proceeds.

Table 190. Processor B scans for transaction information

Step	Action	Description
1	Processor B receives an interrupt from a receive data register (RR*n*).	—
2	Processor B reads the receive data register (RR*n*).	—
3	Processor B scans the receive data register contents.	Processor B scans for transaction information (whether processor A has requested exclusive access).

Table 191. Processor B accepts exclusive access from processor A

Step	Action	Description
1	Processor B triggers a dedicated interrupt.	Processor B acknowledges the request from processor A by triggering a dedicated interrupt (ack) to processor A.
2	Processor B sends a code message to processor A.	With the acknowledge interrupt, processor B sends a code message to processor A through the selected transmit register (TR*n*). The message informs processor A that it can exclusively access the shared memory.

Table 192. Processor B rejects exclusive access from processor A

Step	Action	Description
1	Processor B ignores the request from processor A for exclusive access.	If processor B does not provide permission to processor A, processor B ignores the exclusive-access request.

38.6.4 Packet data transfers

The following table describes an example packet transfer sequence between processor B and processor A subsystems.

Table 193. Packet data transfer sequence

Step	Action	Description
1	Processor B requests DMA.	Processor B sends a DMA request to initiate the packet data transfer.
2	DMA data transfer	DMA acknowledges.
3		DMA starts transferring data from the specified processor B memory location to the specified shared memory.
4		DMA interrupts processor B to signal that the packet transfer has finished.
5	Processor B informs processor A that data is in shared memory.	Using a B-side transmit register, processor B sends a packet information message to processor A about the arrival of new packet data stored in shared memory. The message contains the command, location, and length of packet data.
6	Processor A receives an interrupt.	Processor A receives an interrupt (assuming its corresponding processor A MU-side receive interrupt is enabled). The pending processing task becomes active and processes packet data from memory.
7	Processor A reads data, then writes data.	Processor A reads or processes packet data from shared memory.
8		Processor A writes the result from packet processing to a separate buffer.
9	Processor A informs processor B that the transfer is finished.	After the processing of the packet data finishes, processor A informs processor B (using MU processor A-side transmit register, MUA_TR*n*).
10	Processor A sends an interrupt to processor B (a request for more data).	Processor B receives the next interrupt from processor A, in which processor A requests more packet data.

38.6.5 Freeing a processor from deadlock

During normal operation, one processor may determine that the other processor is not working or is deadlocked. Using Status (SR), the processor can use the methods in the following table to identify and correct the problem.

Table 194. Freeing a processor from deadlock

Processor mode	Technique	Description
—	Processor issues an interrupt.	The other processor can interrupt the processor by issuing one of the 9 (general purpose, receive, or transmit) interrupts.

38.7 Register definition

MU provides transmit and receive data registers (*x*TR0–*n*, *x*RR0–*n*) for communication between processor A and processor B. It also provides control registers (*x*CR) for operations such as interrupts and resets, and status registers (*x*SR) for checking the status of the other MU-side. Figure 154 shows the schematic for MU registers.

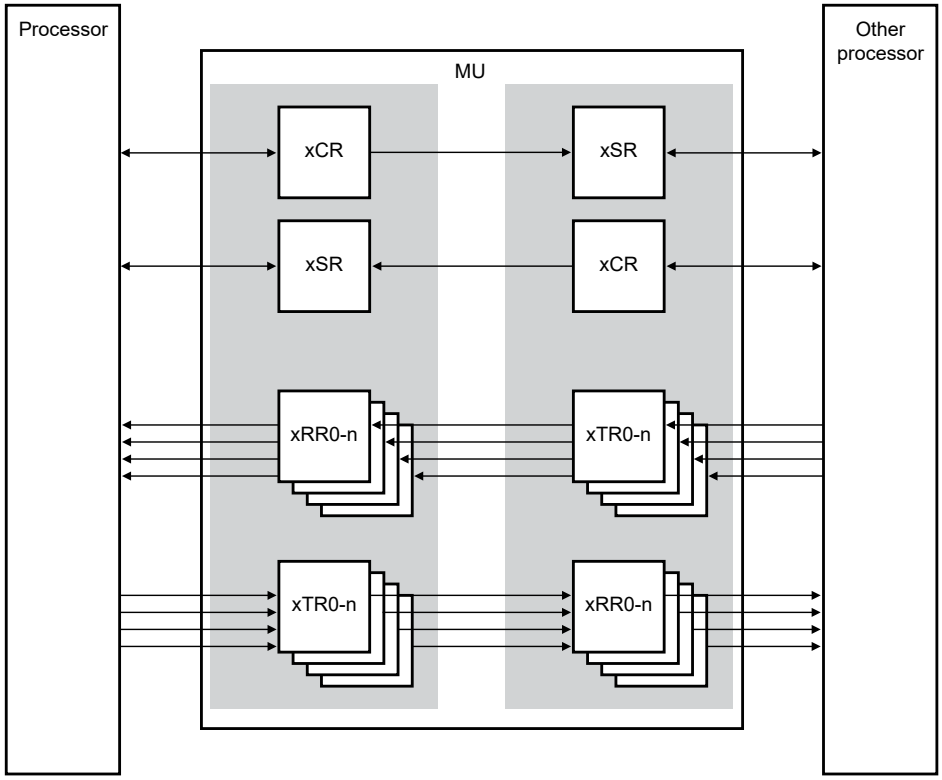


Figure 154. MU registers

38.7.1 MUA register descriptions

This section contains the detailed register descriptions for MUA registers.

NOTE

A module transfer error to processor A or processor B is generated when:

- A read or write access is made to an invalid location.
- A write operation is performed on a read-only register on the processor A side or processor B side of MU.

38.7.1.1 MUA memory map

MU_2.MUA base address: 400B_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VER)	32	R	0309_000Fh
4h	Parameter (PAR)	32	R	0301_0404h
8h	Control (CR)	32	RW	0000_0000h
Ch	Status (SR)	32	RW	See section

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
100h	Flag Control (FCR)	32	RW	0000_0000h
104h	Flag Status (FSR)	32	R	0000_0000h
110h	General-Purpose Interrupt Enable (GIER)	32	RW	0000_0000h
114h	General-Purpose Control (GCR)	32	RW	0000_0000h
118h	General-purpose Status (GSR)	32	RW	0000_0000h
120h	Transmit Control (TCR)	32	RW	0000_0000h
124h	Transmit Status (TSR)	32	R	0000_000Fh
128h	Receive Control (RCR)	32	RW	0000_0000h
12Ch	Receive Status (RSR)	32	R	0000_0000h
200h - 20Ch	Transmit (TR0 - TR3)	32	W	0000_0000h
280h - 28Ch	Receive (RR0 - RR3)	32	R	0000_0000h

38.7.1.2 Version ID (VER)

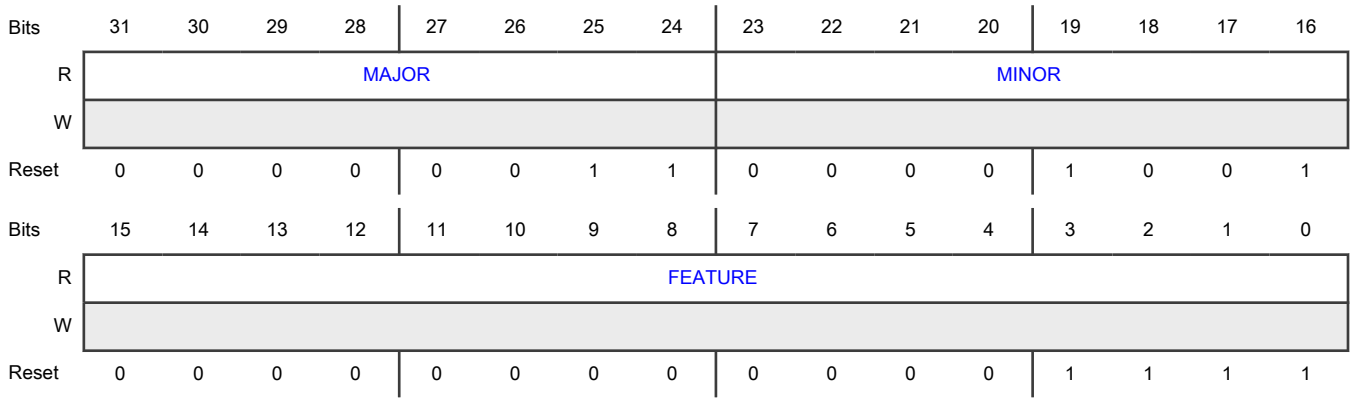
Offset

Register	Offset
VER	0h

Function

Determines the version ID and feature set number of MUA.

Diagram



Fields

Field	Function
31-24 MAJOR	Major Version Number
23-16 MINOR	Minor Version Number
15-0 FEATURE	Feature Set Number Indicates the feature set number. MU implements: • Standard features • Expanded number of TR*n*/RR*n* registers

38.7.1.3 Parameter (PAR)

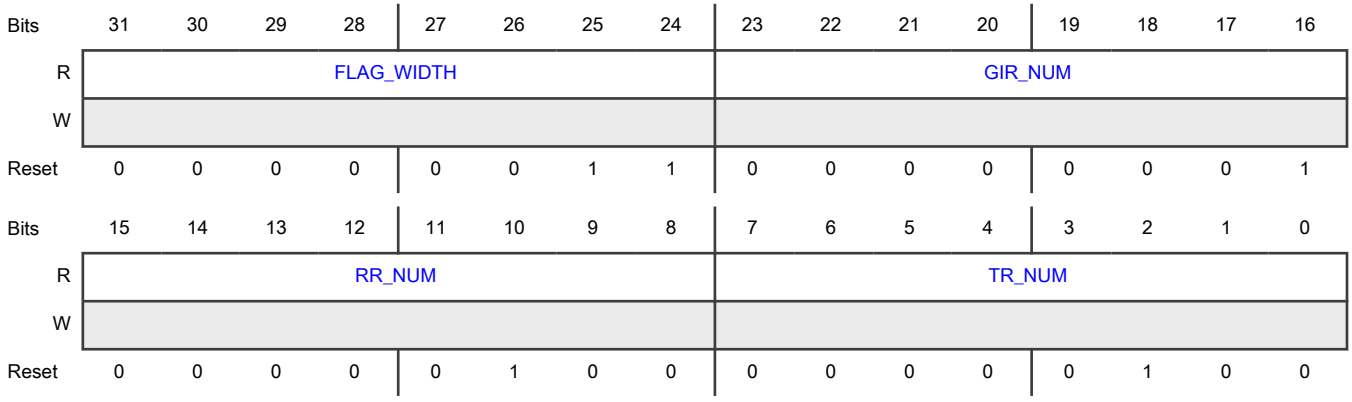
Offset

Register	Offset
PAR	4h

Function

Defines the number of flags, transmit registers, receive registers, and general-purpose interrupt requests available for MU.

Diagram



Fields

Field	Function
31-24	Flag Width

Table continues on the next page...

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Field	Function
FLAG_WIDTH	Specifies the number of flag bits (3) in the Flag Control (FCR) and Flag Status (FSR) registers.
23-16 GIR_NUM	General-Purpose Interrupt Request Number Specifies the number of general-purpose interrupt requests available (1).
15-8 RR_NUM	Receive Register Number Specifies the number of receive registers (4).
7-0 TR_NUM	Transmit Register Number Specifies the number of transmit registers (4).

38.7.1.4 Control (CR)

Offset

Register	Offset
CR	8h

Function
Controls MU reset and reset interrupt enable.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0														MURIE	MUR
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-2 —	Reserved
1	MUA Reset Interrupt Enable

Table continues on the next page...

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Field	Function
MURIE	Enables the processor A-side MU reset interrupt request due to MU reset issued by MUB. If the value of this field is 1, an MU reset interrupt request is issued to processor A when MUA_SR[MURIP] = 1. If the value of this field is 0, MU ignores the value of MURIP and issues no MU reset interrupt request. Only a system reset can reset this field. CR[MUR] cannot reset this field. 0b - Disable 1b - Enable
0 MUR	MU Reset Resets MU. Writing 1 to this field resets the MUA and MUB sides. All internal states are cleared. It forces all control and status registers to return to their default values (except MURIE in MUA/B_CR registers; MURIP and MURS in MUA/B_SR registers). Before writing 1 to this field, interrupt processor B because writing 1 to this field may affect the ongoing processor B program. After writing 1 to this field, monitor the value of MUA_SR[MURS] to know when the reset sequence on the processor B-side has ended. This field always reads 0, and it becomes 0 during the MU reset sequence. 0b - Idle 1b - Reset

38.7.1.5 Status (SR)

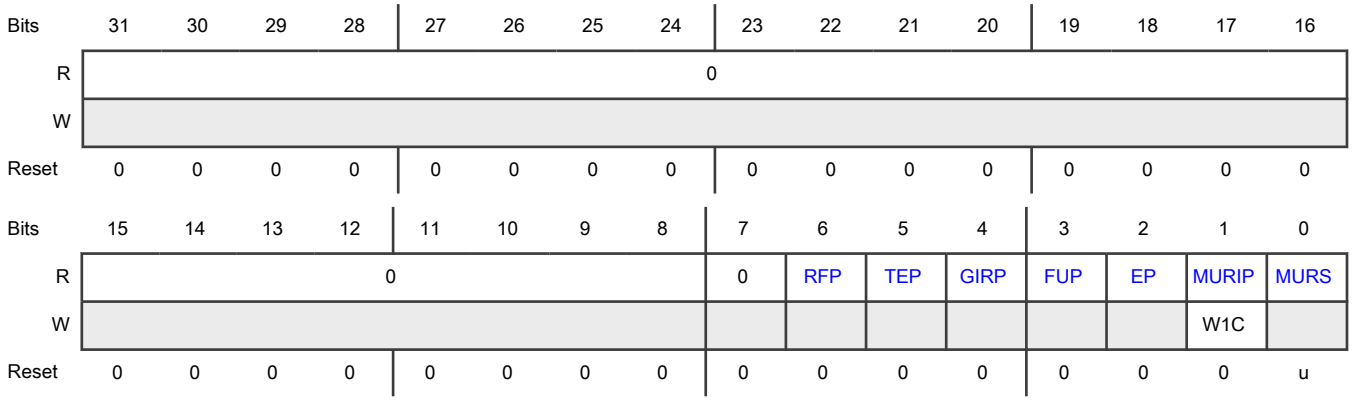
Offset

Register	Offset
SR	Ch

Function

Shows the status of MU resets and the status of pending events and requests.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 —	Reserved
6 RFP	MUA Receive Full Pending Indicates whether a receive full message is pending. This field becomes 1 when MUB writes to a TR*n* register to send data to MUA. After this field becomes 1, MU checks RSR[RF*n*] to determine whether the data in the Receive register is ready for MUA to read it. This field becomes 0 when all MUA RR*n* registers are read, or when MU is reset. 0b - Not pending; MUB is not writing to a Transmit register 1b - Pending; MUB is writing to a Transmit register
5 TEP	MUA Transmit Empty Pending Indicates whether a transmit empty message is pending. This field becomes 1 when any TCR[TIE*n*] field is 1 and TSR[TE*n*] flag is set. After this field becomes 1, MU checks TSR[TE*n*] to determine whether the data in the Transmit (TR*n*) register is ready for MUA to write to it. This field becomes 0 when write operations to all MUA Transmit (TR*n*) registers where TCR[TIE*n*] = 1 (transfer interrupt enabled) are completed, or when MU is reset. 0b - No MUA transmit empty event pending 1b - Pending; any TCR[TIEn] field is 1 and TSR[TEn] flag is set
4 GIRP	MUA General-Purpose Interrupt Pending Indicates that MUB has sent a general-purpose interrupt request. This field becomes 1 when the MUB side sends a general-purpose interrupt request to the MUA side. GSR[GIP0] identifies which general-purpose interrupt request is received.

Table continues on the next page...

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Field	Function
	This field becomes 0 when MUA_GSR[GIP0] is cleared, or when MU is reset. 0b - No request sent 1b - Request sent
3 FUP	MUA Flag Update Pending Indicates whether a flag update request is pending. MU generates this request when there is a change to the F*n*[2:0] bits of MUA_FCR. This field becomes 1 when the MUA side sends a flag update request to the MUB side. This field becomes 0 when MU acknowledges this flag update request internally (the flag is updated) from the MUB side, or during MU reset. No flag update changes are allowed when this field is 1. When FUP = 1, a write to the F*n*[2:0] bits of MUA_FCR does not generate a flag update event. The F*n*[2:0] bits do not change. If SR[EP] = 1 (event pending), writing to MUA_FCR does not immediately cause this field to become 1. 0b - No pending update flags (initiated by MUA) 1b - Pending update flags (initiated by MUA)
2 EP	MUA Side Event Pending Indicates a pending side event when the MUA side sends an event update request to the MUB side. An event is any hardware message that the Status register on the MUB side reflects. For example, an event occurs when Transmit register 0 is the target of a write operation. During normal operations, the update mechanism for this field operates automatically. MU clears this field automatically when the event update acknowledgment is received, or when MU resets. To ensure that events are posted to MUB, verify that this field is 0. If it is 1, wait and continue to poll this field until it becomes 0. 0b - Not pending 1b - Pending
1 MURIP	MU Reset Interrupt Pending Flag Indicates whether processor B has issued an MU reset. This flag is set after processor B initiates an MU reset by setting MUB_CR[MUR]. If CR[MURIE] = 1, the processor A MU reset interrupt request is issued when processor B writes 1 to MUB_CR[MUR]. Clearing this flag also clears the MU reset interrupt request. Only a system reset can reset this flag. MU reset cannot reset this flag. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Reset not issued

Table continues on the next page...

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Field	Function
	1b - Reset issued When writing 0b - No effect 1b - Clear the flag
0 MURS	MUA and MUB Reset State Indicates the reset state of MUA and MUB. This field becomes 1 during any system reset or MU reset from the MUA or MUB side. This field becomes 0 when the reset sequence on both MUA and MUB sides ends. After issuing any of the aforementioned reset events, verify that this field is 0 before starting any access. 0b - Out of reset 1b - In reset

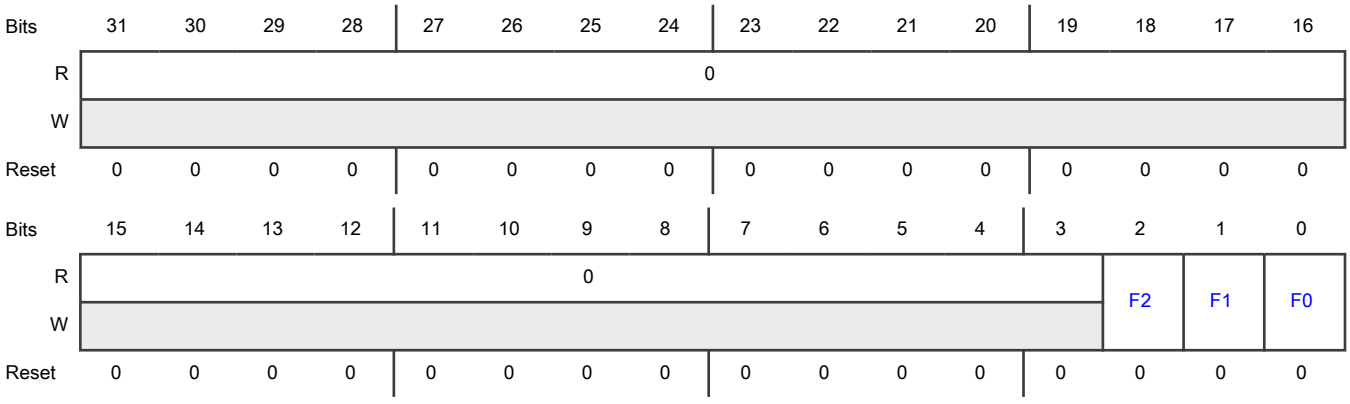
38.7.1.6 Flag Control (FCR)

Offset

Register	Offset
FCR	100h

Function
Configures MUB_FSR[F*n*] flags.

Diagram



Fields

Field	Function
31-3 —	Reserved
2-0 Fn	MUA to MUB Flag Configures MUB_FSR[F*n*] flags, where *n* = 0 to 2. F*n* configures the corresponding MUB_FSR[F*n*] flag. F*n* becomes 0 when MU resets. 0b - Clear MUB_FSR[Fn] 1b - Set MUB_FSR[Fn]

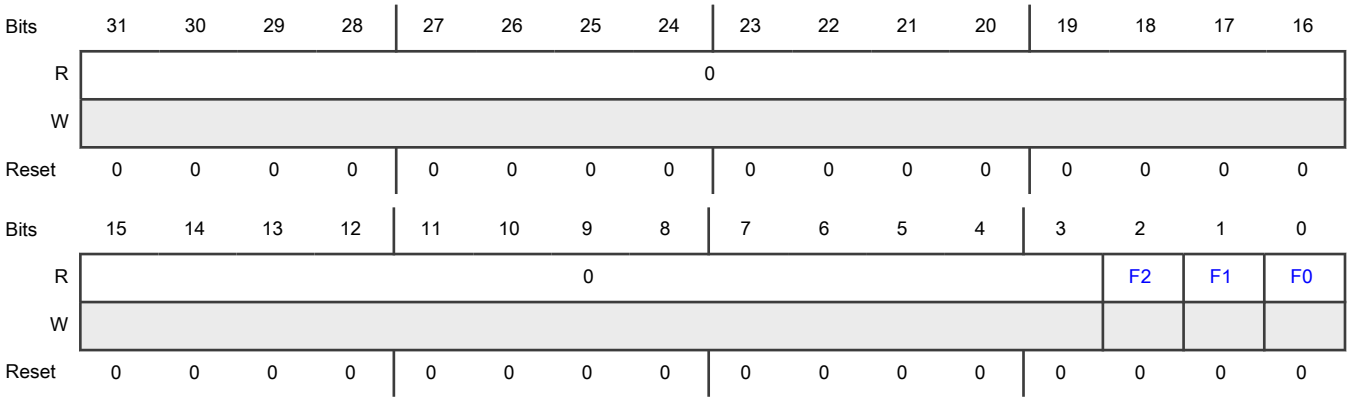
38.7.1.7 Flag Status (FSR)

Offset

Register	Offset
FSR	104h

Function
Contains flags configured by the values written to MUB_FCR[F*n*].

Diagram



Fields

Field	Function
31-3 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
2-0 Fn	MUB to MUA-Side Flag Contains flags configured by the values written to MUB_FCR[F*n*], where *n* = 0 to 2. F*n* is the MUA-side flag configured by the values written to MUB_FCR[F*n*]. When MUB_FCR[F*n*] is written to, the write event updates MUA_FSR[F*n*], after the event update latency. 0b - MUB_FCR[Fn] = 0 1b - MUB_FCR[Fn] = 1

38.7.1.8 General-Purpose Interrupt Enable (GIER)

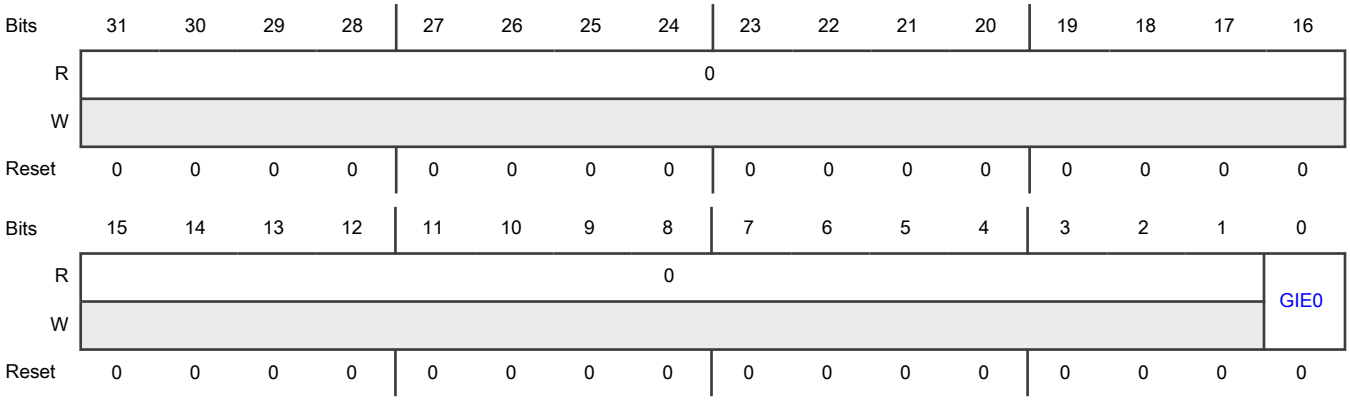
Offset

Register	Offset
GIER	110h

Function

Contains the MUA general-purpose interrupt enable fields.

Diagram



Fields

Field	Function
31-1 —	Reserved
0-0 GIEn	MUA General-purpose Interrupt Enable Enables general-purpose interrupt. There is one general-purpose interrupt (*n* = 0).

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When GIE0 = 1, a general-purpose interrupt *n* request is issued to processor A when MUA GSR[GIP0] = 1. If GIE0 = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt. GIE0 becomes 0 when MU resets. 0b - Disable 1b - Enable

38.7.1.9 General-Purpose Control (GCR)

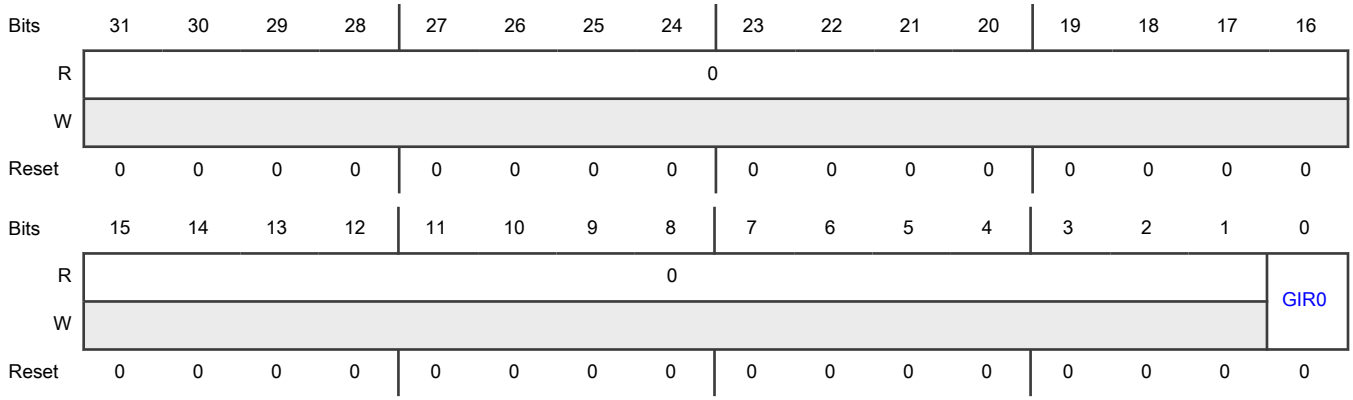
Offset

Register	Offset
GCR	114h

Function

Contains the MUA general-purpose interrupt request fields.

Diagram



Fields

Field	Function
31-1 —	Reserved
0-0 GIRn	MUA General-Purpose Interrupt Request Specifies whether general-purpose interrupts are requested to MUB. There is one general-purpose interrupt (*n* = 0).

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Writing 1 to GIR0 sets MUB_GSR[GIP0]. If MUB_GIER[GIE0] = 1, a general-purpose interrupt request is triggered on processor B. This field becomes 0 when MUB_GSR[GIP0] is cleared. This clearing informs MUA that the interrupt is accepted (cleared by software). To ensure proper operations, verify that GIR0 is 0 (no pending interrupt) before writing 1 to it. This field becomes 0 when MU resets. 0b - Not requested 1b - Requested

38.7.1.10 General-purpose Status (GSR)

Offset

Register	Offset
GSR	118h

Function

Contains the status of the MUA general-purpose interrupt pending requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															GIP0
W																W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved
0-0	MUA General-Purpose Interrupt Request Pending

Table continues on the next page...

Table continued from the previous page...

Field	Function
GIPn	Indicates whether a general-purpose interrupt request is pending. There is one general-purpose interrupt (*n* = 0). GIP0 informs MUA that MUB_GCR[GIR0] changed from 0 to 1. If MUA_GIER[GIE0] = 1, a general-purpose interrupt request is issued to processor A. GIP0 is cleared when MU resets. After GIP0 is cleared, if MUA_GIER[GIE0] = 1, the general-purpose interrupt request is cleared on the MUA side. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not pending 1b - Pending When writing 0b - No effect 1b - Clear the flag

38.7.1.11 Transmit Control (TCR)

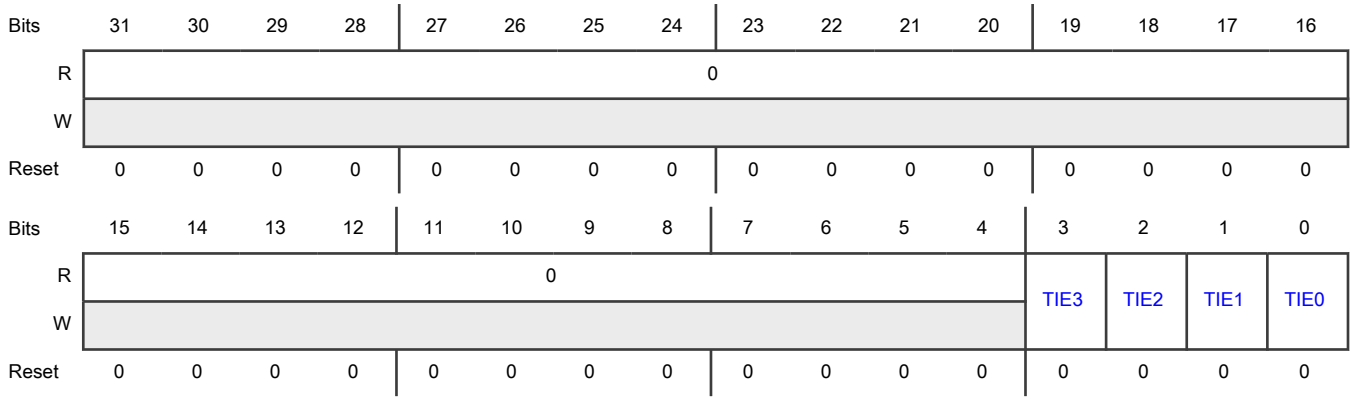
Offset

Register	Offset
TCR	120h

Function

Contains the MUA transmit interrupt enable fields.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 TIEn	MUA Transmit Interrupt Enable Enables MUA transmit interrupt *n*, where *n* = 0 to 3. If this field is 1, an MUA transmit interrupt *n* request is issued when MUA_TSR[TE*n*] is set. If this field is 0, MU ignores the value of MUA_TSR[TE*n*], and no MUA transmit interrupt *n* request is issued. 0b - Disable 1b - Enable

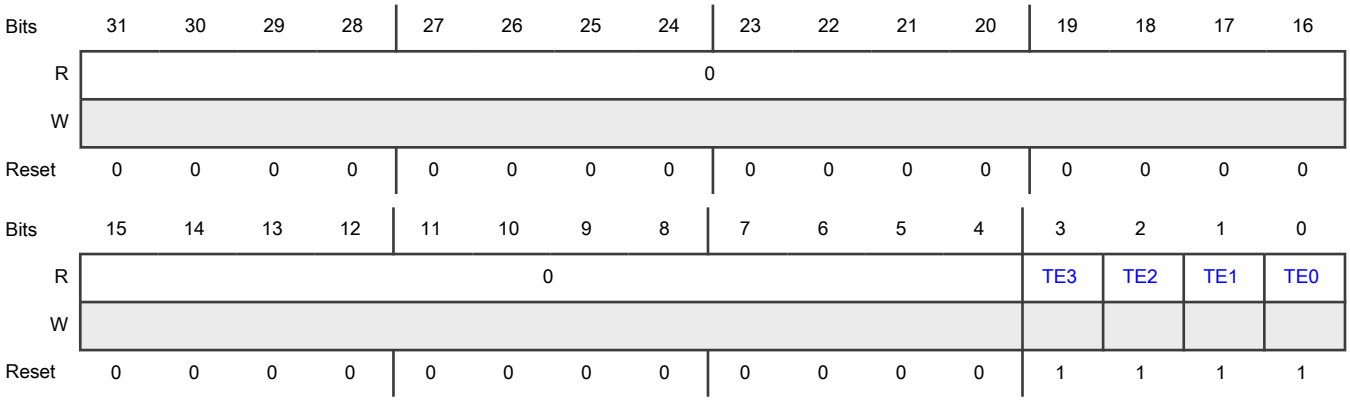
38.7.1.12 Transmit Status (TSR)

Offset

Register	Offset
TSR	124h

Function
Indicates whether the MUA transmit registers are empty.

Diagram



Fields

Field	Function
31-4 —	Reserved

Table continues on the next page...

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Field	Function
3-0 TEn	MUA Transmit Empty Indicates whether MUA Transmit (TR*n*) register is empty, where *n* = 0 to 3. This field becomes 1 after the MUB_RR*n* register is read on the MUB side. When TE*n* = 1, it indicates to the MUA side that the MUA_TR*n* register is ready to be written on the MUA side. If MUA_TCR[TIE*n*] = 1, a transmit *n* interrupt is issued on the MUA side. This field becomes 0 after the MUA_TR*n* register is written to on the MUA side. After this field becomes 0, if MUA_TCR[TIE*n*] = 1, the transmit *n* interrupt request is cleared on the MUA side. This field becomes 1 when MU resets. 0b - Not empty 1b - Empty

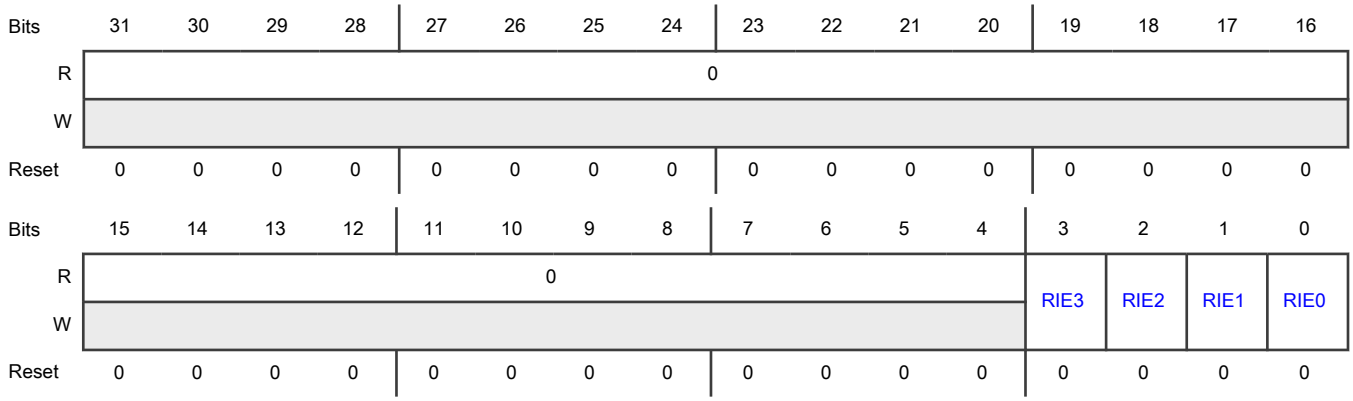
38.7.1.13 Receive Control (RCR)

Offset

Register	Offset
RCR	128h

Function
Contains the MUA receive interrupt enables.

Diagram



Fields

Field	Function
31-4 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
3-0 RIEn	MUA Receive Interrupt Enable Enables MUA receive interrupt *n*, where *n* = 0 to 3. If this field is 1, an MUA receive interrupt *n* request is issued when MUA_RSR[RF*n*] is set. If this field is 0, MU ignores the value of MUA_RSR[RF*n*], and no MUA receive interrupt request is issued. 0b - Disable 1b - Enable

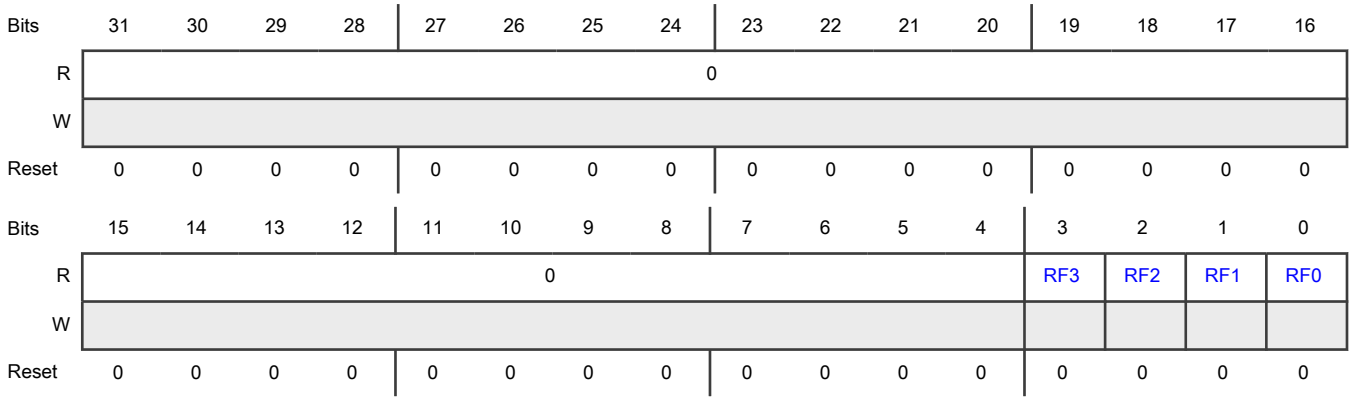
38.7.1.14 Receive Status (RSR)

Offset

Register	Offset
RSR	12Ch

Function
Indicates whether the MUA receive registers are full.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 RFn	MUA Receive Register Full Indicates whether MUA Receive register (RR*n*) is full, where *n* = 0 to 3.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	RF*n* becomes 1 when the MUB_TR*n* register is written to on the MUB side. When RF*n* is 1, it indicates to the MUA side that new data in the MUA_RR*n* register is ready for MUA to read it. If MUA_RCR[RIE*n*] = 1, a receive *n* interrupt is issued on the MUA side. RF*n* becomes 0 when the MUA_RR*n* register is read, or when MU is reset. After RF*n* becomes 0, if MUA_RCR[RIE*n*] = 1, the receive *n* interrupt request is cleared on the MUA side. 0b - Not full 1b - Full

38.7.1.15 Transmit (TR0 - TR3)

Offset

Register	Offset
TR0	200h
TR1	204h
TR2	208h
TR3	20Ch

Function
Contains MUA transmit data.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W	TR_DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W	TR_DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0	MUA Transmit Data

Table continues on the next page...

Field	Function
TR_DATA	Contains MUA transmit data. MUB_RR*n* reflects the data written to this register. The TR*n* and RR*n* registers are not double-buffered. Writing to MUA_TR*n* overrides the data readable in the MUA_RR*n* register. A write to the Transmit register clears MUA_TSR[TE*n*] on the transmitter side, and sets MUB_RSR[RF*n*] on the receiver side. You can write to this register only when MUA_TSR[TE*n*] = 1. Reading this register returns all zeroes.

38.7.1.16 Receive (RR0 - RR3)

Offset

Register	Offset
RR0	280h
RR1	284h
RR2	288h
RR3	28Ch

Function

Contains MUA receive data.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RR_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RR_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RR_DATA	MUA Receive Data Reflects the data written to MUB TR*n*.

Table continues on the next page...

Field	Function
	Reading this register clears MUA_RSR[RF*n*] on the receiver side, and sets MUB_TSR[TE*n*] on the transmitter side. You can read this register only when MUA_RSR[RF*n*] = 1. Reading it before MUA_RSR[RF*n*] becomes 1 may result in reading incorrect data. Poll MUA_RSR[RF*n*] to confirm it is set before reading RR*n*. Writing to this register generates an error response to MUA.

38.7.2 MUB register descriptions

This section contains the detailed register descriptions for MUB registers.

NOTE

A module transfer error to processor A or processor B is generated when:

- A read or write access is made to an invalid location.
- A write operation is performed on a read-only register on the processor A side or processor B side of MU.

38.7.2.1 MUB memory map

MU_0.MUB base address: 4038_C000h

MU_1.MUB base address: 404E_C000h

MU_2.MUB base address: 400B_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VER)	32	R	0309_000Fh
4h	Parameter (PAR)	32	R	See section
8h	Control (CR)	32	RW	0000_0000h
Ch	Status (SR)	32	RW	See section
10h	Core Control 0 (CCR0)	32	RW	0000_0000h
18h	Core Sticky Status 0 (CSSR0)	32	RW	See section
100h	Flag Control (FCR)	32	RW	0000_0000h
104h	Flag Status (FSR)	32	R	0000_0000h
110h	General-Purpose Interrupt Enable (GIER)	32	RW	0000_0000h
114h	General-Purpose Control (GCR)	32	RW	0000_0000h
118h	General-purpose Status (GSR)	32	RW	0000_0000h
120h	Transmit Control (TCR)	32	RW	0000_0000h
124h	Transmit Status (TSR)	32	R	0000_000Fh
128h	Receive Control (RCR)	32	RW	0000_0000h
12Ch	Receive Status (RSR)	32	R	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
200h - 20Ch	Transmit (TR0 - TR3)	32	W	0000_0000h
280h - 28Ch	Receive (RR0 - RR3)	32	R	0000_0000h

38.7.2.2 Version ID (VER)

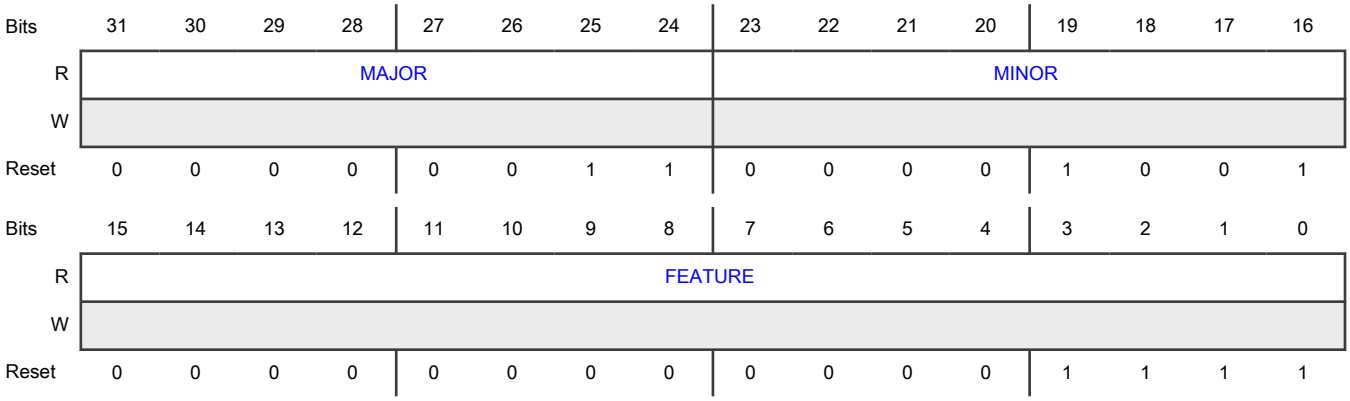
Offset

Register	Offset
VER	0h

Function

Determines the version ID and feature set number of MUB.

Diagram



Fields

Field	Function
31-24 MAJOR	Major Version Number
23-16 MINOR	Minor Version Number
15-0 FEATURE	Feature Set Number Indicates the feature set number.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	MU implements: • Standard features • Expanded number of TR*n*/RR*n* registers

38.7.2.3 Parameter (PAR)

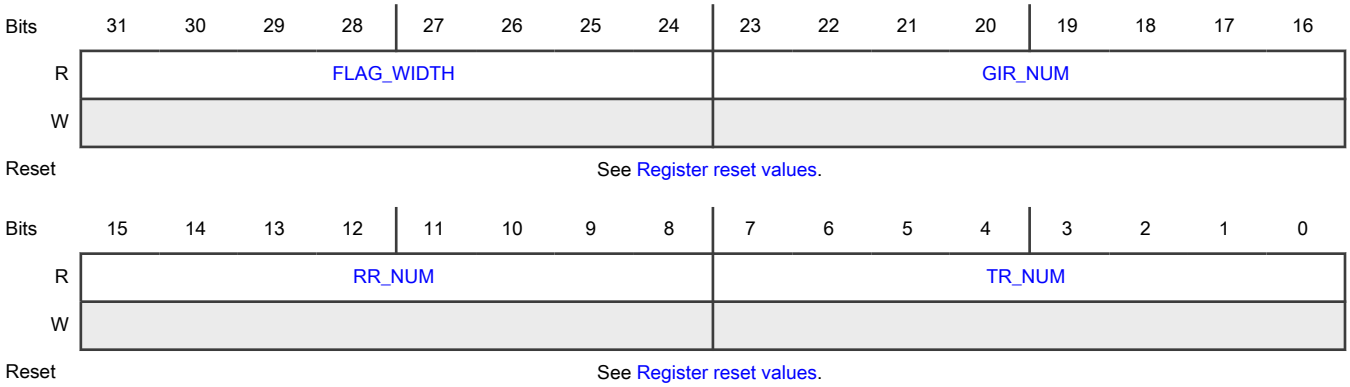
Offset

Register	Offset
PAR	4h

Function

Defines the number of flags, transmit registers, receive registers, and general-purpose interrupt requests available for MU.

Diagram



Register reset values

Register	Reset value
PAR	MU_0.MUB,MU_1.MUB: 2020_0404h MU_2.MUB: 0301_0404h

Fields

Field	Function
31-24 FLAG_WIDTH	Flag Width Specifies the number of flag bits (3) in the Flag Control (FCR) and Flag Status (FSR) registers.

Table continues on the next page...

Table continued from the previous page...

Field	Function
23-16 GIR_NUM	General-Purpose Interrupt Request Number Specifies the number of general-purpose interrupt requests available (1).
15-8 RR_NUM	Receive Register Number Specifies the number of receive registers (4).
7-0 TR_NUM	Transmit Register Number Specifies the number of transmit registers (4).

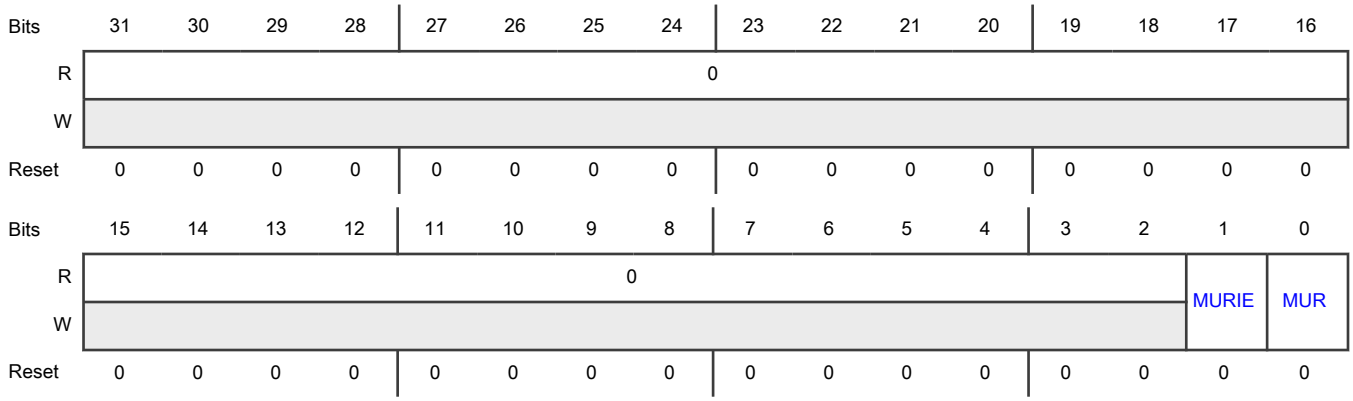
38.7.2.4 Control (CR)

Offset

Register	Offset
CR	8h

Function
Controls MU reset and reset interrupt enable.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 MURIE	MUB Reset Interrupt Enable Enables the processor B-side MU reset interrupt request due to MU reset issued by MUA.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	If the value of this field is 1, an MU reset interrupt request is issued to processor B when MUB_SR[MURIP] = 1. If the value of this field is 0, MU ignores the value of MURIP and issues no MU reset interrupt request. Only a system reset can reset this field. CR[MUR] cannot reset this field. 0b - Disable 1b - Enable
0 MUR	MU Reset Resets MU. Writing 1 to this field resets the MUB and MUA sides. All internal states are cleared. It forces all control and status registers to return to their default values (except MURIE in MUB/A_CR registers; MURIP and MURS in MUB/A_SR registers). Before writing 1 to this field, interrupt processor A because writing 1 to this field may affect the ongoing processor A program. After writing 1 to this field, monitor the value of MUB_SR[MURS] to know when the reset sequence on the processor A-side has ended. This field always reads 0, and it becomes 0 during the MU reset sequence. 0b - Idle 1b - Reset

38.7.2.5 Status (SR)

Offset

Register	Offset
SR	Ch

Function

Shows the status of MU resets and the status of pending events and requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0	RFP	TEP	GIRP	FUP	EP	MURIP	MURS
W															W1C	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	u

Fields

Field	Function
31-8 —	Reserved
7 —	Reserved
6 RFP	MUB Receive Full Pending Indicates whether a receive full message is pending. This field becomes 1 when MUA writes to a TR*n* register to send data to MUB. After this field becomes 1, MU checks RSR[RF*n*] to determine whether the data in the Receive register is ready for MUB to read it. This field becomes 0 when all MUB RR*n* registers are read, or when MU is reset. 0b - Not pending; MUA is not writing to a Transmit register 1b - Pending; MUA is writing to a Transmit register
5 TEP	MUB Transmit Empty Pending Indicates whether a transmit empty message is pending. This field becomes 1 when any TCR[TIE*n*] field is 1 and TSR[TE*n*] flag is set. After this field becomes 1, MU checks TSR[TE*n*] to determine whether the data in the Transmit (TR*n*) register is ready for MUB to write to it. This field becomes 0 when write operations to all MUB Transmit (TR*n*) registers where TCR[TIE*n*] = 1 (transfer interrupt enabled) are completed, or when MU is reset. 0b - No MUB transmit empty event pending 1b - Pending; any TCR[TIEn] field is 1 and TSR[TEn] flag is set
4 GIRP	MUB General-Purpose Interrupt Pending Indicates that MUA has sent a general-purpose interrupt request. This field becomes 1 when the MUA side sends a general-purpose interrupt request to the MUB side. GSR[GIP0] identifies which general-purpose interrupt request is received. This field becomes 0 when MUB_GSR[GIP0] is cleared, or when MU is reset. 0b - No request sent 1b - Request sent
3 FUP	MUB Flag Update Pending Indicates whether a flag update request is pending. MU generates this request when there is a change to the F*n*[2:0] bits of MUB_FCR. This field becomes 1 when the MUB side sends a flag update request to the MUA side. This field becomes 0 when MU acknowledges this flag update request internally (the flag is updated) from the MUA side, or during MU reset. No flag update changes are allowed when this field is 1. When FUP = 1, a write to the F*n*[2:0] bits of MUB_FCR does not generate a flag update event. The F*n*[2:0] bits do not change.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	If SR[EP] = 1 (event pending), writing to MUB_FCR does not immediately cause this field to become 1. 0b - No pending update flags (initiated by MUB) 1b - Pending update flags (initiated by MUB)
2 EP	MUB Side Event Pending Indicates a pending side event when the MUB side sends an event update request to the MUA side. An event is any hardware message that the Status register on the MUA side reflects. For example, an event occurs when Transmit register 0 is the target of a write operation. During normal operations, the update mechanism for this field operates automatically. MU clears this field automatically when the event update acknowledgment is received, or when MU resets. To ensure that events are posted to MUA, verify that this field is 0. If it is 1, wait and continue to poll this field until it becomes 0. 0b - Not pending 1b - Pending
1 MURIP	MU Reset Interrupt Pending Flag Indicates whether processor A has issued an MU reset. This flag is set after processor A initiates an MU reset by setting MUB_CR[MUR]. If CR[MURIE] = 1, the processor B MU reset interrupt request is issued when processor A writes 1 to MUA_CR[MUR]. Clearing this flag also clears the MU reset interrupt request. Only a system reset can reset this flag. MU reset cannot reset this flag. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Reset not issued 1b - Reset issued When writing 0b - No effect 1b - Clear the flag
0 MURS	MUA and MUB Reset State Indicates the reset state of MUA and MUB. This field becomes 1 during any system reset or MU reset from the MUA or MUB side. This field becomes 0 when the reset sequence on both MUA and MUB sides ends. After issuing any of the aforementioned reset events, verify that this field is 0 before starting any access. 0b - Out of reset 1b - In reset

38.7.2.6 Core Control 0 (CCR0)

Offset

Register	Offset
CCR0	10h

Function

Allows MUB to control the processor on the MUA side.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
MU_0.MUB	CCR0	—
MU_1.MUB	CCR0	—
MU_2.MUB	—	CCR0

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0			Reserved	0	Reserved	0	NMI
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-7 —	Reserved
6-5 —	Reserved
4	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
3 —	Reserved
2 —	Reserved
1 —	Reserved
0 NMI	MUA Nonmaskable Interrupt Request Indicates whether Processor B has issued a nonmaskable interrupt to Processor A. When this field becomes 1, it initiates a nonmaskable interrupt to processor A. This field becomes 0 after 1 is written to MUA_CSSR0[NMIC] to clear that field. After this field becomes 0, MUB can initiate another nonmaskable interrupt to MUA. This field is cleared when MU resets. 0b - Nonmaskable interrupt not issued 1b - Nonmaskable interrupt issued

38.7.2.7 Core Sticky Status 0 (CSSR0)

Offset

Register	Offset
CSSR0	18h

Function

Shows the status of interrupts pending (W1C).

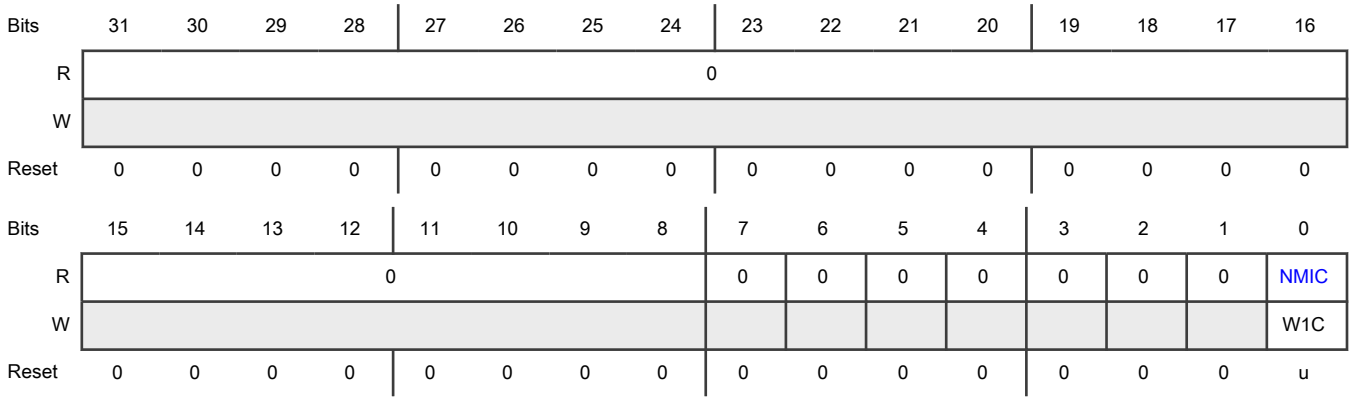
The reset value is chip-specific.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
MU_0.MUB	CSSR0	—
MU_1.MUB	CSSR0	—
MU_2.MUB	—	CSSR0

Diagram



Fields

Field	Function
31-8 —	Reserved
7 —	Reserved
6 —	Reserved
5 —	Reserved
4 —	Reserved
3 —	Reserved
2 —	Reserved
1 —	Reserved
0 NMIC	Processor B Nonmaskable Interrupt Clear Clears the nonmaskable interrupt (NMI) request from the MUA side. The MUB-side NMI service routine uses this field. Writing 1 to this field clears MUA_CCR0[NMI], deasserting the NMI request and enabling MUA_CCR0[NMI] to trigger another NMI request.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field always reads as 0, so you cannot poll it. You can only use this field as part of the NMI service routine, in which you must write 1 to this field only once. This field is cleared when MU resets. 0b - Default 1b - Clear MUA_CCR0[NMI]

38.7.2.8 Flag Control (FCR)

Offset

Register	Offset
FCR	100h

Function
Configures MUA_FSR[F*n*] flags.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	F31	F30	F29	F28	F27	F26	F25	F24	F23	F22	F21	F20	F19	F18	F17	F16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	F15	F14	F13	F12	F11	F10	F9	F8	F7	F6	F5	F4	F3	F2	F1	F0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 F31	MUB to MUA Flag Configures MUA_FSR[F*n*] flags, where *n* = 0 to 31. F*n* configures the corresponding MUA_FSR[F*n*] flag. F*n* becomes 0 when MU resets.

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>30
F30</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>29
F29</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
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<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>28
F28</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>27
F27</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
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<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>26
F26</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>25
F25</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>24
F24</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>23
F23</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

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<tr><th>Field</th><th>Function</th></tr>
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<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>22
F22</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
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<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>21
F21</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
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<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>20
F20</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>19
F19</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

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<tr><th>Field</th><th>Function</th></tr>
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NOTE
This field is not supported in every instance. The following table includes only supported registers.
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<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>18
F18</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>17
F17</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

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<tr><th>Field</th><th>Function</th></tr>
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<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>16
F16</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>15
F15</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
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<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>14
F14</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>13
F13</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

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<tr><th>Field</th><th>Function</th></tr>
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NOTE
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<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>12
F12</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>11
F11</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>10
F10</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>9
F9</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
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<tr><th>Field</th><th>Function</th></tr>
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NOTE
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<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>8
F8</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>7
F7</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>6
F6</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>5
F5</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
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NOTE
This field is not supported in every instance. The following table includes only supported registers.
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<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>4
F4</td><td>
MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>3
F3</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 31.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FCR</td></tr>
</table>
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]
</td></tr>
<tr><td>2
F2</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 2.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]</td></tr>
<tr><td>1
F1</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 2.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]</td></tr>
<tr><td>0
F0</td><td>MUB to MUA Flag
Configures MUA_FSR[Fn] flags, where n = 0 to 2.
Fn configures the corresponding MUA_FSR[Fn] flag.
Fn becomes 0 when MU resets.
0b - Clear MUA_FSR[Fn]
1b - Set MUA_FSR[Fn]</td></tr>
</table>

38.7.2.9 Flag Status (FSR)

Offset

Register	Offset
FSR	104h

Function
Contains flags configured by the values written to MUA_FCR[F*n*].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	F31	F30	F29	F28	F27	F26	F25	F24	F23	F22	F21	F20	F19	F18	F17	F16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	F15	F14	F13	F12	F11	F10	F9	F8	F7	F6	F5	F4	F3	F2	F1	F0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 F31	MUA to MUB-Side Flag Contains flags configured by the values written to MUA_FCR[F*n*], where *n* = 0 to 31. F*n* is the MUB-side flag configured by the values written to MUA_FCR[F*n*]. When MUA_FCR[F*n*] is written to, the write event updates MUB_FSR[F*n*], after the event update latency. **NOTE** This field is not supported in every instance. The following table includes only supported registers. 0b - MUA_FCR[Fn] = 0 1b - MUA_FCR[Fn] = 1

Instance	Field supported in	Field not supported in
MU_0.MUB	FSR	—
MU_1.MUB	FSR	—
MU_2.MUB	—	FSR

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>30
F30</td><td>MUA to MUB-Side Flag
Contains flags configured by the values written to MUA_FCR[Fn], where n = 0 to 31.
Fn is the MUB-side flag configured by the values written to MUA_FCR[Fn].
When MUA_FCR[Fn] is written to, the write event updates MUB_FSR[Fn], after the event update latency.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>FSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>FSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>FSR</td></tr></table>
0b - MUA_FCR[Fn] = 0
1b - MUA_FCR[Fn] = 1</td></tr>
<tr><td>29
F29</td><td>MUA to MUB-Side Flag
Contains flags configured by the values written to MUA_FCR[Fn], where n = 0 to 31.
Fn is the MUB-side flag configured by the values written to MUA_FCR[Fn].
When MUA_FCR[Fn] is written to, the write event updates MUB_FSR[Fn], after the event update latency.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>FSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>FSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>FSR</td></tr></table>
0b - MUA_FCR[Fn] = 0
1b - MUA_FCR[Fn] = 1</td></tr>
<tr><td>28
F28</td><td>MUA to MUB-Side Flag
Contains flags configured by the values written to MUA_FCR[Fn], where n = 0 to 31.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>Fn is the MUB-side flag configured by the values written to MUA_FCR[Fn].
When MUA_FCR[Fn] is written to, the write event updates MUB_FSR[Fn], after the event update latency.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>FSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>FSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>FSR</td></tr></table>0b - MUA_FCR[Fn] = 0
1b - MUA_FCR[Fn] = 1</td></tr>
<tr><td>27
F27</td><td>MUA to MUB-Side Flag
Contains flags configured by the values written to MUA_FCR[Fn], where n = 0 to 31.
Fn is the MUB-side flag configured by the values written to MUA_FCR[Fn].
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F25</td><td>
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F24</td><td>
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F21</td><td>
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F20</td><td>
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F17</td><td>
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F15</td><td>
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Contains flags configured by the values written to MUA_FCR[Fn], where n = 0 to 31.
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F14</td><td>
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Contains flags configured by the values written to MUA_FCR[Fn], where n = 0 to 31.
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F13</td><td>
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F12</td><td>MUA to MUB-Side Flag
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F11</td><td>
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<tr><td>MU_0.MUB</td><td>FSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>FSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>FSR</td></tr>
</table>
0b - MUA_FCR[Fn] = 0
1b - MUA_FCR[Fn] = 1
</td></tr>
<tr><td>2
F2</td><td>
MUA to MUB-Side Flag
Contains flags configured by the values written to MUA_FCR[Fn], where n = 0 to 2.
Fn is the MUB-side flag configured by the values written to MUA_FCR[Fn].
When MUA_FCR[Fn] is written to, the write event updates MUB_FSR[Fn], after the event update latency.
0b - MUA_FCR[Fn] = 0
1b - MUA_FCR[Fn] = 1
</td></tr>
</table>

Table continues on the next page...

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Field	Function
1 F1	MUA to MUB-Side Flag Contains flags configured by the values written to MUA_FCR[F*n*], where *n* = 0 to 2. F*n* is the MUB-side flag configured by the values written to MUA_FCR[F*n*]. When MUA_FCR[F*n*] is written to, the write event updates MUB_FSR[F*n*], after the event update latency. 0b - MUA_FCR[Fn] = 0 1b - MUA_FCR[Fn] = 1
0 F0	MUA to MUB-Side Flag Contains flags configured by the values written to MUA_FCR[F*n*], where *n* = 0 to 2. F*n* is the MUB-side flag configured by the values written to MUA_FCR[F*n*]. When MUA_FCR[F*n*] is written to, the write event updates MUB_FSR[F*n*], after the event update latency. 0b - MUA_FCR[Fn] = 0 1b - MUA_FCR[Fn] = 1

38.7.2.10 General-Purpose Interrupt Enable (GIER)

Offset

Register	Offset
GIER	110h

Function

Contains the MUB general-purpose interrupt enable fields.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	GIE31	GIE30	GIE29	GIE28	GIE27	GIE26	GIE25	GIE24	GIE23	GIE22	GIE21	GIE20	GIE19	GIE18	GIE17	GIE16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	GIE15	GIE14	GIE13	GIE12	GIE11	GIE10	GIE9	GIE8	GIE7	GIE6	GIE5	GIE4	GIE3	GIE2	GIE1	GIE0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>31
GIE31</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
<tr><td>30
GIE30</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
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0b - Disable
1b - Enable</td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>29
GIE29</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
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0b - Disable
1b - Enable</td></tr>
<tr><td>28
GIE28</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
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0b - Disable
1b - Enable</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>27
GIE27</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>26
GIE26</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>25
GIE25</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>24
GIE24</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>23
GIE23</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>22
GIE22</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>21
GIE21</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>20
GIE20</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>19
GIE19</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>18
GIE18</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>17
GIE17</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
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<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
<tr><td>16
GIE16</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>15
GIE15</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>14
GIE14</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>13
GIE13</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>12
GIE12</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
</table>

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Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>11
GIE11</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>10
GIE10</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>9
GIE9</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
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0b - Disable
1b - Enable</td></tr>
<tr><td>8
GIE8</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
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0b - Disable
1b - Enable</td></tr>
</table>

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Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>7
GIE7</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
<tr><td>6
GIE6</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>5
GIE5</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
<tr><td>4
GIE4</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>3
GIE3</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
<tr><td>2
GIE2</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>
0b - Disable
1b - Enable</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>1
GIE1</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There are 32 general-purpose interrupts (n = 0 to 31).
When GIEn = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIPn] = 1.
If GIEn = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIEn becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GIER</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GIER</td></tr></table>0b - Disable
1b - Enable</td></tr>
<tr><td>0
GIE0</td><td>MUB General-purpose Interrupt Enable
Enables general-purpose interrupt. There is one general-purpose interrupt (n = 0).
When GIE0 = 1, a general-purpose interrupt n request is issued to processor B when MUB GSR[GIP0] = 1.
If GIE0 = 0, the general-purpose interrupt request pending does not trigger the general-purpose interrupt.
GIE0 becomes 0 when MU resets.
0b - Disable
1b - Enable</td></tr>
</table>

38.7.2.11 General-Purpose Control (GCR)

Offset

Register	Offset
GCR	114h

Function
Contains the MUB general-purpose interrupt request fields.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	GIR31	GIR30	GIR29	GIR28	GIR27	GIR26	GIR25	GIR24	GIR23	GIR22	GIR21	GIR20	GIR19	GIR18	GIR17	GIR16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	GIR15	GIR14	GIR13	GIR12	GIR11	GIR10	GIR9	GIR8	GIR7	GIR6	GIR5	GIR4	GIR3	GIR2	GIR1	GIR0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>31
GIR31</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested</td></tr>
<tr><td>30
GIR30</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.</td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>
0b - Not requested
1b - Requested</td></tr>
<tr><td>29
GIR29</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table></td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Not requested
1b - Requested</td></tr>
<tr><td>28
GIR28</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>0b - Not requested
1b - Requested</td></tr>
<tr><td>27
GIR27</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>26
GIR26</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>25
GIR25</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>
0b - Not requested
1b - Requested</td></tr>
<tr><td>24
GIR24</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table></td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Not requested
1b - Requested</td></tr>
<tr><td>23
GIR23</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>0b - Not requested
1b - Requested</td></tr>
<tr><td>22
GIR22</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function

Instance	Field supported in	Field not supported in
MU_0.MUB	GCR	—
MU_1.MUB	GCR	—
MU_2.MUB	—	GCR

0b - Not requested

1b - Requested

21

GIR21

MUB General-Purpose Interrupt Request

Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (*n* = 0 to 31).

Writing 1 to GIR*n* sets MUA_GSR[GIP*n*]. If MUA_GIER[GIE*n*] = 1, a general-purpose interrupt request is triggered on processor A.

This field becomes 0 when MUA_GSR[GIP*n*] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).

To ensure proper operations, verify that GIR*n* is 0 (no pending interrupt) before writing 1 to it.

This field becomes 0 when MU resets.

NOTE

This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
MU_0.MUB	GCR	—
MU_1.MUB	GCR	—
MU_2.MUB	—	GCR

0b - Not requested

1b - Requested

20

GIR20

MUB General-Purpose Interrupt Request

Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (*n* = 0 to 31).

Writing 1 to GIR*n* sets MUA_GSR[GIP*n*]. If MUA_GIER[GIE*n*] = 1, a general-purpose interrupt request is triggered on processor A.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>
0b - Not requested
1b - Requested</td></tr>
<tr><td>19
GIR19</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table></td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Not requested
1b - Requested</td></tr>
<tr><td>18
GIR18</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>0b - Not requested
1b - Requested</td></tr>
<tr><td>17
GIR17</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>16
GIR16</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>15
GIR15</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>
0b - Not requested
1b - Requested</td></tr>
<tr><td>14
GIR14</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table></td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Not requested
1b - Requested</td></tr>
<tr><td>13
GIR13</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>0b - Not requested
1b - Requested</td></tr>
<tr><td>12
GIR12</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function

Instance	Field supported in	Field not supported in
MU_0.MUB	GCR	—
MU_1.MUB	GCR	—
MU_2.MUB	—	GCR

0b - Not requested

1b - Requested

11

GIR11

MUB General-Purpose Interrupt Request

Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (*n* = 0 to 31).

Writing 1 to GIR*n* sets MUA_GSR[GIP*n*]. If MUA_GIER[GIE*n*] = 1, a general-purpose interrupt request is triggered on processor A.

This field becomes 0 when MUA_GSR[GIP*n*] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).

To ensure proper operations, verify that GIR*n* is 0 (no pending interrupt) before writing 1 to it.

This field becomes 0 when MU resets.

NOTE

This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
MU_0.MUB	GCR	—
MU_1.MUB	GCR	—
MU_2.MUB	—	GCR

0b - Not requested

1b - Requested

10

GIR10

MUB General-Purpose Interrupt Request

Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (*n* = 0 to 31).

Writing 1 to GIR*n* sets MUA_GSR[GIP*n*]. If MUA_GIER[GIE*n*] = 1, a general-purpose interrupt request is triggered on processor A.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>
0b - Not requested
1b - Requested</td></tr>
<tr><td>9
GIR9</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table></td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Not requested
1b - Requested</td></tr>
<tr><td>8
GIR8</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>0b - Not requested
1b - Requested</td></tr>
<tr><td>7
GIR7</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>6
GIR6</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>5
GIR5</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>
0b - Not requested
1b - Requested</td></tr>
<tr><td>4
GIR4</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table></td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Not requested
1b - Requested</td></tr>
<tr><td>3
GIR3</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr></table>0b - Not requested
1b - Requested</td></tr>
<tr><td>2
GIR2</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>1
GIR1</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There are 32 general-purpose interrupts (n = 0 to 31).
Writing 1 to GIRn sets MUA_GSR[GIPn]. If MUA_GIER[GIEn] = 1, a general-purpose interrupt request is triggered on processor A.
This field becomes 0 when MUA_GSR[GIPn] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software).
To ensure proper operations, verify that GIRn is 0 (no pending interrupt) before writing 1 to it.
This field becomes 0 when MU resets.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GCR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GCR</td></tr>
</table>
0b - Not requested
1b - Requested
</td></tr>
<tr><td>0
GIR0</td><td>MUB General-Purpose Interrupt Request
Specifies whether general-purpose interrupts are requested to MUA. There is one general-purpose interrupt (n = 0).
Writing 1 to GIR0 sets MUA_GSR[GIP0]. If MUA_GIER[GIE0] = 1, a general-purpose interrupt request is triggered on processor A.</td></tr>
</table>

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Field	Function
	This field becomes 0 when MUA_GSR[GIP0] is cleared. This clearing informs MUB that the interrupt is accepted (cleared by software). To ensure proper operations, verify that GIR0 is 0 (no pending interrupt) before writing 1 to it. This field becomes 0 when MU resets. 0b - Not requested 1b - Requested

38.7.2.12 General-purpose Status (GSR)

Offset

Register	Offset
GSR	118h

Function

Contains the status of the MUB general-purpose interrupt pending requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	GIP31	GIP30	GIP29	GIP28	GIP27	GIP26	GIP25	GIP24	GIP23	GIP22	GIP21	GIP20	GIP19	GIP18	GIP17	GIP16
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	GIP15	GIP14	GIP13	GIP12	GIP11	GIP10	GIP9	GIP8	GIP7	GIP6	GIP5	GIP4	GIP3	GIP2	GIP1	GIP0
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 GIP31	MUB General-Purpose Interrupt Request Pending Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (*n* = 0 to 31). GIP*n* informs MUB that MUA_GCR[GIR*n*] changed from 0 to 1. If MUB_GIER[GIE*n*] = 1, a general-purpose interrupt request is issued to processor B. GIP*n* is cleared when MU resets.

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>

NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>30
GIP30</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
</table>
</td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>29
GIP29</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>28
GIP28</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr></table>
NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>27
GIP27</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>26
GIP26</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

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Field	Function

Instance	Field supported in	Field not supported in
MU_0.MUB	GSR	—
MU_1.MUB	GSR	—
MU_2.MUB	—	GSR

NOTE

This field behaves differently for register reads and writes.

When reading

0b - Not pending

1b - Pending

When writing

0b - No effect

1b - Clear the flag

25

GIP25

MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (*n* = 0 to 31).

GIP*n* informs MUB that MUA_GCR[GIR*n*] changed from 0 to 1. If MUB_GIER[GIE*n*] = 1, a general-purpose interrupt request is issued to processor B.

GIP*n* is cleared when MU resets.

After GIP*n* is cleared, if MUB_GIER[GIE*n*] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE

This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
MU_0.MUB	GSR	—
MU_1.MUB	GSR	—
MU_2.MUB	—	GSR

NOTE

This field behaves differently for register reads and writes.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>24
GIP24</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr></table>
NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>23
GIP23</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>22
GIP22</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>21
GIP21</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>20
GIP20</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr></table>
NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>19
GIP19</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>18
GIP18</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>17
GIP17</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.</td></tr>
</table>

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Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>16
GIP16</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr></table>
NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>15
GIP15</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>14
GIP14</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>13
GIP13</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>12
GIP12</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr></table>
NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>11
GIP11</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

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<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>10
GIP10</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
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<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>9
GIP9</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>8
GIP8</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
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NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>7
GIP7</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>6
GIP6</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>5
GIP5</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>4
GIP4</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).
GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.
GIPn is cleared when MU resets.
After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr><tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr></table>
NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>3
GIP3</td><td>MUB General-Purpose Interrupt Request Pending
Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.

<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>MU_0.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_1.MUB</td><td>GSR</td><td>—</td></tr>
<tr><td>MU_2.MUB</td><td>—</td><td>GSR</td></tr>
</table>
NOTE
This field behaves differently for register reads and writes.

When reading
0b - Not pending
1b - Pending
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>2
GIP2</td><td>MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (n = 0 to 31).

GIPn informs MUB that MUA_GCR[GIRn] changed from 0 to 1. If MUB_GIER[GIEn] = 1, a general-purpose interrupt request is issued to processor B.

GIPn is cleared when MU resets.

After GIPn is cleared, if MUB_GIER[GIEn] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function

Instance	Field supported in	Field not supported in
MU_0.MUB	GSR	—
MU_1.MUB	GSR	—
MU_2.MUB	—	GSR

NOTE

This field behaves differently for register reads and writes.

When reading

0b - Not pending

1b - Pending

When writing

0b - No effect

1b - Clear the flag

1

GIP1

MUB General-Purpose Interrupt Request Pending

Indicates whether a general-purpose interrupt request is pending. There are 32 general-purpose interrupts (*n* = 0 to 31).

GIP*n* informs MUB that MUA_GCR[GIR*n*] changed from 0 to 1. If MUB_GIER[GIE*n*] = 1, a general-purpose interrupt request is issued to processor B.

GIP*n* is cleared when MU resets.

After GIP*n* is cleared, if MUB_GIER[GIE*n*] = 1, the general-purpose interrupt request is cleared on the MUB side.

NOTE

This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
MU_0.MUB	GSR	—
MU_1.MUB	GSR	—
MU_2.MUB	—	GSR

NOTE

This field behaves differently for register reads and writes.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When reading 0b - Not pending 1b - Pending When writing 0b - No effect 1b - Clear the flag
0 GIP0	MUB General-Purpose Interrupt Request Pending Indicates whether a general-purpose interrupt request is pending. There is one general-purpose interrupt (*n* = 0). GIP0 informs MUB that MUA_GCR[GIR0] changed from 0 to 1. If MUB_GIER[GIE0] = 1, a general-purpose interrupt request is issued to processor B. GIP0 is cleared when MU resets. After GIP0 is cleared, if MUB_GIER[GIE0] = 1, the general-purpose interrupt request is cleared on the MUB side. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not pending 1b - Pending When writing 0b - No effect 1b - Clear the flag

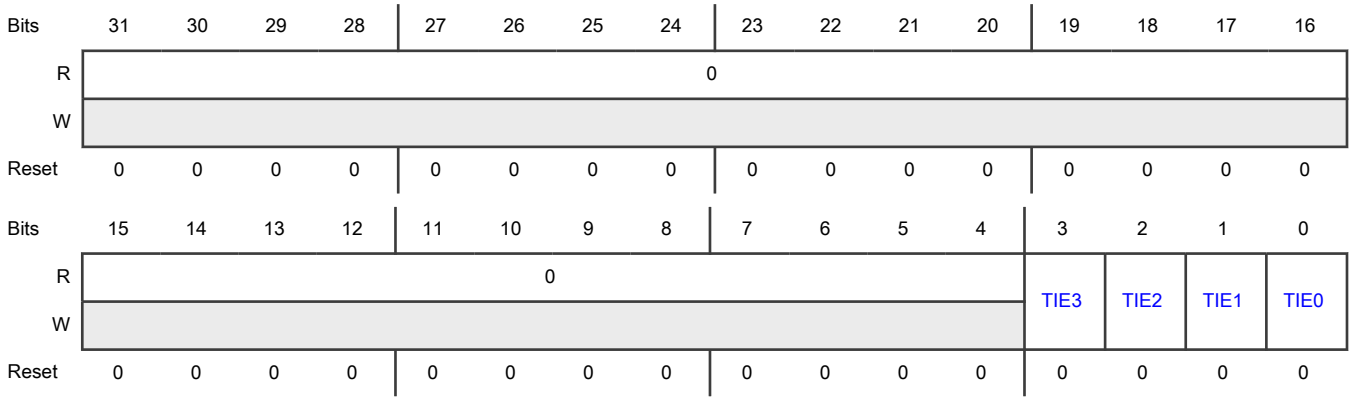
38.7.2.13 Transmit Control (TCR)

Offset

Register	Offset
TCR	120h

Function
Contains the MUB transmit interrupt enable fields.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 TIEn	MUB Transmit Interrupt Enable Enables MUB transmit interrupt *n*, where *n* = 0 to 3. If this field is 1, an MUB transmit interrupt *n* request is issued when MUB_TSR[TE*n*] is set. If this field is 0, MU ignores the value of MUB_TSR[TE*n*], and no MUB transmit interrupt *n* request is issued. 0b - Disable 1b - Enable

38.7.2.14 Transmit Status (TSR)

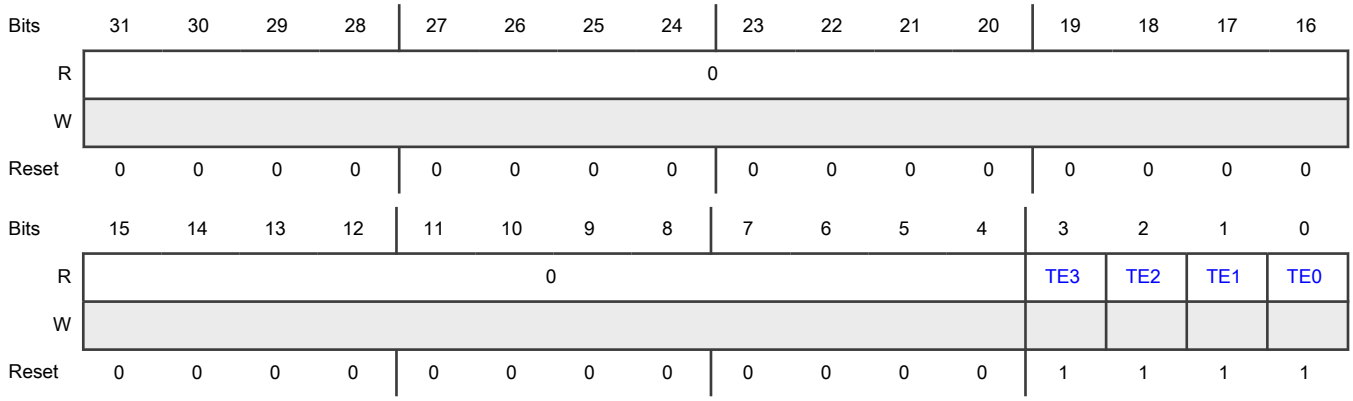
Offset

Register	Offset
TSR	124h

Function

Indicates whether the MUB transmit registers are empty.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 TEn	MUB Transmit Empty Indicates whether MUB Transmit (TR*n*) register is empty, where *n* = 0 to 3. This field becomes 1 after the MUA_RR*n* register is read on the MUA side. When TE*n* = 1, it indicates to the MUB side that the MUB_TR*n* register is ready to be written on the MUB side. If MUB_TCR[TIE*n*] = 1, a transmit *n* interrupt is issued on the MUB side. This field becomes 0 after the MUB_TR*n* register is written to on the MUB side. After this field becomes 0, if MUB_TCR[TIE*n*] = 1, the transmit *n* interrupt request is cleared on the MUB side. This field becomes 1 when MU resets. 0b - Not empty 1b - Empty

38.7.2.15 Receive Control (RCR)

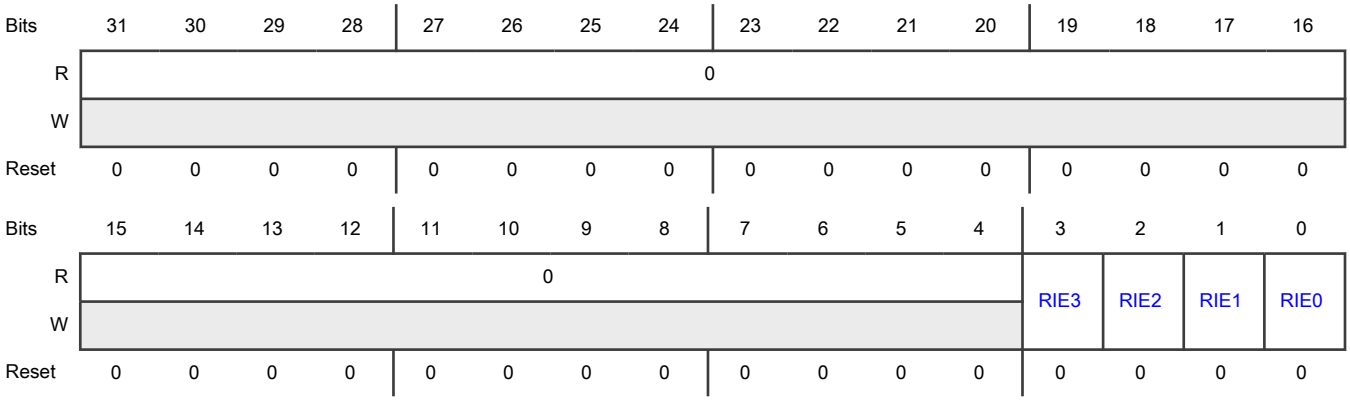
Offset

Register	Offset
RCR	128h

Function

Contains the MUB receive interrupt enables.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 RIEn	MUB Receive Interrupt Enable Enables MUB receive interrupt *n*, where *n* = 0 to 3. If this field is 1, an MUB receive interrupt *n* request is issued when MUB_RSR[RF*n*] is set. If this field is 0, MU ignores the value of MUB_RSR[RF*n*], and no MUB receive interrupt request is issued. 0b - Disable 1b - Enable

38.7.2.16 Receive Status (RSR)

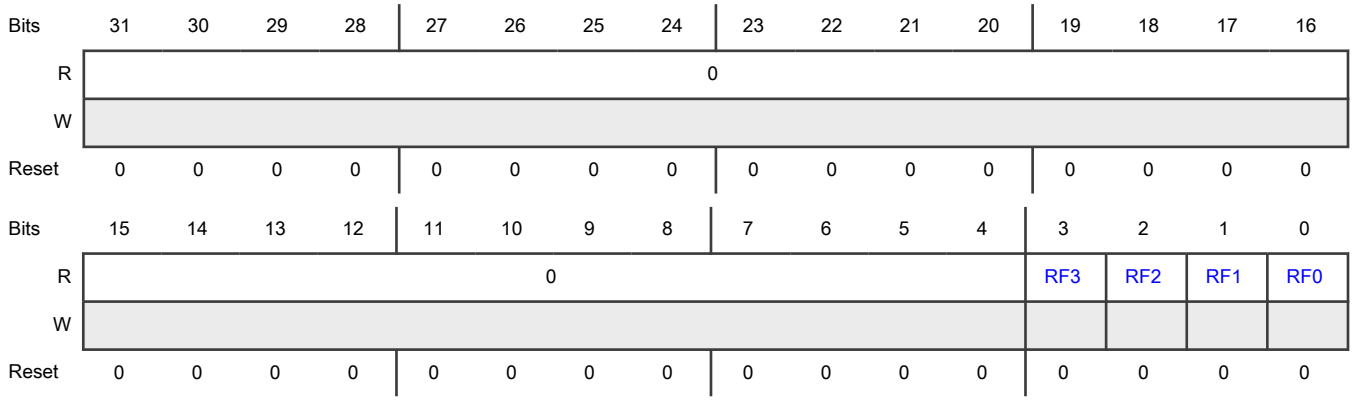
Offset

Register	Offset
RSR	12Ch

Function

Indicates whether the MUB receive registers are full.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 RFn	MUB Receive Register Full Indicates whether MUB Receive register (RR*n*) is full, where *n* = 0 to 3. RF*n* becomes 1 when the MUA_TR*n* register is written to on the MUA side. When RF*n* is 1, it indicates to the MUB side that new data in the MUB_RR*n* register is ready for MUB to read it. If MUB_RCR[RIE*n*] = 1, a receive *n* interrupt is issued on the MUB side. RF*n* becomes 0 when the MUB_RR*n* register is read, or when MU is reset. After RF*n* becomes 0, if MUB_RCR[RIE*n*] = 1, the receive *n* interrupt request is cleared on the MUB side. 0b - Not full 1b - Full

38.7.2.17 Transmit (TR0 - TR3)

Offset

Register	Offset
TR0	200h
TR1	204h
TR2	208h
TR3	20Ch

Function

Contains MUB transmit data.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W	TR_DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W	TR_DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TR_DATA	MUB Transmit Data Contains MUB transmit data. MUA_RR*n* reflects the data written to this register. The TR*n* and RR*n* registers are not double-buffered. Writing to MUB_TR*n* overrides the data readable in the MUA_RR*n* register. A write to the Transmit register clears MUB_TSR[TE*n*] on the transmitter side, and sets MUA_RSR[RF*n*] on the receiver side. You can write to this register only when MUB_TSR[TE*n*] = 1. Reading this register returns all zeroes.

38.7.2.18 Receive (RR0 - RR3)

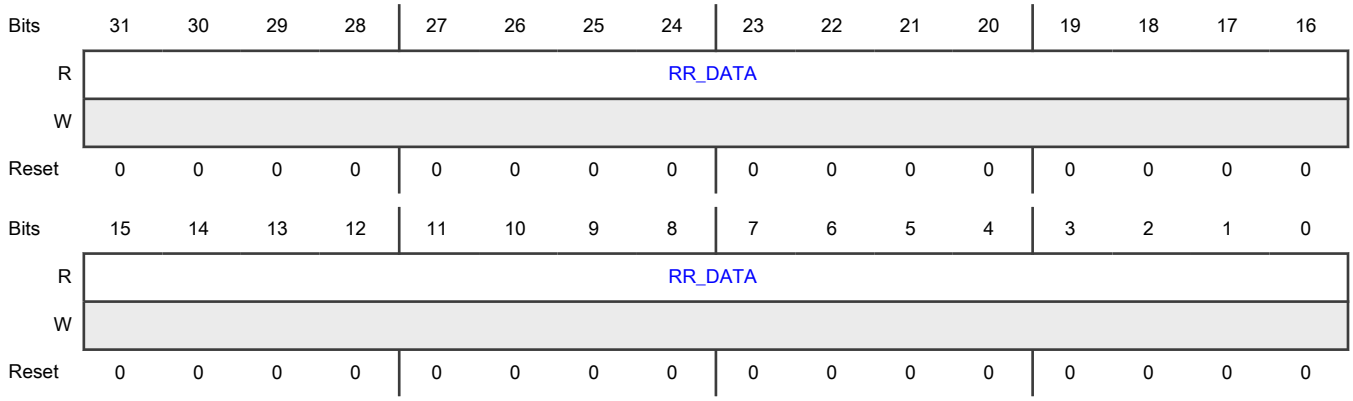
Offset

Register	Offset
RR0	280h
RR1	284h
RR2	288h
RR3	28Ch

Function

Contains MUB receive data.

Diagram



Fields

Field	Function
31-0 RR_DATA	MUB Receive Data Reflects the data written to MUA TR*n*. Reading this register clears MUB_RSR[RF*n*] on the receiver side, and sets MUA_TSR[TE*n*] on the transmitter side. You can read this register only when MUB_RSR[RF*n*] = 1. Reading it before MUB_RSR[RF*n*] becomes 1 may result in reading incorrect data. Poll MUB_RSR[RF*n*] to confirm it is set before reading RR*n*. Writing to this register generates an error response to MUB.

38.8 Glossary

EP	Event Pending
GIR	General-purpose Interrupt Request
GIP	General-purpose Interrupt Pending
MUR	Messaging Unit Reset
RF	Receiver Full
RFP	Receive Full Pending
TE	Transmitter Empty
TEP	Transmit Empty Pending
MUA	Messaging Unit A
MUB	Messaging Unit B

Chapter 39
Power Management

39.1 Overview

The power management system monitors and controls power supplies and related resets. This chapter describes the system's interaction with other peripherals.

The power management system includes the modules listed below.

Table 195. Power management system modules and functions

Module	Function
MC_ME	Initiates entry into Low-Power mode
MC_PCU	Controls entry into and exit from Low-Power mode
PMC	Regulates and monitors power supplies of the Run and the Standby domains
MC_RGM	Ensures a clean state and correct Run domain functionality by controlling the reset sequence
FIRC, WKPU, and other chip peripherals	Controls Standby mode wake-up and operations in Run and Standby modes

39.1.1 Block diagram

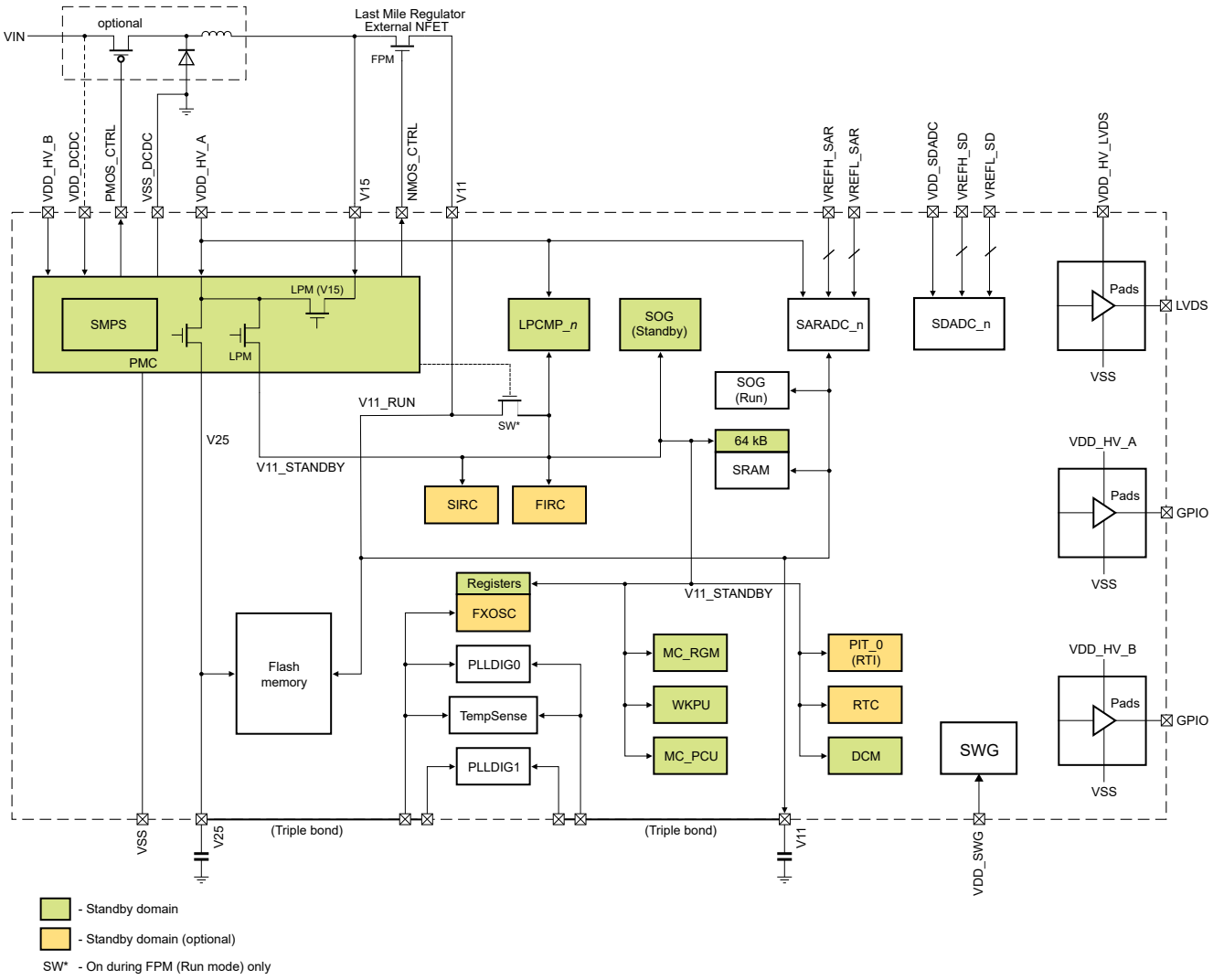


Figure 155. Block diagram

39.1.2 Features

- Supports a low-power regulator (LPM) that supplies core logic during Standby mode (V11_STANDBY)
- PMC maintains 1.4–1.5 V output voltage when using the DC-to-DC buck converter stage
- Chip controls an external NMOS transistor, and uses V15 generated from SMPS as input to generate V11 for a load current up to 1.5 A (disabled in Standby mode)
- Includes Last-mile (FPM) regulator for driving logic in Run mode.
- Supports power switches that isolate voltage islands and configure the chip in Standby mode
- Includes a linear regulator that generates a 2.5 V supply (V25) from VDD_HV_A
- Supports voltage monitors ensuring transitions to a safe state (POR) when a supply is out of the valid range
- Controls power-mode transitions through an interaction with the digital interface
- Provides a pad-keeping feature that retains the I/O configuration after exiting Standby mode

- Separates ADC reference supplies (VREFH and VREFL)

39.1.3 Operational power modes

This chip has two power modes:

- Run mode (FPM): Main operation mode with full-chip performance and a higher current consumption than Standby mode.
- Standby mode (LPM): Low-power mode of the chip in which the Run domain is switched off. Most of the cores and peripherals are off in this mode.
  - We have two option of the standby mode (configured by the DCMRWF1[PMIC_PGOOD_HNDSHK_BYP]):
    - Standalone (Only the MCU is going into the standby mode)
    - PMIC handshake (Together with the MCU, the PMIC device are going to standby mode), selected by default.

39.1.4 Regulator

The LPM regulator manages the chip in Standby mode.

39.1.5 Requirement

Separate VREFH and VREFL supplies are required for SD-ADC operation. The SD_ADC power supply is isolated at the die level and must be shorted with VDD_HV_A at PCB level.

39.1.6 External 1.5 V source

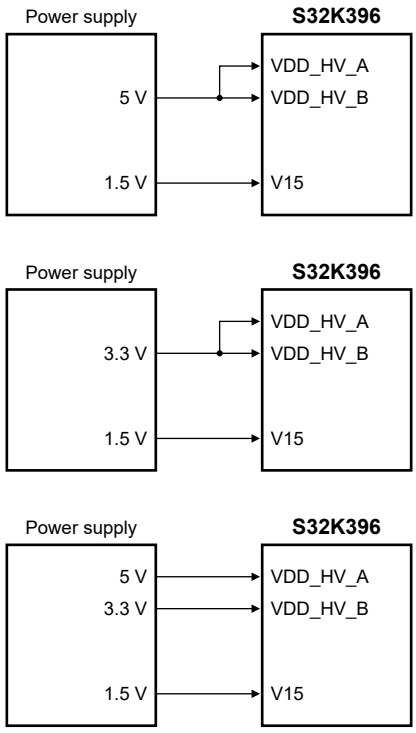


Figure 156. External 1.5 V source

39.2 Power-up sequence

Figure 157 shows the reset sequence for a power-up or Standby mode event. This sequence starts from the POR phase. For the Run domain logic, Standby mode exit operation is the same for power-up.

See the Reset Overview chapter for more information about the chip reset sequence.

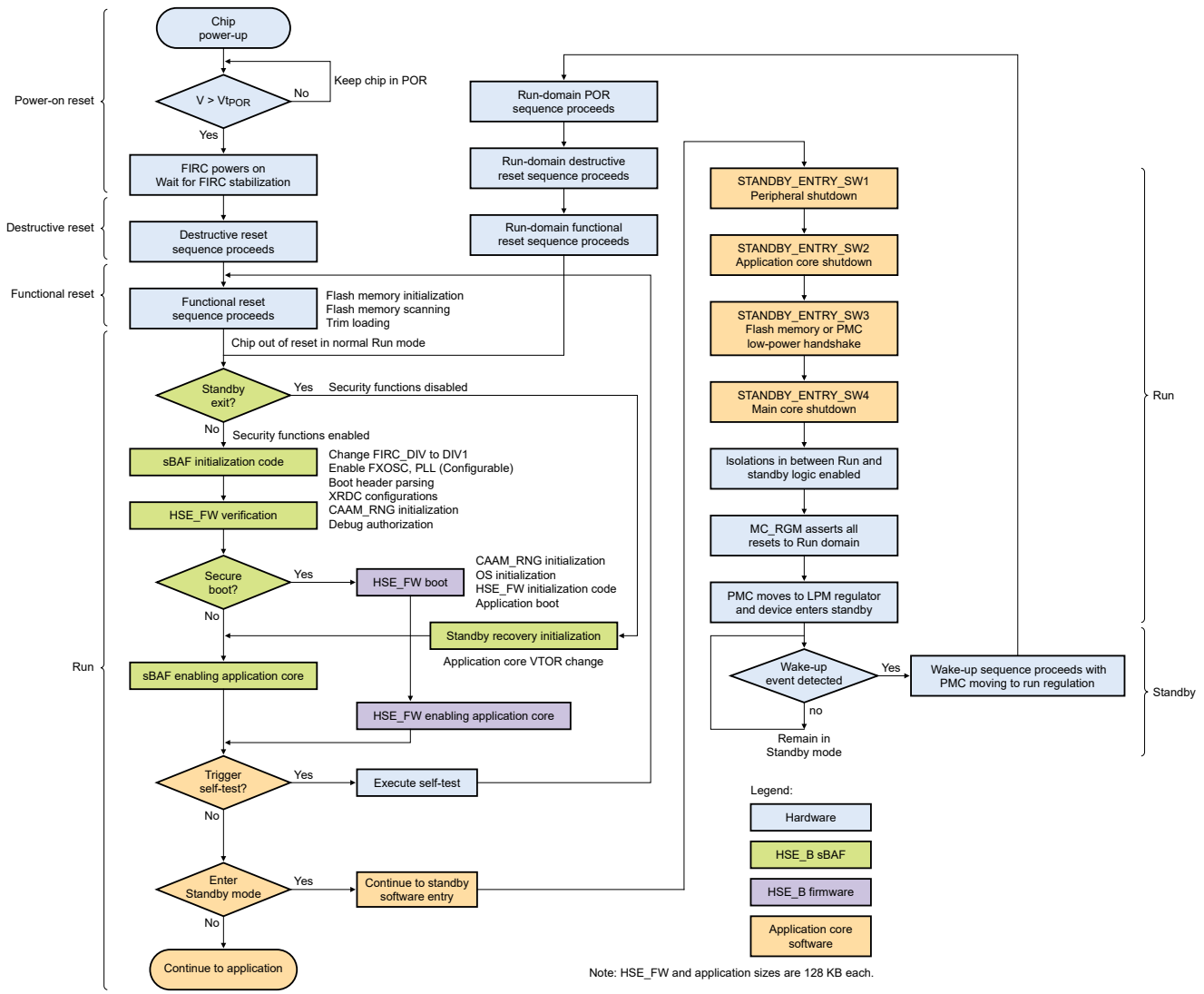


Figure 157. Power-up sequence

39.3 Supplies exposed to ADC0

- Bandgap voltage
- Chip temperature sensor
- VDD_HV_A (2.97–5.5 V) divided by two
- VDD_HV_B (2.97–5.5 V) divided by two to ensure that the supply limits are not exceeded during rising or falling
- V15 divided by two
- VDD_HV_OSC (~2.5 V)
- VDD_LV_hot (~1.1 V)
- VDD_LV_cold (~1.1 V))
- VDD_LV_OSC (~1.1 V)

- VDD_LV_PD0 (~1.1 V)
- VSS

39.4 Supplies Exposed to ADC1

- VDD1P1_PLL2 (~1.1 V)
- VDD2P5_PLL2 (~2.5 V)
- VDD33_LVDS (~3.3 V)

39.5 Standby mode entry sequence

The Standby mode entry sequence consists of three phases:

- Standby mode entry configuration phase or software Standby mode entry sequence
- Standby mode entry handshake phase or hardware Standby mode entry sequence
- Standby mode entry or PMC Standby mode entry

NOTE

The Standby mode entry sequence described in this section is the only supported sequence. Contact NXP support if you require an alternate Standby mode entry sequence.

NOTE

After triggering Standby Entry from Application, If Reset is asserted before Standby entry then reset can be issued to system, which will be visible at RESET_B pad.

39.5.1 Software Standby mode entry sequence

The Standby mode entry sequence includes chip configuration as described in the following sections.

Before entering the software Standby mode sequence, the system clock source must be changed to FIRC. This is done because PLLDIG is not available in Standby mode. In Standby mode, all clock sources can be optionally disabled (including FIRC, which results in a no-clock, low-power consumption mode). You could also use FXOSC, if enabled, when the 2.5 V supply is available by appropriate configuration of PMC.CONFIG[LPM25EN].

NOTE

You also need to configure DCMRWF1[PMIC_PGOOD_HNDSHK_BYP] bit as per your requirement.

The software Standby mode entry sequence consists of four steps:

1. SW1: Module shutdown process
2. SW2: Application core shutdown process
3. SW3: Flash memory low-power handshake
4. SW4: Main core shutdown process

The following sections describe each step. See Figure 157 for the relationship between these four steps in a flow diagram.

39.5.1.1 SW1: Module shutdown process

I/O and module configuration for Standby mode discusses the procedure to configure I/O and the chip modules for Standby mode.

The entry sequence for this mode includes module clock-disabling steps (see the "Clocking" chapter for module clock turn-on and turn-off processes). You must use MC_ME.PRTN*n*_COFB*m*_CLKEN[REQ*p*] fields to enable or disable module clocks.

39.5.1.1.1 Disabling modules

Disable modules by configuring the appropriate fields in their registers for Standby mode operation. See specific module chapters for more information.

The Standby mode entry sequence includes the module clock-disabling step, with which you can disable the modules that you do not need for Standby mode operation.

The sequence of disabling modules is shown in I/O and module configuration for Standby mode.

NOTE

- While enabling or disabling modules, you must verify that the module is disabled when you read MC_ME.PRTN*n*_COFB*m*_STAT register and the module disable field, if applicable. In there is a discrepancy, you must perform proper diagnostic steps.
- You must clear the I/O controls for the pads that you do not require in Standby mode (OBE, IBE, and so on). This avoids any unwanted pad-keeping settings. See Pad-keeping for more information on the chip pad-keeping process.
- For any standby wake source, if an interrupt occurs it must be disabled before entering Standby mode. Only the wake-up event of that source must be enabled. This action avoids any software conflict in the interrupt handling for multi-application core cases.

The MC_ME.PRTN*n*_COFB*m*_STAT register indicates the status of peripheral clock enable or disable. It may take up to three clock cycles for MC_ME.PRTN*n*_COFB*m*_STAT register to update after MC_ME.PRTN*n*_COFB*m*_CLKEN register is updated.

39.5.1.1.2 I/O and module configuration for Standby mode

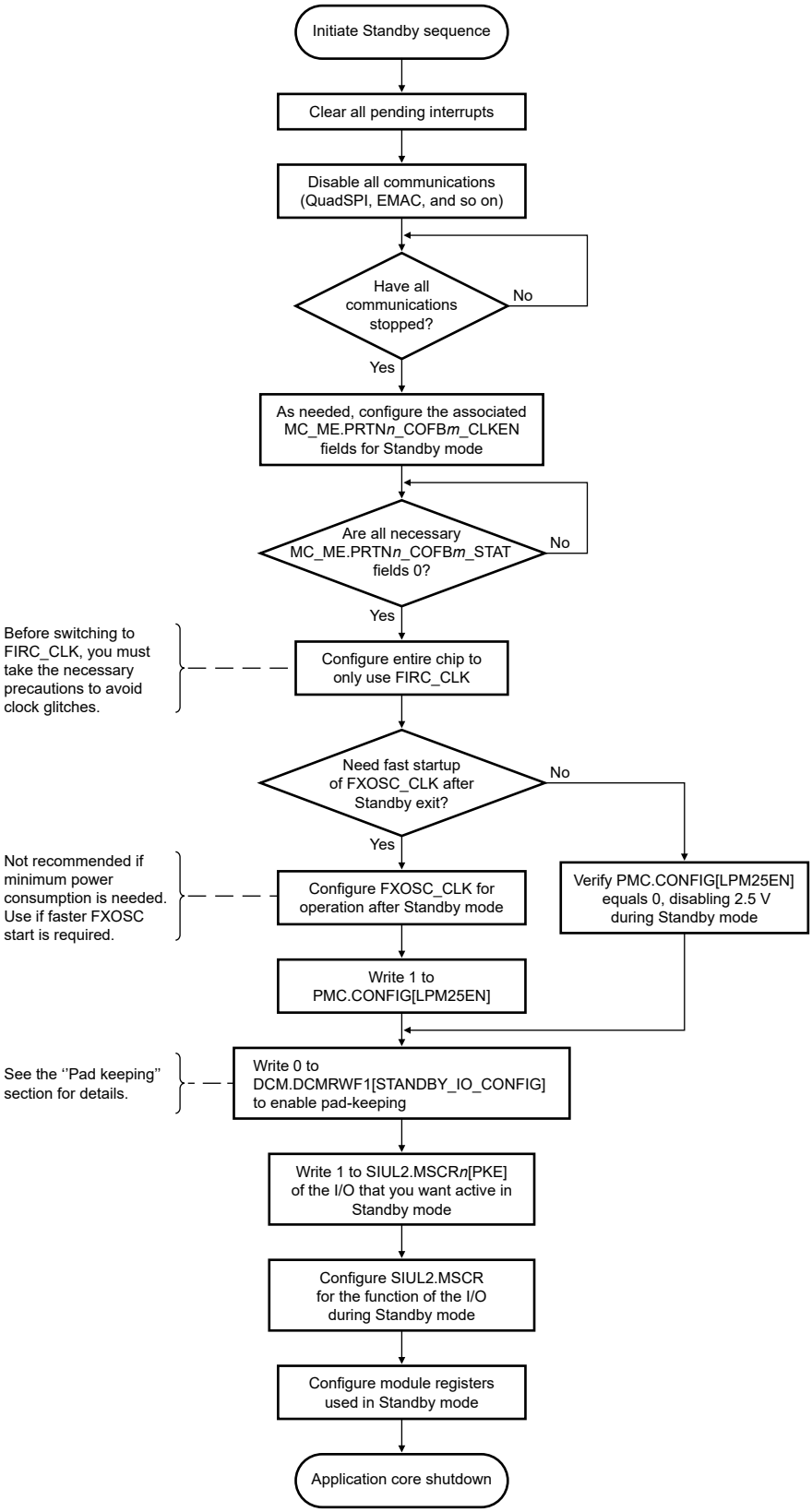


Figure 158. I/O and module configuration for Standby mode

39.5.1.2 SW2: Application core shutdown process

The application cores(s) execute a WFI (as opposed to the main core running the Standby mode entry sequence). See the section "Application core shutdown" in the MC_ME chapter for more information.

The main core configuration (programming valid core ID and enabling standby entry process) and the wake-up source configuration must also be set in SW2, so that SW4 contains only the main core WFI execution.

39.5.1.3 SW3: Flash memory low-power handshake

In this process, you execute a flash memory low-power handshake by executing the procedures indicated in Figure 159.

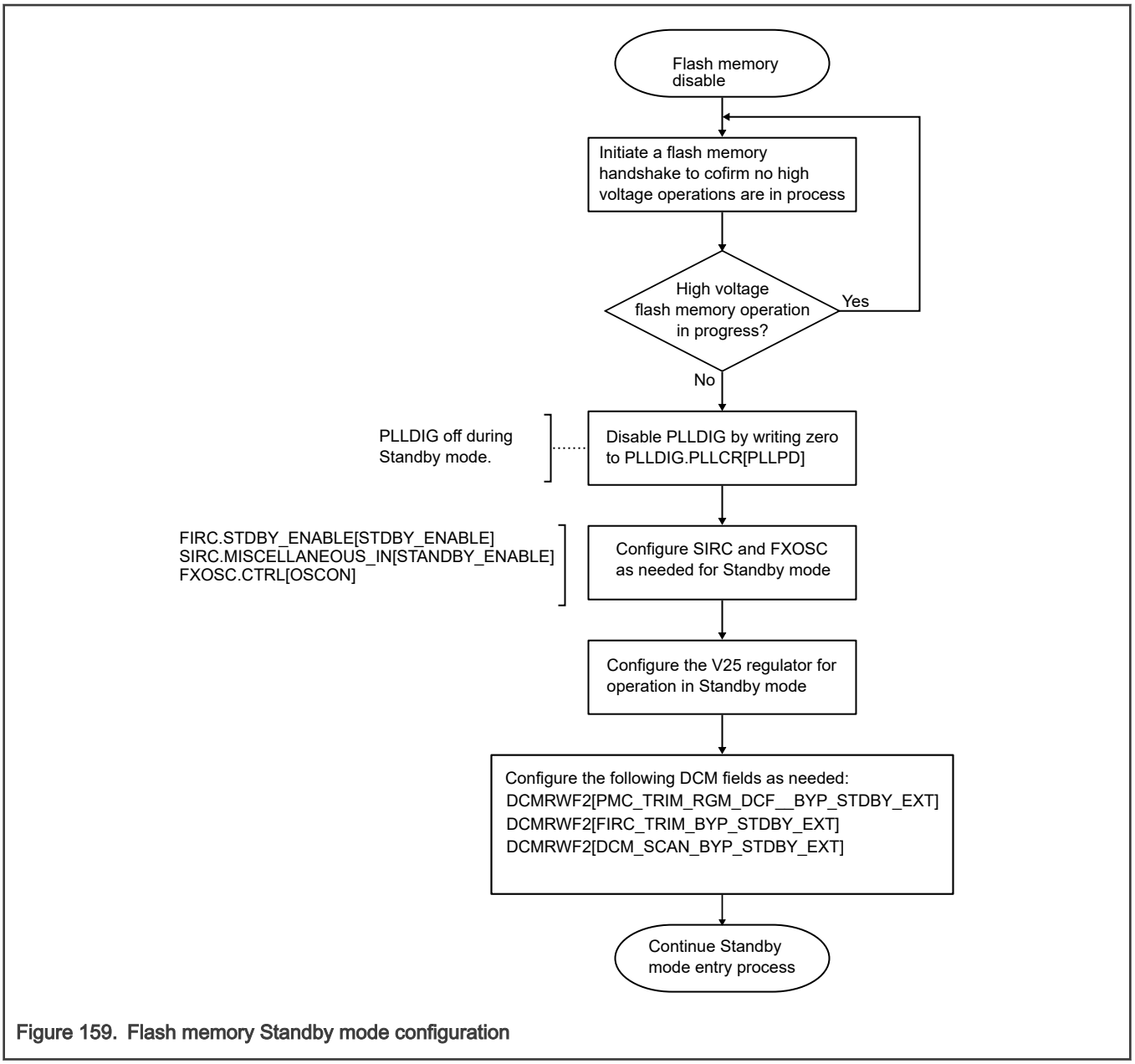


Figure 159. Flash memory Standby mode configuration

39.5.1.4 SW4: Main core shutdown process

For information on this process, see the following portions of the "Mode Entry Module (MC_ME)" chapter:

- Figure "Standby entry sequence along with main core shutdown"

- Section "Main core shutdown and Standby mode entry"

You must configure WKPU before disabling interrupts to avoid missing any events, as shown in the Standby entry sequence along with main core shutdown flowchart in the MC_ME chapter. You must program WKPU, disable interrupts, and configure MC_ME's Standby mode entry in SW1 (see SW1: Module shutdown process for more information). In SW4, you must perform only the main-core WFI execution.

39.5.2 Hardware Standby mode entry sequence

The hardware Standby mode entry sequence consists of the handshaking between MC_PCU and MC_ME occurring after Software Standby mode entry sequence completes. The FSM in MC_PCU performs these steps automatically and does not require your intervention (see Power sequence FSM in the Power Control Unit (MC_PCU) chapter for more information).

When PMIC handshake Standby mode is selected, the PGOOD, EXTWAKE, and RESET_B need to be connected to the PMIC (See PMIC Handshake with MCU for more information).

39.5.2.1 PMC Standby mode entry

The PMC Standby mode entry sequence starts after Hardware Standby mode entry sequence completes, and consists of MC_PCU automatically performing the following steps after receiving a Standby mode entry request:

1. Acknowledge the request and initiate an internal low-power process.
2. Disable the V25 regulator and the FPM LVR monitors.
3. Disable the V25 regulator (oscillator and flash memory supply) and the LPM monitor, unless it is enabled during Standby mode (see PMC.CONFIG[LPM25EN] in the "Power management controller (PMC)" chapter for more information).
4. Disable the VDD_HV_B LPM monitors.

39.6 Chip status at the end of Standby mode entry sequence

After PMC Standby mode entry completes, then the chip completes Standby mode entry as follows:

1. Configures Standby domain peripherals according to SW1 (see SW1: Module shutdown process).
2. Enables pad-keeping on pins as described in SW1 (see SW1: Module shutdown process). See Pad-keeping for other details.
3. Powers down all memory types except Standby RAM (in SRAM0).
   - The V25 regulator can remain on during Standby mode. However, for maximum power savings, it must remain off in this mode.
4. Isolates Standby and Run domains from each other:
   - Standby domain is functional.
   - Run domain is held in reset.
5. Configures the system clock (FIRC_CLK or PLL_PHI*n*_CLK, depending on their configuration) and other clock sources according to SW3 (see Figure 159 for the procedure details).

   The cores are now off and in the Standby domain.
6. Turns off the FPM regulator.
7. Waits for a wake-up event to initiate recovery from Standby mode.

39.7 Chip operation in Standby mode

This chip supports the following functionalities in Standby mode:

- STANDBY_RAM content retention during Standby mode.

- Wake-up from up to 60 digital inputs (for details, see the signals WKUP[*n*] functions of WKPU module in the IOMUX file attached to this document). The section WKPU configuration on the chip in the "Wakeup Unit (WKPU)" chapter shows mapping of the wake-up sources.
- Wake-up from up to 16 analog inputs through the Trigger mode functionality (see the signals LPCMP*n*_IN*m* functions of LPCMP*n* modules in the IOMUX file attached to this document).
- Wake-up from on-chip timers:
  - RTI (function of PIT[0])
  - SWT0
  - RTC
- Ability to configure the chip clocking modules to optionally enable or disable in Standby mode (FIRC and SIRC).

39.8 Standby mode exit

This chip supports Standby mode exit from any of these events:

- Wake-up
- Functional reset
- Destructive reset

The sources that cause chip Standby mode exit are:

- MC_RGM functional reset event
- MC_RGM destructive reset event
- WKPU wake-up events, WKPU[0]–WKPU[63] (see the WKPU chapter for more information)

After Standby mode exit, the following events occur (for more information, see "Power sequence FSM" in the MC_PCU chapter for MC_PCU FSM transitions during entry into and exit from Standby mode):

1. A wake-up event arrives.
2. If PMIC handshake is enabled (default enabled), see PMIC Handshake with MCU for additional hardware sequence.
3. FIRC begins powering up (if disabled in Standby mode).
4. PMC begins the transition process to FPM
5. MC_PCU removes the isolation between Run and Standby domains.
6. Run domain reset deasserts (asserts on Standby mode entry) and the chip undergoes a functional reset exit sequence for this domain.
7. The chip enters Run mode of operation.

39.8.1 Faster Standby mode exit

This chip supports an optional feature for the Standby mode exit sequence that bypasses:

- FIRC trimming
- PMC trimming
- DCM scanning

To use the bypass operation, write 1 to DCM.DCMRWF2[5], DCM.DCMRWF2[4], and DCM.DCMRWF2[3] respectively before Standby mode entry. This results in a considerable reduction in Standby mode exit duration. The trim values are retained across Standby mode and bypassing these values does not cause any impact.

39.9 PMIC Handshake with MCU

For interfacing with PMIC where handshake is required, MCU will follow a sequence to come out of standby. This handshake will make sure that power supply to the MCU is in proper condition.

3 GPIOs will be used to perform this handshake as shown in below figure.

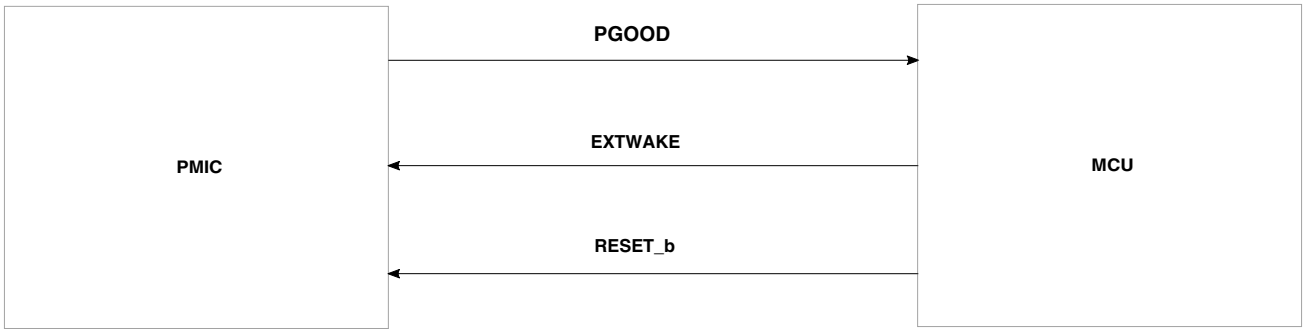


Figure 160. PMIC Handshake with MCU

MCU will assert EXTWAKE signal on receiving a wakeup request from any of the available wakeup sources. If the EXTWAKE signal is enabled via the MSCR configuration (see S32K39_and_S32K37_IOMUX file attached to this document), this wakeup will be triggered to the external PMIC and the PMIC will use it to come out of standby mode. MCU sends the reset_b signal to PMIC to reset the PMIC.

NOTE

After EXTWAKE assertion, POR WDOG is triggered. If PGOOD assertion does not arrive within the configured time, POR WDOG will issue a reset to the MCU.

PMIC will raise PGOOD signal towards MCU for indicating the MCU that it is now able to provide the supplies in proper conditions. If the PGOOD input is enabled via the corresponding IMCR configuration (see S32K39_and_S32K37_IOMUX file attached to this document) and the appropriate PGOOD polarity and enable settings are selected in the corresponding DCMRWF configuration registers (see PMIC_PGOOD_HNDSHK_BYP and PGOOD_POLARITY in Chapter 36, Device Configuration Module General-Purpose Registers (DCM_GPR)), the MCU will proceed to exit from STANDBY mode once the PGOOD input is asserted.

39.10 Chip power domain partitioning

The Standby domain includes the modules listed below. For more information, see "Peripheral reset status" in the "Reset Overview" chapter.

- FIRC
- FXOSC
- MC_RGM
- DCM
- WKPU
- PIT_0 (RTI)
- LPCMP_[0:1]
- PMC
- SIRC
- RTC
- SWT_0

- DCF clients

39.10.1 Module power status

Table 196. Module power status

PD0 contents	K396
External pin wake-ups	Minimum 77 external pin wake-ups
RTC_API	Yes
LPCMP0	Yes
LPCMP1	Yes
SWT0	Yes
WKPU	Yes
PMC	Yes
RGM	Yes
FXOSC	Yes
FIRC	Yes
SIRC	Yes
CLK	Yes
64 KB SRAM	Yes
PIT_RTI_0	Yes
DCM	Yes

SWT0 (Cortex-M7_0) resides in the Standby domain and supports a configurable hardware-based timer operation during Standby mode, depending on the configuration of SWTs.

All clock sources (except PLLDIG) are available in Standby mode. SIRC is present in the Standby domain for low-power wake-up, but can be enabled.

NOTE

This chip does not support Stop and Wait modes. The only low-power mode it supports is Standby.

39.11 Pad-keeping

Pad-keeping enables you to return to I/O Run mode configuration settings after using I/O during Standby mode. It eliminates the need for I/O reconfiguration in Run mode.

39.11.1 Pad-keeping on Run domain pins

The process of entering Standby mode ensures that the chip maintains the Run domain configuration settings. Software Standby mode entry sequence specifies that you must write 0 to DCM.DCMRWF1[STANDBY_IO_CONFIG] before configuring I/O pad-keeping. You could consider DCM.DCMRWF1[STANDBY_IO_CONFIG] field as a global enable for all pad-keeping purposes during Standby mode. If you are unable to write to this field as described, pad-keeping works as explained in this chapter, during Standby mode.

After the chip exits Standby mode, you must write 1 to DCM.DCMRWF1[STANDBY_IO_CONFIG] (see "Chip-specific register descriptions" in the DCM chapter). Writing 1 to this field disables pad-keeping and configures chip I/O according to its Run mode configuration.

39.11.2 Pad-keeping on Standby domain pins

The Standby domain pads can have pad-keeping enabled or disabled based on pad availability in Standby mode. Writing to SIUL2.MSCR*n*[PKE] configures Standby mode pad-keeping on a selected I/O.

Ensure that DCM.DCMRWF1[STANDBY_IO_CONFIG] = 0 before Standby mode entry for pad-keeping on Standby domain pads. Write 0 to the field in case its value is not 0 already.

If a pad is not required during Standby mode, then the value of the corresponding SIUL2.MSCR*n*[PKE] field must be 0.

39.11.3 Pad-keeping configuration procedure

This procedure specifies how to enable an I/O for pad-keeping:

1. Configure SIUL2.MSCR*n* to control the pad state prior to Standby mode entry (for example, by writing 0 to SIUL2.MSCR*n*[OBE], SIUL2.MSCR*n*[IBE], and SIUL2.MSCR[PUE] 3-states the corresponding I/O).
2. Configure SIUL2.MSCR*n*[PKE] as needed for an I/O pad-keeping state during Standby mode.
3. Write 0 to DCM.DCMRWF1[STANDBY_IO_CONFIG].

   The application core executes a WFI, and Standby mode sequence starts.
4. Write 1 to DCM.DCMRWF1[STANDBY_IO_CONFIG] on Standby mode exit to disable pad-keeping. This configures SIUL2 according to its previous settings.

If you write 1 to DCM.DCMRWF1[STANDBY_IO_CONFIG] before entering Standby mode, the isolation removal hardware removes pad-keeping on Standby mode exit. This action (writing 1 to DCM.DCMRWF1[STANDBY_IO_CONFIG] before Standby mode entry) is useful in case of low-power debug, because enabling pad-keeping does not allow low-power debug protocol to work properly (because the TDO pad is pad-kept). For low-power debug, you must write 1 to DCM.DCMRWF1[STANDBY_IO_CONFIG] prior to Standby mode entry.

In case of Standby mode exit by reset, the pad-keeping of the reset pin is removed when the chip is reset on Standby mode wake-up. See the "GPIO padkeeping enable" signal in Figure 162. This signal corresponds to wake-up via reset event case.

39.11.4 Pad-keeping waveforms

39.11.4.1 Pad-keeping when the chip wakes up from Standby mode via an interrupt event

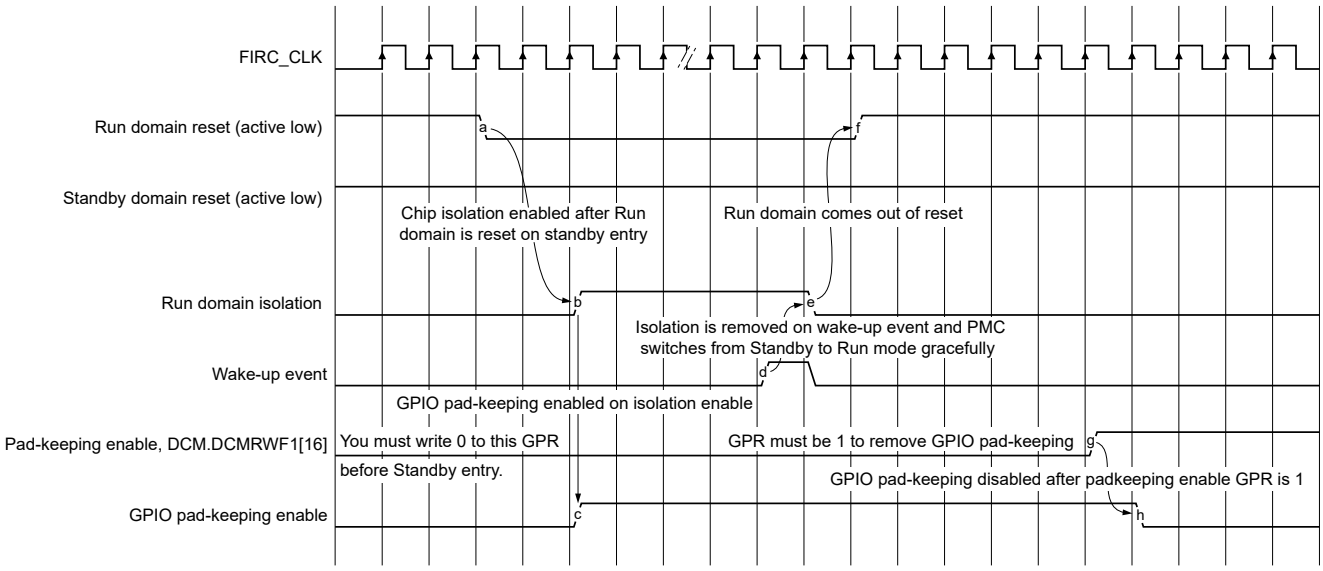


Figure 161. Pad-keeping when the chip wakes up from Standby mode via an interrupt event

39.11.4.2 Pad-keeping when the chip wakes up from Standby mode via reset

If the chip exits Standby mode through reset, the reset pad-keeping is removed when the chip resets after Standby-mode wake-up. See the figure's "GPIO padkeeping enable" waveform corresponding to wake-up via a reset event.

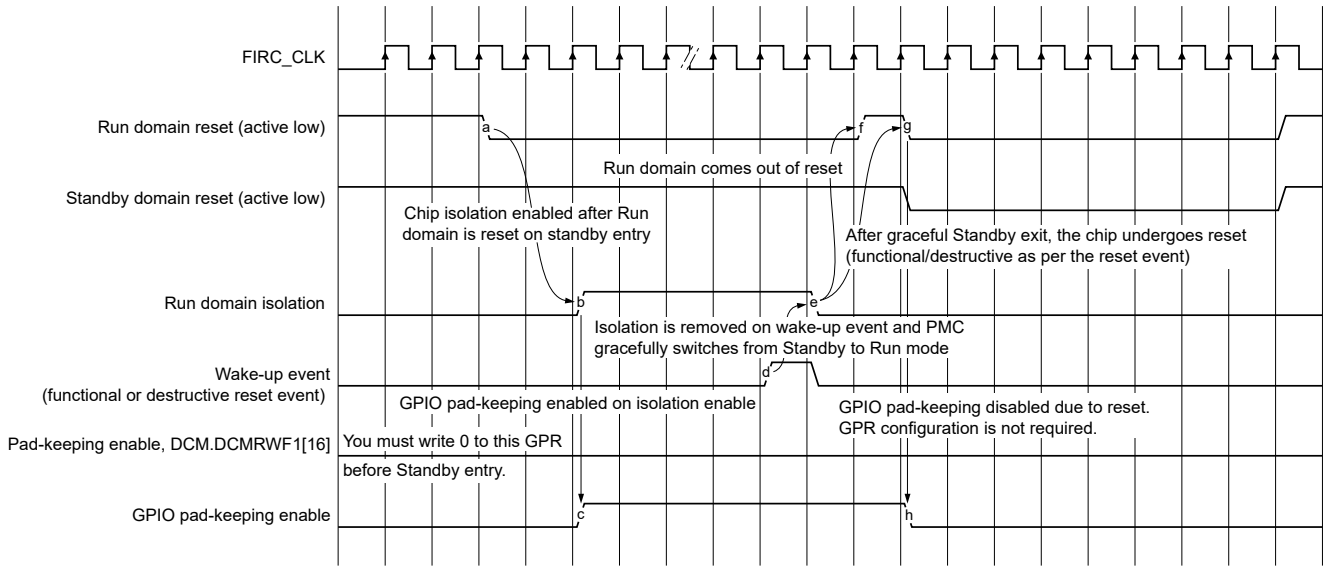


Figure 162. Pad-keeping when the chip wakes up from Standby mode via reset

39.11.5 SIUL2's fields for actively-driven pins in Standby mode

If you use a WKPU pin as a wake-up input, perform these operations:

1. Write 1 to SIUL2.MSCR*x*[IBE].
2. Program SIUL2.MSCR*x*[PUE] and SIUL2.MSCR*x*[PUS] according to the use case.
3. Write 0 to SIUL2.MSCR*x*[PKE].

For the GPIO pins that are driven to high impedance during Standby mode:

1. Write 0 to DCM.DCMRWF1[STANDBY_IO_CONFIG].
2. Write 0 to SIUL2.MSCR*x*[SSS] (GPIO mode).
3. Write 0 to SIUL2.MSCR*x*[IBE] and SIUL2.MSCR*x*[OBE].

Some of the pins are, by default, actively driven in Standby mode. If these pins retain a static value throughout the mode, program the corresponding MSCR*x*[PKE] bits individually.

This table shows the list of pins available in Standby mode along with the functions they perform.

Table 197. Active pins in Standby mode

Pin[1]	Function
GPIO_4	LPCMP0_OUT
GPIO_5	RESET_b
GPIO_8	LPCMP0_OUT/EXTWAKE
GPIO_9	LPCMP1_OUT
GPIO_10	JTAG_TDO

Table continues on the next page...

Table 197. Active pins in Standby mode (continued)

Pin[1]	Function
GPIO_22	CLKOUT_STANDBY
GPIO_25	EXTWAKE
GPIO_26	PGOOD
GPIO_69	JTAG_TDI
GPIO_84	LPCMP0_RRT
GPIO_94	LPCMP1_OUT
GPIO_110	LPCMP0_RRT
GPIO_128	LPCMP0_OUT
GPIO_129	LPCMP1_OUT
GPIO_138	CLKOUT_STANDBY
GPIO_143	LPCMP1_RRT
GPIO_149	EXTWAKE
GPIO_158	LPCMP1_OUT
GPIO_159	LPCMP1_RRT
GPIO_174	LPCMP0_OUT
GPIO_175	LPCMP0_RRT
GPIO_183	LPCMP0_OUT

1. See the IOMUX sheet attached to this document for details on pin configuration in different chips.

39.12 Standby mode entry

The Standby mode entry sequence includes three phases:

- SW Configurations phase
- MC_ME and PCU phase
- PMC phase

39.12.1 Software configuration phase

During the software configuration phase, software:

- Clears all pending interrupts.
- Disables all communications (for example, Ethernet).
- Switches to FIRC as the system clock.
- Disables PLL LFASTPLL and waits for clock status.
- Disables FXOSC/SIRC (if needed) and waits for clock status.
- Configures STANDBY entry.
- Programs SIUL/IOMUX and DCM to configure EXTWAKE and PGOOD functionalities (only for PMIC handshake Standby mode).
- Sends SPI command to PMIC to enter standby before going to WFI state (only for PMIC handshake Standby mode).

- Executes a WFI instruction on all running cores.

39.12.2 MC_ME and PCU phase

During the MC_ME and PCU phase, MC_ME and PCU:

- Enable FIRC.
- Deassert isolation.
- Deassert reset to PD1.

39.12.3 PMC phase

During PMC phase, after receiving an LPM request, PMC:

- Deasserts FPM ready signal.
- Starts the courtesy timer.
- When the courtesy timer expires, PMC:
  - Disables the V25 regulator.
  - Disables the HP reference blocks.
  - Disables the external NMOS.
  - Opens the PD0 switch.
  - Enables a core LPM request.
  - If selected, enables a 2.5 V LPM request.
  - Disengages FPM monitors.
  - Disables the VDD_HV_B LPM monitor, if present and deselected.
- Waits for LPM signal deassertion.

39.13 Glossary

Application core	Core in addition to the main core
FSM	Finite state machine
FPM	Full-power mode (Run mode)—uses the last-mile regulator and 1.5 V source to generate the 1.1 V core logic supply during a full-power operation (V11_RUN)
LPM	Low-power mode (Standby mode)—uses the low-power regulator to generate the 1.1 V core logic supply during low-power operation (V11_STANDBY)
LVR	Low voltage reset
Main core	Core initiating the chip Standby mode request (for example, the core corresponding to the "core index" in MC_ME's MAIN_COREID register)
Pad-keeping	Maintains I/O pad configuration during Standby mode, if enabled
V11_STANDBY	Core logic and clock sources, low-voltage supply to Standby domain
V11_RUN	Low-voltage supply to Run domain
V15	High-current input for core or logic supply from either an external BJT or from direct 1.5 V external supply
V25	Flash memory, FXOSC, and PLLDIG high-voltage supply
VDDA_ADC	ADC supply voltage

VREFH	ADC high-voltage reference supply
VREFL	ADC low-voltage reference supply
VSS	Core logic ground supply
VDD_HV_A	Main I/O voltage supply (5 V or 3.3 V)
VDD_HV_B	Other I/O domain voltage supply (5 V or 3.3 V)
VRC_CTRL	PMC voltage regulator control output using the BJT option to generate a 1.5 V supply
WFI	Wait for interrupt software instruction

Chapter 40
Power Management Controller (PMC)

40.1 Introduction

PMC is the power management controller for the S32K3 family of microcontrollers. It provides multiple power options to allow you to optimize power consumption for the level of functionality needed. It includes internal voltage regulators, POR, and the integrated low/high voltage detector system with reset (brown-out) capability. The voltage regulator requires a 3.3 V or 5 V input to generate all the required secondary supplies.

40.2 Features

- Combination of internal and external voltage regulator options, offering Run and Standby modes
- Active POR providing brown-out detect
- LVR for all system-relevant power domains
- LVD and HVD as indication for software
- Two bandgaps to enable independent supply generation and monitoring
- Two independent LVR monitors for each safety-relevant power supply domain

40.3 Modes of operation

PMC provides two basic modes of operation for voltage regulators and monitors:

- FPM, which is used on chip-level in Run modes (for high-current consumption)
- LPM, which is used on chip-level for Standby modes (for low-current consumption)

40.4 Block diagram

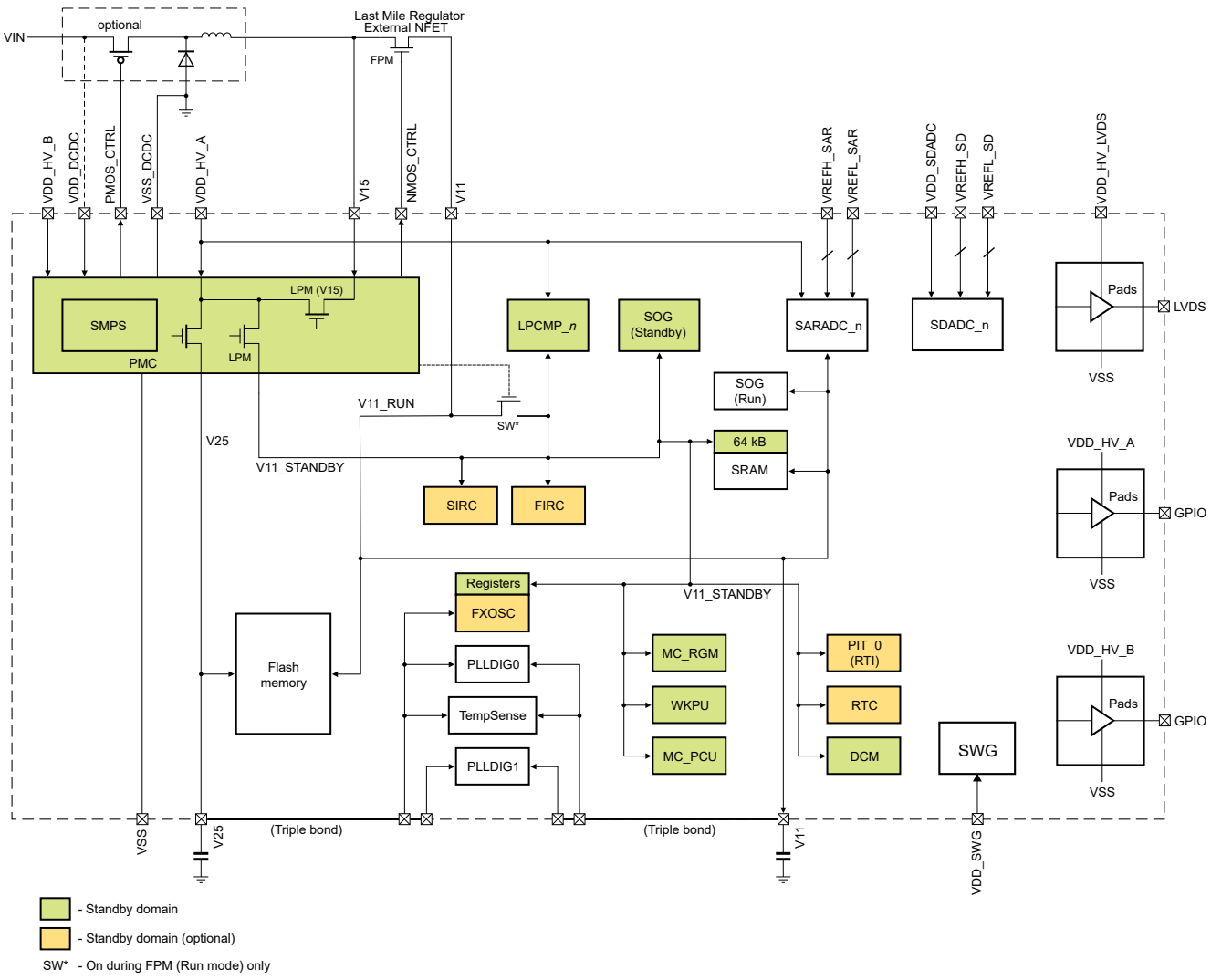


Figure 163. PMC block diagram

40.5 Signals

Table 198. Signal description

Signal	I/O	Description
VDD_HV_A	Supply input	VDD_HV_A is the primary high-voltage supply input to PMC. It is used for the PMC internal precision references. After the VDD_HV_A domain is powered up, you must keep it powered at all times of operation (FPM and LPM).
VDD_HV_B	Supply input	VDD_HV_B is the secondary high-voltage supply input that PMC supervises. After the VDD_HV_B domain is powered up, you must keep it powered at all times of operation (FPM and LPM).

Table continues on the next page...

Table 198. Signal description (continued)

Signal	I/O	Description
V25	Supply output	A fully integrated low-dropout linear voltage regulator drives this V25 power supply domain. It supplies the flash memory and (via a double bond) the clock modules.
V15	Supply input	The V15 supply is generated by the SMPS or by an external source (see Figure 163). PMC uses this pin to measure the voltage level on V15. Optionally, for SMPS, a PMC internal trickle LDO can sustain the V15 supply in LPM.
NMOS_CTRL	Output	NMOS_CTRL connects to the gate of an external NFET, which is used to regulate V15 down to V11 (core voltage). For the 1.1 V core regulator, an external NFET with low-threshold voltage (v_{th} smaller than 1.0 V) is needed, for example, Vishay SQ2310ES. Additionally 1 nF at the gate is required for stability reasons.
V11	Supply input	V11 is the core and logic supply. It is driven by the external NFET which is controlled by a linear regulator inside PMC.
VSS	Ground	VSS must be grounded. All VSS pins need to be externally connected to the same ground node.
VDD_DCDC	SMPS supply input	VDD_DCDC is the power supply domain for the SMPS gate driver. It must be shorted with the source voltage of the external power FET. An off-chip decoupling capacitor between VDD_DCDC and ground is required. See Datasheet for the recommended value. **NOTE** If SMPS (DCDC) mode is used and the PMC is in low power mode, it must be ensured that SMPS supply input VDD_DCDC is fully operational and loadable before wake-up from low power mode. Otherwise a low voltage reset might occur on wake-up.
VSS_DCDC	SMPS ground	VSS_DCDC is the power ground for the SMPS gate driver. It must be shorted with the main ground node and the ground node of the external Schottky diode.
PMOS_CTRL	PMOS control, gate drive output	PMOS_CTRL is the gate driver output for the external power FET.
VDD_SD_ADC0, VDD_SD_ADC1	Supply input (double bond)	VDD_SD_ADC is the power domain for sigma-delta ADCs. You must short on-board level to VDD_HV_A.
VDD_SWG	Supply input	VDD_SWG is the power domain for the sine wave generator (SWG). You must short on-board level to VDD_HV_A.
VDD_LVDS	Supply input	VDD_LVDS is the power domain supply pin. This is the power supply used by the 3.3 V Zipwire interface to the companion die.

40.6 Functional description

40.6.1 Reset

The POR and all LVRs are combined into one single MCU POR.

After an MCU POR event, you can determine which power domain caused the event by reading LVSC[PORF] and the relevant LVR*x* field (for example, LVSC[LVR11LPF]).

After an initial power ramp-up of the MCU, PMC writes 1 to LVSC[PORF] and all LVSC[LVR*x*] fields. The Go/Nogo fields have an arbitrary value.

NOTE

After an initial power ramp-up, you must write FFFFFFFFh to LVSC to clear all flags.

Because the flags are sticky bits, you must clear them before using them. Doing so makes it possible to track and debug the source of the problem by reading the Low Voltage Status and Control (LVSC) fields, if there is an unexpected MCU POR.

40.6.2 Interrupts

PMC includes two interrupt sources:

- HVD: Combines all HVD monitors into a single interrupt source. You enable the interrupt with CONFIG[HVDIE].
- LVD: Combines the LVD5A and LVDS monitors into a single interrupt source. You enable the interrupt with CONFIG[LVDIE].

See PMC Configuration (CONFIG) and Low Voltage Status and Control (LVSC) for details.

40.7 PMC register descriptions

40.7.1 PMC memory map

This section includes the PMC module memory map and detailed descriptions for all the registers. Registers marked "Reserved" should not be modified from their reset value by a write access.

PMC base address: 402E_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Low Voltage Status and Control (LVSC)	32	RW	See section
4h	PMC Configuration (CONFIG)	32	RW	0000_0081h
8h	SMPS Configuration (SMPSCONFIG)	32	RW	See section
Ch	Version ID (VERID)	32	R	0500_0001h

40.7.2 Low Voltage Status and Control (LVSC)

Offset

Register	Offset
LVSC	0h

Function

Contains status and control fields that support the low-voltage reset and LVD or HVD function. When the PMC is in LPM, the LVD or HVD systems are disabled.

For flags that are not affected by reset (POR flag, all LVR flags, all GNG flags), if a reset occurs at the same time as an attempt to clear the flags (by writing 1), the flag value is not defined appropriately. In this case, you need to clear the flag again after exit from reset.

For the GNG flags, if a GNG event occurs at the same time as the GNG flag is read, the flag value might not be defined appropriately. In this case, you need to read the flag twice and consider the value only if it both read values match.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PORF	GNGSWGF	GNGSDAD...	GNGSDAD...	GNG11OS...	GNG25OS...	GNG11OS...	GNG25OS...	LVR11LPF	LVR11F	LVR25LPF	LVR25F	LVRBLPF	LVRBF	LVRALPF	LVRAF
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LVDSS	HVD15S	Reserved	LVD5AS	HVD11S	HVD25S	HVDBS	HVDAS	LVDSF	HVD15F	0	LVD5AF	HVD11F	HVD25F	HVDBF	HVDAF
W									W1C	W1C		W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 PORF	POR Flag Indicates that a POR event has occurred. Other reset sources have no effect. 0b - No POR event 1b - POR event
30 GNGSWGF	Go/NoGo Detect Flag On VDD_SWG Domain Indicates that the Go/NoGo sensor has detected a low voltage on the VDD_SWG domain in FPM. Other reset sources have no effect. 0b - No event 1b - NoGo event
29 GNGSDADC1F	Go/NoGo Detect Flag On VDD_SD_ADC1 Domain Indicates that the Go/NoGo sensor has detected a low voltage on the VDD_SD_ADC1 domain in FPM. Other reset sources have no effect. 0b - No event 1b - NoGo event
28	Go/NoGo Detect Flag On VDD_SD_ADC0 Domain

Table continues on the next page...

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Field	Function
GNGSDADC0F	Indicates that the Go/NoGo sensor has detected a low voltage on the VDD_SD_ADC0 domain in FPM. Other reset sources have no effect. 0b - No event 1b - NoGo vent
27 GNG11OSC2F	Go/NoGo Detect Flag On Second PLL Part Of V11 Domain Indicates that the Go/NoGo sensor has detected a low voltage on the V11 domain in FPM. This applies to only the part of the domain that supplies the second PLL. Other reset sources have no effect. 0b - No event 1b - NoGo event
26 GNG25OSC2F	GO/NoGo Detect Flag On Second PLL Part Of V25 Domain Indicates that the Go/NoGo sensor has detected a low voltage on the V25 domain in FPM. This applies to only the part of the domain that supplies the second PLL. Other reset sources have no effect. 0b - No event 1b - NoGo event
25 GNG11OSCF	Go/NoGo Detect Flag On Osc Part Of V11 Domain Indicates that the Go/NoGo sensor has detected a low voltage on the V11 domain in FPM. This applies to only the part of the domain that supplies the 1.1 V clocking modules (for example, PLL or IRC). Other reset sources have no effect. 0b - No event 1b - NoGo event
24 GNG25OSCF	GO/NoGo Detect Flag On Osc Part Of V25 Domain Indicates that the Go/NoGo sensor has detected a low voltage on the V25 domain in FPM. This applies to only the part of the domain that supplies the 2.5 V clocking modules (for example, PLL, XOSC, and IRC). Other reset sources have no effect. 0b - No event 1b - NoGo event
23 LVR11LPF	LVR11LP Flag On V11 Domain Indicates that an LVR event has occurred on the 1.1 V V11 power domain (FPM or LPM). Other reset sources have no effect. 0b - No event 1b - Event
22 LVR11F	LVR11 Flag On V11 Domain In FPM Indicates that an LVR event has occurred on the 1.1 V V11 power domain in the FPM. Other reset sources have no effect.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No event 1b - Event
21 LVR25LPF	LVR25LP Flag On V25 Domain Indicates that an LVR event has occurred on the V25 power domain (FPM or LPM). Other reset sources have no effect. 0b - No event 1b - Event
20 LVR25F	LVR25 Flag On V25 Domain In FPM Indicates that an LVR event has occurred on the V25 power domain in FPM. Other reset sources have no effect. 0b - No event 1b - Event
19 LVRBLPF	LVRBLP Flag On VDD_HV_B Domain Indicates that an LVR event has occurred on the VDD_HV_B power domain (FPM or LPM). Other reset sources have no effect. 0b - No event 1b - Event
18 LVRBF	LVRB Flag On VDD_HV_B Domain In FPM Indicates that an LVR event has occurred on the VDD_HV_B power domain in FPM. Other reset sources have no effect. 0b - No event 1b - Event
17 LVRALPF	LVRALP Flag On VDD_HV_A Domain Indicates that an LVR event has occurred on the VDD_HV_A power domain (FPM or LPM). Other reset sources have no effect. 0b - No event 1b - Event
16 LVRAF	LVRA Flag On VDD_HV_A Domain In FPM Indicates that an LVR event has occurred on the VDD_HV_A power domain in FPM. Other reset sources have no effect. 0b - No event 1b - Event
15	LVDS Status On VDD_LVDS Domain In FPM

Table continues on the next page...

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Field	Function
LVDSS	Shows the status of the low-voltage detect, LVDSS, on the VDD_LVDS power domain. This monitor indicates if the voltage is below a certain threshold. This feature is available only in FPM and is disabled in LPM. After a reset or wake-up from LPM, you must write 0 to LVDSF and check the status field LVDSS to determine if the voltage level on VDD_LVDS is sufficient. 0b - Above threshold 1b - Below threshold
14 HVD15S	HVD15 Status On V15 Domain In FPM Shows the status of the high-voltage detect, HVD15, on the V15 power domain. This feature is available only in FPM and is disabled in LPM. 0b - Below threshold or LPM 1b - Above threshold and FPM
13 —	Reserved
12 LVD5AS	LVD5A Status On VDD_HV_A Domain In FPM Shows the status of the 5 V LVD, LVD5A, on the VDD_HV_A power domain. This monitor indicates if the voltage is below a certain threshold, which is set slightly below 4.5 V (see the data sheet for the exact value). This feature is available only in FPM and is disabled in LPM. After a reset or wake-up from LPM, you must clear the LVD5AF flag and check the status field LVD5AS to determine the voltage level on the VDD_HV_A supply. 0b - Above threshold 1b - Below threshold
11 HVD11S	HVD11 Status On V11 Domain In FPM Shows the status of HVD11 on the V11 power domain. This feature is available only in FPM and is disabled in LPM. 0b - Below threshold or LPM 1b - Above threshold and FPM
10 HVD25S	HVD25 Status On V25 Domain In FPM Shows the status of the high-voltage detect, HVD25, on the V25 power domain. This feature is available only in FPM and is disabled in LPM. 0b - Below threshold or LPM 1b - Above threshold and FPM
9 HVDBS	HVDB Status On VDD_HV_B Domain In FPM Shows the status of the high-voltage detect, HVDB, on the VDD_HV_B power domain. This feature is available only in FPM and is disabled in LPM. 0b - Below threshold or LPM

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Above threshold and FPM
8 HVDAS	HVDA Status On VDD_HV_A Domain In FPM Shows the status of the high-voltage detect HVDA on the VDD_HV_A power domain. This feature is available only in FPM and is disabled in LPM. 0b - Below threshold or LPM 1b - Above threshold and FPM
7 LVDSF	LVDS Flag On VDD_LVDS Domain In FPM PMC writes 1 to this field when the LVDSS status field changes. To clear LVDSF, write 1 to it. If enabled, LVDSF causes an interrupt request. 0b - Not changed 1b - Changed
6 HVD15F	HVD15 Flag On V15 Domain In FPM PMC writes 1 to this field when the HVD15S status field changes. To clear HVD15F, write 1 to it. If enabled, HVD15F causes an interrupt request. 0b - Not changed 1b - Changed
5 —	Reserved
4 LVD5AF	LVD5A Flag On VDD_HV_A Domain In FPM PMC writes 1 to this field when the LVD5AS status field changes. To clear LVD5AF, write 1 to it. If enabled, LVD5AF causes an interrupt request. 0b - Not changed 1b - Changed
3 HVD11F	HVD11 Flag On V11 Domain In FPM PMC writes 1 to this field when the HVD11S status field changes. To clear HVD11F, write 1 to it. If enabled, HVD11F causes an interrupt request. 0b - Not changed 1b - Changed
2 HVD25F	HVD25 Flag On V25 Domain In FPM PMC writes 1 to this field when the HVD25S status field changes. To clear HVD25F, write 1 to it. If enabled, HVD25F causes an interrupt request. 0b - Not changed 1b - Changed

Table continues on the next page...

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Field	Function
1 HVDBF	HVDB Flag On VDD_HV_B Domain In FPM PMC writes 1 to this field when the HVDBS status field changes. To clear HVDBF, write 1 to it. If enabled, HVDBF causes an interrupt request. 0b - Not changed 1b - Changed
0 HVDAF	HVDA Flag On VDD_HV_A Domain In FPM PMC writes 1 to this field when the HVDAS status field changes. To clear HVDAF, write 1 to it. If enabled, HVDAF causes an interrupt request. 0b - Not changed 1b - Changed

40.7.3 PMC Configuration (CONFIG)

Offset

Register	Offset
CONFIG	4h

Function

Configures the various PMC options.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0						LVDIE	HVDIE	LMSMPSEN	0		LVRBLPEN	LPM25EN	Reserved	0	LMEN
W																
Reset	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1

Fields

Field	Function
31-10	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
9 LVDIE	Low Voltage Detect Interrupt Enable Enables hardware interrupt requests if either LVSC[LVD5AF] = 1 or LVSC[LVDSF] = 1. The LVD interrupt must be disabled before entering LPM. If enabled, there is a request for an LVD hardware interrupt. If disabled, LVD hardware interrupt is disabled (use polling). 0b - Disables 1b - Enables
8 HVDIE	HVD Interrupt Enable Enables hardware interrupt requests if any of the following fields = 1: • LVSC[HVDAF] • LVSC[HVDBF] • LVSC[HVD25F] • LVSC[HVD11F] 0b - Disables 1b - Enables
7 LMSMPSEN	V15 Switched-Mode Power Supply Enable Enables the SMPS regulator (switched-mode power supply), which regulates from VDD_DCDC down to 1.5 V on the V15 pin to supply the last mile regulator. Because LMSMPSEN = 1 after startup or reset, if SMPS is not used, you must write 0 to LMBSMPSEN after each reset to turn the feature off. When LMSMPSEN = 0, you can no longer write 1 to it until the next reset. 0b - Disables 1b - Enables
6-5 —	Reserved
4 LVRBLPEN	LVRBLP Enable During LPM Enables low-voltage reset detection (LVRBLP) on the VDD_HV_B power domain in LPM. 0b - Disables 1b - Enables
3 LPM25EN	V25 Domain Enable During LPM Enables a low-power V25 regulator and the low-voltage reset detection (LVR25LP) in LPM. In FPM, this low-power regulator is always off. 0b - Disables 1b - Enables

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 —	Reserved
1 —	Reserved
0 LMEN	Last Mile Regulator Enable Enables the last mile regulator, which regulates an external 1.5 V voltage on V15 down to the core and logic supply (V11 power domain), which is typically 1.1 V. Because the last mile regulator is always enabled on this chip, LMEN always reads 1.

40.7.4 SMPS Configuration (SMPSCONFIG)

Offset

Register	Offset
SMPSCONFIG	8h

Function

Configures the various options of the switched-mode power supply (SMPS) generating V15 (1.5 V input supply to the last mile regulator).

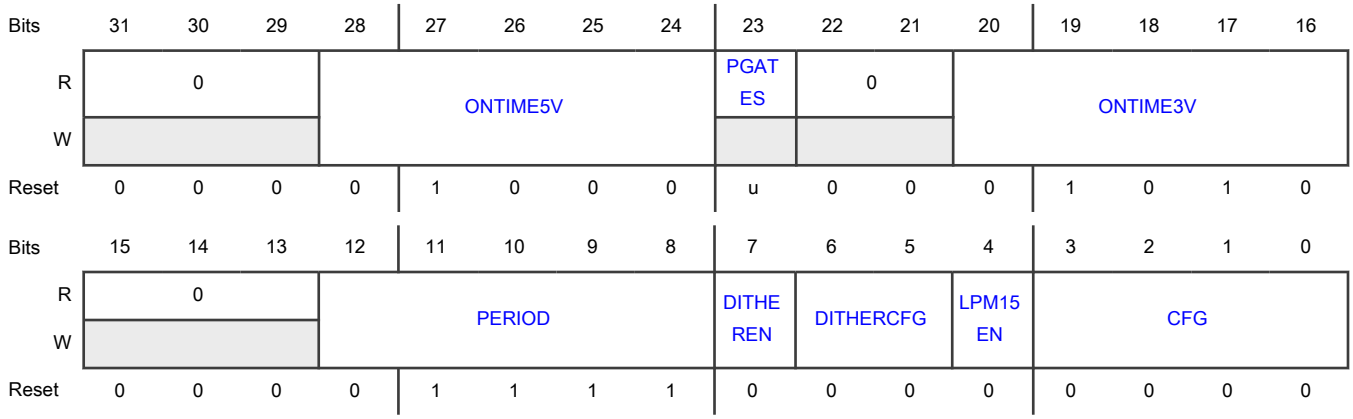
Table 199. SMPS configurations for driving the PMOS_CTRL pin

CFG[3:0]	PMOS_CTRL frequency	PMOS_CTRL duty cycle 3 V	PMOS_CTRL duty cycle 5 V
0000	470 kHz	58.8%	47.1%
0001	470 kHz	64.7%	52.9%
0010	470 kHz	52.9%	41.2%
0011	533 kHz	60%	46.7%
0100	533 kHz	66.7%	53.3%
0101	533 kHz	53.3%	40%
0110	421 kHz	57.9%	47.4%
0111	421 kHz	63.2%	52.6%
1000	421 kHz	52.6%	42.1%
1001–1110	Reserved	Reserved	Reserved
1111	8 MHz ÷ (PERIOD[4:0] + 1)	ONTIME3V[4:0] ÷ (PERIOD[4:0] + 1)	ONTIME5V[4:0] ÷ (PERIOD[4:0] + 1)

Table 200. 8 MHz IRC dither configurations

DITHERCFG[1:0]	Dither amplitude	Dither frequency
00	± 0.4 MHz	400 kHz
01	± 0.6 MHz	286 kHz
10	± 0.8 MHz	222 kHz
11	± 1 MHz	182 kHz

Diagram



Fields

Field	Function
31-29 —	Reserved
28-24 ONTIME5V	SMPS Duty Cycle For 5 V Range Determines the duty cycle of the output signal at the PMOS_CTRL pin. This duty cycle is applied when VDD_DCDC is greater than or equal to 4 V. The duty cycle is calculated as follows: Duty_pmos_ctrl = ONTIME3V[4:0] ÷ (PERIOD[4:0] + 1)
23 PGATES	PMOS_CTRL Status Reflects the status of the PMOS_CTRL pin. If = 0, note that VSS_DCDC is connected to GND. 0b - Driven to VSS_DCDC 1b - Driven to VDD_DCDC
22-21 —	Reserved
20-16 ONTIME3V	SMPS Duty Cycle For 3 V Range Determines the duty cycle of the output signal at the PMOS_CTRL pin. This duty cycle is applied when VDD_DCDC is smaller than 4 V.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	The duty cycle is calculated as follows: Duty_pmos_ctrl = ONTIME3V[4:0] ÷ (PERIOD[4:0] + 1)
15-13 —	Reserved
12-8 PERIOD	SMPS Period Determines the frequency of the output signal at the PMOS_CTRL pin. The frequency is calculated as follows: Freq_pmos_ctrl = 8 MHz ÷ (PERIOD[4:0] + 1)
7 DITHEREN	IRC Dither Enable Enables dithering of the 8 MHz IRC. The amplitude and frequency of the dithering is determined by the DITHERCFG[1:0] bits. 0b - Disables 1b - Enables
6-5 DITHERCFG	IRC Dither Configuration Selects the IRC dithering amplitude and frequency. This feature spreads the frequency spectrum of driving the PMOS_CTRL pin to reduce radiated emission. To change the value: 1. Write 0 to DITHEREN. 2. Write the dither configuration (DITHERCFG[1:0]). 3. Write 1 to DITHEREN. See Table 200 for configuration options.
4 LPM15EN	V15 Domain Enable During LPM Enables V15 in LPM. This is useful for fast recovery to FPM when using the SMPS mode to generate V15. This feature is active only in LPM, and is turned off in FPM. For this purpose, there is a small LDO inside the PMC that regulates V15 to the target value during LPM. **NOTE** LPM15EN is only used if SMPS generates V15. All other options to generate V15 are forbidden, and in those cases you must always write 0 to LPM15EN. 0b - Not kept on target 1b - Kept on target
3-0 CFG	SMPS Configuration Select Selects a configuration for frequency and duty cycle (on-time) of the switched-mode power supply, which drives (via PMOS_CTRL) the external power FET, according to Table 199.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE As seen in the table, CFG[3:0] = 1111 allows for free customization of PERIOD[4:0], ONTIME5V[4:0], and ONTIME3V[3:0]. If you choose this option, you must carefully consider the value of these bits. To ensure proper functioning of SMPS, and to keep EMI in check, you must program the switching frequency and duty cycle within a reasonable range.

40.7.5 Version ID (VERID)

Offset

Register	Offset
VERID	Ch

Function

Returns the major and minor version numbers of hardware implementation.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MAJOR								MINOR							
W																
Reset	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															LMFEAT
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-24 MAJOR	Major Version Number Returns the version number for the specification. K344 = 2, K31x = 3, K358 = 4, K396 = 5
23-16 MINOR	Minor Version Number Returns the version number for the hardware implementation.
15-1	Reserved

Table continues on the next page...

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Field	Function
—	
0 LMFEAT	Last Mile Regulator Feature Indicates whether the last mile regulator feature (1.5 V to 1.1 V) is available. 0b - Not available 1b - Available

40.8 Glossary

FPM	Full Performance mode
HVD	High voltage detector
IRC	Internal RC oscillator
LM	Last mile regulator
LPM	Low Performance mode
LVD	Low voltage detector
LVR	Low voltage reset
NVM	Nonvolatile memory
POR	Power on reset
XOSC	External crystal oscillator
SMPS	Switched-mode power supply

Chapter 41
Mode Entry Module (MC_ME)

41.1 Chip-specific MC_ME information

41.1.1 MC_ME modes

This chip implements these modes:

- Reset
- Run
- Standby

The chip always enters Run mode after exiting Reset mode wherein you can configure the chip to perform its computational and communication functions. In Run mode:

- The chip remains fully powered. The boot core is the only core enabled on Run entry.
- You can enable and disable application cores and peripherals as needed, based on functional and power requirements.
- You can configure the pins and self-test as needed. See "Self-Test programming sequence" section in the STCU2 chapter for the self-test programming sequence to be followed before initiating self-test, in which:
  - Pins are safe-stated.
  - No computational or communication activities are possible.
- The chip automatically enters Reset mode after self-test (BIST) is complete.

41.1.2 Core operation modes

The CM7_0 and CM7_1 cores support below two modes of operation. The CM7_2 and CM7_3 always operate in coupled/lockstep mode:

- Decoupled/independent operation
- Coupled/lockstep operation

The device configuration clients (utest_misc DCF client) control these modes of operation. See the DCF clients file attached to this document for details.

41.1.3 MC_ME partition mapping of cores and peripherals

MC_ME provides registers and interface signals to support multiple partitions. These MC_ME partitions are different from the chip's LBIST partitions described in the "Safety Overview" chapter. This chip has four MC_ME partitions:

- Partition 0: Contains application cores, the on-platform and the off-platform slots on AIPS_0 bridge.
- Partition 1: Contains the on-platform and the off-platform slots on AIPS_1 bridge.
- Partition 2: Contains the on-platform and the off-platform slots on AIPS_2 bridge.
- Partition 3: Contains the on-platform and the off-platform slots on AIPS_3 bridge.

Core clock gating and Peripheral clock gating specify the core and peripheral mapping on MC_ME partitions and their associated clock gating possibilities.

MC_ME also provides provisions to control the booting address for application cores, which can be configured to start from a non-default address location by appropriately configuring PRTN*x*_CORE*n*_ADDR[ADDR].

41.1.4 MC_ME partition 0 mapping

The following table shows partition 0 and its register mapping.

Table 201. MC_ME partition 0 mapping

Register	Register field	Description	Used for
MC_ME_PRTN0_PCONF	PCE	Partition clock enable	Read Only
MC_ME_PRTN0_PUPD	PCUD	Partition clock update	NA
MC_ME_PRTN0_STAT	PCS	Partition clock status	Read Only
MC_ME_PRTN0_CORE_LOCKSTEP	LS2	Lockstep 2	NA

41.1.5 MC_ME partition 1 mapping

The following table below shows partition 1 and its register mapping.

Table 202. MC_ME partition 1 mapping

Register	Register field	Description	Used for
MC_ME_PRTN1_PUPD	PCUD	Partition clock update	Reset domain 1
MC_ME_PRTN1_STAT	PCS	Partition clock status	Reset domain 1

41.1.6 MC_ME partition 2 mapping

The following table shows partition 2 and its register mapping.

Table 203. MC_ME partition 2 mapping

Register	Register field	Description	Used for
MC_ME_PRTN2_PUPD	PCUD	Partition clock update	Reset domain 2
MC_ME_PRTN2_STAT	PCS	Partition clock status	Reset domain 2

41.1.7 MC_ME partition 3 mapping

The following table shows partition 3 and its register mapping.

Table 204. MC_ME partition 3 mapping

Register	Register field	Description	Used for
MC_ME_PRTN3_PUPD	PCUD	Partition clock update	Reset domain 3
MC_ME_PRTN3_STAT	PCS	Partition clock status	Reset domain 3

41.1.8 Core clock gating

MC_ME has individual core-clock enable fields that gate the application core clocks, which can also be clock gated by executing Waiting for Interrupt (WFI).

You can enable the application cores by configuring the respective CCE fields. See Application core initialization process and Application core shutdown process for proper initialization and shutdown of application cores. There is no clock control for the HSE_B core. It needs to be only put into WFI if required to be shutdown (for example, in Standby mode).

Table 205. MC_ME partition core mapping

Core	MC_ME partition	MC_ME clock enable register field	Applicability
Cortex-M7_0	0	MC_ME.PRTN0_CORE0_PCONF[CCE]	Yes
Cortex-M7_1	0	MC_ME.PRTN0_CORE1_PCONF[CCE]	Yes
Cortex-M4	0	Not Applicable (Reserved)	Not Applicable
Reserved	0	Not Applicable (Reserved)	Not Applicable
Cortex-M7_2	0	MC_ME.PRTN0_CORE4_PCONF[CCE]	Yes
CM7_2 (Cortex M7_3)[1]	0	MC_ME_PRTN0_CORE5_PCONF[CCE]	Not Applicable (Cortex-M7_3 is always in lockstep with Cortex-M7_2)

1. In the lockstep configuration, the checker core controls are not applicable, i.e. Cortex-M7_3 clock is not programmable using MC_ME.PRTN0_CORE5_PCONF[CCE]. The main core (Cortex-M7_2) clock control register will control the checker core (Cortex-M7_3) clock.

41.1.9 Peripheral clock gating

See Peripheral initialization process and Peripheral shutdown process for proper initialization and shutdown of peripherals. See Table 206 for peripheral clock gating possibilities.

The application core can program the reserved configurations.

NOTE

Before accessing the registers of a peripheral to start using it, its clock must be turned on, otherwise, a Hard-Fault event will occur.

Table 206. MC_ME partition peripheral mapping and clock control

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
0	Reserved	PRTN0_COFB0_CLKEN[REQ0]	0	0	0	0	YES	0
0	Reserved	PRTN0_COFB0_CLKEN[REQ1]	1	1	0	0	YES	1
0	Reserved	PRTN0_COFB0_CLKEN[REQ2]	2	2	0	0	YES	2
0	ERM1	PRTN0_COFB0_CLKEN[REQ3]	3	3	1	0	YES	3

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
0	eDMA_1 control & status (MP_CSR; MP_ES; MP_HRS)	PRTN0_COFB0_CLKEN[REQ4]	4	4	1	0	YES	4
0	eDMA_1 transfer control descriptor 0	PRTN0_COFB0_CLKEN[REQ5]	5	5	1	0	YES	5
0	eDMA_1 transfer control descriptor 1	PRTN0_COFB0_CLKEN[REQ6]	6	6	1	0	YES	6
0	eDMA_1 transfer control descriptor 2	PRTN0_COFB0_CLKEN[REQ7]	7	7	1	0	YES	7
0	eDMA_1 transfer control descriptor 3	PRTN0_COFB0_CLKEN[REQ8]	8	8	1	0	YES	8
0	eDMA_1 transfer control descriptor 4	PRTN0_COFB0_CLKEN[REQ9]	9	9	1	0	YES	9
0	eDMA_1 transfer control descriptor 5	PRTN0_COFB0_CLKEN[REQ10]	10	10	1	0	YES	10
0	eDMA_1 transfer control descriptor 6	PRTN0_COFB0_CLKEN[REQ11]	11	11	1	0	YES	11
0	eDMA_1 transfer control descriptor 7	PRTN0_COFB0_CLKEN[REQ12]	12	12	1	0	YES	12

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
0	eDMA_1 transfer control descriptor 8	PRTN0_COFB0_CLKEN[REQ13]	13	13	1	0	YES	13
0	eDMA_1 transfer control descriptor 9	PRTN0_COFB0_CLKEN[REQ14]	14	14	1	0	YES	14
0	eDMA_1 transfer control descriptor 10	PRTN0_COFB0_CLKEN[REQ15]	15	15	1	0	YES	15
0	eDMA_1 transfer control descriptor 11	PRTN0_COFB0_CLKEN[REQ16]	16	16	1	0	YES	16
0	eDMA_1 transfer control descriptor 12	PRTN0_COFB0_CLKEN[REQ17]	17	17	1	0	YES	17
0	eDMA_1 transfer control descriptor 13	PRTN0_COFB0_CLKEN[REQ18]	18	18	1	0	YES	18
0	eDMA_1 transfer control descriptor 14	PRTN0_COFB0_CLKEN[REQ19]	19	19	1	0	YES	19
0	eDMA_1 transfer control descriptor 15	PRTN0_COFB0_CLKEN[REQ20]	20	20	1	0	YES	20

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
0	Reserved	PRTN0_COFB0_CLKEN[REQ21]	21	21	0	0	YES	21
0	Reserved	PRTN0_COFB0_CLKEN[REQ22]	22	22	0	0	YES	22
0	Reserved	PRTN0_COFB0_CLKEN[REQ23]	23	23	0	0	YES	23
0	Reserved	PRTN0_COFB0_CLKEN[REQ24]	24	24	0	0	YES	24
0	Reserved	PRTN0_COFB0_CLKEN[REQ25]	25	25	0	0	YES	25
0	Reserved	PRTN0_COFB0_CLKEN[REQ26]	26	26	0	0	YES	26
0	Reserved	PRTN0_COFB0_CLKEN[REQ27]	27	27	0	0	YES	27
0	Reserved	PRTN0_COFB0_CLKEN[REQ28]	28	28	0	0	YES	28
0	Reserved	PRTN0_COFB0_CLKEN[REQ29]	29	29	0	0	YES	29
0	Reserved	PRTN0_COFB0_CLKEN[REQ30]	30	30	0	0	YES	30
0	Reserved	PRTN0_COFB0_CLKEN[REQ31]	31	31	0	0	YES	31
0	TRGMUX_APP	PRTN0_COFB1_CLKEN[REQ32]	32	32	1	0	NO	0

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
0	Body Cross Triggering Unit 0	PRTN0_COFB1_CLKEN[REQ33]	33	33	1	0	NO	1
0	eMIOS 0	PRTN0_COFB1_CLKEN[REQ34]	34	34	1	0	NO	2
0	Reserved	PRTN0_COFB1_CLKEN[REQ35]	35	35	1	0	NO	3
0	Reserved	PRTN0_COFB1_CLKEN[REQ36]	36	36	1	0	NO	4
0	Reserved	PRTN0_COFB1_CLKEN[REQ37]	37	37	0	0	NO	5
0	Logic Control Unit 0	PRTN0_COFB1_CLKEN[REQ38]	38	38	1	0	NO	6
0	Logic Control Unit 1	PRTN0_COFB1_CLKEN[REQ39]	39	39	1	0	NO	7
0	Analog-to-digital converter 0	PRTN0_COFB1_CLKEN[REQ40]	40	40	1	0	NO	8
0	Analog-to-digital converter 1	PRTN0_COFB1_CLKEN[REQ41]	41	41	1	0	NO	9
0	Analog-to-digital converter 2	PRTN0_COFB1_CLKEN[REQ42]	42	42	1	0	NO	10
0	Analog-to-digital converter 3	PRTN0_COFB1_CLKEN[REQ43]	43	43	1	0	NO	11
0	Programmable Interrupt Timer 0	PRTN0_COFB1_CLKEN[REQ44]	44	44	1	1	NO	12

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
0	Programmable Interrupt Timer 1	PRTN0_COFB1_CLKEN[REQ45]	45	45	1	0	NO	13
0	MU_A	PRTN0_COFB1_CLKEN[REQ46]	46	46	1	0	NO	14
0	MU_B	PRTN0_COFB1_CLKEN[REQ47]	47	47	1	0	NO	15
1	System crossbar switch	PRTN1_COFB0_CLKEN[REQ0]	128	0	0	1	YES	0
1	Crossbar Integrity Checker (System AXBS / AXBS Lite)	PRTN1_COFB0_CLKEN[REQ1]	129	1	0	1	YES	1
1	Crossbar Integrity Checker (Peripheral AXBS-Lite)	PRTN1_COFB0_CLKEN[REQ2]	130	2	0	1	YES	2
1	eDMA_0 control & status (MP_CSR; MP_ES; MP_HRS)	PRTN1_COFB0_CLKEN[REQ3]	131	3	1	0	YES	3
1	eDMA_0 transfer control descriptor 0	PRTN1_COFB0_CLKEN[REQ4]	132	4	1	0	YES	4
1	eDMA_0 transfer control descriptor 1	PRTN1_COFB0_CLKEN[REQ5]	133	5	1	0	YES	5
1	eDMA_0 transfer	PRTN1_COFB0_CLKEN[REQ6]	134	6	1	0	YES	6

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
	control descriptor 2							
1	eDMA_0 transfer control descriptor 3	PRTN1_COFB0_CLKEN[REQ7]	135	7	1	0	YES	7
1	eDMA_0 transfer control descriptor 4	PRTN1_COFB0_CLKEN[REQ8]	136	8	1	0	YES	8
1	eDMA_0 transfer control descriptor 5	PRTN1_COFB0_CLKEN[REQ9]	137	9	1	0	YES	9
1	eDMA_0 transfer control descriptor 6	PRTN1_COFB0_CLKEN[REQ10]	138	10	1	0	YES	10
1	eDMA_0 transfer control descriptor 7	PRTN1_COFB0_CLKEN[REQ11]	139	11	1	0	YES	11
1	eDMA_0 transfer control descriptor 8	PRTN1_COFB0_CLKEN[REQ12]	140	12	1	0	YES	12
1	eDMA_0 transfer control descriptor 9	PRTN1_COFB0_CLKEN[REQ13]	141	13	1	0	YES	13
1	eDMA_0 transfer control descriptor 10	PRTN1_COFB0_CLKEN[REQ14]	142	14	1	0	YES	14
1	eDMA_0 transfer control descriptor 11	PRTN1_COFB0_CLKEN[REQ15]	143	15	1	0	YES	15

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	Debug APB Page0	PRTN1_COFB0_CLKEN[REQ16]	144	16	0	1	YES	16
1	Debug APB Page1	PRTN1_COFB0_CLKEN[REQ17]	145	17	0	1	YES	17
1	Debug APB Page2	PRTN1_COFB0_CLKEN[REQ18]	146	18	0	1	YES	18
1	Debug APB Page3	PRTN1_COFB0_CLKEN[REQ19]	147	19	0	1	YES	19
1	Debug APB Paged Area	PRTN1_COFB0_CLKEN[REQ20]	148	20	0	1	YES	20
1	SDA-AP	PRTN1_COFB0_CLKEN[REQ21]	149	21	1	1	YES	21
1	Reserved	PRTN1_COFB0_CLKEN[REQ22]	150	22	0	0	YES	22
1	ERM0	PRTN1_COFB0_CLKEN[REQ23]	151	23	1	0	YES	23
1	MSCM	PRTN1_COFB0_CLKEN[REQ24]	152	24	1	0	YES	24
1	RAM controller 0	PRTN1_COFB0_CLKEN[REQ25]	153	25	0	1	YES	25
1	Flash controller	PRTN1_COFB0_CLKEN[REQ26]	154	26	0	1	YES	26
1	Flash controller alternate	PRTN1_COFB0_CLKEN[REQ27]	155	27	0	1	YES	27

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	Software Watchdog 0	PRTN1_COFB0_CLKEN[REQ28]	156	28	1	1	YES	28
1	System Timer Module 0	PRTN1_COFB0_CLKEN[REQ29]	157	29	1	0	YES	29
1	XRDC	PRTN1_COFB0_CLKEN[REQ30]	158	30	0	1	YES	30
1	Interrupt Monitor	PRTN1_COFB0_CLKEN[REQ31]	159	31	1	0	YES	31
1	DMA Channel Multiplexer 0	PRTN1_COFB1_CLKEN[REQ32]	160	32	1	0	NO	0
1	DMA Channel Multiplexer 1	PRTN1_COFB1_CLKEN[REQ33]	161	33	1	0	NO	1
1	Real-time clock	PRTN1_COFB1_CLKEN[REQ34]	162	34	1	1	NO	2
1	Reset Generation Module	PRTN1_COFB1_CLKEN[REQ35]	163	35	0	1	NO	3
1	SIUL_VIRT WRAPPER _PDAC0	PRTN1_COFB1_CLKEN[REQ36]	164	36	0	1	NO	4
1	SIUL_VIRT WRAPPER _PDAC0	PRTN1_COFB1_CLKEN[REQ37]	165	37	0	1	NO	5
1	SIUL_VIRT WRAPPER _PDAC1	PRTN1_COFB1_CLKEN[REQ38]	166	38	0	1	NO	6
1	SIUL_VIRT WRAPPER _PDAC1	PRTN1_COFB1_CLKEN[REQ39]	167	39	0	1	NO	7

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	SIUL_VIRT WRAPPER _PDAC2	PRTN1_CO FB1_CLKE N[REQ40]	168	40	0	1	NO	8
1	SIUL_VIRT WRAPPER _PDAC2	PRTN1_CO FB1_CLKE N[REQ41]	169	41	0	1	NO	9
1	SIUL_VIRT WRAPPER _PDAC3	PRTN1_CO FB1_CLKE N[REQ42]	170	42	1	1	NO	10
1	System Status and Configuratio n Module	PRTN1_CO FB1_CLKE N[REQ43]	171	43	0	1	NO	11
1	Reserved	PRTN1_CO FB1_CLKE N[REQ44]	172	44	0	0	NO	12
1	Wakeup Unit	PRTN1_CO FB1_CLKE N[REQ45]	173	45	1	1	NO	13
1	Reserved	PRTN1_CO FB1_CLKE N[REQ46]	174	46	0	0	NO	14
1	CMU 0-6	PRTN1_CO FB1_CLKE N[REQ47]	175	47	1	0	NO	15
1	Reserved	PRTN1_CO FB1_CLKE N[REQ48]	176	48	0	0	NO	16
1	Reserved	PRTN1_CO FB1_CLKE N[REQ49]	177	49	1	1	NO	17
1	32 kHz Slow Internal RC Oscillator	PRTN1_CO FB1_CLKE N[REQ50]	178	50	0	1	NO	18
1	Reserved	PRTN1_CO FB1_CLKE N[REQ51]	179	51	1	1	NO	19

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	48 MHz Fast Internal RC Oscillator	PRTN1_COFB1_CLKEN[REQ52]	180	52	0	1	NO	20
1	8-40 MHz Fast External Crystal Oscillator	PRTN1_COFB1_CLKEN[REQ53]	181	53	1	1	NO	21
1	Clock Generation Module	PRTN1_COFB1_CLKEN[REQ54]	182	54	0	1	NO	22
1	Mode Entry Module	PRTN1_COFB1_CLKEN[REQ55]	183	55	0	1	NO	23
1	Frequency Modulated Phase-Locked Loop	PRTN1_COFB1_CLKEN[REQ56]	184	56	1	0	NO	24
1	Reserved	PRTN1_COFB1_CLKEN[REQ57]	185	57	1	0	NO	25
1	Power management controller	PRTN1_COFB1_CLKEN[REQ58]	186	58	0	1	NO	26
1	Flash memory	PRTN1_COFB1_CLKEN[REQ59]	187	59	0	1	NO	27
1	Flash memory alternate	PRTN1_COFB1_CLKEN[REQ60]	188	60	0	1	NO	28
1	SIUL_VIRT WRAPPER_PDAC4	PRTN1_COFB1_CLKEN[REQ61]	189	61	0	1	NO	29
1	SIUL_VIRT WRAPPER_PDAC4	PRTN1_COFB1_CLKEN[REQ62]	190	62	0	1	NO	30

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	Programmable Interrupt Timer 2	PRTN1_COFB1_CLKEN[REQ63]	191	63	1	0	NO	31
1	Reserved	PRTN1_COFB2_CLKEN[REQ64]	192	64	0	0	NO	32
1	FlexCAN 0	PRTN1_COFB2_CLKEN[REQ65]	193	65	1	0	NO	33
1	FlexCAN 1	PRTN1_COFB2_CLKEN[REQ66]	194	66	1	0	NO	34
1	FlexCAN 2	PRTN1_COFB2_CLKEN[REQ67]	195	67	1	0	NO	35
1	FlexCAN 3	PRTN1_COFB2_CLKEN[REQ68]	196	68	1	0	NO	36
1	FlexCAN 4	PRTN1_COFB2_CLKEN[REQ69]	197	69	1	0	NO	37
1	FlexCAN 5	PRTN1_COFB2_CLKEN[REQ70]	198	70	1	0	NO	38
1	Reserved	PRTN1_COFB2_CLKEN[REQ71]	199	71	1	0	NO	39
1	Reserved	PRTN1_COFB2_CLKEN[REQ72]	200	72	1	0	NO	40
1	Flexible IO	PRTN1_COFB2_CLKEN[REQ73]	201	73	1	0	NO	41
1	Low Power UART 0	PRTN1_COFB2_CLKEN[REQ74]	202	74	1	0	NO	42

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	Low Power UART 1	PRTN1_COFB2_CLKEN[REQ75]	203	75	1	0	NO	43
1	Low Power UART 2	PRTN1_COFB2_CLKEN[REQ76]	204	76	1	0	NO	44
1	Low Power UART 3	PRTN1_COFB2_CLKEN[REQ77]	205	77	1	0	NO	45
1	Reserved	PRTN1_COFB2_CLKEN[REQ78]	206	78	1	0	NO	46
1	Reserved	PRTN1_COFB2_CLKEN[REQ79]	207	79	1	0	NO	47
1	Reserved	PRTN1_COFB2_CLKEN[REQ80]	208	80	1	0	NO	48
1	Reserved	PRTN1_COFB2_CLKEN[REQ81]	209	81	1	0	NO	49
1	Reserved	PRTN1_COFB2_CLKEN[REQ82]	210	82	0	0	NO	50
1	Reserved	PRTN1_COFB2_CLKEN[REQ83]	211	83	0	0	NO	51
1	Low Power I2C 0	PRTN1_COFB2_CLKEN[REQ84]	212	84	1	0	NO	52
1	Low Power I2C 1	PRTN1_COFB2_CLKEN[REQ85]	213	85	1	0	NO	53
1	Low Power SPI 0	PRTN1_COFB2_CLKEN[REQ86]	214	86	1	0	NO	54

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	Low Power SPI 1	PRTN1_COFB2_CLKEN[REQ87]	215	87	1	0	NO	55
1	Low Power SPI 2	PRTN1_COFB2_CLKEN[REQ88]	216	88	1	0	NO	56
1	Low Power SPI 3	PRTN1_COFB2_CLKEN[REQ89]	217	89	1	0	NO	57
1	Reserved	PRTN1_COFB2_CLKEN[REQ90]	218	90	0	0	NO	58
1	Reserved	PRTN1_COFB2_CLKEN[REQ91]	219	91	1	0	NO	59
1	Low Power Comparator 0	PRTN1_COFB2_CLKEN[REQ92]	220	92	1	1	NO	60
1	Low Power Comparator 1	PRTN1_COFB2_CLKEN[REQ93]	221	93	1	1	NO	61
1	Reserved	PRTN1_COFB2_CLKEN[REQ94]	222	94	0	0	NO	62
1	TMU Temperature Sensor Unit	PRTN1_COFB2_CLKEN[REQ95]	223	95	1	0	NO	63
1	CRC	PRTN1_COFB3_CLKEN[REQ96]	224	96	1	0	NO	64
1	FCCU (+FOSU)	PRTN1_COFB3_CLKEN[REQ97]	225	97	0	1	NO	65
1	HSE_MU0_B	PRTN1_COFB3_CLKEN[REQ99]	227	99	0	1	NO	67

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
1	Reserved	PRTN1_COFB3_CLKEN[REQ100]	228	100	0	1	NO	68
1	JDC (JTAG Data Communication)	PRTN1_COFB3_CLKEN[REQ101]	229	101	0	1	NO	69
1	Configuration GPR	PRTN1_COFB3_CLKEN[REQ103]	231	103	0	1	NO	71
1	Self-Test Control Unit	PRTN1_COFB3_CLKEN[REQ104]	232	104	1	1	NO	72
1	Selftest GPR	PRTN1_COFB3_CLKEN[REQ108]	236	108	0	1	NO	76
1	Reserved	PRTN1_COFB3_CLKEN[REQ109]	237	109	0	0	NO	77
2	Crossbar Integrity Checker (TCM backdoor AHB Splitter)	PRTN2_COFB0_CLKEN[REQ0]	256	0	0	1	YES	0
2	Crossbar Integrity Checker (eDMA_0)	PRTN2_COFB0_CLKEN[REQ1]	257	1	0	1	YES	1
2	Reserved	PRTN2_COFB0_CLKEN[REQ2]	258	2	0	1	YES	2
2	Reserved	PRTN2_COFB0_CLKEN[REQ3]	259	3	0	0	YES	3
2	eDMA_0 transfer control	PRTN2_COFB0_CLKEN[REQ4]	260	4	1	0	YES	4

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
	descriptor 12							
2	eDMA_0 transfer control descriptor 13	PRTN2_COFB0_CLKEN[REQ5]	261	5	1	0	YES	5
2	eDMA_0 transfer control descriptor 14	PRTN2_COFB0_CLKEN[REQ6]	262	6	1	0	YES	6
2	eDMA_0 transfer control descriptor 15	PRTN2_COFB0_CLKEN[REQ7]	263	7	1	0	YES	7
2	eDMA_0 transfer control descriptor 16	PRTN2_COFB0_CLKEN[REQ8]	264	8	1	0	YES	8
2	eDMA_0 transfer control descriptor 17	PRTN2_COFB0_CLKEN[REQ9]	265	9	1	0	YES	9
2	eDMA_0 transfer control descriptor 18	PRTN2_COFB0_CLKEN[REQ10]	266	10	1	0	YES	10
2	eDMA_0 transfer control descriptor 19	PRTN2_COFB0_CLKEN[REQ11]	267	11	1	0	YES	11
2	eDMA_0 transfer control	PRTN2_COFB0_CLKEN[REQ12]	268	12	1	0	YES	12

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
	descriptor 20							
2	eDMA_0 transfer control descriptor 21	PRTN2_COFB0_CLKEN[REQ13]	269	13	1	0	YES	13
2	eDMA_0 transfer control descriptor 22	PRTN2_COFB0_CLKEN[REQ14]	270	14	1	0	YES	14
2	eDMA_0 transfer control descriptor 23	PRTN2_COFB0_CLKEN[REQ15]	271	15	1	0	YES	15
2	eDMA_0 transfer control descriptor 24	PRTN2_COFB0_CLKEN[REQ16]	272	16	1	0	YES	16
2	eDMA_0 transfer control descriptor 25	PRTN2_COFB0_CLKEN[REQ17]	273	17	1	0	YES	17
2	eDMA_0 transfer control descriptor 26	PRTN2_COFB0_CLKEN[REQ18]	274	18	1	0	YES	18
2	eDMA_0 transfer control descriptor 27	PRTN2_COFB0_CLKEN[REQ19]	275	19	1	0	YES	19
2	eDMA_0 transfer control	PRTN2_COFB0_CLKEN[REQ20]	276	20	1	0	YES	20

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
	descriptor 28							
2	eDMA_0 transfer control descriptor 29	PRTN2_COFB0_CLKEN[REQ21]	277	21	1	0	YES	21
2	eDMA_0 transfer control descriptor 30	PRTN2_COFB0_CLKEN[REQ22]	278	22	1	0	YES	22
2	eDMA_0 transfer control descriptor 31	PRTN2_COFB0_CLKEN[REQ23]	279	23	1	0	YES	23
2	Semaphores2	PRTN2_COFB0_CLKEN[REQ24]	280	24	1	0	YES	24
2	RAM controller 1	PRTN2_COFB0_CLKEN[REQ25]	281	25	0	1	YES	25
2	Reserved	PRTN2_COFB0_CLKEN[REQ26]	282	26	0	1	YES	26
2	Software Watchdog 1	PRTN2_COFB0_CLKEN[REQ27]	283	27	1	0	YES	27
2	Software Watchdog 2	PRTN2_COFB0_CLKEN[REQ28]	284	28	1	0	YES	28
2	System Timer Module 1	PRTN2_COFB0_CLKEN[REQ29]	285	29	1	0	YES	29
2	System Timer Module 2	PRTN2_COFB0_CLKEN[REQ30]	286	30	1	0	YES	30

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
2	Reserved	PRTN2_COFB0_CLKEN[REQ31]	287	31	0	0	YES	31
2	EMAC	PRTN2_COFB1_CLKEN[REQ32]	288	32	1	0	NO	0
2	Reserved	PRTN2_COFB1_CLKEN[REQ33]	289	33	1	0	NO	1
2	Reserved	PRTN2_COFB1_CLKEN[REQ34]	290	34	0	0	NO	2
2	Reserved	PRTN2_COFB1_CLKEN[REQ35]	291	35	1	0	NO	3
2	Reserved	PRTN2_COFB1_CLKEN[REQ36]	292	36	1	0	NO	4
2	Reserved	PRTN2_COFB1_CLKEN[REQ37]	293	37	1	0	NO	5
2	Reserved	PRTN2_COFB1_CLKEN[REQ38]	294	38	1	0	NO	6
2	Reserved	PRTN2_COFB1_CLKEN[REQ39]	295	39	1	0	NO	7
2	Reserved	PRTN2_COFB1_CLKEN[REQ40]	296	40	1	0	NO	8
2	Reserved	PRTN2_COFB1_CLKEN[REQ41]	297	41	1	0	NO	9
2	Reserved	PRTN2_COFB1_CLKEN[REQ42]	298	42	1	0	NO	10

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
2	Reserved	PRTN2_COFB1_CLKEN[REQ43]	299	43	0	0	NO	11
2	Reserved	PRTN2_COFB1_CLKEN[REQ44]	300	44	0	0	NO	12
2	Reserved	PRTN2_COFB1_CLKEN[REQ45]	301	45	0	0	NO	13
2	Reserved	PRTN2_COFB1_CLKEN[REQ46]	302	46	0	0	NO	14
2	Low Power SPI 4	PRTN2_COFB1_CLKEN[REQ47]	303	47	1	0	NO	15
2	Low Power SPI 5	PRTN2_COFB1_CLKEN[REQ48]	304	48	1	0	NO	16
2	Reserved	PRTN2_COFB1_CLKEN[REQ49]	305	49	0	0	NO	17
2	Reserved	PRTN2_COFB1_CLKEN[REQ50]	306	50	0	0	NO	18
2	QuadSPI	PRTN2_COFB1_CLKEN[REQ51]	307	51	1	0	NO	19
2	Reserved	PRTN2_COFB1_CLKEN[REQ52]	308	52	0	0	NO	20
2	Reserved	PRTN2_COFB1_CLKEN[REQ53]	309	53	0	0	NO	21
2	Reserved	PRTN2_COFB1_CLKEN[REQ54]	310	54	0	0	NO	22

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
2	Reserved	PRTN2_COFB1_CLKEN[REQ55]	311	55	1	0	NO	23
2	Reserved	PRTN2_COFB1_CLKEN[REQ56]	312	56	0	0	NO	24
2	Reserved	PRTN2_COFB1_CLKEN[REQ57]	313	57	1	0	NO	25
2	Reserved	PRTN2_COFB1_CLKEN[REQ58]	314	58	1	1	NO	26
2	HSE_MU1_B	PRTN2_COFB1_CLKEN[REQ59]	315	59	0	1	NO	27
2	SIPI	PRTN2_COFB1_CLKEN[REQ60]	316	60	1	0	NO	28
2	LFAST	PRTN2_COFB1_CLKEN[REQ61]	317	61	1	0	NO	29
2	LPUART_MSC	PRTN2_COFB2_CLKEN[REQ65]	321	65	1	0	NO	33
2	DSPI_MSC	PRTN2_COFB2_CLKEN[REQ66]	322	66	1	0	NO	34
2	EIM0	PRTN2_COFB2_CLKEN[REQ67]	323	67	1	0	NO	35
2	EIM1	PRTN2_COFB2_CLKEN[REQ68]	324	68	1	0	NO	36
2	EIM2	PRTN2_COFB2_CLKEN[REQ69]	325	69	1	0	NO	37

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
2	OMU0	PRTN2_COFB2_CLKEN[REQ70]	326	70	0	1	NO	38
2	OMU0	PRTN2_COFB2_CLKEN[REQ71]	327	71	0	1	NO	39
2	OMU1	PRTN2_COFB2_CLKEN[REQ72]	328	72	0	1	NO	40
2	OMU1	PRTN2_COFB2_CLKEN[REQ73]	329	73	0	1	NO	41
2	OMU2	PRTN2_COFB2_CLKEN[REQ74]	330	74	0	1	NO	42
2	OMU2	PRTN2_COFB2_CLKEN[REQ75]	331	75	0	1	NO	43
3	eDMA_1 transfer control descriptor 16	PRTN3_COFB0_CLKEN[REQ0]	384	0	1	0	YES	0
3	eDMA_1 transfer control descriptor 17	PRTN3_COFB0_CLKEN[REQ1]	385	1	1	0	YES	1
3	eDMA_1 transfer control descriptor 18	PRTN3_COFB0_CLKEN[REQ2]	386	2	1	0	YES	2
3	eDMA_1 transfer control descriptor 19	PRTN3_COFB0_CLKEN[REQ3]	387	3	1	0	YES	3

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
3	eDMA_1 transfer control descriptor 20	PRTN3_COFB0_CLKEN[REQ4]	388	4	1	0	YES	4
3	eDMA_1 transfer control descriptor 21	PRTN3_COFB0_CLKEN[REQ5]	389	5	1	0	YES	5
3	eDMA_1 transfer control descriptor 22	PRTN3_COFB0_CLKEN[REQ6]	390	6	1	0	YES	6
3	eDMA_1 transfer control descriptor 23	PRTN3_COFB0_CLKEN[REQ7]	391	7	1	0	YES	7
3	eDMA_1 transfer control descriptor 24	PRTN3_COFB0_CLKEN[REQ8]	392	8	1	0	YES	8
3	eDMA_1 transfer control descriptor 25	PRTN3_COFB0_CLKEN[REQ9]	393	9	1	0	YES	9
3	eDMA_1 transfer control descriptor 26	PRTN3_COFB0_CLKEN[REQ10]	394	10	1	0	YES	10
3	eDMA_1 transfer control descriptor 27	PRTN3_COFB0_CLKEN[REQ11]	395	11	1	0	YES	11

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Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
3	eDMA_1 transfer control descriptor 28	PRTN3_COFB0_CLKEN[REQ12]	396	12	1	0	YES	12
3	eDMA_1 transfer control descriptor 29	PRTN3_COFB0_CLKEN[REQ13]	397	13	1	0	YES	13
3	eDMA_1 transfer control descriptor 30	PRTN3_COFB0_CLKEN[REQ14]	398	14	1	0	YES	14
3	eDMA_1 transfer control descriptor 31	PRTN3_COFB0_CLKEN[REQ15]	399	15	1	0	YES	15
3	Reserved	PRTN3_COFB0_CLKEN[REQ16]	400	16	0	0	YES	16
3	Reserved	PRTN3_COFB0_CLKEN[REQ17]	401	17	0	0	YES	17
3	Reserved	PRTN3_COFB0_CLKEN[REQ18]	402	18	0	0	YES	18
3	Reserved	PRTN3_COFB0_CLKEN[REQ19]	403	19	0	0	YES	19
3	Reserved	PRTN3_COFB0_CLKEN[REQ20]	404	20	0	0	YES	20
3	Reserved	PRTN3_COFB0_CLKEN[REQ21]	405	21	0	0	YES	21

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
3	Reserved	PRTN3_COFB0_CLKEN[REQ22]	406	22	0	0	YES	22
3	Reserved	PRTN3_COFB0_CLKEN[REQ23]	407	23	0	0	YES	23
3	Reserved	PRTN3_COFB0_CLKEN[REQ24]	408	24	0	0	YES	24
3	Reserved	PRTN3_COFB0_CLKEN[REQ25]	409	25	0	0	YES	25
3	Reserved	PRTN3_COFB0_CLKEN[REQ26]	410	26	0	0	YES	26
3	Reserved	PRTN3_COFB0_CLKEN[REQ27]	411	27	0	0	YES	27
3	Reserved	PRTN3_COFB0_CLKEN[REQ28]	412	28	0	0	YES	28
3	Crossbar Integrity Checker (Lock-stepped eDMA_1 AHB Splitter)	PRTN3_COFB0_CLKEN[REQ29]	413	29	0	1	YES	29
3	Crossbar Integrity Checker (Zipwire ABH Splitter)	PRTN3_COFB0_CLKEN[REQ30]	414	30	0	0	YES	30
3	Reserved	PRTN3_COFB0_CLKEN[REQ31]	415	31	0	0	YES	31

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
3	eTPU_A/B Registers	PRTN3_COFB1_CLKEN[REQ32]	416	32	1	0	NO	0
3	Reserved	PRTN3_COFB1_CLKEN[REQ33]	417	33	0	0	NO	1
3	eTPU Parameter RAM (SDM)	PRTN3_COFB1_CLKEN[REQ34]	418	34	1	0	NO	2
3	eTPU Parameter RAM Mirror	PRTN3_COFB1_CLKEN[REQ35]	419	35	1	0	NO	3
3	eTPU Code RAM 1 (SCM)	PRTN3_COFB1_CLKEN[REQ36]	420	36	1	0	NO	4
3	eTPU Code RAM 2 (SCM)	PRTN3_COFB1_CLKEN[REQ37]	421	37	1	0	NO	5
3	Reserved	PRTN3_COFB1_CLKEN[REQ38]	422	38	0	0	NO	6
3	Reserved	PRTN3_COFB1_CLKEN[REQ39]	423	39	0	0	NO	7
3	DMA Channel Multiplexer 2	PRTN3_COFB1_CLKEN[REQ40]	424	40	1	0	NO	8
3	DMA Channel Multiplexer 3	PRTN3_COFB1_CLKEN[REQ41]	425	41	1	0	NO	9
3	Reserved	PRTN3_COFB1_CLKEN[REQ42]	426	42	1	0	NO	10
3	Reserved	PRTN3_COFB1_CLKEN[REQ43]	427	43	1	0	NO	11

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
3	IGF_0	PRTN3_COFB1_CLKEN[REQ44]	428	44	1	0	NO	12
3	Reserved	PRTN3_COFB1_CLKEN[REQ45]	429	45	1	0	NO	13
3	eFlexPWM_0	PRTN3_COFB1_CLKEN[REQ46]	430	46	1	0	NO	14
3	eFlexPWM_1	PRTN3_COFB1_CLKEN[REQ47]	431	47	1	0	NO	15
3	TRGMUX_MSC	PRTN3_COFB1_CLKEN[REQ48]	432	48	1	0	NO	16
3	Body Cross Triggering Unit 1	PRTN3_COFB1_CLKEN[REQ49]	433	49	1	0	NO	17
3	SGEN_0	PRTN3_COFB1_CLKEN[REQ50]	434	50	1	0	NO	18
3	SGEN_1	PRTN3_COFB1_CLKEN[REQ51]	435	51	1	0	NO	19
3	Analog-to-digital converter 4	PRTN3_COFB1_CLKEN[REQ52]	436	52	1	0	NO	20
3	Analog-to-digital converter 5	PRTN3_COFB1_CLKEN[REQ53]	437	53	1	0	NO	21
3	Analog-to-digital converter 6	PRTN3_COFB1_CLKEN[REQ54]	438	54	1	0	NO	22
3	Coolflux / DSP16L	PRTN3_COFB1_CLKEN[REQ55]	439	55	1	0	NO	23

Table continues on the next page...

Table 206. MC_ME partition peripheral mapping and clock control (continued)

AIPS	Peripheral description	MC_ME COFB control register	MC_ME peripheral control register	MC_ME peripheral slot no. in partition	PRTNx_ COFBy_ CLKEN [REQn] is configurable	PRTNx_ COFBy_ CLKEN [REQn] default value	On Platform	IPS Slot Number
3	Coolflux I-RAM (P-MEM)	PRTN3_COFB1_CLKEN[REQ56]	440	56	1	0	NO	24
3	Coolflux I-RAM (P-MEM)	PRTN3_COFB1_CLKEN[REQ57]	441	57	1	0	NO	25
3	Coolflux D-RAM (X-MEM)	PRTN3_COFB1_CLKEN[REQ58]	442	58	1	0	NO	26
3	Coolflux D-RAM (X-MEM)	PRTN3_COFB1_CLKEN[REQ59]	443	59	1	0	NO	27
3	Reserved	PRTN3_COFB1_CLKEN[REQ60]	444	60	1	0	NO	28
3	Sigma-Delta ADC 0	PRTN3_COFB1_CLKEN[REQ61]	445	61	1	0	NO	29
3	Sigma-Delta ADC 1	PRTN3_COFB1_CLKEN[REQ62]	446	62	1	0	NO	30
3	Sigma-Delta ADC 2	PRTN3_COFB1_CLKEN[REQ63]	447	63	1	0	NO	31
3	Sigma-Delta ADC 3	PRTN3_COFB2_CLKEN[REQ64]	448	64	1	0	NO	32
3	ADC-Bist	PRTN3_COFB2_CLKEN[REQ65]	449	65	1	0	NO	33
3	Reserved	PRTN3_COFB2_CLKEN[REQ66]	450	66	0	0	NO	34

41.1.10 Application core initialization process

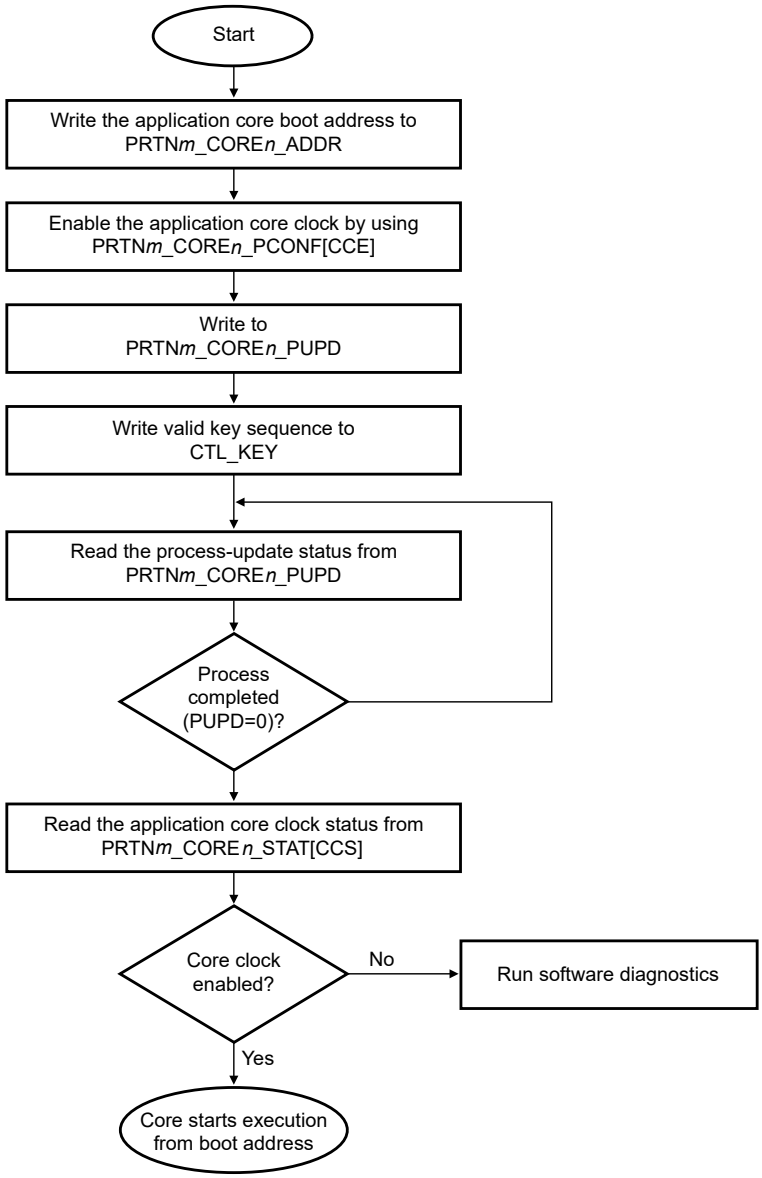

Figure 164. Application core initialization process

41.1.11 Application core shutdown process

If a debugger is attached to the chip and application debug is enabled, the application core continues running if you write 0 to MDM_AP.MDMAPCT[CM7_*n*_CORE_ACCESS].

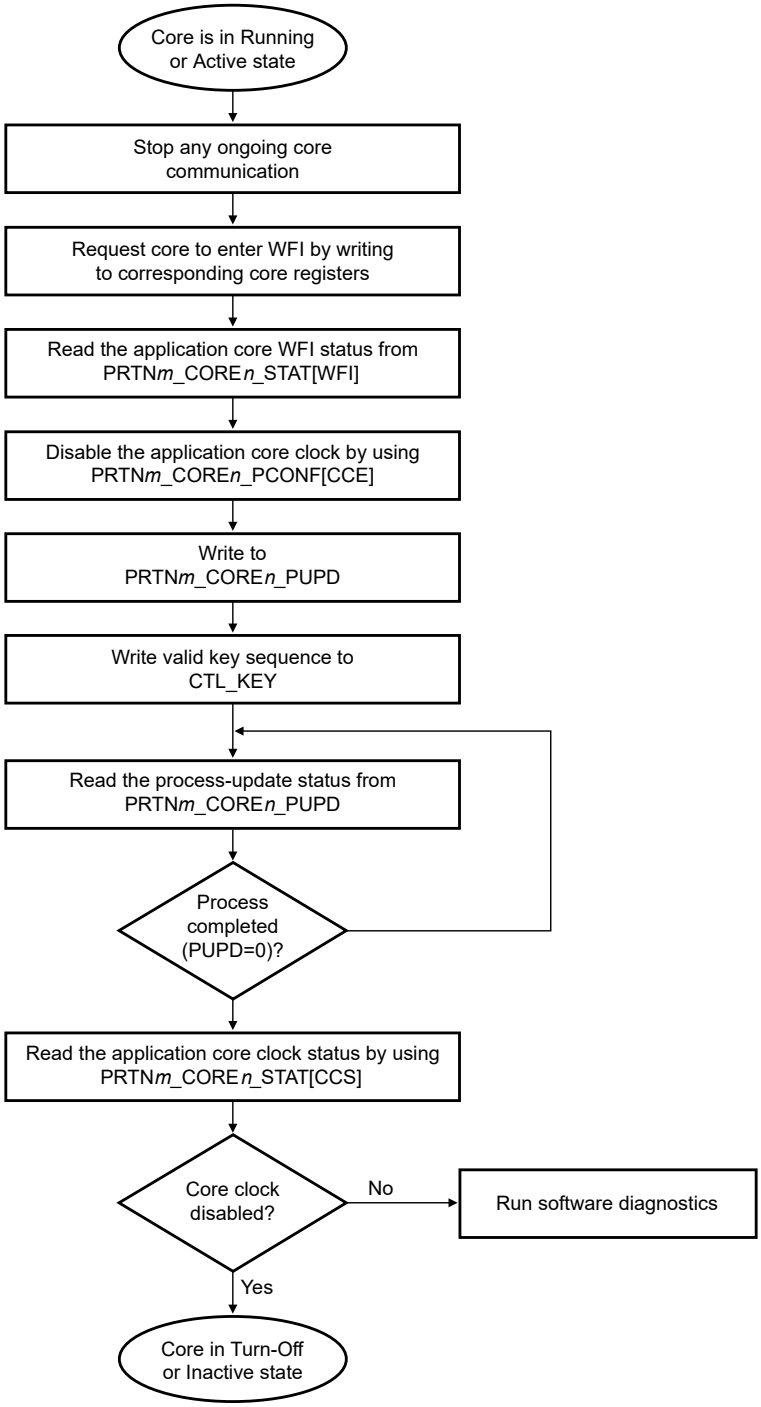

Figure 165. Application core shutdown process

41.1.12 Peripheral initialization process

You cannot control all the peripherals. For example, you cannot turn on and turn off the peripherals required for chip functionality across reset or power-up. They always remain on.

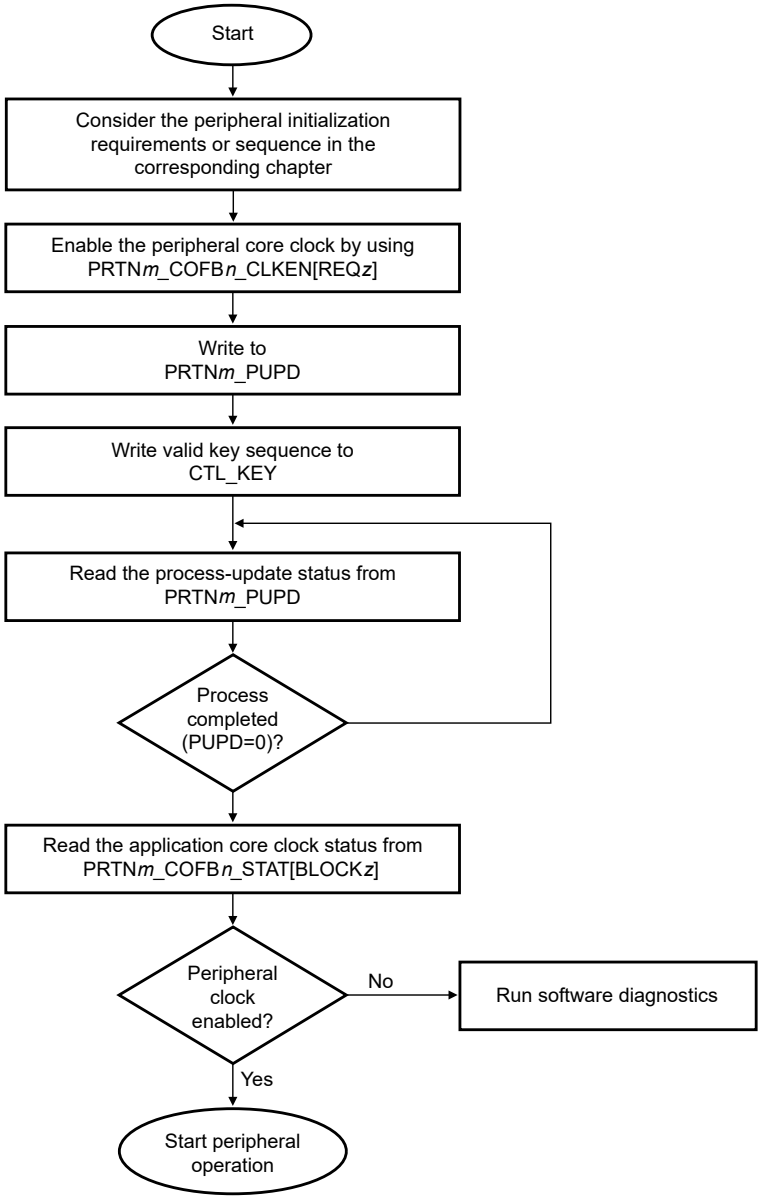

Figure 166. Peripheral initialization process

41.1.13 Peripheral shutdown process

You cannot control all the peripherals. For example, you cannot turn on and turn off the peripherals required for chip functionality across reset or power-up. They always remain on.

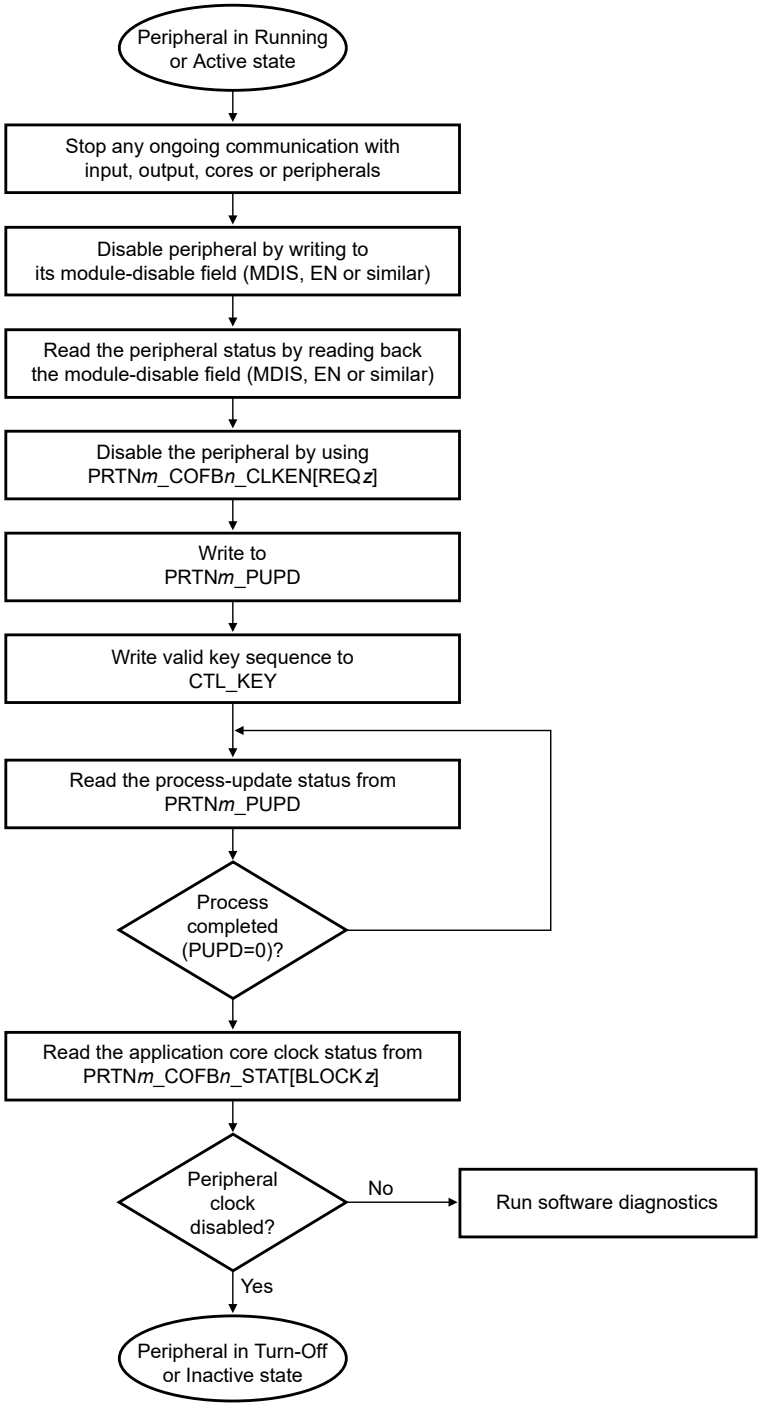

Figure 167. Peripheral shutdown process

41.2 Introduction

The MC_ME module generates control signals for a set of modules of the SoC. The set of signals are defined in corresponding 'Partition Configuration Registers'. It also implements a software-based mechanism for initiating a functional and destructive reset sequence and standby entry handshake with power management of SoC. See Figure 168 for the MC_ME block diagram.

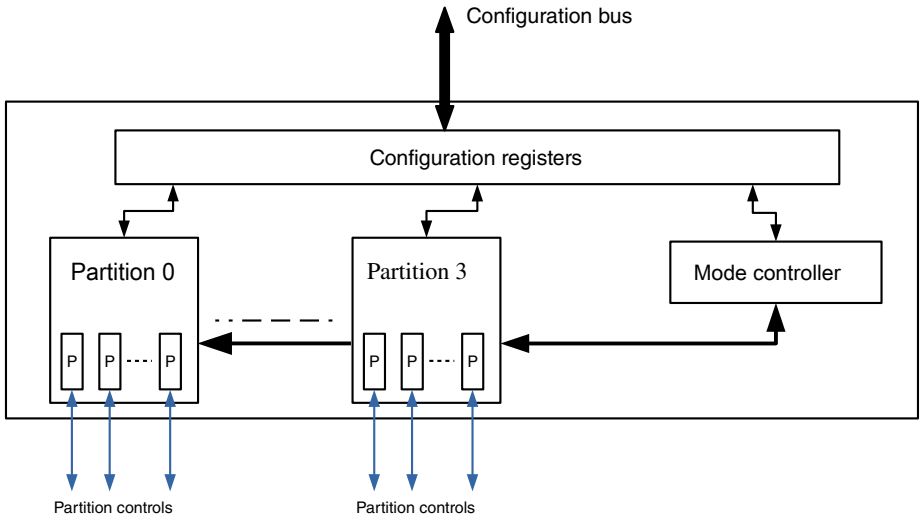

Figure 168. MC_ME block diagram

41.3 Features

MC_ME includes the following features:

- 4 logic partitions implementation and their controls
- Core clock controls
- Partition clock control
- Control mechanism for initiating a destructive or functional reset sequence to MC_RGM
- Control mechanism for initiating standby mode entry for SoC

The logic partition inside MC_ME refers to a certain group of on-chip resources (or IP blocks) that are clubbed together to represent a single 'Partition' inside MC_ME. The MC_ME partition can be the same or different than an LBIST partition. Each of the MC_ME partitions implements a certain number of hardware processes. These hardware processes provide a mechanism to regulate various control signals provided to or received from the IP blocks. The corresponding status signals can also be monitored from MC_ME register(s). Each of the hardware processes is bound to finish in 512 cycles of the MC_ME register configuration clocks. Therefore, the hardware processes are non blocking in nature. Mismatch in the expected versus actual status of any hardware process is controlled by a pre-defined software.

41.4 Partition processes

Each of the processes inside the partition controls register space and corresponds to a control signal provided to that partition. A partition can include a core, or COFBs, or both. The MC_ME hardware processes provide control and status via signals provided to partitions. Each partition can be assigned a signal for control and a signal for status. Each of the control signals implements functionality for the partition. For example, clock gating and peripheral control.

The hardware process can be triggered and monitored using a set of three registers:

- Configuration register; for example, Partition n Process Configuration register
- Update register; for example, Partition n Process Update register
- Status register; for example, Partition n Status register

Similar registers exist for cores inside the partition.

The process setup and triggering procedure is shown in Figure 169. Each of the processes is independent of others and can be triggered or re-triggered in parallel or sequential to other processes. The triggering or re-triggering mechanism remains the same.

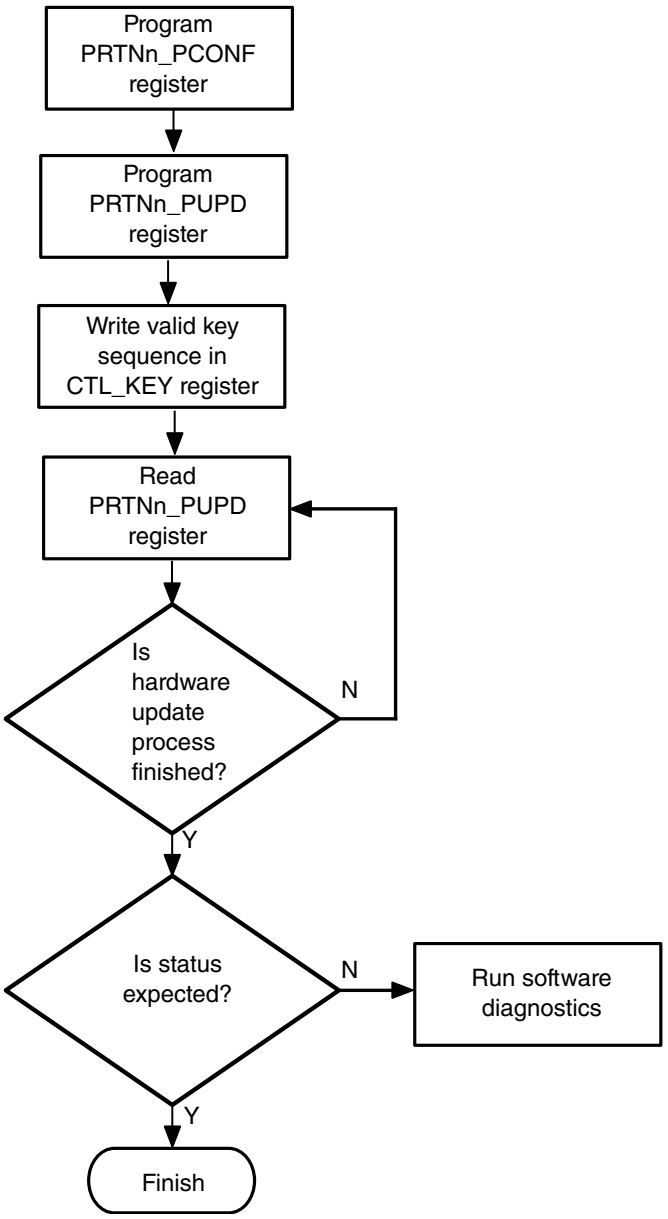

Figure 169. Partition process setup procedure

All the hardware processes are bound to finish in 512 cycles of the MC_ME configuration clock. If the actual and the expected status for a process does not match, then the diagnostics is left as a software responsibility. The software diagnostic can include further wait cycles for the status to match.

41.5 Mode transition

MC_ME implements a mode transition mechanism, whereby the mode of operation for SoC can be changed. Then module implements a mechanism that can lead to:

- Destructive reset
- Functional reset
- Standby mode entry

Destructive reset and functional reset requests from MC_ME are non-retractable transitions. After it is initiated, the other MC_ME functionality is rendered unusable and bus errors are provided for upcoming access to the MC_ME register until a reset sequence is executed by MC_RGM. Hence, it is vital that MC_RGM should never ignore or gate the reset requests from MC_ME.

For transition into the standby mode, the software should ensure that required IP blocks such as clock sources and I/O communication are in their respective inactive states before initiating a standby mode transition to MC_ME. After MC_ME initiates a power down sequence request, it cannot be retracted. The SoC enters a standby power down sequence and then reenter power-up sequence even for cases where the standby wakeup happens right at the time of initiating a power-down sequence request.

Steps for initiating the MC_ME mode transition:

1. Setup the MODE_CONF register with the corresponding target mode bit set to logic-1.
2. Perform the same update as done in the MODE_CONF register on the CONF_UPD register.
3. Write the valid control key (0x5AF0) on the CTL_KEY register.
4. Write the valid invert control key (0xA50F) on the CTL_KEY register.

Mode transition to MC_ME is initiated, after the sequence mentioned above is completed.

In step 1, if both FUNC_RST and DEST_RST in Mode Configuration Register (MODE_CONF) are 1:

- After step 4 is complete, MC_ME initiates a mode transition to a destructive (not functional) reset.
- After the chip exits reset, MC_RGM records that both MC_ME's destructive reset and MC_ME's functional reset were the reset source.

NOTE

Any hardware partition processes setup, along with mode transition, is executed in parallel to the mode transition of MC_ME.

41.6 Standby entry

MC_ME provides hardware processes that implement shutdown sequencing of on-chip resources, such as cores and COFBs. The standby entry sequencing can be achieved or implemented using these hardware processes. The order of the hardware process is determined by the software and MC_ME. It requires no restriction in sequencing of the operation. Following is an example sequence for initiating a power-down sequence for entering the standby mode for SoC. The standby entry sequence should include (but not limited to) the following steps:

1. Setting up wakeup lines
2. Shutting down cores and COFBs
3. Switching all MC_CGM muxes to FIRC with PCFS
4. Powering down all clock sources except FIRC
5. Setting up MC_ME using the main core and initiating a standby mode transition
6. Executing WFI instruction on the main core (per Arm specification)

41.6.1 Application core shutdown

This section describes a mechanism for shutting down an application core. The sequence proposed here is extendible with the housekeeping tasks required for other IPs. Each of the tasks mentioned in the following sequence, can be further integrated with an SoC-specific task.

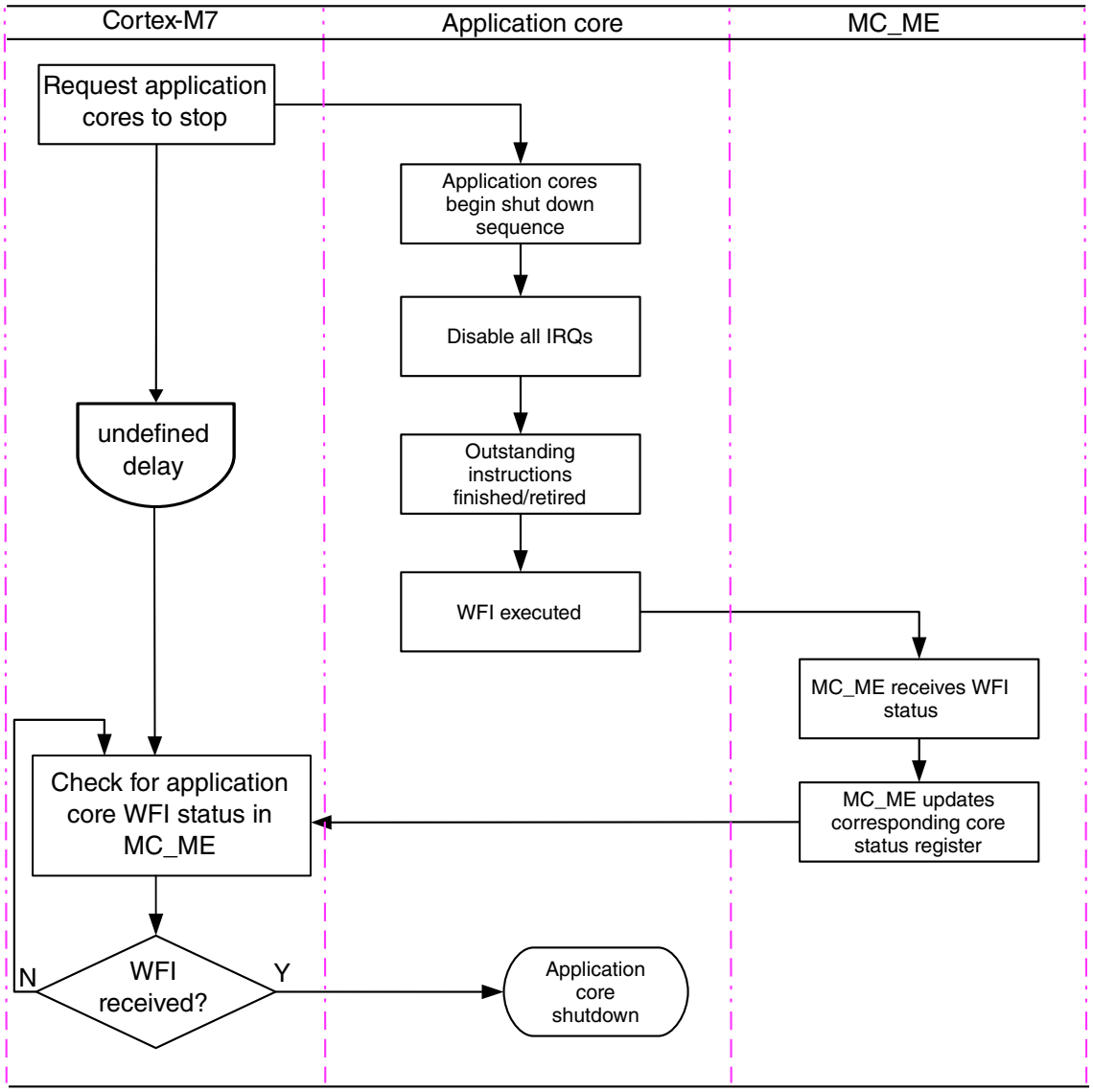

Figure 170. Application core shutdown

After the application core is shutdown, the main core can optionally decide to gate the respective core clock using the corresponding core clock hardware process.

41.6.2 Main core shutdown and standby entry

This section describes standby entry sequence along with the main core shutdown. This sequence should only be initiated after SoC is ready for entering standby and has completed all the housekeeping activities. It is necessary that the main core has completed all the operations pertaining to other (application cores) and is the last active core before initiating the standby entry sequence. See Figure 171.

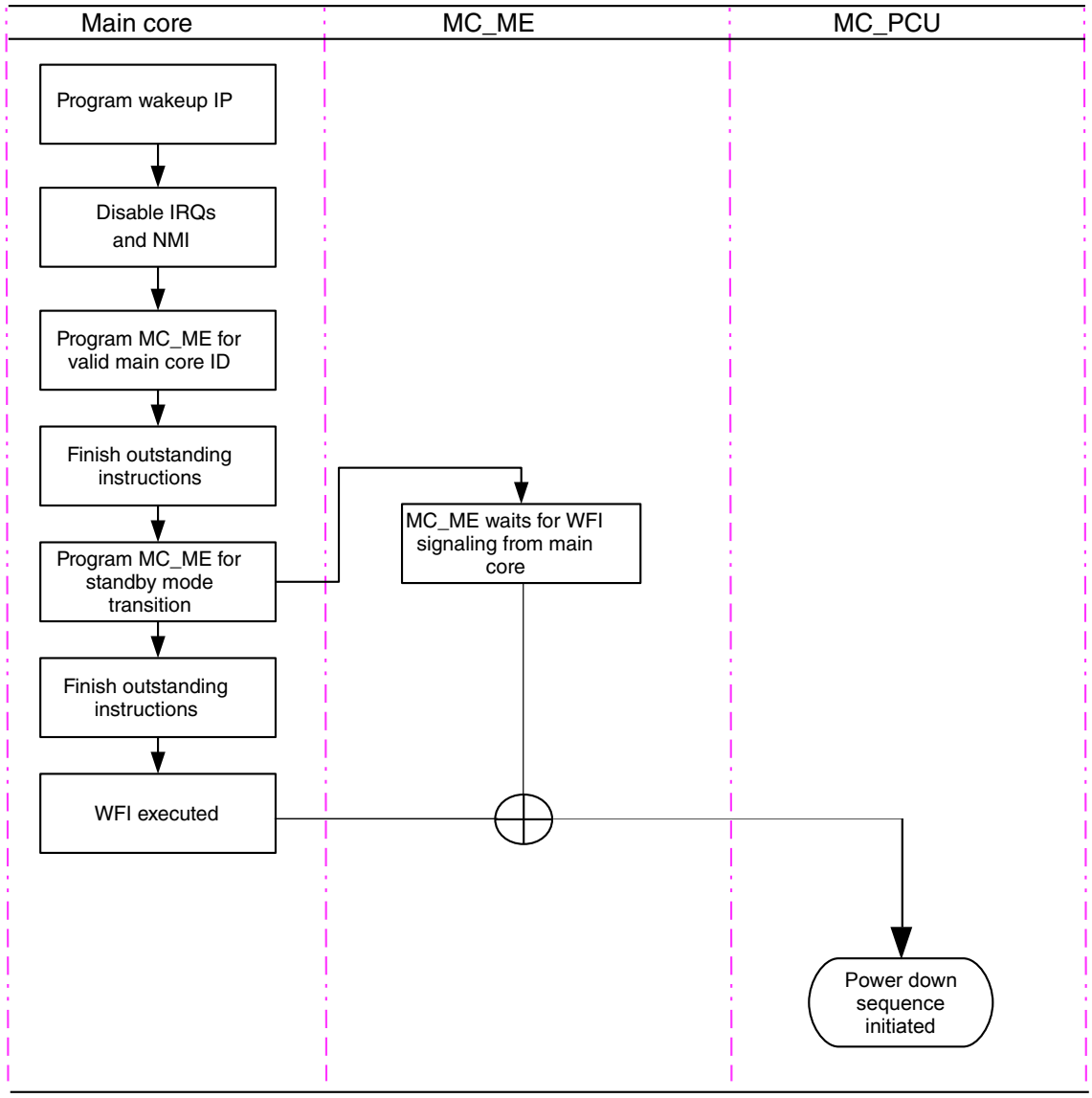

Figure 171. Standby entry sequence along with main core shutdown

NOTE

- MC_ME initiates the power sequence to MC_PCU. This enables the main core to remain inactive (WFI state) until it is reset and power-up again at standby exit.

41.7 MC_ME register descriptions

MC_ME implements set hardware processes that can be used by the software for changing the mode of operation for a partition. Following are the features of MC_ME registers:

- All registers are 32-bit wide.
- Only 32-bit read and write accesses are supported.
- Read/write accesses of less than 32 bits terminate with an error.
- Writes to read-only register fields in writable registers are ignored and do not provide an error message.

- Writes to read-only registers are aborted with an error message.

41.7.1 MC_ME memory map

MC_ME base address: 402D_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Control Key Register (CTL_KEY)	32	RW	0000_5AF0h
4h	Mode Configuration Register (MODE_CONF)	32	RW	0000_0000h
8h	Mode Update Register (MODE_UPD)	32	RW	0000_0000h
Ch	Mode Status Register (MODE_STAT)	32	R	0000_0000h
10h	Main Core ID Register (MAIN_COREID)	32	RW	0000_0000h
100h	Partition 0 Process Configuration Register (PRTN0_PCONF)	32	RW	0000_0001h
104h	Partition 0 Process Update Register (PRTN0_PUPD)	32	RW	0000_0000h
108h	Partition 0 Status Register (PRTN0_STAT)	32	R	0000_0001h
10Ch	Partition 0 Core Lockstep Control Register (PRTN0_CORE_LOCKSTEP)	32	RW	0000_0000h
110h	Partition 0 COFB Set 0 Clock Status Register (PRTN0_COFB0_STAT)	32	R	0000_0000h
114h	Partition 0 COFB Set 1 Clock Status Register (PRTN0_COFB1_STAT)	32	R	0000_1000h
130h	Partition 0 COFB Set 0 Clock Enable Register (PRTN0_COFB0_CLKEN)	32	RW	0000_0000h
134h	Partition 0 COFB Set 1 Clock Enable Register (PRTN0_COFB1_CLKEN)	32	RW	0000_1000h
140h	Partition 0 Core 0 Process Configuration Register (PRTN0_CORE0_PCONF)	32	RW	0000_0000h
144h	Partition 0 Core 0 Process Update Register (PRTN0_CORE0_PUPD)	32	RW	0000_0000h
148h	Partition 0 Core 0 Status Register (PRTN0_CORE0_STAT)	32	R	0000_0000h
14Ch	Partition 0 Core 0 Address Register (PRTN0_CORE0_ADDR)	32	RW	0040_0000h
160h	Partition 0 Core 1 Process Configuration Register (PRTN0_CORE1_PCONF)	32	RW	0000_0000h
164h	Partition 0 Core 1 Process Update Register (PRTN0_CORE1_PUPD)	32	RW	0000_0000h
168h	Partition 0 Core 1 Status Register (PRTN0_CORE1_STAT)	32	R	0000_0000h
16Ch	Partition 0 Core 1 Address Register (PRTN0_CORE1_ADDR)	32	RW	0041_0000h
188h	Partition 0 Core 2 Status Register (PRTN0_CORE2_STAT)	32	R	0000_0001h
18Ch	Partition 0 Core 2 Address Register (PRTN0_CORE2_ADDR)	32	R	009F_FC00h

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Offset	Register	Width (In bits)	Access	Reset value
1C0h	Partition 0 Core 4 Process Configuration Register (PRTN0_CORE4_PCONF)	32	RW	0000_0000h
1C4h	Partition 0 Core 4 Process Update Register (PRTN0_CORE4_PUPD)	32	RW	0000_0000h
1C8h	Partition 0 Core 4 Status Register (PRTN0_CORE4_STAT)	32	R	0000_0000h
1CCh	Partition 0 Core 4 Address Register (PRTN0_CORE4_ADDR)	32	RW	0042_0000h
1E0h	Partition 0 Core 5 Process Configuration Register (PRTN0_CORE5_PCONF)	32	RW	0000_0000h
1E4h	Partition 0 Core 5 Process Update Register (PRTN0_CORE5_PUPD)	32	RW	0000_0000h
1E8h	Partition 0 Core 5 Status Register (PRTN0_CORE5_STAT)	32	R	0000_0000h
1ECh	Partition 0 Core 5 Address Register (PRTN0_CORE5_ADDR)	32	RW	0042_0000h
300h	Partition 1 Process Configuration Register (PRTN1_PCONF)	32	RW	0000_0001h
304h	Partition 1 Process Update Register (PRTN1_PUPD)	32	RW	0000_0000h
308h	Partition 1 Status Register (PRTN1_STAT)	32	R	0000_0001h
310h	Partition 1 COFB Set 0 Clock Status Register (PRTN1_COFB0_STAT)	32	R	5E3F_0007h
314h	Partition 1 COFB Set 1 Clock Status Register (PRTN1_COFB1_STAT)	32	R	7CF4_2FFCh
318h	Partition 1 COFB Set 2 Clock Status Register (PRTN1_COFB2_STAT)	32	R	3000_0000h
31Ch	Partition 1 COFB Set 3 Clock Status Register (PRTN1_COFB3_STAT)	32	R	0000_5FEEh
330h	Partition 1 COFB Set 0 Clock Enable Register (PRTN1_COFB0_CLKEN)	32	RW	5E3F_0007h
334h	Partition 1 COFB Set 1 Clock Enable Register (PRTN1_COFB1_CLKEN)	32	RW	7CF4_2FFCh
338h	Partition 1 COFB Set 2 Clock Enable Register (PRTN1_COFB2_CLKEN)	32	RW	3000_0000h
33Ch	Partition 1 COFB Set 3 Clock Enable Register (PRTN1_COFB3_CLKEN)	32	RW	0000_5FEEh
500h	Partition 2 Process Configuration Register (PRTN2_PCONF)	32	RW	0000_0001h
504h	Partition 2 Process Update Register (PRTN2_PUPD)	32	RW	0000_0000h
508h	Partition 2 Status Register (PRTN2_STAT)	32	R	0000_0001h
510h	Partition 2 COFB Set 0 Clock Status Register (PRTN2_COFB0_STAT)	32	R	0200_0003h

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Offset	Register	Width (In bits)	Access	Reset value
514h	Partition 2 COFB Set 1 Clock Status Register (PRTN2_COFB1_STAT)	32	R	C800_0000h
518h	Partition 2 COFB Set 2 Clock Status Register (PRTN2_COFB2_STAT)	32	R	0000_0FC1h
530h	Partition 2 COFB Set 0 Clock Enable Register (PRTN2_COFB0_CLKEN)	32	RW	0200_0003h
534h	Partition 2 COFB Set 1 Clock Enable Register (PRTN2_COFB1_CLKEN)	32	RW	C800_0000h
538h	Partition 2 COFB Set 2 Clock Enable Register (PRTN2_COFB2_CLKEN)	32	RW	0000_0FC1h
700h	Partition 3 Process Configuration Register (PRTN3_PCONF)	32	RW	0000_0001h
704h	Partition 3 Process Update Register (PRTN3_PUPD)	32	RW	0000_0000h
708h	Partition 3 Status Register (PRTN3_STAT)	32	R	0000_0001h
710h	Partition 3 COFB Set 0 Clock Status Register (PRTN3_COFB0_STAT)	32	R	6000_0000h
714h	Partition 3 COFB Set 1 Clock Status Register (PRTN3_COFB1_STAT)	32	R	0000_0000h
718h	Partition 3 COFB Set 2 Clock Status Register (PRTN3_COFB2_STAT)	32	R	0000_0000h
730h	Partition 3 COFB Set 0 Clock Enable Register (PRTN3_COFB0_CLKEN)	32	RW	6000_0000h
734h	Partition 3 COFB Set 1 Clock Enable Register (PRTN3_COFB1_CLKEN)	32	RW	0000_0000h
738h	Partition 3 COFB Set 2 Clock Enable Register (PRTN3_COFB2_CLKEN)	32	RW	0000_0000h

41.7.2 Control Key Register (CTL_KEY)

Offset

Register	Offset
CTL_KEY	0h

Function

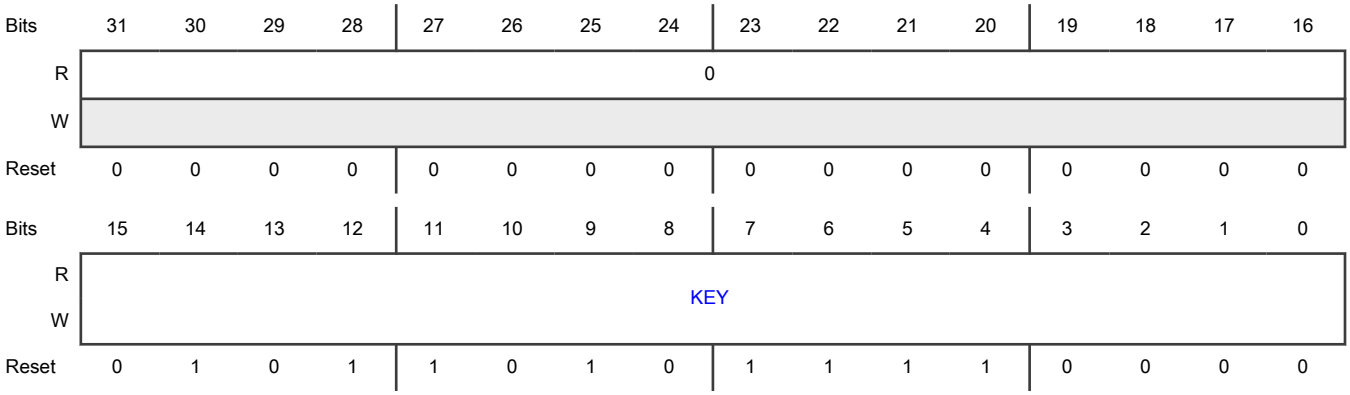
This register provides the mechanism to MC_ME for starting the hardware processes for the partition(s) and standby entry sequence. The hardware processes for partitions are triggered through the corresponding PRTNn_PCONF register. The mechanism to trigger the hardware processes of the respective partitions require two write operations: first time with key and second time with inverted key. The hexadecimal value of key is 0x5AF0 whereas for inverted key is 0xA50F.

For initiating a standby entry sequence, the MODE_CONF register is used for providing a standby entry request along with a valid key combination.

NOTE

Reads from this register return a valid key value to be written next.

Diagram



Fields

Field	Function
31-16 —	Reserved This field is reserved and read returns zeros.
15-0 KEY	Control key Key for starting the hardware processes. Writes with a value other than key or inverted key are ignored. Reads return bit inverted value corresponding to last write.

41.7.3 Mode Configuration Register (MODE_CONF)

Offset

Register	Offset
MODE_CONF	4h

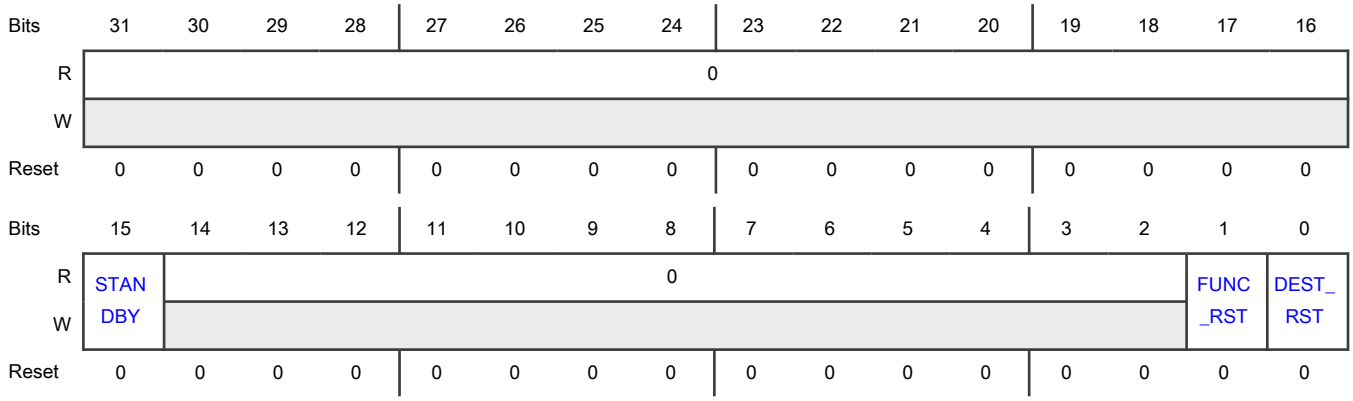
Function

This register is used for initiating a standby request or a reset event (destructive or functional) for the chip. The functional or destructive events are signaled to MC_RGM for further handling.

NOTE

Software must not enable mode entry if the value of multiple fields is 1 in the MODE_CONF register.

Diagram



Fields

Field	Function
31-16 —	Reserved This field is reserved and read returns zeros.
15 STANDBY	Standby request Writing a logic-1 to this bit along with the MODE_UPD register configuration and followed with a valid key combination makes a standby entry sequence request to MC_ME.
14-2 —	Reserved This field is reserved and read returns zeros.
1 FUNC_RST	Functional reset request Writing a logic-1 to this bit along with the MODE_UPD register configuration and followed with a valid key combination makes a functional reset event signaling to MC_RGM.
0 DEST_RST	Destructive reset request Writing a logic-1 to this bit along with the MODE_UPD register configuration and followed with a valid key combination makes a destructive reset event signaling to MC_RGM.

41.7.4 Mode Update Register (MODE_UPD)

Offset

Register	Offset
MODE_UPD	8h

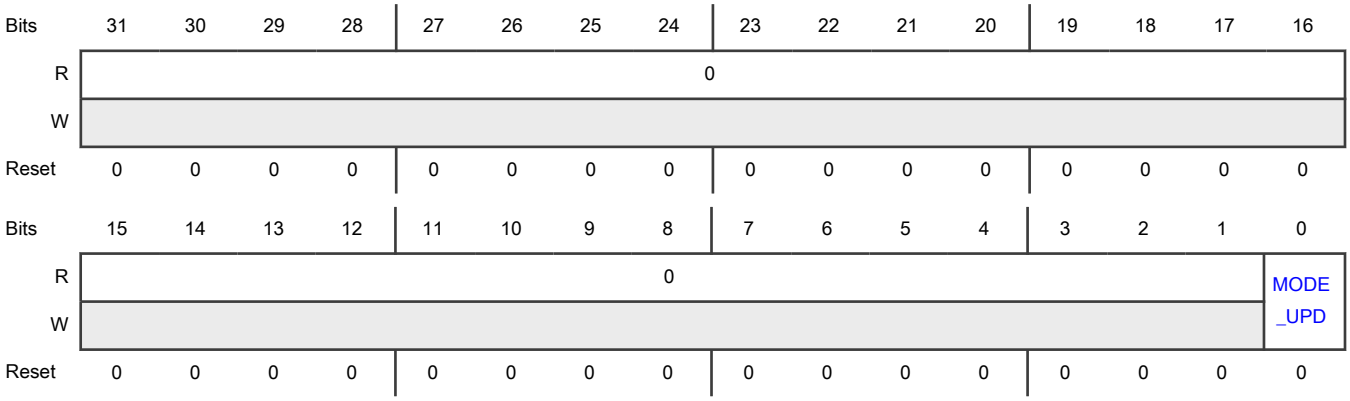
Function

This register is used for initiating a mode change. Mode change refers to initiating a standby request, or generating a destructive or functional reset event to MC_RGM. Setting mode update field to logic-1, along with programming MODE_CONF registers and then followed by a valid key combination will generate a mode transition request.

NOTE

The MODE_UPD register is implemented to make mode transition programming model the same as partition programming model. This is for future expansion inside MC_ME.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 MODE_UPD	Mode update Writing a logic-1 to this bit, followed by a valid key combination initiates a mode change as per the MODE_CONF register.

41.7.5 Mode Status Register (MODE_STAT)

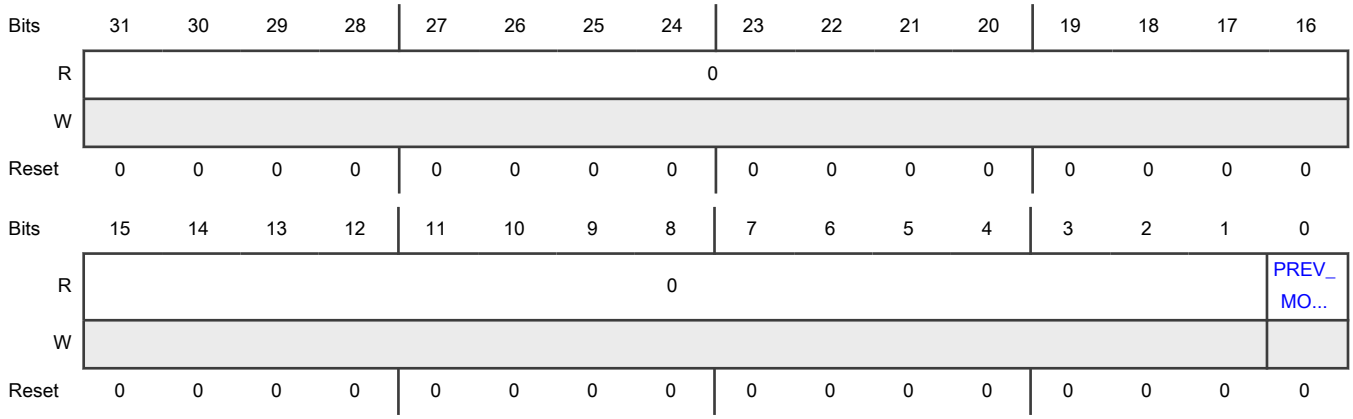
Offset

Register	Offset
MODE_STAT	Ch

Function

This register provides the status of the previous mode. In case of standby exit, if the reset event status register of MC_RGM are set, then contents of this register should be ignored.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 PREV_MODE	Previous mode This bit shows the status of the previous mode. 0b - The previous mode was reset (any reset). 1b - The previous mode was standby.

41.7.6 Main Core ID Register (MAIN_COREID)

Offset

Register	Offset
MAIN_COREID	10h

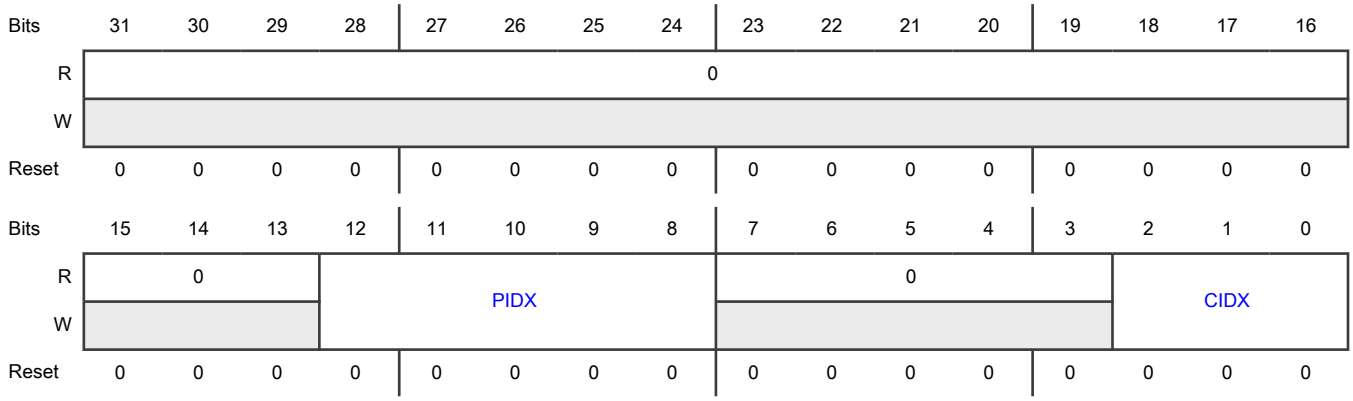
Function

This register provides the ID of the main core sequencing the operation for the standby sequence. Core ID is required for entering in the standby mode, and using this MC_ME locates the WFI instruction execution of the main core. The core ID in this register is specified by the partition index along with the core index.

NOTE

Before initiating a standby entry sequence, the contents of this register should point to the correct main core. Providing non-existing or incorrect core ID leads to unpredictable hardware behavior.

Diagram



Fields

Field	Function
31-13 —	Reserved This field is reserved and read returns zeros.
12-8 PIDX	Partition index Provides the partition index of the main core. Only values 0 - 3 can be written.
7-3 —	Reserved This field is reserved and read returns zeros.
2-0 CIDX	Core index Provides the core index of the main core inside the partition.

41.7.7 Partition 0 Process Configuration Register (PRTN0_PCONF)

Offset

Register	Offset
PRTN0_PCONF	100h

Function

This register provides a configuration for the hardware processes corresponding to Partition 0. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN0_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN0_PCONF and PRTN0_PUPD registers are used to determine the hardware processes to be executed. These are triggered in parallel and independent of each other. All dependent processes should be requested one after another from the software.

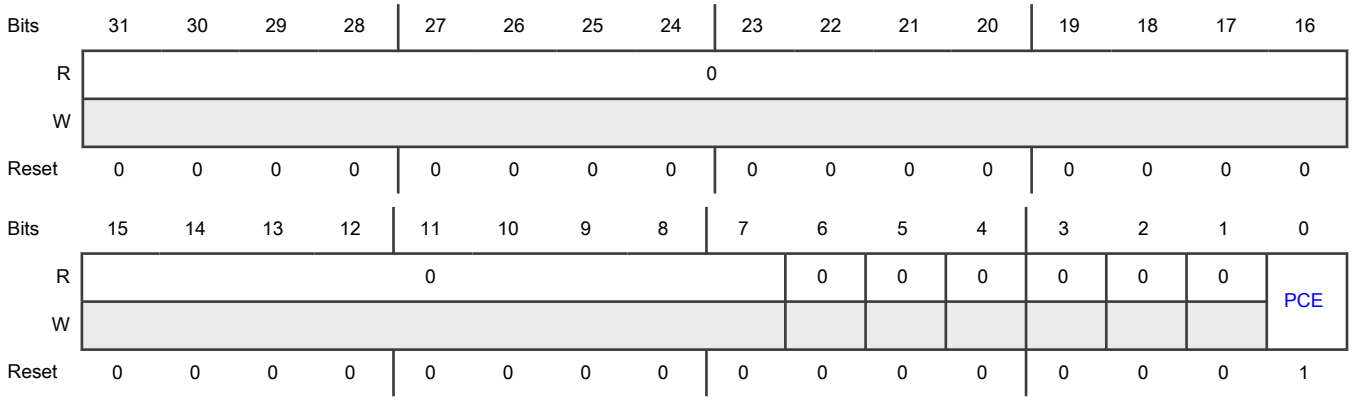
NOTE

The partition clock enable/disable are not standalone and must be done coherently in a fixed sequence. For details, see Software Reset Partition Turn-On Flow Chart and Software reset partition turn-off flowchart in Reset chapter.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCE	Partition clock enable This bit controls whether the clock to IPs (other than core(s)) in the partition should be enabled or disabled. 0b - Disable the clock to IPs 1b - Enable the clock to IPs

41.7.8 Partition 0 Process Update Register (PRTN0_PUPD)

Offset

Register	Offset
PRTN0_PUPD	104h

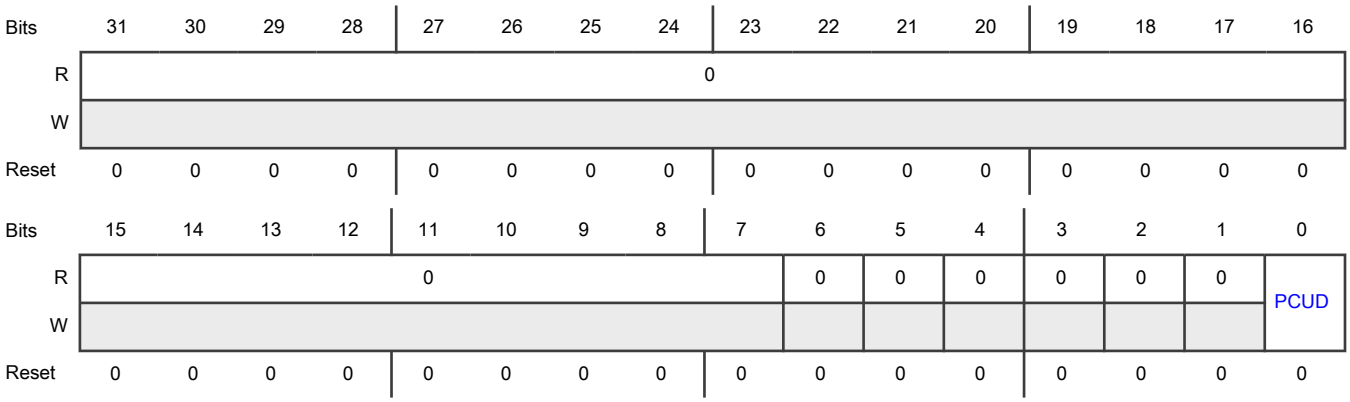
Function

This register provides trigger signaling for the hardware processes corresponding to Partition 0. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN0_PCONF register. When the hardware process is finished the corresponding bit in this register is auto-cleared to logic-0.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCUD	Partition clock update This bit controls whether the hardware processes for enabling/disabling the clock to IPs (other than core(s)) in the partition should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.9 Partition 0 Status Register (PRTN0_STAT)

Offset

Register	Offset
PRTN0_STAT	108h

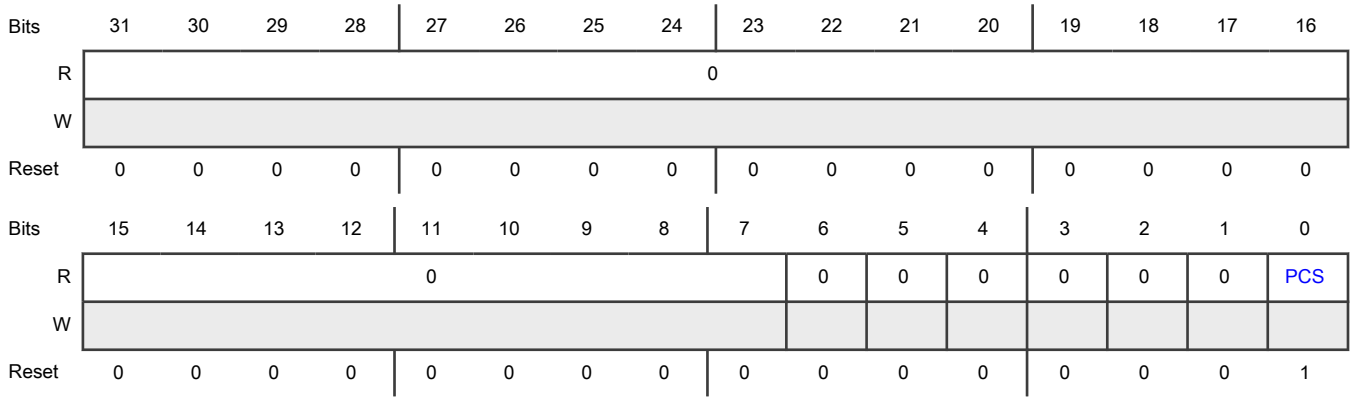
Function

This register provides the current status of the control signals from the Partition 0.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCS	Partition clock status This bit provides the status of the clock to partition. 0b - Clock is inactive 1b - Clock is active

41.7.10 Partition 0 Core Lockstep Control Register (PRTN0_CORE_LOCKSTEP)

Offset

Register	Offset
PRTN0_CORE_LOCKSTEP	10Ch

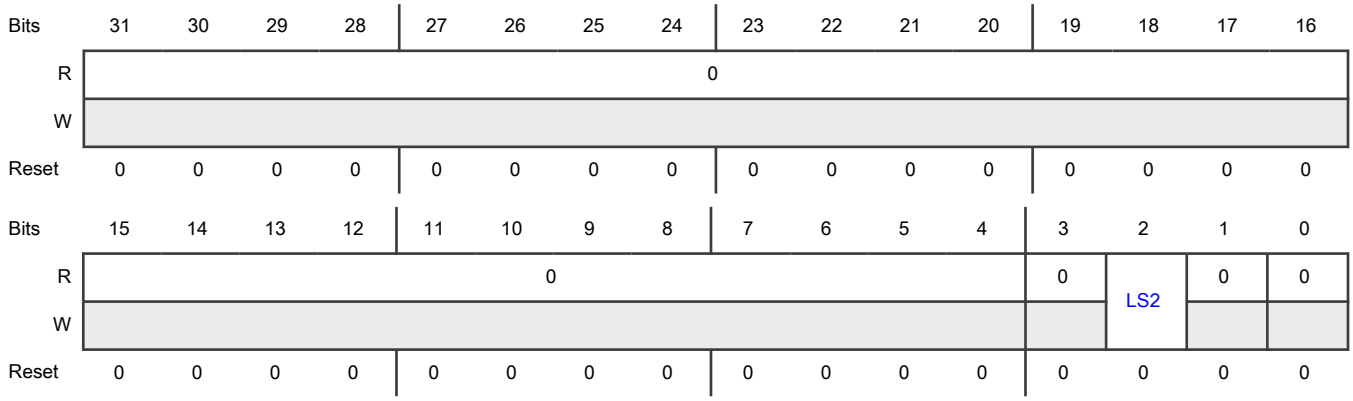
Function

This register provides the control for indicating a set of cores for lockstep execution in Partition 0. Writes to this register immediately provide the corresponding bit to the described cores. No hardware process updates are required.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved
2 LS2	Lockstep 2 This bit provides the lockstep indication to Core 4 & Core 5 in partition 0. 0b - Lockstep disabled 1b - Lockstep enabled
1 —	Reserved
0 —	Reserved

41.7.11 Partition 0 COFB Set 0 Clock Status Register (PRTN0_COFB0_STAT)

Offset

Register	Offset
PRTN0_COFB0_STAT	110h

Function

This register provides the status of set 0 of COFBs inside Partition 0.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside Partition 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	BLOCK20	BLOCK19	BLOCK18	BLOCK17	BLOCK16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK15	BLOCK14	BLOCK13	BLOCK12	BLOCK11	BLOCK10	BLOCK9	BLOCK8	BLOCK7	BLOCK6	BLOCK5	BLOCK4	BLOCK3	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22	Reserved

Table continues on the next page...

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Field	Function
—	This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 BLOCK20	IP block status This bit provides the clock status of block 20 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
19 BLOCK19	IP block status This bit provides the clock status of block 19 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
18 BLOCK18	IP block status This bit provides the clock status of block 18 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
17 BLOCK17	IP block status This bit provides the clock status of block 17 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
16 BLOCK16	IP block status This bit provides the clock status of block 16 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
15 BLOCK15	IP block status This bit provides the clock status of block 15 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
14 BLOCK14	IP block status This bit provides the clock status of block 14 in Partition 0. 0b - Clock is not running. 1b - Clock is running.

Table continues on the next page...

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Field	Function
13 BLOCK13	IP block status This bit provides the clock status of block 13 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
12 BLOCK12	IP block status This bit provides the clock status of block 12 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
11 BLOCK11	IP block status This bit provides the clock status of block 11 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
10 BLOCK10	IP block status This bit provides the clock status of block 10 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK9	IP block status This bit provides the clock status of block 9 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK8	IP block status This bit provides the clock status of block 8 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK7	IP block status This bit provides the clock status of block 7 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK6	IP block status This bit provides the clock status of block 6 in Partition 0. 0b - Clock is not running.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is running.
5 BLOCK5	IP block status This bit provides the clock status of block 5 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
4 BLOCK4	IP block status This bit provides the clock status of block 4 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
3 BLOCK3	IP block status This bit provides the clock status of block 3 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 —	Reserved This field is reserved and read returns zeros.

41.7.12 Partition 0 COFB Set 1 Clock Status Register (PRTN0_COFB1_STAT)

Offset

Register	Offset
PRTN0_COFB1_STAT	114h

Function

This register provides the status of set 1 of COFBs inside Partition 0.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside Partition 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLOCK49	BLOCK48
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK47	BLOCK46	BLOCK45	BLOCK44	BLOCK43	BLOCK42	BLOCK41	BLOCK40	BLOCK39	BLOCK38	0	0	0	BLOCK34	BLOCK33	BLOCK32
W																
Reset	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 BLOCK49	IP block status This bit provides the clock status of block 49 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
16 BLOCK48	IP block status This bit provides the clock status of block 48 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
15 BLOCK47	IP block status This bit provides the clock status of block 47 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
14 BLOCK46	IP block status This bit provides the clock status of block 46 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
13 BLOCK45	IP block status This bit provides the clock status of PIT_1 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
12	IP block status

Table continues on the next page...

Table continued from the previous page...

Field	Function
BLOCK44	This bit provides the clock status of PIT_0 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
11 BLOCK43	IP block status This bit provides the clock status of block 43 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
10 BLOCK42	IP block status This bit provides the clock status of ADC_2 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK41	IP block status This bit provides the clock status of ADC_1 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK40	IP block status This bit provides the clock status of ADC_0 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK39	IP block status This bit provides the clock status of LCU_1 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK38	IP block status This bit provides the clock status of LCU_0 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 —	Reserved This field is reserved and read returns zeros.
2 BLOCK34	IP block status This bit provides the clock status of eMIOS_0 in Partition 0. 0b - Clock is not running. 1b - Clock is running.
1 BLOCK33	IP block status This bit provides the clock status of BCTU in Partition 0. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK32	IP block status This bit provides the clock status of TRGMUX in Partition 0. 0b - Clock is not running. 1b - Clock is running.

41.7.13 Partition 0 COFB Set 0 Clock Enable Register (PRTN0_COFB0_CLKEN)

Offset

Register	Offset
PRTN0_COFB0_CLKEN	130h

Function

This register provides clock control signaling to the individual COFBs in set 0 inside Partition 0. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	REQ20	REQ19	REQ18	REQ17	REQ16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ15	REQ14	REQ13	REQ12	REQ11	REQ10	REQ9	REQ8	REQ7	REQ6	REQ5	REQ4	REQ3	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
21 —	Reserved This field is reserved and read returns zeros.
20 REQ20	Clock enable This bit provides the clock enable control for block 20 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
19 REQ19	Clock enable This bit provides the clock enable control for block 19 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
18 REQ18	Clock enable This bit provides the clock enable control for block 18 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
17 REQ17	Clock enable This bit provides the clock enable control for block 17 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
16 REQ16	Clock enable This bit provides the clock enable control for block 16 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
15 REQ15	Clock enable This bit provides the clock enable control for block 15 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
14 REQ14	Clock enable This bit provides the clock enable control for block 14 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
13	Clock enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
REQ13	This bit provides the clock enable control for block 13 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
12 REQ12	Clock enable This bit provides the clock enable control for block 12 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
11 REQ11	Clock enable This bit provides the clock enable control for block 11 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
10 REQ10	Clock enable This bit provides the clock enable control for block 10 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
9 REQ9	Clock enable This bit provides the clock enable control for block 9 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
8 REQ8	Clock enable This bit provides the clock enable control for block 8 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
7 REQ7	Clock enable This bit provides the clock enable control for block 7 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
6 REQ6	Clock enable This bit provides the clock enable control for block 6 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.

Table continues on the next page...

Table continued from the previous page...

Field	Function
5 REQ5	Clock enable This bit provides the clock enable control for block 5 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
4 REQ4	Clock enable This bit provides the clock enable control for block 4 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
3 REQ3	Clock enable This bit provides the clock enable control for block 3 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 —	Reserved This field is reserved and read returns zeros.

41.7.14 Partition 0 COFB Set 1 Clock Enable Register (PRTN0_COFB1_CLKEN)

Offset

Register	Offset
PRTN0_COFB1_CLKEN	134h

Function

This register provides clock control signaling to the individual COFBs in set 1 inside Partition 0. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	REQ49	REQ48
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ47	REQ46	REQ45	REQ44	REQ43	REQ42	REQ41	REQ40	REQ39	REQ38	0	0	0	REQ34	REQ33	REQ32
W																
Reset	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 REQ49	Clock enable This bit provides the clock enable control for block 49 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
16 REQ48	Clock enable This bit provides the clock enable control for block 48 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
15 REQ47	Clock enable This bit provides the clock enable control for block 47 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
14 REQ46	Clock enable This bit provides the clock enable control for block 46 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
13 REQ45	Clock enable This bit provides the clock enable control for PIT_1 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
12 REQ44	Clock enable This bit provides the clock enable control for PIT_0 in Partition 0.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
11 REQ43	Clock enable This bit provides the clock enable control for block 43 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
10 REQ42	Clock enable This bit provides the clock enable control for ADC_2 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
9 REQ41	Clock enable This bit provides the clock enable control for ADC_1 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
8 REQ40	Clock enable This bit provides the clock enable control for ADC_0 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
7 REQ39	Clock enable This bit provides the clock enable control for LCU_1 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
6 REQ38	Clock enable This bit provides the clock enable control for LCU_0 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
2 REQ34	Clock enable This bit provides the clock enable control for eMIOS_0 in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
1 REQ33	Clock enable This bit provides the clock enable control for BCTU in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.
0 REQ32	Clock enable This bit provides the clock enable control for TRGMUX in Partition 0. 0b - Clock is turned off. 1b - Clock is turned on.

41.7.15 Partition 0 Core 0 Process Configuration Register (PRTN0_CORE0_PCONF)

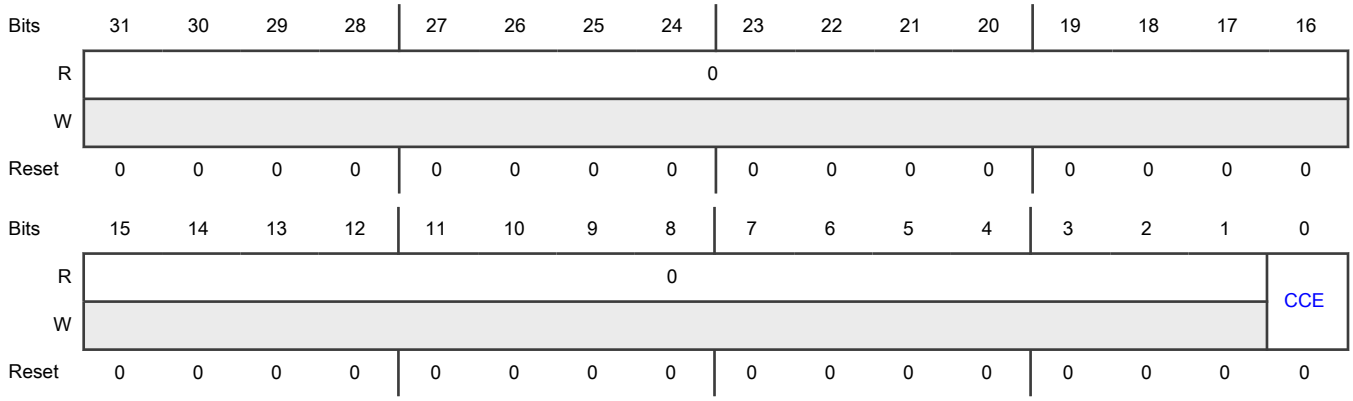
Offset

Register	Offset
PRTN0_CORE0_PCONF	140h

Function

This register provides configurations for the Core 0 hardware processes corresponding to Partition 0. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN0_CORE0_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN0_CORE0_PUPD and PRTN0_CORE0_PCONF registers are used to determine the hardware processes to be executed. These processes are triggered in parallel and are independent of each other. All dependent processes should be requested one after another from the software.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCE	Core 0 clock enable This bit controls whether the clock to Core 0 in Partition 0 should be enabled or disabled. 0b - Disable the core clock 1b - Enable the core clock

41.7.16 Partition 0 Core 0 Process Update Register (PRTN0_CORE0_PUPD)

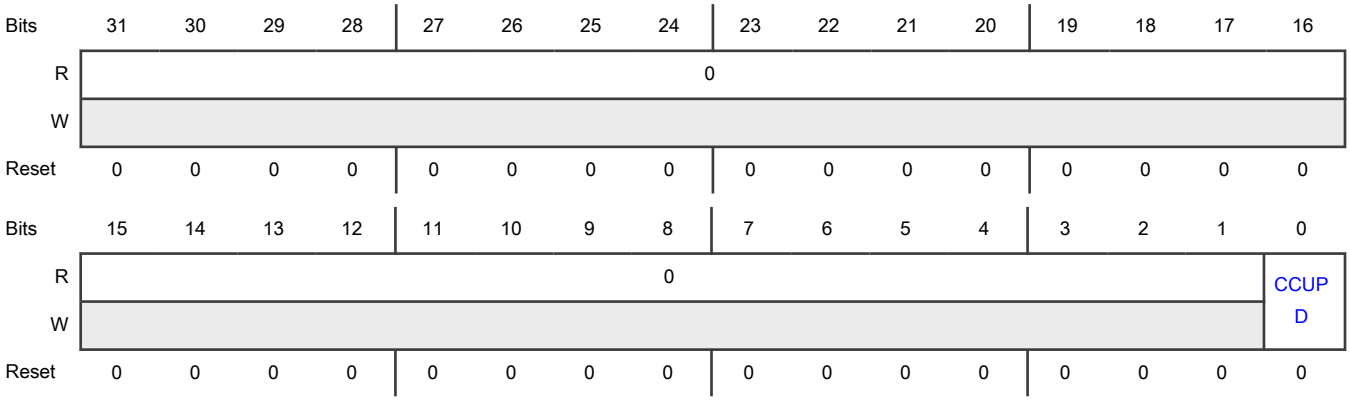
Offset

Register	Offset
PRTN0_CORE0_PUPD	144h

Function

This register provides trigger signaling for the core hardware processes corresponding to Partition 0. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN0_CORE0_PCONF register. When the hardware process is finished, the corresponding bit in this register is auto-cleared to logic-0.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCUPD	Core 0 clock update This bit controls whether the hardware processes for enabling/disabling the clock to Core 0 in the Partition 0 should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.17 Partition 0 Core 0 Status Register (PRTN0_CORE0_STAT)

Offset

Register	Offset
PRTN0_CORE0_STAT	148h

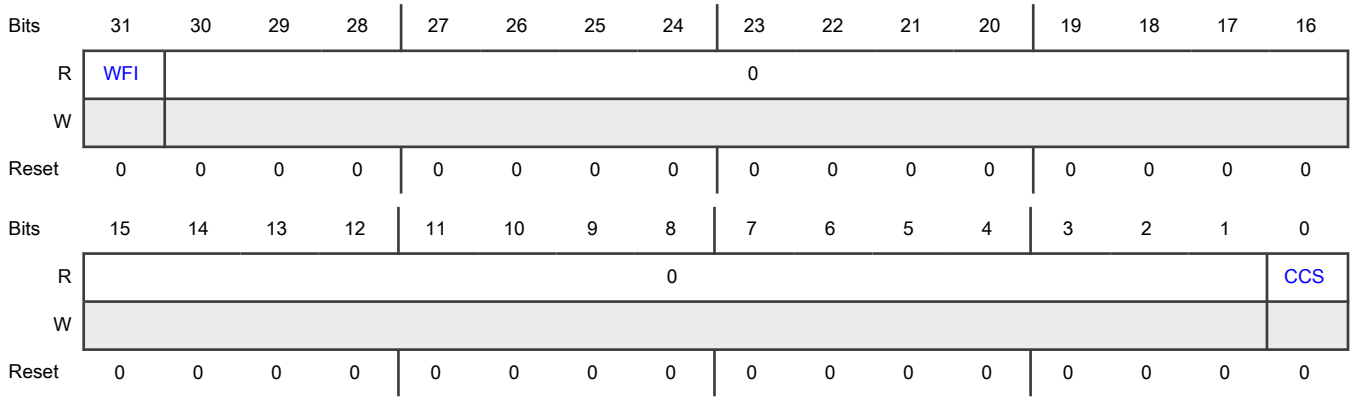
Function

This register provides the status corresponding to Core 0 in Partition 0. The status signal corresponds to clock states and the WFI signal included from Core 0.

NOTE

The value held in WFI field of this STATUS register is "current" value of the WFISTANDBY signal from the core. Hence out-of-reset, the reset value of this field will depend on the status of the core (core is running or in low power mode). So, simple reset read sweep will always return current value (different than other register reads such as on control registers).

Diagram



Fields

Field	Function
31 WFI	Wait for interrupt status This bit provides the WFI status approaching from Core 0 in Partition 0. 0b - No WFI executed 1b - WFI executed
30-1 —	Reserved This field is reserved and read returns zeros.
0 CCS	Core 0 clock process status This bit provides the status of the clock corresponding to core clock enablement/disablement. 0b - Clock is inactive. 1b - Clock is active.

41.7.18 Partition 0 Core 0 Address Register (PRTN0_CORE0_ADDR)

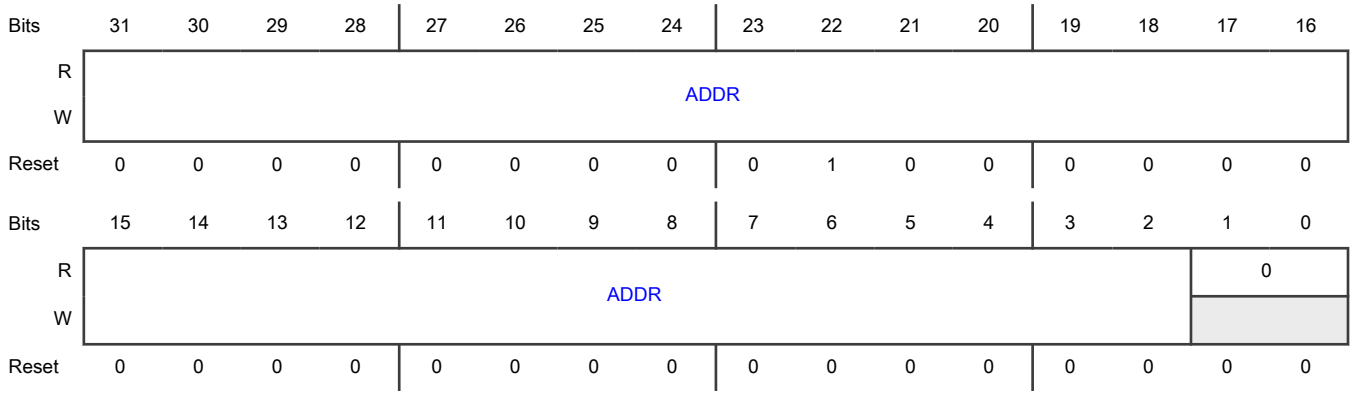
Offset

Register	Offset
PRTN0_CORE0_ADDR	14Ch

Function

This register contains the boot address for Core 0 in Partition 0.

Diagram



Fields

Field	Function
31-2 ADDR	Address Core 0 boot address
1-0 —	Reserved This field is reserved and read returns zeros.

41.7.19 Partition 0 Core 1 Process Configuration Register (PRTN0_CORE1_PCONF)

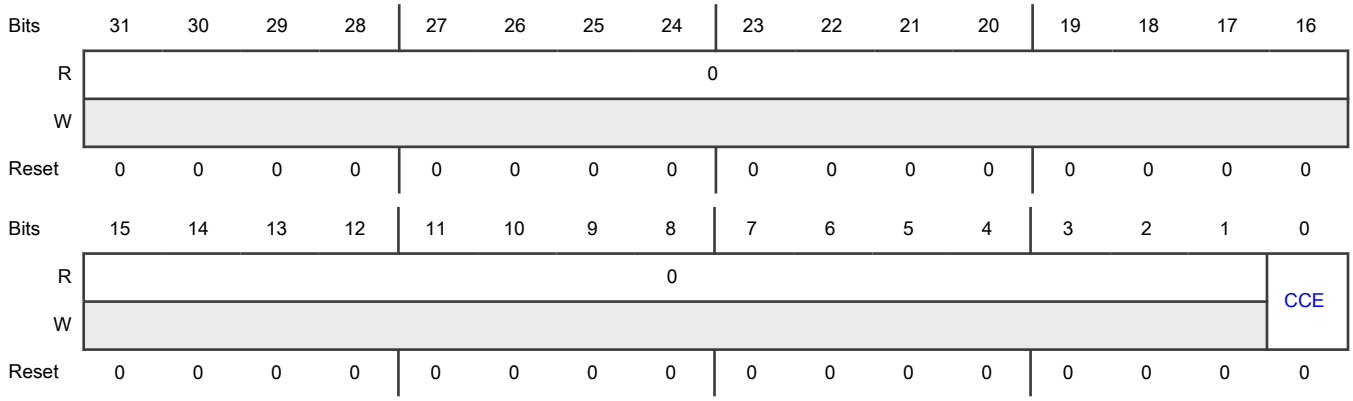
Offset

Register	Offset
PRTN0_CORE1_PCONF	160h

Function

This register provides configurations for the Core 1 hardware processes corresponding to Partition 0. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN0_CORE1_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN0_CORE1_PUPD and PRTN0_CORE1_PCONF registers are used to determine the hardware processes to be executed. These processes are triggered in parallel and are independent of each other. All dependent processes should be requested one after another from the software.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCE	Core 1 clock enable This bit controls whether the clock to Core 1 in Partition 0 should be enabled or disabled. 0b - Disable the core clock 1b - Enable the core clock

41.7.20 Partition 0 Core 1 Process Update Register (PRTN0_CORE1_PUPD)

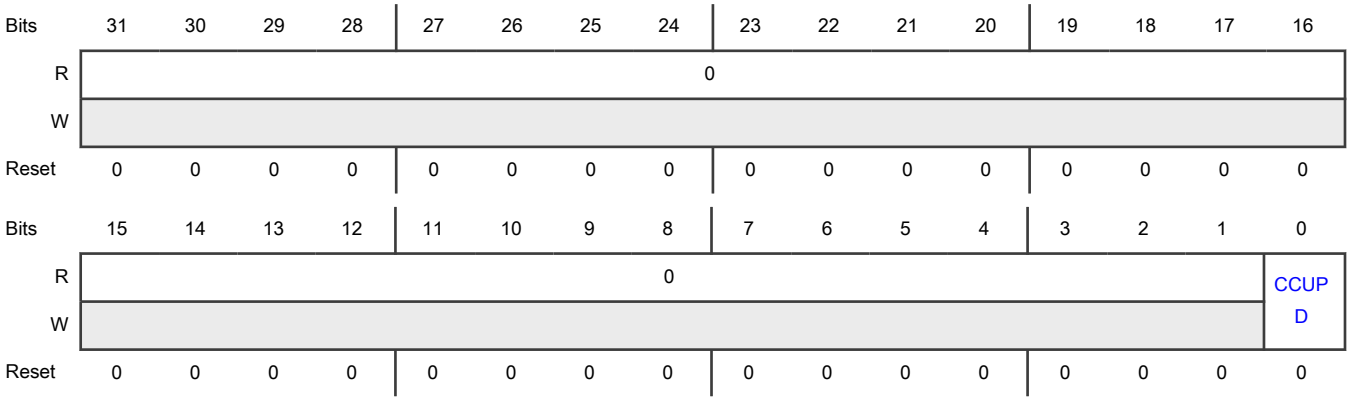
Offset

Register	Offset
PRTN0_CORE1_PUPD	164h

Function

This register provides trigger signaling for the core hardware processes corresponding to Partition 0. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN0_CORE1_PCONF register. When the hardware process is finished, the corresponding bit in this register is auto-cleared to logic-0.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCUPD	Core 1 clock update This bit controls whether the hardware processes for enabling/disabling the clock to Core 1 in the Partition 0 should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.21 Partition 0 Core 1 Status Register (PRTN0_CORE1_STAT)

Offset

Register	Offset
PRTN0_CORE1_STAT	168h

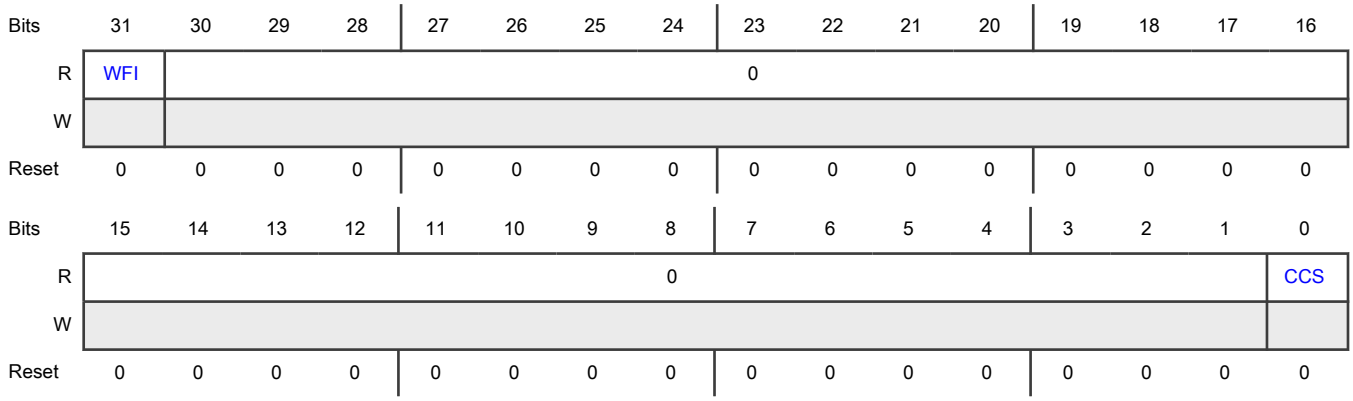
Function

This register provides the status corresponding to Core 1 in Partition 0. The status signal corresponds to clock states and the WFI signal included from Core 1.

NOTE

The value held in WFI field of this STATUS register is "current" value of the WFISTANDBY signal from the core. Hence out-of-reset, the reset value of this field will depend on the status of the core (core is running or in low power mode). So, simple reset read sweep will always return current value (different than other register reads such as on control registers).

Diagram



Fields

Field	Function
31 WFI	Wait for interrupt status This bit provides the WFI status approaching from Core 1 in Partition 0. 0b - No WFI executed 1b - WFI executed
30-1 —	Reserved This field is reserved and read returns zeros.
0 CCS	Core 1 clock process status This bit provides the status of the clock corresponding to core clock enablement/disablement. 0b - Clock is inactive. 1b - Clock is active.

41.7.22 Partition 0 Core 1 Address Register (PRTN0_CORE1_ADDR)

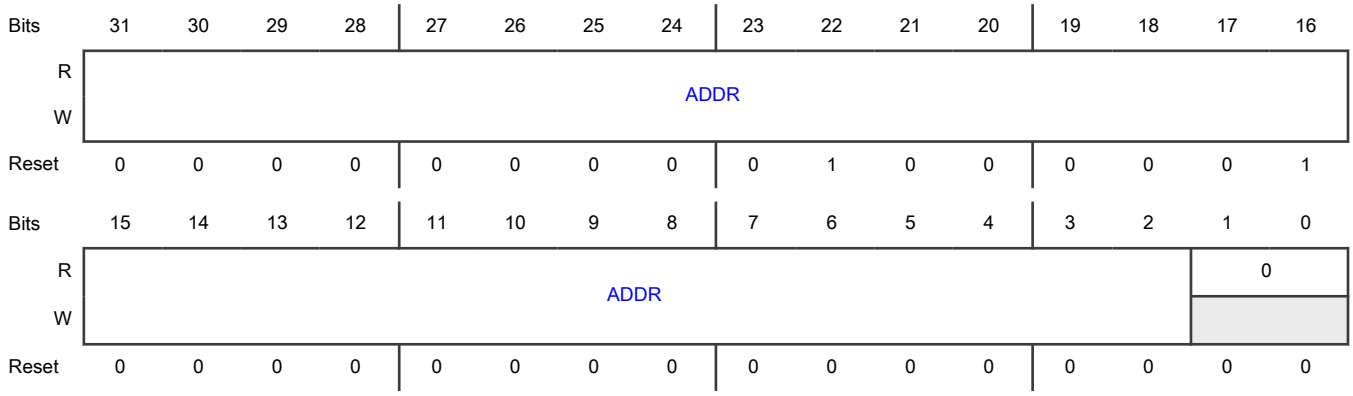
Offset

Register	Offset
PRTN0_CORE1_ADDR	16Ch

Function

This register contains the boot address for Core 1 in Partition 0.

Diagram



Fields

Field	Function
31-2 ADDR	Address Core 1 boot address
1-0 —	Reserved This field is reserved and read returns zeros.

41.7.23 Partition 0 Core 2 Status Register (PRTN0_CORE2_STAT)

Offset

Register	Offset
PRTN0_CORE2_STAT	188h

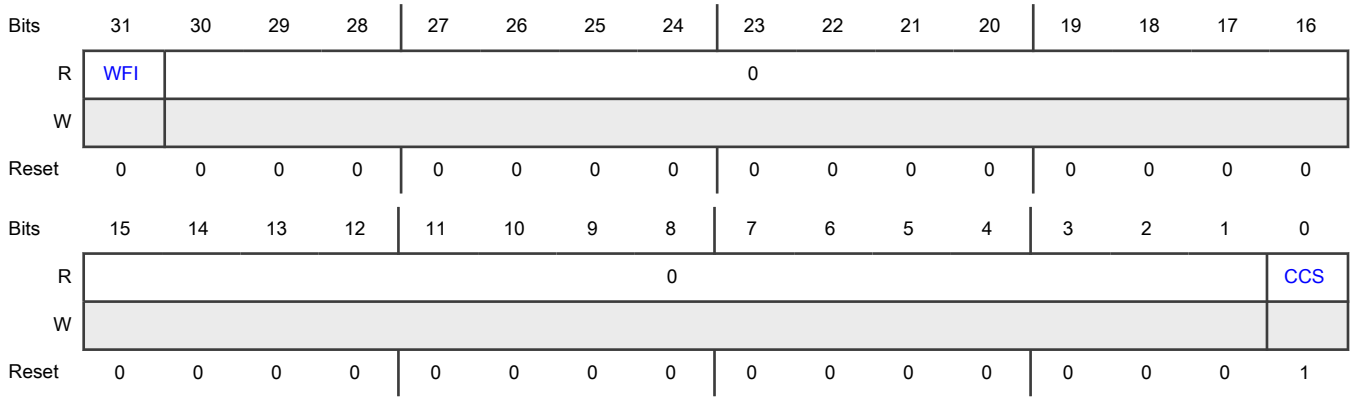
Function

This register provides the status corresponding to Core 2 in Partition 0. The status signal corresponds to clock states and the WFI signal included from Core 2.

NOTE

The value held in WFI field of this STATUS register is "current" value of the WFISTANDBY signal from the core. Hence out-of-reset, the reset value of this field will depend on the status of the core (core is running or in low power mode). So, simple reset read sweep will always return current value (different than other register reads such as on control registers).

Diagram



Fields

Field	Function
31 WFI	Wait for interrupt status This bit provides the WFI status approaching from Core 2 in Partition 0. 0b - No WFI executed 1b - WFI executed
30-1 —	Reserved This field is reserved and read returns zeros.
0 CCS	Core 2 clock process status This bit provides the status of the clock corresponding to core clock enablement/disablement. 1b - Clock is active.

41.7.24 Partition 0 Core 2 Address Register (PRTN0_CORE2_ADDR)

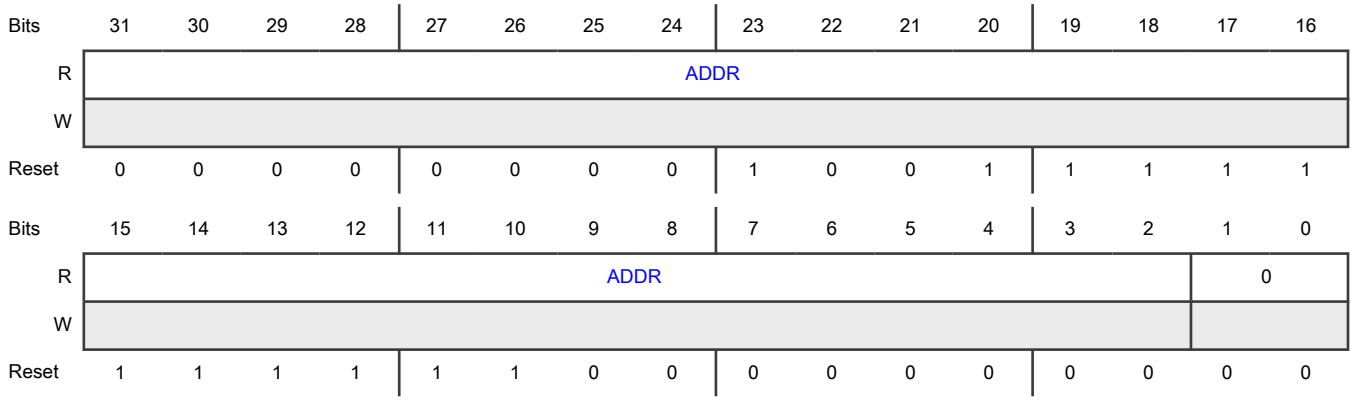
Offset

Register	Offset
PRTN0_CORE2_ADDR	18Ch

Function

This register contains the boot address for Core 2 in Partition 0.

Diagram



Fields

Field	Function
31-2 ADDR	Address Core 2 boot address
1-0 —	Reserved This field is reserved and read returns zeros.

41.7.25 Partition 0 Core 4 Process Configuration Register (PRTN0_CORE4_PCONF)

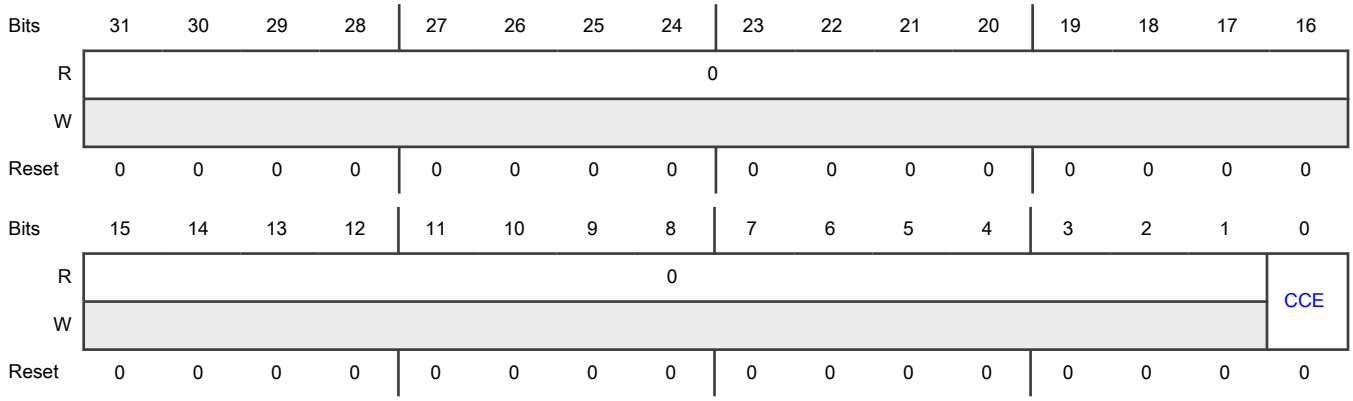
Offset

Register	Offset
PRTN0_CORE4_PCONF	1C0h

Function

This register provides configurations for the Core 4 hardware processes corresponding to Partition 0. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN0_CORE4_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN0_CORE4_PUPD and PRTN0_CORE4_PCONF registers are used to determine the hardware processes to be executed. These processes are triggered in parallel and are independent of each other. All dependent processes should be requested one after another from the software.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCE	Core 4 clock enable This bit controls whether the clock to Core 4 in Partition 0 should be enabled or disabled. 0b - Disable the core clock 1b - Enable the core clock

41.7.26 Partition 0 Core 4 Process Update Register (PRTN0_CORE4_PUPD)

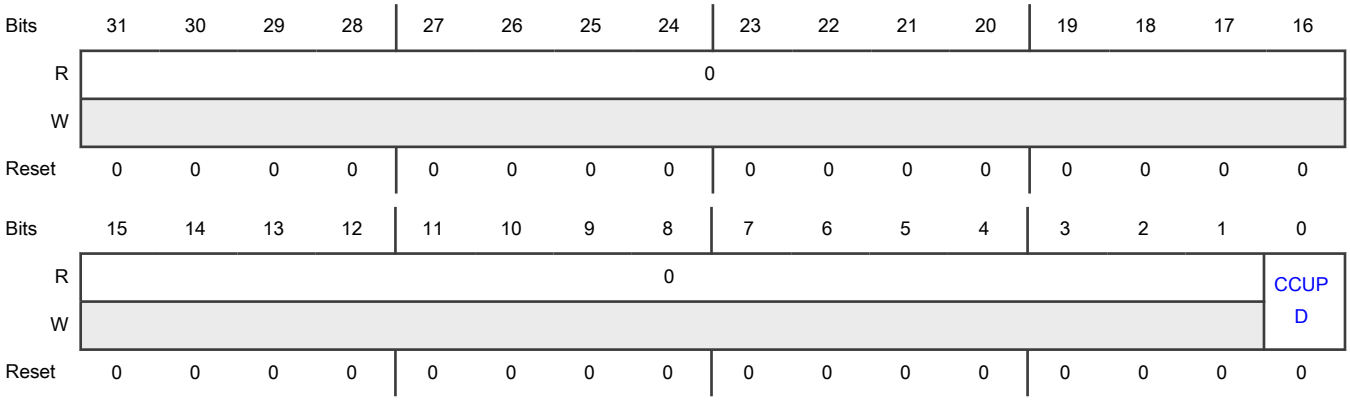
Offset

Register	Offset
PRTN0_CORE4_PUPD	1C4h

Function

This register provides trigger signaling for the core hardware processes corresponding to Partition 0. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN0_CORE4_PCONF register. When the hardware process is finished, the corresponding bit in this register is auto-cleared to logic-0.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCUPD	Core 4 clock update This bit controls whether the hardware processes for enabling/disabling the clock to Core 4 in the Partition 0 should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.27 Partition 0 Core 4 Status Register (PRTN0_CORE4_STAT)

Offset

Register	Offset
PRTN0_CORE4_STAT	1C8h

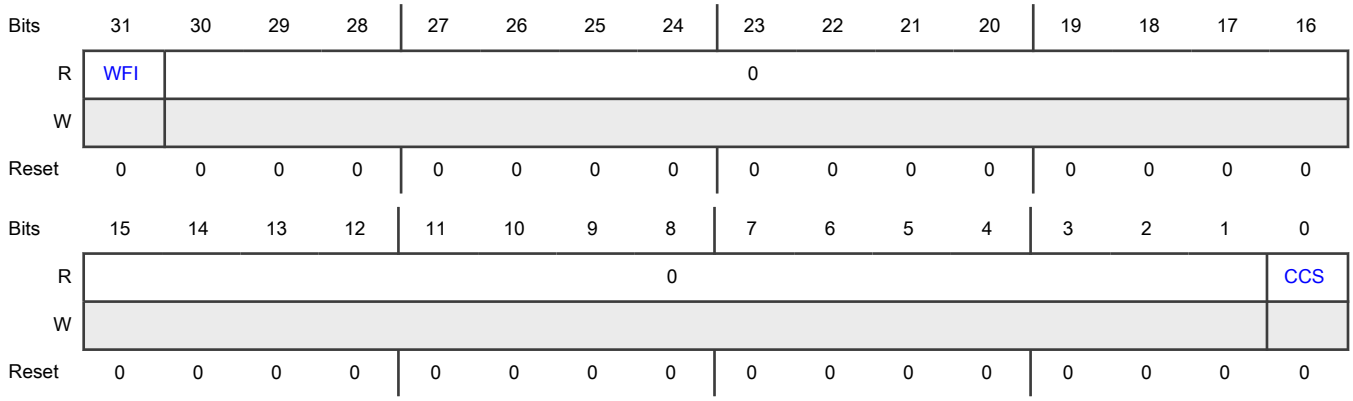
Function

This register provides the status corresponding to Core 4 in Partition 0. The status signal corresponds to clock states and the WFI signal included from Core 4.

NOTE

The value held in WFI field of this STATUS register is "current" value of the WFISTANDBY signal from the core. Hence out-of-reset, the reset value of this field will depend on the status of the core (core is running or in low power mode). So, simple reset read sweep will always return current value (different than other register reads such as on control registers).

Diagram



Fields

Field	Function
31 WFI	Wait for interrupt status This bit provides the WFI status approaching from Core 4 in Partition 0. 0b - No WFI executed 1b - WFI executed
30-1 —	Reserved This field is reserved and read returns zeros.
0 CCS	Core 4 clock process status This bit provides the status of the clock corresponding to core clock enablement/disablement. 0b - Clock is inactive. 1b - Clock is active.

41.7.28 Partition 0 Core 4 Address Register (PRTN0_CORE4_ADDR)

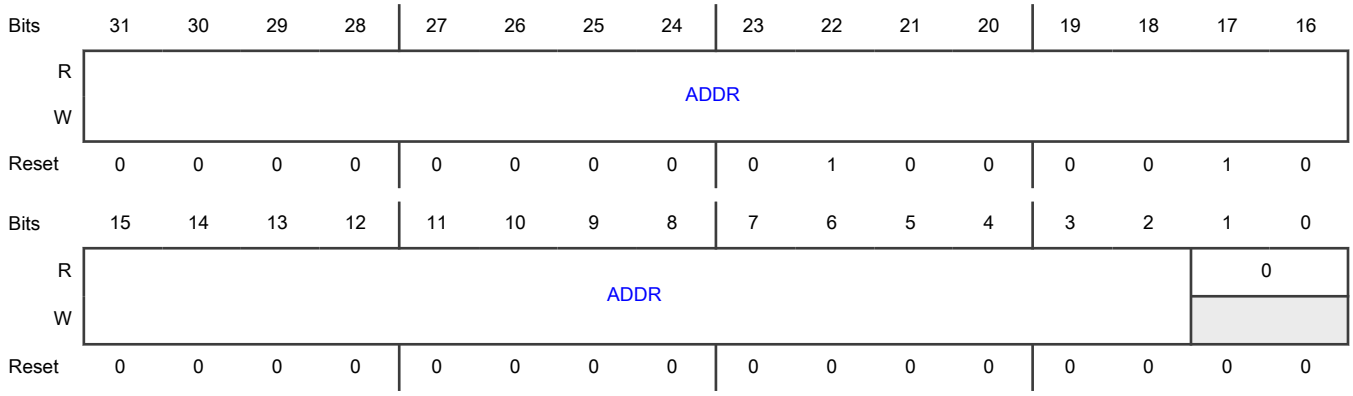
Offset

Register	Offset
PRTN0_CORE4_ADDR	1CCh

Function

This register contains the boot address for Core 4 in Partition 0.

Diagram



Fields

Field	Function
31-2 ADDR	Address Core 4 boot address
1-0 —	Reserved This field is reserved and read returns zeros.

41.7.29 Partition 0 Core 5 Process Configuration Register (PRTN0_CORE5_PCONF)

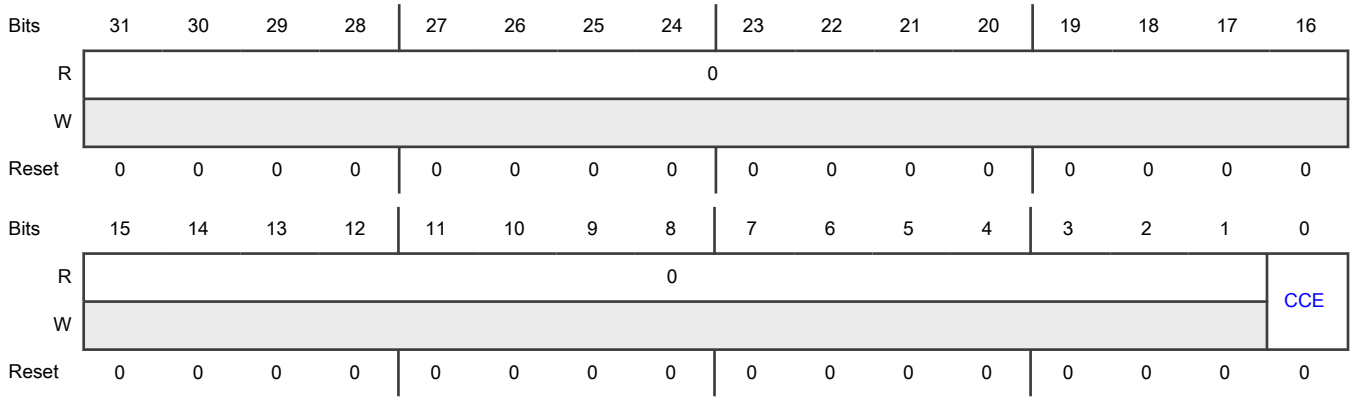
Offset

Register	Offset
PRTN0_CORE5_PCONF	1E0h

Function

This register provides configurations for the Core 5 hardware processes corresponding to Partition 0. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN0_CORE5_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN0_CORE5_PUPD and PRTN0_CORE5_PCONF registers are used to determine the hardware processes to be executed. These processes are triggered in parallel and are independent of each other. All dependent processes should be requested one after another from the software.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCE	Core 5 clock enable This bit controls whether the clock to Core 5 in Partition 0 should be enabled or disabled. 0b - Disable the core clock 1b - Enable the core clock

41.7.30 Partition 0 Core 5 Process Update Register (PRTN0_CORE5_PUPD)

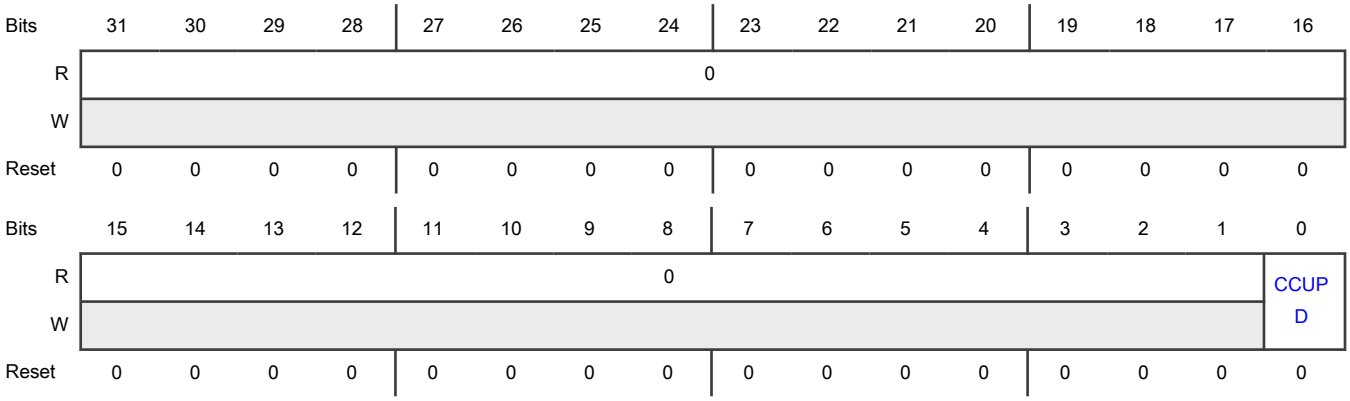
Offset

Register	Offset
PRTN0_CORE5_PUPD	1E4h

Function

This register provides trigger signaling for the core hardware processes corresponding to Partition 0. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN0_CORE5_PCONF register. When the hardware process is finished, the corresponding bit in this register is auto-cleared to logic-0.

Diagram



Fields

Field	Function
31-1 —	Reserved This field is reserved and read returns zeros.
0 CCUPD	Core 5 clock update This bit controls whether the hardware processes for enabling/disabling the clock to Core 5 in the Partition 0 should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.31 Partition 0 Core 5 Status Register (PRTN0_CORE5_STAT)

Offset

Register	Offset
PRTN0_CORE5_STAT	1E8h

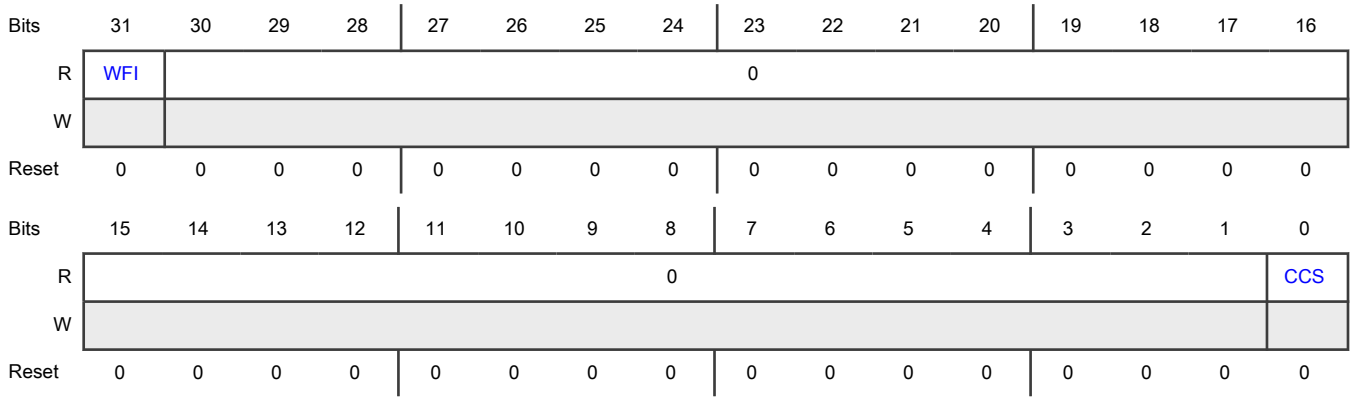
Function

This register provides the status corresponding to Core 5 in Partition 0. The status signal corresponds to clock states and the WFI signal included from Core 5.

NOTE

The value held in WFI field of this STATUS register is "current" value of the WFISTANDBY signal from the core. Hence out-of-reset, the reset value of this field will depend on the status of the core (core is running or in low power mode). So, simple reset read sweep will always return current value (different than other register reads such as on control registers).

Diagram



Fields

Field	Function
31 WFI	Wait for interrupt status This bit provides the WFI status approaching from Core 5 in Partition 0. 0b - No WFI executed 1b - WFI executed
30-1 —	Reserved This field is reserved and read returns zeros.
0 CCS	Core 5 clock process status This bit provides the status of the clock corresponding to core clock enablement/disablement. 0b - Clock is inactive. 1b - Clock is active.

41.7.32 Partition 0 Core 5 Address Register (PRTN0_CORE5_ADDR)

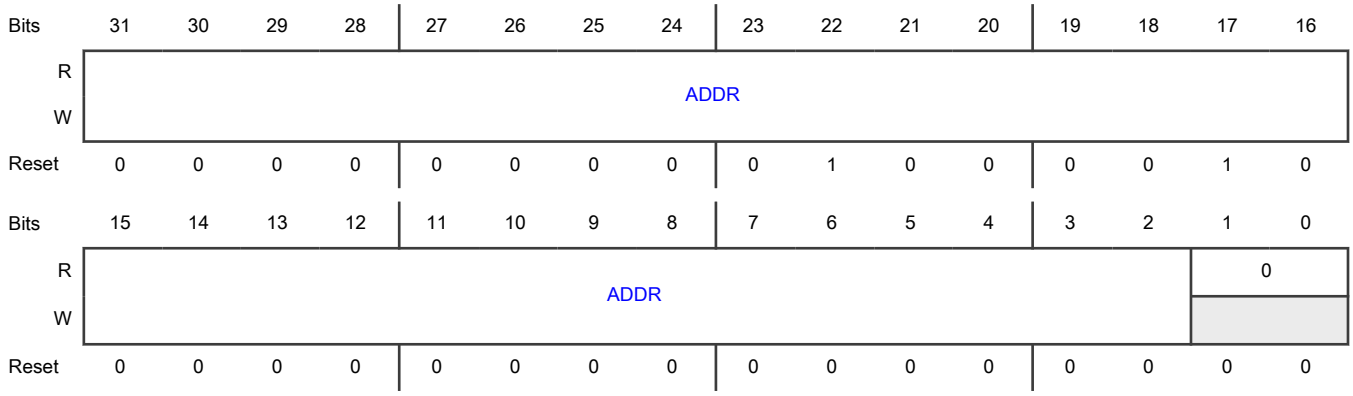
Offset

Register	Offset
PRTN0_CORE5_ADDR	1ECh

Function

This register contains the boot address for Core 5 in Partition 0.

Diagram



Fields

Field	Function
31-2 ADDR	Address Core 5 boot address
1-0 —	Reserved This field is reserved and read returns zeros.

41.7.33 Partition 1 Process Configuration Register (PRTN1_PCONF)

Offset

Register	Offset
PRTN1_PCONF	300h

Function

This register provides a configuration for the hardware processes corresponding to partition 1. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN1_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN1_PCONF and PRTN1_PUPD registers are used to determine the hardware processes to be executed. These are triggered in parallel and independent of each other. All dependent processes should be requested one after another from the software.

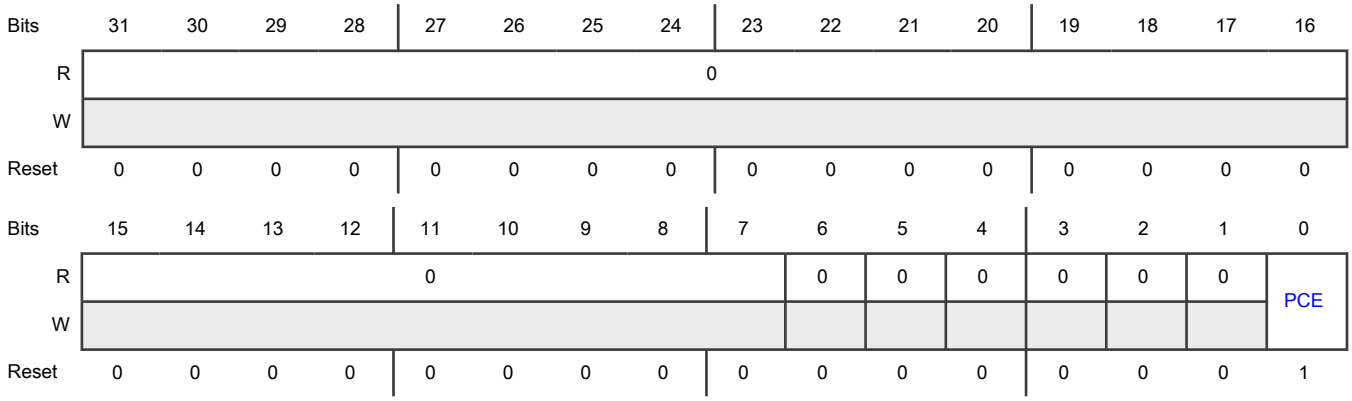
NOTE

The partition clock enable/disable are not standalone and must be done coherently in a fixed sequence. For details, see Software Reset Partition Turn-On Flow Chart and Software reset partition turn-off flowchart in Reset chapter.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCE	Partition clock enable This bit controls whether the clock to IPs (other than core(s)) in the partition should be enabled or disabled. 0b - Disable the clock to IPs 1b - Enable the clock to IPs

41.7.34 Partition 1 Process Update Register (PRTN1_PUPD)

Offset

Register	Offset
PRTN1_PUPD	304h

Function

This register provides trigger signaling for the hardware processes corresponding to partition 1. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN1_PCONF register. When the hardware process is finished the corresponding bit in this register is auto-cleared to logic-0.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0									0	0	0	0	0	0	PCUD
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCUD	Partition clock update This bit controls whether the hardware processes for enabling/disabling the clock to IPs (other than core(s)) in the partition should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.35 Partition 1 Status Register (PRTN1_STAT)

Offset

Register	Offset
PRTN1_STAT	308h

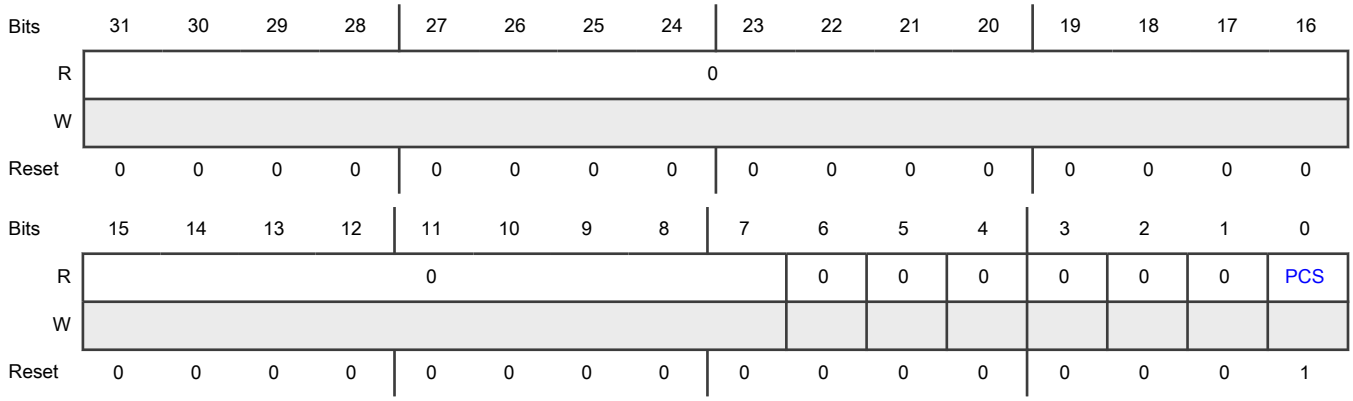
Function

This register provides the current status of the control signals from the partition 1.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCS	Partition clock status This bit provides the status of the clock to partition. 0b - Clock is inactive 1b - Clock is active

41.7.36 Partition 1 COFB Set 0 Clock Status Register (PRTN1_COFB0_STAT)

Offset

Register	Offset
PRTN1_COFB0_STAT	310h

Function

This register provides the status of set 0 of COFBs inside partition 1.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BLOCK31	BLOCK30	BLOCK29	BLOCK28	BLOCK27	BLOCK26	BLOCK25	BLOCK24	BLOCK23	0	BLOCK21	BLOCK20	BLOCK19	BLOCK18	BLOCK17	BLOCK16
W																
Reset	0	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK15	BLOCK14	BLOCK13	BLOCK12	BLOCK11	BLOCK10	BLOCK9	BLOCK8	BLOCK7	BLOCK6	BLOCK5	BLOCK4	BLOCK3	BLOCK2	BLOCK1	BLOCK0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1

Fields

Field	Function
31 BLOCK31	IP block status This bit provides the clock status of INTM in partition 1. 0b - Clock is not running. 1b - Clock is running.
30 BLOCK30	IP block status This bit provides the clock status of XRDC in partition 1. 0b - Clock is not running. 1b - Clock is running.
29 BLOCK29	IP block status This bit provides the clock status of STM_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
28 BLOCK28	IP block status This bit provides the clock status of SWT_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
27 BLOCK27	IP block status This bit provides the clock status of PFC_alt in partition 1. 0b - Clock is not running. 1b - Clock is running.
26	IP block status

Table continues on the next page...

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Field	Function
BLOCK26	This bit provides the clock status of PFC in partition 1. 0b - Clock is not running. 1b - Clock is running.
25 BLOCK25	IP block status This bit provides the clock status of PRAM_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
24 BLOCK24	IP block status This bit provides the clock status of MSCM in partition 1. 0b - Clock is not running. 1b - Clock is running.
23 BLOCK23	IP block status This bit provides the clock status of ERM in partition 1. 0b - Clock is not running. 1b - Clock is running.
22 —	Reserved This field is reserved and read returns zeros.
21 BLOCK21	IP block status This bit provides the clock status of SDA-AP in partition 1. 0b - Clock is not running. 1b - Clock is running.
20 BLOCK20	IP block status This bit provides the clock status of Debug_APB in partition 1. 0b - Clock is not running. 1b - Clock is running.
19 BLOCK19	IP block status This bit provides the clock status of Debug_APB in partition 1. 0b - Clock is not running. 1b - Clock is running.
18 BLOCK18	IP block status This bit provides the clock status of Debug_APB in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is not running. 1b - Clock is running.
17 BLOCK17	IP block status This bit provides the clock status of Debug_APB in partition 1. 0b - Clock is not running. 1b - Clock is running.
16 BLOCK16	IP block status This bit provides the clock status of Debug_APB in partition 1. 0b - Clock is not running. 1b - Clock is running.
15 BLOCK15	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
14 BLOCK14	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
13 BLOCK13	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
12 BLOCK12	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
11 BLOCK11	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
10	IP block status

Table continues on the next page...

Table continued from the previous page...

Field	Function
BLOCK10	This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK9	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK8	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK7	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK6	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
5 BLOCK5	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
4 BLOCK4	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.
3 BLOCK3	IP block status This bit provides the clock status of eDMA in partition 1. 0b - Clock is not running. 1b - Clock is running.

Table continues on the next page...

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Field	Function
2 BLOCK2	IP block status This bit provides the clock status of XBIC in partition 1. 0b - Clock is not running. 1b - Clock is running.
1 BLOCK1	IP block status This bit provides the clock status of XBIC in partition 1. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK0	IP block status This bit provides the clock status of AXBS in partition 1. 0b - Clock is not running. 1b - Clock is running.

41.7.37 Partition 1 COFB Set 1 Clock Status Register (PRTN1_COFB1_STAT)

Offset

Register	Offset
PRTN1_COFB1_STAT	314h

Function

This register provides the status of set 1 of COFBs inside partition 1.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BLOCK63	BLOCK62	BLOCK61	BLOCK60	BLOCK59	BLOCK58	0	BLOCK56	BLOCK55	BLOCK54	BLOCK53	BLOCK52	0	BLOCK50	0	0
W																
Reset	0	1	1	1	1	1	0	0	1	1	1	1	0	1	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK47	0	BLOCK45	0	BLOCK43	BLOCK42	BLOCK41	BLOCK40	BLOCK39	BLOCK38	BLOCK37	BLOCK36	BLOCK35	BLOCK34	BLOCK33	BLOCK32
W																
Reset	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0

Fields

Field	Function
31 BLOCK63	IP block status This bit provides the clock status of block 63 in partition 1. 0b - Clock is not running. 1b - Clock is running.
30 BLOCK62	IP block status This bit provides the clock status of block 62 in partition 1. 0b - Clock is not running. 1b - Clock is running.
29 BLOCK61	IP block status This bit provides the clock status of block 61 in partition 1. 0b - Clock is not running. 1b - Clock is running.
28 BLOCK60	IP block status This bit provides the clock status of FMU_alt in partition 1. 0b - Clock is not running. 1b - Clock is running.
27 BLOCK59	IP block status This bit provides the clock status of FMU in partition 1. 0b - Clock is not running. 1b - Clock is running.
26 BLOCK58	IP block status This bit provides the clock status of PMC in partition 1. 0b - Clock is not running. 1b - Clock is running.
25 —	Reserved This field is reserved and read returns zeros.
24 BLOCK56	IP block status This bit provides the clock status of PLL in partition 1. 0b - Clock is not running. 1b - Clock is running.
23	IP block status

Table continues on the next page...

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Field	Function
BLOCK55	This bit provides the clock status of MC_ME in partition 1. 0b - Clock is not running. 1b - Clock is running.
22 BLOCK54	IP block status This bit provides the clock status of MC_CGM in partition 1. 0b - Clock is not running. 1b - Clock is running.
21 BLOCK53	IP block status This bit provides the clock status of FXOSC in partition 1. 0b - Clock is not running. 1b - Clock is running.
20 BLOCK52	IP block status This bit provides the clock status of FIRC in partition 1. 0b - Clock is not running. 1b - Clock is running.
19 —	Reserved This field is reserved and read returns zeros.
18 BLOCK50	IP block status This bit provides the clock status of SIRC in partition 1. 0b - Clock is not running. 1b - Clock is running.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 BLOCK47	IP block status This bit provides the clock status of CMU_0-5 in partition 1. 0b - Clock is not running. 1b - Clock is running.
14	Reserved

Table continues on the next page...

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Field	Function
—	This field is reserved and read returns zeros.
13 BLOCK45	IP block status This bit provides the clock status of WKPU in partition 1. 0b - Clock is not running. 1b - Clock is running.
12 —	Reserved This field is reserved and read returns zeros.
11 BLOCK43	IP block status This bit provides the clock status of DCM in partition 1. 0b - Clock is not running. 1b - Clock is running.
10 BLOCK42	IP block status This bit provides the clock status of SIUL_VIRTWRAPPER_PDAC3 in partition 1. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK41	IP block status This bit provides the clock status of SIUL_VIRTWRAPPER_PDAC2_M7_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK40	IP block status This bit provides the clock status of SIUL_VIRTWRAPPER_PDAC2_M7_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK39	IP block status This bit provides the clock status of SIUL_VIRTWRAPPER_PDAC1_M7_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK38	IP block status This bit provides the clock status of SIUL_VIRTWRAPPER_PDAC1_M7_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.

Table continues on the next page...

Table continued from the previous page...

Field	Function
5 BLOCK37	IP block status This bit provides the clock status of SIUL_VIRTWRAPPER_PDAC0_HSE in partition 1. 0b - Clock is not running. 1b - Clock is running.
4 BLOCK36	IP block status This bit provides the clock status of SIUL_VIRTWRAPPER_PDAC0_HSE in partition 1. 0b - Clock is not running. 1b - Clock is running.
3 BLOCK35	IP block status This bit provides the clock status of MC_RGM in partition 1. 0b - Clock is not running. 1b - Clock is running.
2 BLOCK34	IP block status This bit provides the clock status of RTC in partition 1. 0b - Clock is not running. 1b - Clock is running.
1 BLOCK33	IP block status This bit provides the clock status of DMAMUX_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK32	IP block status This bit provides the clock status of DMAMUX_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.

41.7.38 Partition 1 COFB Set 2 Clock Status Register (PRTN1_COFB2_STAT)

Offset

Register	Offset
PRTN1_COFB2_STAT	318h

Function

This register provides the status of set 2 of COFBs inside partition 1.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BLOCK95	0	BLOCK93	BLOCK92	0	0	BLOCK89	BLOCK88	BLOCK87	BLOCK86	BLOCK85	BLOCK84	0	0	0	0
W																
Reset	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	BLOCK77	BLOCK76	BLOCK75	BLOCK74	BLOCK73	0	0	BLOCK70	BLOCK69	BLOCK68	BLOCK67	BLOCK66	BLOCK65	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 BLOCK95	IP block status This bit provides the clock status of TMU in partition 1. 0b - Clock is not running. 1b - Clock is running.
30 —	Reserved This field is reserved and read returns zeros.
29 BLOCK93	IP block status This bit provides the clock status of CMP_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
28 BLOCK92	IP block status This bit provides the clock status of CMP_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
25 BLOCK89	IP block status This bit provides the clock status of LPSPI_3 in partition 1. 0b - Clock is not running. 1b - Clock is running.
24 BLOCK88	IP block status This bit provides the clock status of LPSPI_2 in partition 1. 0b - Clock is not running. 1b - Clock is running.
23 BLOCK87	IP block status This bit provides the clock status of LPSPI_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
22 BLOCK86	IP block status This bit provides the clock status of LPSPI_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
21 BLOCK85	IP block status This bit provides the clock status of LPI2C_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
20 BLOCK84	IP block status This bit provides the clock status of LPI2C_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.
14 —	Reserved This field is reserved and read returns zeros.
13 BLOCK77	IP block status This bit provides the clock status of LPUART_3 in partition 1. 0b - Clock is not running. 1b - Clock is running.
12 BLOCK76	IP block status This bit provides the clock status of LPUART_2 in partition 1. 0b - Clock is not running. 1b - Clock is running.
11 BLOCK75	IP block status This bit provides the clock status of LPUART_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
10 BLOCK74	IP block status This bit provides the clock status of LPUART_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK73	IP block status This bit provides the clock status of FlexIO in partition 1. 0b - Clock is not running. 1b - Clock is running.
8 —	Reserved This field is reserved and read returns zeros.
7 —	Reserved This field is reserved and read returns zeros.
6	IP block status

Table continues on the next page...

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Field	Function
BLOCK70	This bit provides the clock status of FlexCAN_5 in partition 1. 0b - Clock is not running. 1b - Clock is running.
5 BLOCK69	IP block status This bit provides the clock status of FlexCAN_4 in partition 1. 0b - Clock is not running. 1b - Clock is running.
4 BLOCK68	IP block status This bit provides the clock status of FlexCAN_3 in partition 1. 0b - Clock is not running. 1b - Clock is running.
3 BLOCK67	IP block status This bit provides the clock status of FlexCAN_2 in partition 1. 0b - Clock is not running. 1b - Clock is running.
2 BLOCK66	IP block status This bit provides the clock status of FlexCAN_1 in partition 1. 0b - Clock is not running. 1b - Clock is running.
1 BLOCK65	IP block status This bit provides the clock status of FlexCAN_0 in partition 1. 0b - Clock is not running. 1b - Clock is running.
0 —	Reserved This field is reserved and read returns zeros.

41.7.39 Partition 1 COFB Set 3 Clock Status Register (PRTN1_COFB3_STAT)

Offset

Register	Offset
PRTN1_COFB3_STAT	31Ch

Function

This register provides the status of set 3 of COFBs inside partition 1.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	BLOCK110	0	BLOCK108	BLOCK107	BLOCK106	BLOCK105	BLOCK104	BLOCK103	BLOCK102	BLOCK101	0	BLOCK99	BLOCK98	BLOCK97	BLOCK96
W																
Reset	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.
14 BLOCK110	IP block status This bit provides the clock status of block 110 in partition 1. 0b - Clock is not running. 1b - Clock is running.
13 —	Reserved This field is reserved and read returns zeros.
12 BLOCK108	IP block status This bit provides the clock status of block 108 in partition 1. 0b - Clock is not running. 1b - Clock is running.
11	IP block status This bit provides the clock status of block 107 in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
BLOCK107	0b - Clock is not running. 1b - Clock is running.
10 BLOCK106	IP block status This bit provides the clock status of block 106 in partition 1. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK105	IP block status This bit provides the clock status of block 105 in partition 1. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK104	IP block status This bit provides the clock status of STCU2 in partition 1. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK103	IP block status This bit provides the clock status of HSE_GPR in partition 1. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK102	IP block status This bit provides the clock status of block 102 in partition 1. 0b - Clock is not running. 1b - Clock is running.
5 BLOCK101	IP block status This bit provides the clock status of JDC in partition 1. 0b - Clock is not running. 1b - Clock is running.
4 —	Reserved This field is reserved and read returns zeros.
3 BLOCK99	IP block status This bit provides the clock status of HSE in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is not running. 1b - Clock is running.
2 BLOCK98	IP block status This bit provides the clock status of MBIST Master Controller in partition 1. 0b - Clock is not running. 1b - Clock is running.
1 BLOCK97	IP block status This bit provides the clock status of FCCU in partition 1. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK96	IP block status This bit provides the clock status of CRC in partition 1. 0b - Clock is not running. 1b - Clock is running.

41.7.40 Partition 1 COFB Set 0 Clock Enable Register (PRTN1_COFB0_CLKEN)

Offset

Register	Offset
PRTN1_COFB0_CLKEN	330h

Function

This register provides clock control signaling to the individual COFBs in set 0 inside partition 1. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	REQ31	0	REQ29	REQ28	0	0	0	REQ24	REQ23	0	REQ21	0	0	0	0	0
W																
Reset	0	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ15	REQ14	REQ13	REQ12	REQ11	REQ10	REQ9	REQ8	REQ7	REQ6	REQ5	REQ4	REQ3	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1

Fields

Field	Function
31 REQ31	Clock enable This bit provides the clock enable control for INTM in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
30 —	Reserved This field is reserved and read returns zeros.
29 REQ29	Clock enable This bit provides the clock enable control for STM_0 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
28 REQ28	Clock enable This bit provides the clock enable control for SWT_0 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24	Clock enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
REQ24	This bit provides the clock enable control for MSCM in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
23 REQ23	Clock enable This bit provides the clock enable control for ERM in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
22 —	Reserved This field is reserved and read returns zeros.
21 REQ21	Clock enable This bit provides the clock enable control for SDA-AP in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 REQ15	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
14 REQ14	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is turned on.
13 REQ13	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
12 REQ12	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
11 REQ11	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
10 REQ10	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
9 REQ9	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
8 REQ8	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
7 REQ7	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
6 REQ6	Clock enable This bit provides the clock enable control for eDMA in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
5 REQ5	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
4 REQ4	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
3 REQ3	Clock enable This bit provides the clock enable control for eDMA in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 —	Reserved This field is reserved and read returns zeros.

41.7.41 Partition 1 COFB Set 1 Clock Enable Register (PRTN1_COFB1_CLKEN)

Offset

Register	Offset
PRTN1_COFB1_CLKEN	334h

Function

This register provides clock control signaling to the individual COFBs in set 1 inside partition 1. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	REQ63	0	0	0	0	0	0	REQ56	0	0	REQ53	0	0	0	0	0
W																
Reset	0	1	1	1	1	1	0	0	1	1	1	1	0	1	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ47	0	REQ45	0	0	REQ42	0	0	0	0	0	0	0	REQ34	REQ33	REQ32
W																
Reset	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0

Fields

Field	Function
31 REQ63	Clock enable This bit provides the clock enable control for block 63 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 REQ56	Clock enable This bit provides the clock enable control for PLL in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.
21 REQ53	Clock enable This bit provides the clock enable control for FXOSC in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 REQ47	Clock enable This bit provides the clock enable control for CMU_0-5 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
14 —	Reserved This field is reserved and read returns zeros.
13 REQ45	Clock enable This bit provides the clock enable control for WKPU in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.

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Field	Function
12 —	Reserved This field is reserved and read returns zeros.
11 —	Reserved This field is reserved and read returns zeros.
10 REQ42	Clock enable This bit provides the clock enable control for SIUL_VIRTWRAPPER_PDAC3 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
9 —	Reserved This field is reserved and read returns zeros.
8 —	Reserved This field is reserved and read returns zeros.
7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 REQ34	Clock enable This bit provides the clock enable control for RTC in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
1 REQ33	Clock enable This bit provides the clock enable control for DMAMUX_1 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 REQ32	Clock enable This bit provides the clock enable control for DMAMUX_0 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.

41.7.42 Partition 1 COFB Set 2 Clock Enable Register (PRTN1_COFB2_CLKEN)

Offset

Register	Offset
PRTN1_COFB2_CLKEN	338h

Function

This register provides clock control signaling to the individual COFBs in set 2 inside partition 1. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	REQ95	0	REQ93	REQ92	0	0	REQ89	REQ88	REQ87	REQ86	REQ85	REQ84	0	0	0	0
W																
Reset	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	REQ77	REQ76	REQ75	REQ74	REQ73	0	0	REQ70	REQ69	REQ68	REQ67	REQ66	REQ65	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 REQ95	Clock enable This bit provides the clock enable control for TMU in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
30 —	Reserved This field is reserved and read returns zeros.
29 REQ93	Clock enable This bit provides the clock enable control for CMP_1 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
28 REQ92	Clock enable This bit provides the clock enable control for CMP_0 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 REQ89	Clock enable This bit provides the clock enable control for LPSPI_3 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
24 REQ88	Clock enable This bit provides the clock enable control for LPSPI_2 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
23 REQ87	Clock enable This bit provides the clock enable control for LPSPI_1 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
22 REQ86	Clock enable This bit provides the clock enable control for LPSPI_0 in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
21 REQ85	Clock enable This bit provides the clock enable control for LPI2C_1 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
20 REQ84	Clock enable This bit provides the clock enable control for LPI2C_0 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.
14 —	Reserved This field is reserved and read returns zeros.
13 REQ77	Clock enable This bit provides the clock enable control for LPUART_3 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
12 REQ76	Clock enable This bit provides the clock enable control for LPUART_2 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.

Table continues on the next page...

Table continued from the previous page...

Field	Function
11 REQ75	Clock enable This bit provides the clock enable control for LPUART_1 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
10 REQ74	Clock enable This bit provides the clock enable control for LPUART_0 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
9 REQ73	Clock enable This bit provides the clock enable control for FlexIO in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
8 —	Reserved This field is reserved and read returns zeros.
7 —	Reserved This field is reserved and read returns zeros.
6 REQ70	Clock enable This bit provides the clock enable control for FlexCAN_5 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
5 REQ69	Clock enable This bit provides the clock enable control for FlexCAN_4 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
4 REQ68	Clock enable This bit provides the clock enable control for FlexCAN_3 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
3 REQ67	Clock enable This bit provides the clock enable control for FlexCAN_2 in partition 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
2 REQ66	Clock enable This bit provides the clock enable control for FlexCAN_1 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
1 REQ65	Clock enable This bit provides the clock enable control for FlexCAN_0 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
0 —	Reserved This field is reserved and read returns zeros.

41.7.43 Partition 1 COFB Set 3 Clock Enable Register (PRTN1_COFB3_CLKEN)

Offset

Register	Offset
PRTN1_COFB3_CLKEN	33Ch

Function

This register provides clock control signaling to the individual COFBs in set 3 inside partition 1. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	REQ104	0	REQ102	0	0	0	0	0	REQ96
W																
Reset	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.
14 —	Reserved This field is reserved and read returns zeros.
13 —	Reserved This field is reserved and read returns zeros.
12 —	Reserved This field is reserved and read returns zeros.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 —	Reserved This field is reserved and read returns zeros.
8 REQ104	Clock enable This bit provides the clock enable control for STCU2 in partition 1. 0b - Clock is turned off.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is turned on.
7 —	Reserved This field is reserved and read returns zeros.
6 REQ102	Clock enable This bit provides the clock enable control for block 102 in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 REQ96	Clock enable This bit provides the clock enable control for CRC in partition 1. 0b - Clock is turned off. 1b - Clock is turned on.

41.7.44 Partition 2 Process Configuration Register (PRTN2_PCONF)

Offset

Register	Offset
PRTN2_PCONF	500h

Function

This register provides a configuration for the hardware processes corresponding to partition 2. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN2_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN2_PCONF

and PRTN2_PUPD registers are used to determine the hardware processes to be executed. These are triggered in parallel and independent of each other. All dependent processes should be requested one after another from the software.

NOTE

The partition clock enable/disable are not standalone and must be done coherently in a fixed sequence. For details, see Software Reset Partition Turn-On Flow Chart and Software reset partition turn-off flowchart in Reset chapter.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0	0	0	0	0	0	0	PCE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
0 PCE	Partition clock enable This bit controls whether the clock to IPs (other than core(s)) in the partition should be enabled or disabled. 0b - Disable the clock to IPs 1b - Enable the clock to IPs

41.7.45 Partition 2 Process Update Register (PRTN2_PUPD)

Offset

Register	Offset
PRTN2_PUPD	504h

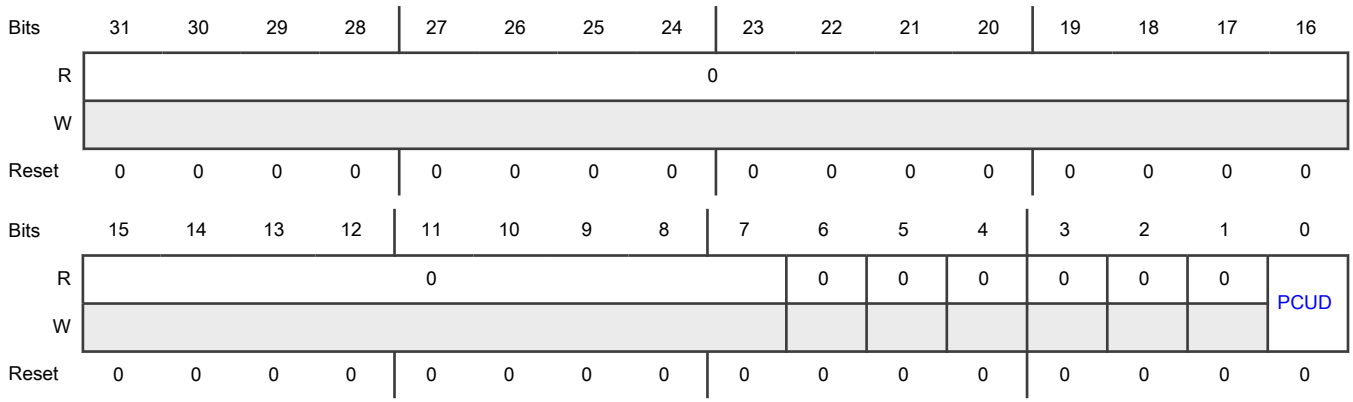
Function

This register provides trigger signaling for the hardware processes corresponding to partition 2. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN2_PCONF register. When the hardware process is finished the corresponding bit in this register is auto-cleared to logic-0.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCUD	Partition clock update This bit controls whether the hardware processes for enabling/disabling the clock to IPs (other than core(s)) in the partition should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.46 Partition 2 Status Register (PRTN2_STAT)

Offset

Register	Offset
PRTN2_STAT	508h

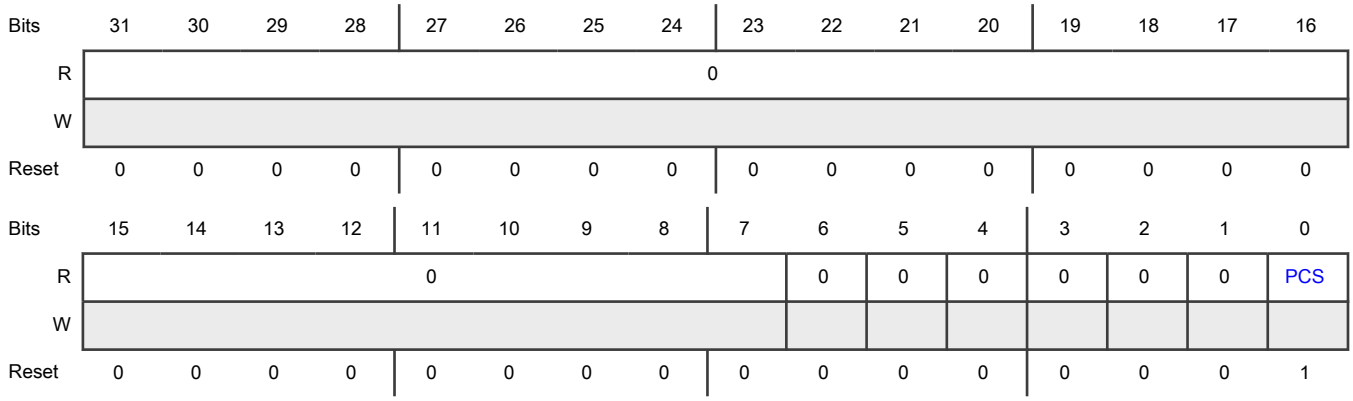
Function

This register provides the current status of the control signals from the partition 2.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCS	Partition clock status This bit provides the status of the clock to partition. 0b - Clock is inactive 1b - Clock is active

41.7.47 Partition 2 COFB Set 0 Clock Status Register (PRTN2_COFB0_STAT)

Offset

Register	Offset
PRTN2_COFB0_STAT	510h

Function

This register provides the status of set 0 of COFBs inside partition 2.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 2.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	BLOCK30	BLOCK29	BLOCK28	BLOCK27	0	BLOCK25	BLOCK24	BLOCK23	BLOCK22	BLOCK21	BLOCK20	BLOCK19	BLOCK18	BLOCK17	BLOCK16
W																
Reset	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK15	BLOCK14	BLOCK13	BLOCK12	BLOCK11	BLOCK10	BLOCK9	BLOCK8	BLOCK7	BLOCK6	BLOCK5	BLOCK4	0	0	BLOCK1	BLOCK0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 BLOCK30	IP block status This bit provides the clock status of block 30 in partition 2. 0b - Clock is not running. 1b - Clock is running.
29 BLOCK29	IP block status This bit provides the clock status of STM_1 in partition 2. 0b - Clock is not running. 1b - Clock is running.

Table continues on the next page...

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Field	Function
28 BLOCK28	IP block status This bit provides the clock status of block 28 in partition 2. 0b - Clock is not running. 1b - Clock is running.
27 BLOCK27	IP block status This bit provides the clock status of SWT_1 in partition 2. 0b - Clock is not running. 1b - Clock is running.
26 —	Reserved This field is reserved and read returns zeros.
25 BLOCK25	IP block status This bit provides the clock status of PRAM_1 in partition 2. 0b - Clock is not running. 1b - Clock is running.
24 BLOCK24	IP block status This bit provides the clock status of SEMA42 in partition 2. 0b - Clock is not running. 1b - Clock is running.
23 BLOCK23	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
22 BLOCK22	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
21 BLOCK21	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
20	IP block status

Table continues on the next page...

Table continued from the previous page...

Field	Function
BLOCK20	This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
19 BLOCK19	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
18 BLOCK18	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
17 BLOCK17	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
16 BLOCK16	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
15 BLOCK15	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
14 BLOCK14	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
13 BLOCK13	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.

Table continues on the next page...

Table continued from the previous page...

Field	Function
12 BLOCK12	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
11 BLOCK11	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
10 BLOCK10	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK9	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK8	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK7	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK6	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
5 BLOCK5	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is running.
4 BLOCK4	IP block status This bit provides the clock status of eDMA in partition 2. 0b - Clock is not running. 1b - Clock is running.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 BLOCK1	IP block status This bit provides the clock status of XBIC in partition 2. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK0	IP block status This bit provides the clock status of XBIC in partition 2. 0b - Clock is not running. 1b - Clock is running.

41.7.48 Partition 2 COFB Set 1 Clock Status Register (PRTN2_COFB1_STAT)

Offset

Register	Offset
PRTN2_COFB1_STAT	514h

Function

This register provides the status of set 1 of COFBs inside partition 2.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 2.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BLOCK63	BLOCK62	BLOCK61	BLOCK60	BLOCK59	0	0	0	0	0	0	0	BLOCK51	0	0	BLOCK48
W																
Reset	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLOCK32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 BLOCK63	IP block status This bit provides the clock status of Cortex-M7_1 TCM in partition 2. 0b - Clock is not running. 1b - Clock is running.
30 BLOCK62	IP block status This bit provides the clock status of Cortex-M7_0 TCM in partition 2. 0b - Clock is not running. 1b - Clock is running.
29 BLOCK61	IP block status This bit provides the clock status of MU in partition 2. 0b - Clock is not running. 1b - Clock is running.
28 BLOCK60	IP block status This bit provides the clock status of MU in partition 2. 0b - Clock is not running. 1b - Clock is running.
27 BLOCK59	IP block status This bit provides the clock status of HSE in partition 2. 0b - Clock is not running. 1b - Clock is running.
26	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 BLOCK51	IP block status This bit provides the clock status of QuadSPI in partition 2. 0b - Clock is not running. 1b - Clock is running.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 BLOCK48	IP block status This bit provides the clock status of LPSPI_5 in partition 2. 0b - Clock is not running. 1b - Clock is running.
15 BLOCK47	IP block status This bit provides the clock status of LPSPI_4 in partition 2. 0b - Clock is not running. 1b - Clock is running.
14	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
13 —	Reserved This field is reserved and read returns zeros.
12 —	Reserved This field is reserved and read returns zeros.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 —	Reserved This field is reserved and read returns zeros.
8 —	Reserved This field is reserved and read returns zeros.
7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 BLOCK32	IP block status This bit provides the clock status of EMAC in partition 2.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is not running. 1b - Clock is running.

41.7.49 Partition 2 COFB Set 2 Clock Status Register (PRTN2_COFB2_STAT)

Offset

Register	Offset
PRTN2_COFB2_STAT	518h

Function

This register provides the status of set 2 of COFBs inside partition 2.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 2.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	BLOCK75	BLOCK74	BLOCK73	BLOCK72	BLOCK71	BLOCK70	BLOCK69	BLOCK68	BLOCK67	BLOCK66	BLOCK65	BLOCK64
W																
Reset	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	1

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
14 —	Reserved This field is reserved and read returns zeros.
13 —	Reserved This field is reserved and read returns zeros.
12 —	Reserved This field is reserved and read returns zeros.
11 BLOCK75	IP block status This bit provides the clock status of block 75 in partition 2. 0b - Clock is not running. 1b - Clock is running.
10 BLOCK74	IP block status This bit provides the clock status of block 74 in partition 2. 0b - Clock is not running. 1b - Clock is running.
9 BLOCK73	IP block status This bit provides the clock status of block 73 in partition 2. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK72	IP block status This bit provides the clock status of block 72 in partition 2. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK71	IP block status This bit provides the clock status of block 71 in partition 2. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK70	IP block status This bit provides the clock status of block 70 in partition 2. 0b - Clock is not running. 1b - Clock is running.
5	IP block status

Table continues on the next page...

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Field	Function
BLOCK69	This bit provides the clock status of block 69 in partition 2. 0b - Clock is not running. 1b - Clock is running.
4 BLOCK68	IP block status This bit provides the clock status of block 68 in partition 2. 0b - Clock is not running. 1b - Clock is running.
3 BLOCK67	IP block status This bit provides the clock status of block 67 in partition 2. 0b - Clock is not running. 1b - Clock is running.
2 BLOCK66	IP block status This bit provides the clock status of block 66 in partition 2. 0b - Clock is not running. 1b - Clock is running.
1 BLOCK65	IP block status This bit provides the clock status of block 65 in partition 2. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK64	IP block status This bit provides the clock status of Cortex-M7_2 TCM in partition 2. 0b - Clock is not running. 1b - Clock is running.

41.7.50 Partition 2 COFB Set 0 Clock Enable Register (PRTN2_COFB0_CLKEN)

Offset

Register	Offset
PRTN2_COFB0_CLKEN	530h

Function

This register provides clock control signaling to the individual COFBs in set 0 inside partition 2. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	REQ30	REQ29	REQ28	REQ27	0	0	REQ24	REQ23	REQ22	REQ21	REQ20	REQ19	REQ18	REQ17	REQ16
W																
Reset	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ15	REQ14	REQ13	REQ12	REQ11	REQ10	REQ9	REQ8	REQ7	REQ6	REQ5	REQ4	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 REQ30	Clock enable This bit provides the clock enable control for block 30 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
29 REQ29	Clock enable This bit provides the clock enable control for STM_1 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
28 REQ28	Clock enable This bit provides the clock enable control for block 28 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
27 REQ27	Clock enable This bit provides the clock enable control for SWT_1 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.

Table continues on the next page...

Table continued from the previous page...

Field	Function
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 REQ24	Clock enable This bit provides the clock enable control for SEMA42 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
23 REQ23	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
22 REQ22	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
21 REQ21	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
20 REQ20	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
19 REQ19	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
18 REQ18	Clock enable This bit provides the clock enable control for eDMA in partition 2.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
17 REQ17	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
16 REQ16	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
15 REQ15	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
14 REQ14	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
13 REQ13	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
12 REQ12	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
11 REQ11	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
10	Clock enable

Table continues on the next page...

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Field	Function
REQ10	This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
9 REQ9	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
8 REQ8	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
7 REQ7	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
6 REQ6	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
5 REQ5	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
4 REQ4	Clock enable This bit provides the clock enable control for eDMA in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
1 —	Reserved This field is reserved and read returns zeros.
0 —	Reserved This field is reserved and read returns zeros.

41.7.51 Partition 2 COFB Set 1 Clock Enable Register (PRTN2_COFB1_CLKEN)

Offset

Register	Offset
PRTN2_COFB1_CLKEN	534h

Function

This register provides clock control signaling to the individual COFBs in set 1 inside partition 2. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	REQ63	REQ62	REQ61	REQ60	0	0	0	0	0	0	0	0	REQ51	0	0	REQ48
W																
Reset	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	REQ32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 REQ63	Clock enable This bit provides the clock enable control for Cortex-M7_1 TCM in partition 2.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
30 REQ62	Clock enable This bit provides the clock enable control for Cortex-M7_0 TCM in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
29 REQ61	Clock enable This bit provides the clock enable control for MU in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
28 REQ60	Clock enable This bit provides the clock enable control for MU in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
19 REQ51	Clock enable This bit provides the clock enable control for QuadSPI in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 REQ48	Clock enable This bit provides the clock enable control for LPSPI_5 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
15 REQ47	Clock enable This bit provides the clock enable control for LPSPI_4 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
14 —	Reserved This field is reserved and read returns zeros.
13 —	Reserved This field is reserved and read returns zeros.
12 —	Reserved This field is reserved and read returns zeros.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 —	Reserved This field is reserved and read returns zeros.
8 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

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Field	Function
7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 REQ32	Clock enable This bit provides the clock enable control for EMAC in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.

41.7.52 Partition 2 COFB Set 2 Clock Enable Register (PRTN2_COFB2_CLKEN)

Offset

Register	Offset
PRTN2_COFB2_CLKEN	538h

Function

This register provides clock control signaling to the individual COFBs in set 2 inside partition 2. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	REQ69	REQ68	REQ67	REQ66	REQ65	REQ64
W																
Reset	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	1

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.
14 —	Reserved This field is reserved and read returns zeros.
13 —	Reserved This field is reserved and read returns zeros.
12 —	Reserved This field is reserved and read returns zeros.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 —	Reserved This field is reserved and read returns zeros.
8 —	Reserved This field is reserved and read returns zeros.
7	Reserved

Table continues on the next page...

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Field	Function
—	This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 REQ69	Clock enable This bit provides the clock enable control for block 69 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
4 REQ68	Clock enable This bit provides the clock enable control for block 68 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
3 REQ67	Clock enable This bit provides the clock enable control for block 67 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
2 REQ66	Clock enable This bit provides the clock enable control for block 66 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
1 REQ65	Clock enable This bit provides the clock enable control for block 65 in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.
0 REQ64	Clock enable This bit provides the clock enable control for Cortex-M7_2 TCM in partition 2. 0b - Clock is turned off. 1b - Clock is turned on.

41.7.53 Partition 3 Process Configuration Register (PRTN3_PCONF)

Offset

Register	Offset
PRTN3_PCONF	700h

Function

This register provides a configuration for the hardware processes corresponding to partition 3. Each of the configuration bit corresponds to the 'nature' of the processes; for example, enabling/disabling and the trigger is controlled by the corresponding field in the PRTN3_PUPD register. When valid KEY combinations are written onto the CTL_KEY register, the PRTN3_PCONF and PRTN3_PUPD registers are used to determine the hardware processes to be executed. These are triggered in parallel and independent of each other. All dependent processes should be requested one after another from the software.

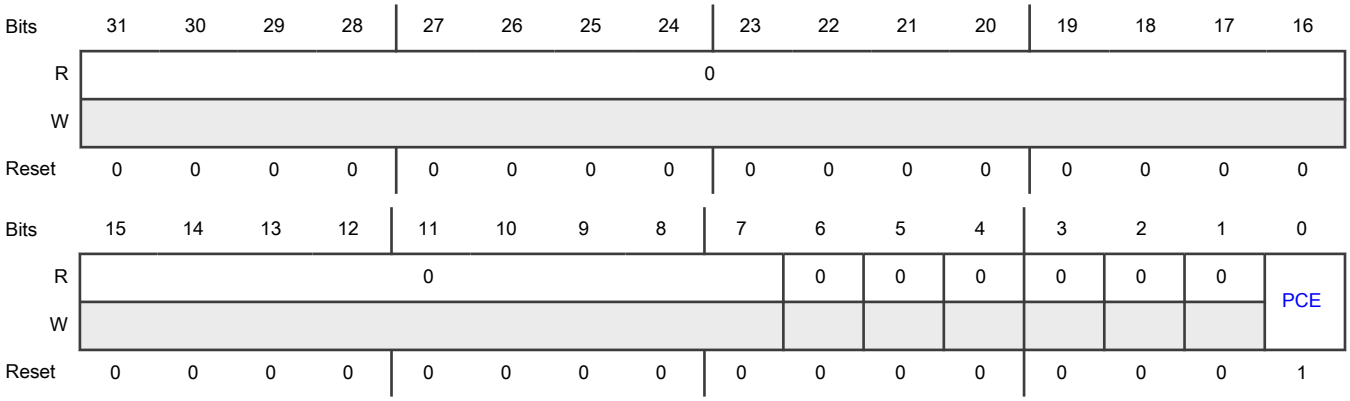
NOTE

The partition clock enable/disable are not standalone and must be done coherently in a fixed sequence. For details, see Software Reset Partition Turn-On Flow Chart and Software reset partition turn-off flowchart in Reset chapter.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCE	Partition clock enable This bit controls whether the clock to IPs (other than core(s)) in the partition should be enabled or disabled. 0b - Disable the clock to IPs 1b - Enable the clock to IPs

41.7.54 Partition 3 Process Update Register (PRTN3_PUPD)

Offset

Register	Offset
PRTN3_PUPD	704h

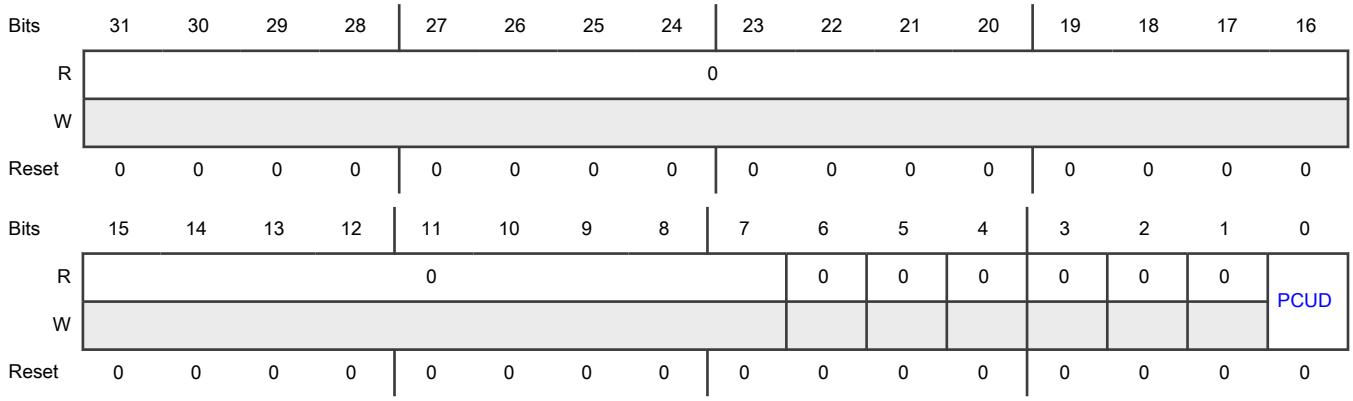
Function

This register provides trigger signaling for the hardware processes corresponding to partition 3. Each of the control bit acts as a trigger for the corresponding hardware processes. When valid KEY combinations are written onto the CTL_KEY register, the hardware checks the bit fields that are programmed as logic-1 in this register, and then triggers the hardware process per the value in the corresponding bit field in the PRTN3_PCONF register. When the hardware process is finished the corresponding bit in this register is auto-cleared to logic-0.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram



Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCUD	Partition clock update This bit controls whether the hardware processes for enabling/disabling the clock to IPs (other than core(s)) in the partition should be triggered or not. 0b - Do not trigger the hardware process 1b - Trigger the hardware process

41.7.55 Partition 3 Status Register (PRTN3_STAT)

Offset

Register	Offset
PRTN3_STAT	708h

Function

This register provides the current status of the control signals from the partition 3.

NOTE

See chip-specific MC_ME information to check if this register is implemented on chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0	0	0	0	0	0	0	PCS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
1 —	Reserved This field is reserved and read returns zeros.
0 PCS	Partition clock status This bit provides the status of the clock to partition. 0b - Clock is inactive 1b - Clock is active

41.7.56 Partition 3 COFB Set 0 Clock Status Register (PRTN3_COFB0_STAT)

Offset

Register	Offset
PRTN3_COFB0_STAT	710h

Function

This register provides the status of set 0 of COFBs inside partition 3.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 3.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	BLOCK30	BLOCK29	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK15	BLOCK14	BLOCK13	BLOCK12	BLOCK11	BLOCK10	BLOCK9	BLOCK8	BLOCK7	BLOCK6	BLOCK5	BLOCK4	BLOCK3	BLOCK2	BLOCK1	BLOCK0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 BLOCK30	IP block status This bit provides the clock status of block 30 in partition 3. 0b - Clock is not running. 1b - Clock is running.
29 BLOCK29	IP block status This bit provides the clock status of block 29 in partition 3. 0b - Clock is not running. 1b - Clock is running.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 BLOCK15	IP block status This bit provides the clock status of block 15 in partition 3. 0b - Clock is not running. 1b - Clock is running.
14 BLOCK14	IP block status This bit provides the clock status of block 14 in partition 3. 0b - Clock is not running. 1b - Clock is running.
13 BLOCK13	IP block status This bit provides the clock status of block 13 in partition 3. 0b - Clock is not running. 1b - Clock is running.
12 BLOCK12	IP block status This bit provides the clock status of block 12 in partition 3. 0b - Clock is not running. 1b - Clock is running.
11 BLOCK11	IP block status This bit provides the clock status of block 11 in partition 3. 0b - Clock is not running. 1b - Clock is running.
10 BLOCK10	IP block status This bit provides the clock status of block 10 in partition 3. 0b - Clock is not running.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is running.
9 BLOCK9	IP block status This bit provides the clock status of block 9 in partition 3. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK8	IP block status This bit provides the clock status of block 8 in partition 3. 0b - Clock is not running. 1b - Clock is running.
7 BLOCK7	IP block status This bit provides the clock status of block 7 in partition 3. 0b - Clock is not running. 1b - Clock is running.
6 BLOCK6	IP block status This bit provides the clock status of block 6 in partition 3. 0b - Clock is not running. 1b - Clock is running.
5 BLOCK5	IP block status This bit provides the clock status of block 5 in partition 3. 0b - Clock is not running. 1b - Clock is running.
4 BLOCK4	IP block status This bit provides the clock status of block 4 in partition 3. 0b - Clock is not running. 1b - Clock is running.
3 BLOCK3	IP block status This bit provides the clock status of block 3 in partition 3. 0b - Clock is not running. 1b - Clock is running.
2 BLOCK2	IP block status This bit provides the clock status of block 2 in partition 3.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Clock is not running. 1b - Clock is running.
1 BLOCK1	IP block status This bit provides the clock status of block 1 in partition 3. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK0	IP block status This bit provides the clock status of block 0 in partition 3. 0b - Clock is not running. 1b - Clock is running.

41.7.57 Partition 3 COFB Set 1 Clock Status Register (PRTN3_COFB1_STAT)

Offset

Register	Offset
PRTN3_COFB1_STAT	714h

Function

This register provides the status of set 1 of COFBs inside partition 3.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 3.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BLOCK63	BLOCK62	BLOCK61	0	BLOCK59	BLOCK58	BLOCK57	BLOCK56	BLOCK55	BLOCK54	BLOCK53	BLOCK52	BLOCK51	BLOCK50	BLOCK49	BLOCK48
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BLOCK47	BLOCK46	0	BLOCK44	0	0	BLOCK41	BLOCK40	0	0	BLOCK37	BLOCK36	BLOCK35	BLOCK34	0	BLOCK32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 BLOCK63	IP block status This bit provides the clock status of block 63 in partition 3. 0b - Clock is not running. 1b - Clock is running.
30 BLOCK62	IP block status This bit provides the clock status of block 62 in partition 3. 0b - Clock is not running. 1b - Clock is running.
29 BLOCK61	IP block status This bit provides the clock status of block 61 in partition 3. 0b - Clock is not running. 1b - Clock is running.
28 —	Reserved This field is reserved and read returns zeros.
27 BLOCK59	IP block status This bit provides the clock status of block 59 in partition 3. 0b - Clock is not running. 1b - Clock is running.
26 BLOCK58	IP block status This bit provides the clock status of block 58 in partition 3. 0b - Clock is not running. 1b - Clock is running.
25 BLOCK57	IP block status This bit provides the clock status of block 57 in partition 3. 0b - Clock is not running. 1b - Clock is running.
24 BLOCK56	IP block status This bit provides the clock status of block 56 in partition 3. 0b - Clock is not running. 1b - Clock is running.
23	IP block status

Table continues on the next page...

Table continued from the previous page...

Field	Function
BLOCK55	This bit provides the clock status of block 55 in partition 3. 0b - Clock is not running. 1b - Clock is running.
22 BLOCK54	IP block status This bit provides the clock status of block 54 in partition 3. 0b - Clock is not running. 1b - Clock is running.
21 BLOCK53	IP block status This bit provides the clock status of block 53 in partition 3. 0b - Clock is not running. 1b - Clock is running.
20 BLOCK52	IP block status This bit provides the clock status of block 52 in partition 3. 0b - Clock is not running. 1b - Clock is running.
19 BLOCK51	IP block status This bit provides the clock status of block 51 in partition 3. 0b - Clock is not running. 1b - Clock is running.
18 BLOCK50	IP block status This bit provides the clock status of block 50 in partition 3. 0b - Clock is not running. 1b - Clock is running.
17 BLOCK49	IP block status This bit provides the clock status of block 49 in partition 3. 0b - Clock is not running. 1b - Clock is running.
16 BLOCK48	IP block status This bit provides the clock status of block 48 in partition 3. 0b - Clock is not running. 1b - Clock is running.

Table continues on the next page...

Table continued from the previous page...

Field	Function
15 BLOCK47	IP block status This bit provides the clock status of block 47 in partition 3. 0b - Clock is not running. 1b - Clock is running.
14 BLOCK46	IP block status This bit provides the clock status of block 46 in partition 3. 0b - Clock is not running. 1b - Clock is running.
13 —	Reserved This field is reserved and read returns zeros.
12 BLOCK44	IP block status This bit provides the clock status of block 44 in partition 3. 0b - Clock is not running. 1b - Clock is running.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 BLOCK41	IP block status This bit provides the clock status of block 41 in partition 3. 0b - Clock is not running. 1b - Clock is running.
8 BLOCK40	IP block status This bit provides the clock status of block 40 in partition 3. 0b - Clock is not running. 1b - Clock is running.
7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.

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Field	Function
5 BLOCK37	IP block status This bit provides the clock status of block 37 in partition 3. 0b - Clock is not running. 1b - Clock is running.
4 BLOCK36	IP block status This bit provides the clock status of block 36 in partition 3. 0b - Clock is not running. 1b - Clock is running.
3 BLOCK35	IP block status This bit provides the clock status of block 35 in partition 3. 0b - Clock is not running. 1b - Clock is running.
2 BLOCK34	IP block status This bit provides the clock status of block 34 in partition 3. 0b - Clock is not running. 1b - Clock is running.
1 —	Reserved This field is reserved and read returns zeros.
0 BLOCK32	IP block status This bit provides the clock status of block 32 in partition 3. 0b - Clock is not running. 1b - Clock is running.

41.7.58 Partition 3 COFB Set 2 Clock Status Register (PRTN3_COFB2_STAT)

Offset

Register	Offset
PRTN3_COFB2_STAT	718h

Function

This register provides the status of set 2 of COFBs inside partition 3.

NOTE

The reset value of this register can vary depending on the availability of active clock pulses inside partition 3.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLOCK65	BLOCK64
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.

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Field	Function
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.
14 —	Reserved This field is reserved and read returns zeros.
13 —	Reserved This field is reserved and read returns zeros.
12 —	Reserved This field is reserved and read returns zeros.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 —	Reserved This field is reserved and read returns zeros.
8 —	Reserved This field is reserved and read returns zeros.
7	Reserved

Table continues on the next page...

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Field	Function
—	This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 BLOCK65	IP block status This bit provides the clock status of block 65 in partition 3. 0b - Clock is not running. 1b - Clock is running.
0 BLOCK64	IP block status This bit provides the clock status of block 64 in partition 3. 0b - Clock is not running. 1b - Clock is running.

41.7.59 Partition 3 COFB Set 0 Clock Enable Register (PRTN3_COFB0_CLKEN)

Offset

Register	Offset
PRTN3_COFB0_CLKEN	730h

Function

This register provides clock control signaling to the individual COFBs in set 0 inside partition 3. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	REQ15	REQ14	REQ13	REQ12	REQ11	REQ10	REQ9	REQ8	REQ7	REQ6	REQ5	REQ4	REQ3	REQ2	REQ1	REQ0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29 —	Reserved This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 REQ15	Clock enable This bit provides the clock enable control for block 15 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
14 REQ14	Clock enable This bit provides the clock enable control for block 14 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
13 REQ13	Clock enable This bit provides the clock enable control for block 13 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
12 REQ12	Clock enable This bit provides the clock enable control for block 12 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
11 REQ11	Clock enable This bit provides the clock enable control for block 11 in partition 3.

Table continues on the next page...

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Field	Function
	0b - Clock is turned off. 1b - Clock is turned on.
10 REQ10	Clock enable This bit provides the clock enable control for block 10 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
9 REQ9	Clock enable This bit provides the clock enable control for block 9 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
8 REQ8	Clock enable This bit provides the clock enable control for block 8 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
7 REQ7	Clock enable This bit provides the clock enable control for block 7 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
6 REQ6	Clock enable This bit provides the clock enable control for block 6 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
5 REQ5	Clock enable This bit provides the clock enable control for block 5 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
4 REQ4	Clock enable This bit provides the clock enable control for block 4 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
3	Clock enable

Table continues on the next page...

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Field	Function
REQ3	This bit provides the clock enable control for block 3 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
2 REQ2	Clock enable This bit provides the clock enable control for block 2 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
1 REQ1	Clock enable This bit provides the clock enable control for block 1 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
0 REQ0	Clock enable This bit provides the clock enable control for block 0 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.

41.7.60 Partition 3 COFB Set 1 Clock Enable Register (PRTN3_COFB1_CLKEN)

Offset

Register	Offset
PRTN3_COFB1_CLKEN	734h

Function

This register provides clock control signaling to the individual COFBs in set 1 inside partition 3. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	REQ63	REQ62	REQ61	0	REQ59	REQ58	REQ57	REQ56	REQ55	REQ54	REQ53	REQ52	REQ51	REQ50	REQ49	REQ48
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ47	REQ46	0	REQ44	0	0	REQ41	REQ40	0	0	REQ37	REQ36	REQ35	REQ34	0	REQ32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 REQ63	Clock enable This bit provides the clock enable control for block 63 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
30 REQ62	Clock enable This bit provides the clock enable control for block 62 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
29 REQ61	Clock enable This bit provides the clock enable control for block 61 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
28 —	Reserved This field is reserved and read returns zeros.
27 REQ59	Clock enable This bit provides the clock enable control for block 59 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
26 REQ58	Clock enable This bit provides the clock enable control for block 58 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.

Table continues on the next page...

Table continued from the previous page...

Field	Function
25 REQ57	Clock enable This bit provides the clock enable control for block 57 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
24 REQ56	Clock enable This bit provides the clock enable control for block 56 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
23 REQ55	Clock enable This bit provides the clock enable control for block 55 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
22 REQ54	Clock enable This bit provides the clock enable control for block 54 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
21 REQ53	Clock enable This bit provides the clock enable control for block 53 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
20 REQ52	Clock enable This bit provides the clock enable control for block 52 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
19 REQ51	Clock enable This bit provides the clock enable control for block 51 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
18 REQ50	Clock enable This bit provides the clock enable control for block 50 in partition 3. 0b - Clock is turned off.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is turned on.
17 REQ49	Clock enable This bit provides the clock enable control for block 49 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
16 REQ48	Clock enable This bit provides the clock enable control for block 48 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
15 REQ47	Clock enable This bit provides the clock enable control for block 47 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
14 REQ46	Clock enable This bit provides the clock enable control for block 46 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
13 —	Reserved This field is reserved and read returns zeros.
12 REQ44	Clock enable This bit provides the clock enable control for block 44 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 REQ41	Clock enable This bit provides the clock enable control for block 41 in partition 3. 0b - Clock is turned off.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is turned on.
8 REQ40	Clock enable This bit provides the clock enable control for block 40 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 REQ37	Clock enable This bit provides the clock enable control for block 37 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
4 REQ36	Clock enable This bit provides the clock enable control for block 36 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
3 REQ35	Clock enable This bit provides the clock enable control for block 35 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
2 REQ34	Clock enable This bit provides the clock enable control for block 34 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.
1 —	Reserved This field is reserved and read returns zeros.
0 REQ32	Clock enable This bit provides the clock enable control for block 32 in partition 3. 0b - Clock is turned off.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is turned on.

41.7.61 Partition 3 COFB Set 2 Clock Enable Register (PRTN3_COFB2_CLKEN)

Offset

Register	Offset
PRTN3_COFB2_CLKEN	738h

Function

This register provides clock control signaling to the individual COFBs in set 2 inside partition 3. Whenever a partition clock enable (non-core) hardware process is initiated, the value of logic-1 in the corresponding bit locations of this register enables the clock to the corresponding block in the partition.

NOTE

The reset value of this register is not defined and is as per the availability of the clock source. See Chip-specific MC_ME information for clock source availability.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	REQ65	REQ64
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved This field is reserved and read returns zeros.
30 —	Reserved This field is reserved and read returns zeros.
29	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	This field is reserved and read returns zeros.
28 —	Reserved This field is reserved and read returns zeros.
27 —	Reserved This field is reserved and read returns zeros.
26 —	Reserved This field is reserved and read returns zeros.
25 —	Reserved This field is reserved and read returns zeros.
24 —	Reserved This field is reserved and read returns zeros.
23 —	Reserved This field is reserved and read returns zeros.
22 —	Reserved This field is reserved and read returns zeros.
21 —	Reserved This field is reserved and read returns zeros.
20 —	Reserved This field is reserved and read returns zeros.
19 —	Reserved This field is reserved and read returns zeros.
18 —	Reserved This field is reserved and read returns zeros.
17 —	Reserved This field is reserved and read returns zeros.
16 —	Reserved This field is reserved and read returns zeros.
15 —	Reserved This field is reserved and read returns zeros.

Table continues on the next page...

Table continued from the previous page...

Field	Function
14 —	Reserved This field is reserved and read returns zeros.
13 —	Reserved This field is reserved and read returns zeros.
12 —	Reserved This field is reserved and read returns zeros.
11 —	Reserved This field is reserved and read returns zeros.
10 —	Reserved This field is reserved and read returns zeros.
9 —	Reserved This field is reserved and read returns zeros.
8 —	Reserved This field is reserved and read returns zeros.
7 —	Reserved This field is reserved and read returns zeros.
6 —	Reserved This field is reserved and read returns zeros.
5 —	Reserved This field is reserved and read returns zeros.
4 —	Reserved This field is reserved and read returns zeros.
3 —	Reserved This field is reserved and read returns zeros.
2 —	Reserved This field is reserved and read returns zeros.
1 REQ65	Clock enable This bit provides the clock enable control for block 65 in partition 3. 0b - Clock is turned off.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clock is turned on.
0 REQ64	Clock enable This bit provides the clock enable control for block 64 in partition 3. 0b - Clock is turned off. 1b - Clock is turned on.

41.8 Glossary

WFI Wait for interrupt

COFB Collection of functional blocks also referred as number of peripherals

Chapter 42
Power Control Unit (MC_PCU)

42.1 Introduction

The power control unit (MC_PCU) is used for initiating a Standby mode entry that reduces the overall chip power consumption. Power can be saved by disconnecting parts of the chip from the power supply. The blocks inside the chip are grouped into multiple parts having this capability, which are called "power domains".

When a power domain is disconnected from the supply, the power consumption is reduced to zero and the configuration of the every core and module that belongs to such power domain is completely lost. When you reconnect a power domain to the supply voltage, the domain draws an increased current until the power domain reaches its operational voltage. Maximum power saving is achieved by entering the Standby mode.

After the MC_ME asserts a standby entry request, MC_PCU initiates the power sequence, which is non-retractable and includes the handshake with the chip power management controller. The power-up/down sequences are handled by FSMs to ensure a smooth and safe transition into and out of the Standby mode. Exiting the Standby mode can only be done through a system wakeup event, power-on reset, destructive reset, or a functional reset.

42.2 Power sequence FSM

MC_PCU implements an FSM to initiate the power sequencing of the Standby mode entry/exit sequence for the chip.

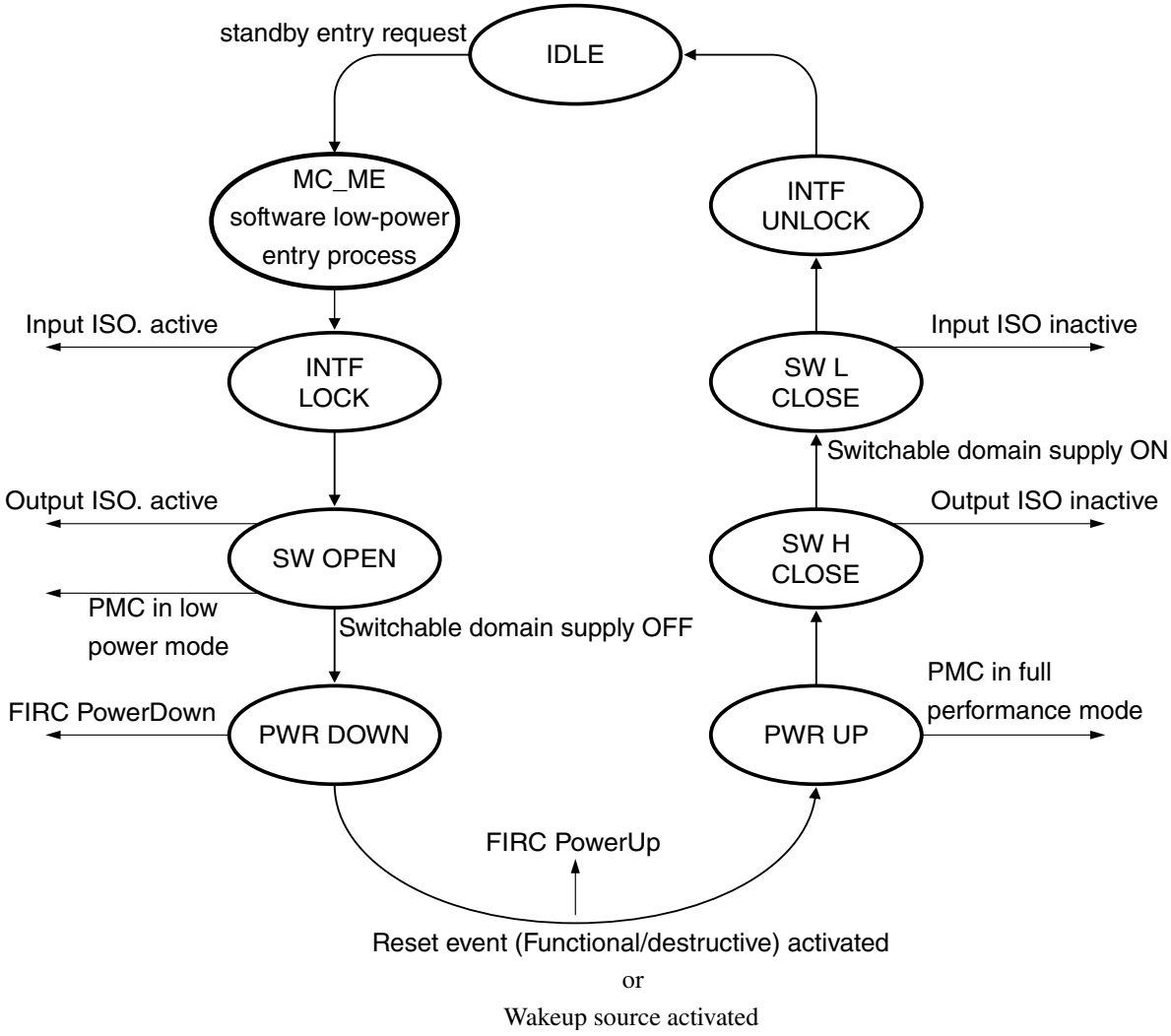


Figure 172. MC_PCU FSM

NOTE

When destructive reset is asserted from MC_RGM, MC_PCU FSM moves to the IDLE state immediately. Indication of this is not shown in the above figure.

Table 207. MC_PCU FSM transition description

State	Name	Exit condition	Signal controlled	Signal monitored
IDLE	Idle state	Standby request received from MC_ME	-	-
MC_ME software low power entry process	MC_ME software low power entry process	Software entry sequence completed (SW4 process completed)	-	-
INTF LOCK	Interface lock state	Input isolation active	Input isolation activation	Input isolation active

Table continues on the next page...

Table 207. MC_PCU FSM transition description (continued)

State	Name	Exit condition	Signal controlled	Signal monitored
SW OPEN	Switch open state	Output isolation active, Switchable domain supply turned off	Output isolation activation, low power mode request to PMC	Output isolation active, Switchable domain supply
PWR DOWN	Power down state	Wakeup/functional reset occurrence	FIRC power down	Wakeup and functional reset
PWR UP	Power up state	PMC in full performance mode	-	-
SW H CLOSE	Switch H close state	Switchable domain supply turned on	-	Switchable domain supply
SW L CLOSE	Switch L close state	Input isolation inactive	Input isolation inactive	Input isolation active
INTF UNLOCK	Interface unlock	-	-	-

42.3 Glossary

FSM Finite state machine

Chapter 43
Wakeup Unit (WKPU)

43.1 Chip-specific WKPU information

43.1.1 WKPU configuration on the chip

WKPU provides the following features:

- A configurable, low-power wake-up capability to the chip from multiple configurable asynchronous wake-up events.
- Support for four internal and 60 external sources that can generate interrupts or wake-up events.
- Support for an NMI input.

Table 208. WKPU configuration on the chip

Number of sources, interrupts, and vectors	Value	Description
NMI sources	1	Single NMI pin routed to all application cores
Internal wake-up sources	4	• SWT_0 wake-up, RTC-API wake-up • RTC timeout • Analog comparator round robin wake-up (from LPCMP_0 and 1 round robin wake-up)[1] • RTI wake-up
External wake-up sources	77	77 GPIO pins are muxed to 60 WKPU sources (WKPU[0]-WKPU[59]) support the wake-up functionality. See the IOMUX file and DCF sheet attached to this document for details.
Glitch filters for external interrupts	77	Glitch filter one on each external wake-up source
External interrupt vectors	8	—

1. Both wake-up sources 0 (RTC-API) and 2 (CMP_x trigger mode wake-up) use RTC-API wake-up, with Trigger mode having a higher priority. This means, if you configure LPCMP_x.RRCR0[ERR_EN] for either of the comparators, the RTC_API wake-up is used only for the CMP_x trigger mode operation. The RTC-API wake-up does not cause wake-up from Standby mode in this scenario.

All of the aforementioned wake-up sources can be enabled or disabled. Also, you can configure these wake-up sources, by using WKPU configuration registers, to provide wake-up on rising or falling events. See the WKPU register memory map for details.

NOTE

You must use SIUL2 to perform WKPU pin configurations (PUE, PUS, and IBE). For this, you must first configure SIUL2.MSCR[IBE] for the corresponding pin. This chip does not support WKPU-provided pin configurations; it supports only bypass control.

43.1.2 WKPU NMI configuration

WKPU supports one external source that can cause non-maskable interrupts to on-chip cores and wake-up events to the system.

The following figure shows two application cores, Cortex-M7_0 , Cortex-M7_1 and Cortex-M7_2. In case of a wake-up event (internal or external), WKPU initiates the recovery of the chip and feeds an interrupt to the core(s) depending on the configuration. The sections that follow provide details related to the associated configurations.

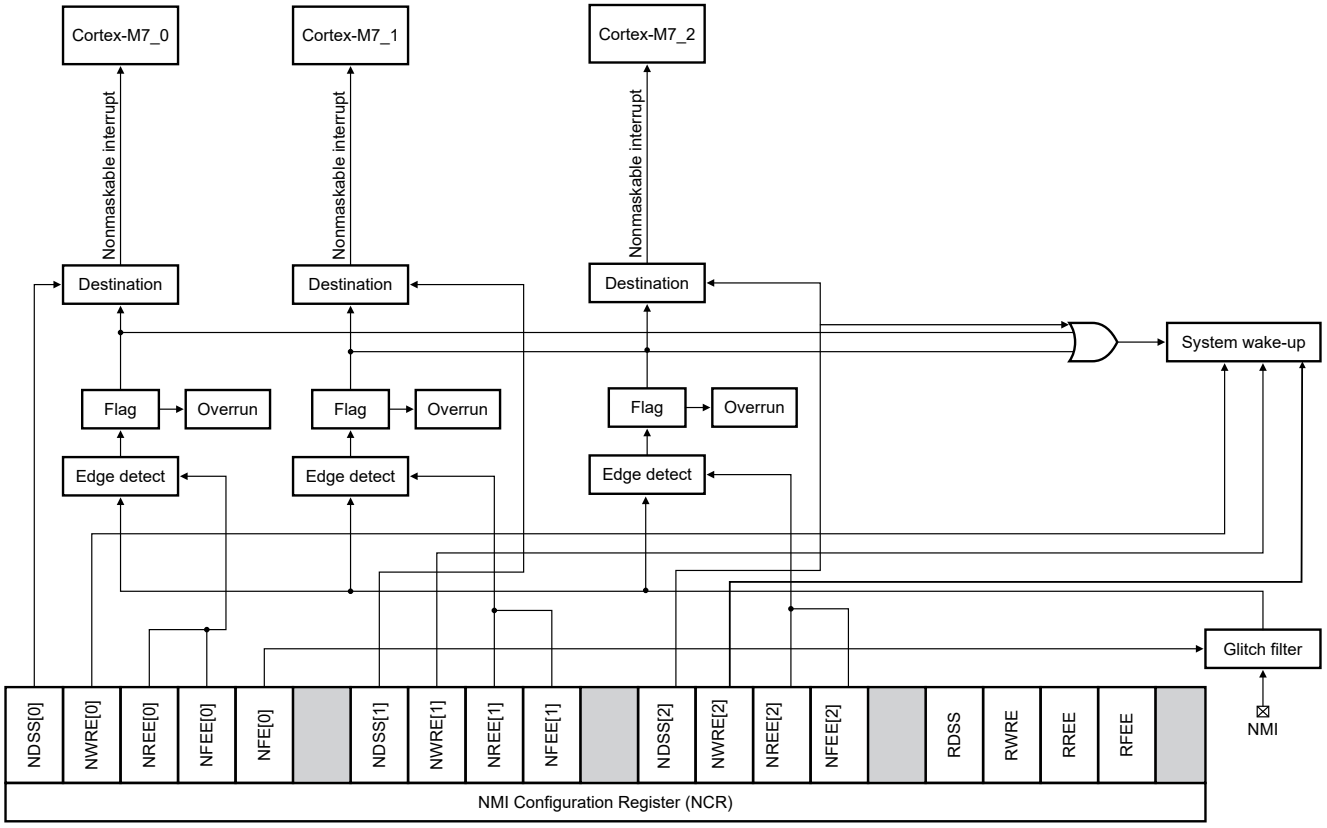


Figure 173. WKPU NMI configuration

43.1.3 WKPU wake-up source connectivity

WKPU allows the external NMI pin to assert the core NMIs on the chip. NMI supports NSR's status and overrun flags. This is what you could do using NCR:

- Control the NMI destination interrupt by configuring NCR[NDSS].
- Control the rising edge, falling edge, or either of the edge reactions to the NMI pin by using bits 2:0 of NCR[NFEE] and NCR[NREE]. The enabling of these edge reactions to the NMI pin is independent of each core.

WKPU supports the capturing of a second event per NMI input before the interrupt is cleared, thus reducing the chance of losing an NMI event.

The following figure shows routing of external wake-up events or interrupts with WKPU and the system interrupt controller.

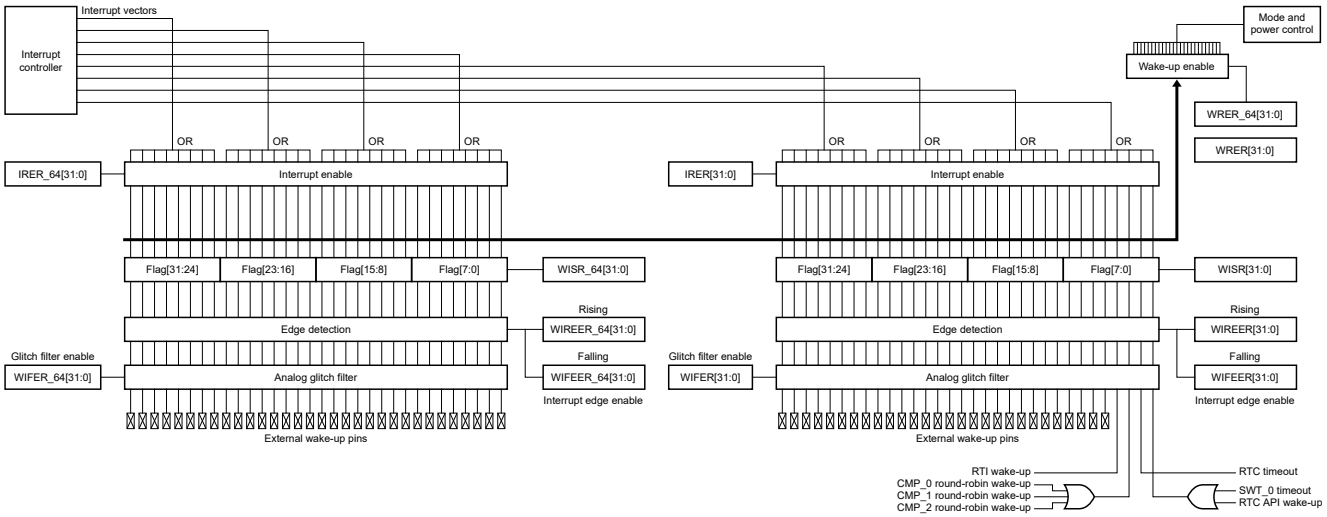


Figure 174. WKPU wake-up source connectivity

This is the wake-up source mapping to WKPU:

- Wake-up source 0 : SWT_0 timeout, RTC-API API wake-up
- Wake-up source 1 : RTC-API RTC timeout
- Wake-up source 2 : Round robin wake-up interrupt (Trigger mode interrupt) from LPCMP_0, or LPCMP_1
- Wake-up source 3 : RTI wake-up
- Wake-up source 4 : Wake-up source 77—external pin wake-up sources, WKPU[0] - WKPU[59]

If you configure any or all of the LPCMP_*x*.RRCR0[RR_EN] fields to be active, the corresponding CMP_*x* pins must be dedicated for the CMP_*x* operation. In case you are not using any of the CMPs, you can use SIUL2.MSCR*x*[SSS] to configure the pins for digital functionalities.

NOTE

You must enable WKPU (by using MC_ME.PRTN*x*_COFB*y*_CLKEN) before entering any of the chip's low-power modes.

43.2 Overview

WKPU supports 64 external sources that can generate interrupts or wake-up events, and 0 external sources that can cause nonmaskable interrupt requests or wake-up events. Additionally, it combines its wake-up events with those generated by other wake-up sources to supply a single wake-up to the system.

43.2.1 Block diagram

The figure below shows the WKPU and its interfaces with the other system components.

NOTE

The signal widths in the following diagram does not depict the particular configuration of this device. Refer to chip-specific WKPU for more details.

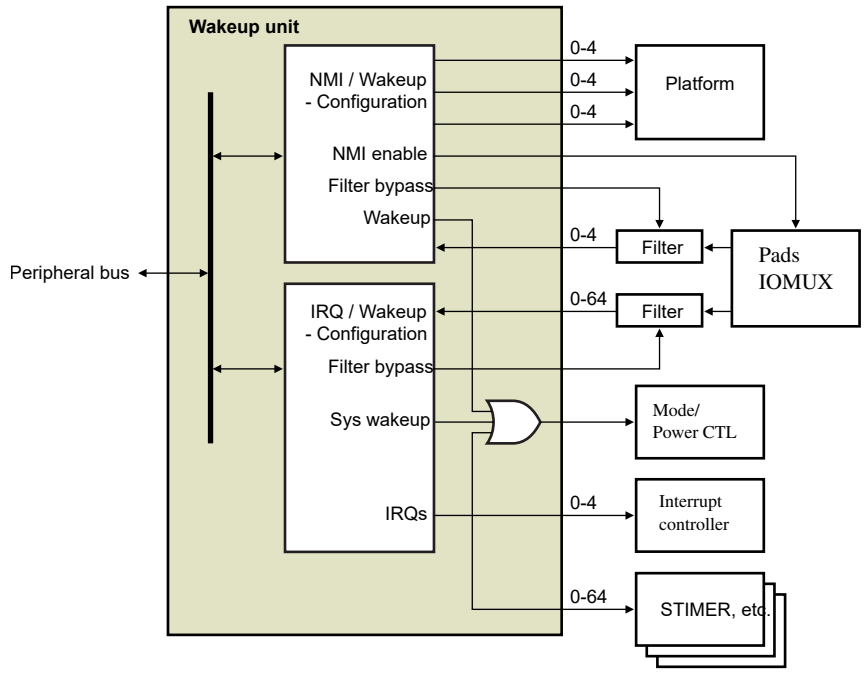


Figure 175. Block diagram

43.2.2 Features

- Supports nonmaskable interrupts that includes:
  - 3 NMI sources
  - 3 analog glitch filters
  - Independent interrupt destination for each core:
    - Nonmaskable interrupt
    - https://nxp.acrolinx.cloud

      Critical interrupt
  - Active edge selection control (rise/fall) for events
  - Configurable system wake-up triggering from NMI sources
- Supports external wake-up/interrupt that includes:
  - One System interrupt vector for interrupt sources
  - 64 analog glitch filters
  - Independent interrupt mask
  - Edge detection
  - Configurable system wake-up triggering from all interrupt sources

43.3 Functional description

This section provides functional description of WKPU.

43.3.1 Non-maskable interrupts

The WKPU supports the capturing of a second event per NMI input before the interrupt is cleared, thus reducing the chance of losing an NMI event, although it creates an overrun condition.

Each NMI passes through a bypassable analog glitch filter.

NOTE

Glitch filter control and pad configuration should be performed when NMI is disabled, to avoid erroneous triggering by glitches caused by the configuration process itself.

NOTE

The figure below represents a generic configuration and might not represent this particular device's configuration. See the chip-specific information for details on this chip's WKPU.

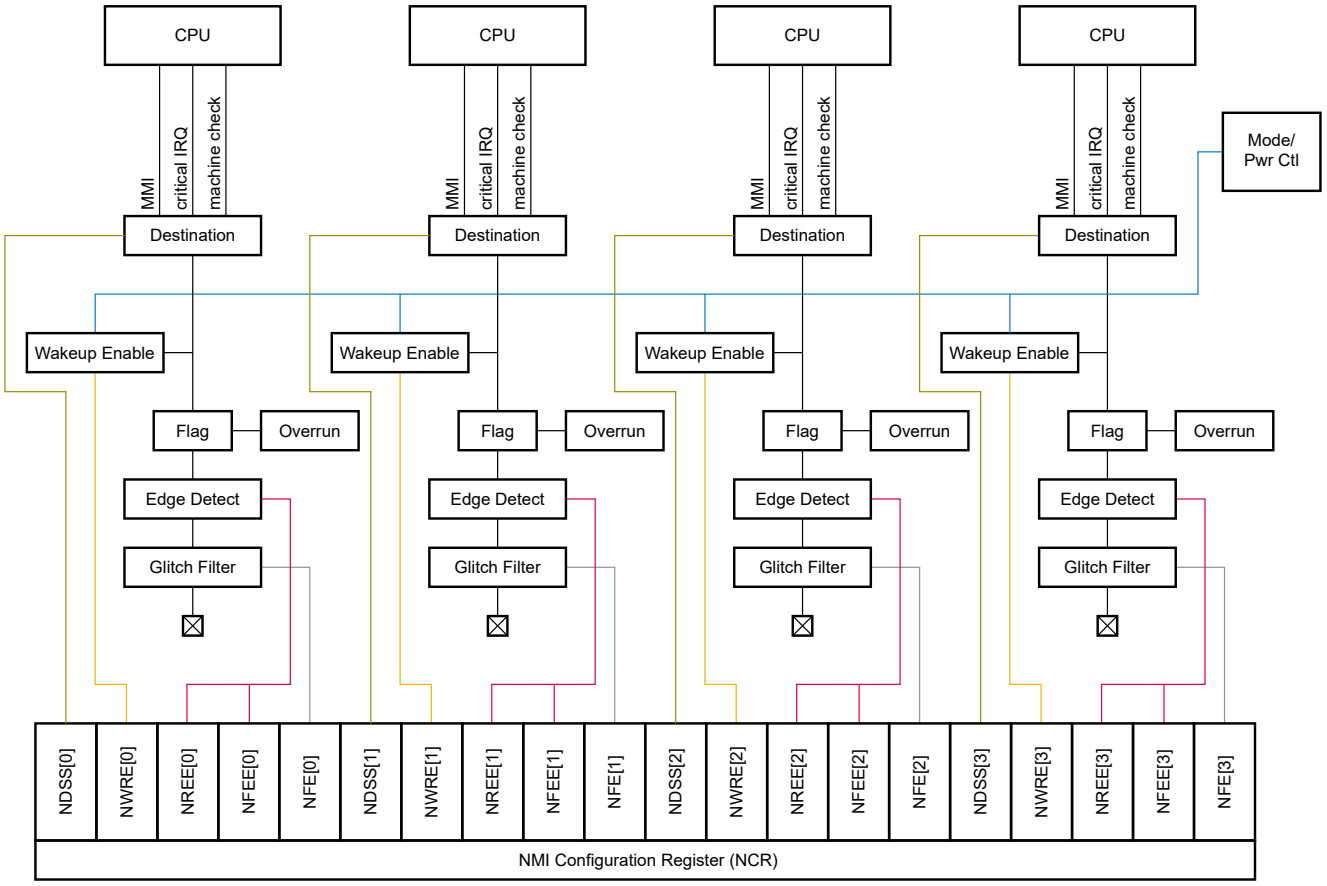


Figure 176. NMI pad diagram

43.3.1.1 NMI management

Each NMI can be enabled or disabled independently. This can be performed using the NCR laid out to contain all configuration bits for a given NMI in a single byte (see NMI Configuration Register (NCR)). A pad defined as an NMI can be configured by the user to recognize interrupts with an active rising edge, an active falling edge, or both edges being active. A setting of having both edge events disabled results in no interrupt being detected and should not be configured.

The active NMI edge is controlled by the user through the configuration of the NCR[NREEn] and NCR[NFEEn] bits.

NOTE

After reset, NREE and NFEE are set to '0'; therefore, the NMI functionality is disabled after reset and must be enabled explicitly by software.

After a pad's NMI functionality is enabled, the pad cannot be reconfigured to override or disable the NMI. See the chip-specific WKPU information for details of NMI implementation.

The NMI destination interrupt is controlled by the user through the configuration of the NCR[NDSSn] bits. See NMI Configuration Register (NCR) for details.

Each NMI supports a status flag and an overrun flag, which are located in the NSR register (see NMI Status Flag Register (NSR)). This register is a clear-by-write-1 register type, preventing inadvertent overwriting of other flags in the same register. The status flag is set whenever an NMI event is detected. The overrun flag is set whenever an NMI event is detected and the status flag is set (that is, status flag has not been cleared).

NOTE

The overrun flag is cleared by writing a '1' to the appropriate overrun bit in the NSR register. If the status bit is cleared and the overrun bit is still set, the pending interrupt is not cleared.

During an NMI ISR, on wakeup of the chip from an NMI, any writes to the ECC-protected memory must have the correct ECC.

43.3.2 Clocking

This module has no clocking considerations.

The WKPU has ipg_clk and ipg_clk_s as input clocks having same clock frequency for register configuration and internal logic.

43.3.3 Interrupts

The WKPU supports 4 interrupt vectors to the interrupt controller of the chip. Each interrupt vector can support up to the number of external interrupt sources from the device pads, with the total across all vectors being equal to the number of external interrupt sources. Each external interrupt source is assigned to exactly one interrupt vector. The interrupt vector assignment is sequential so that one interrupt vector is for external interrupt sources 0 through N-1, the next is for N through N+M-1, and so forth.

See the following figure for an overview of the external interrupt implementation, showing an example of four interrupt vectors with eight external interrupt sources each.

NOTE

The figure below shows a generic representation of WKPU. See the chip-specific WKPU information for details on how this device's configuration might differ from this figure.

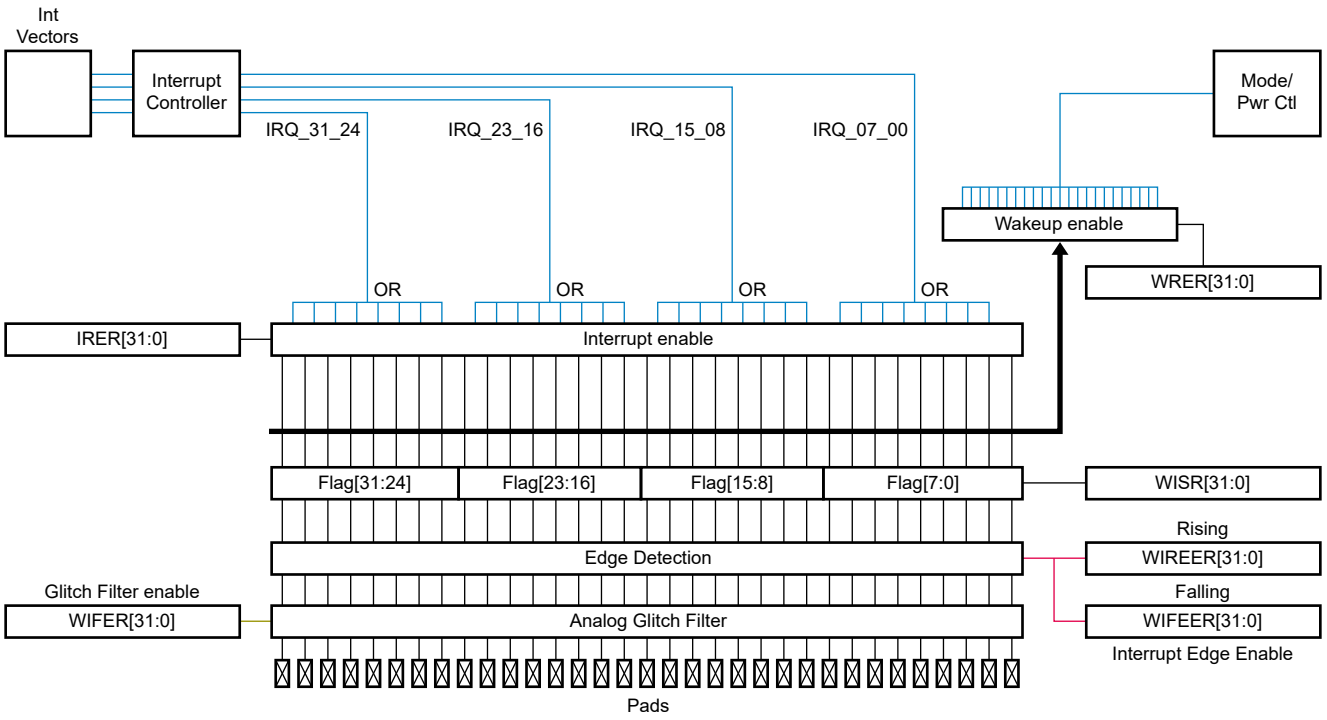


Figure 177. External interrupt pad diagram

All of the external interrupt pads within a single group have equal priority. It is the responsibility of the user software to search through the group of sources in the most appropriate way for their application.

The priority of the vectors used by the external interrupt pads is set based on the platform and the interrupt controller's priority levels, but the allocation of pads to each group of interrupts can be independently configured by the chip.

External interrupt lines have a digital glitch filter applied to them.

43.3.3.1 External interrupt management

Each interrupt can be enabled or disabled independently. This can be performed using a single rolled-up register (Interrupt Request Enable Register (IRER)). A pad defined as an external interrupt can be configured by the user to recognize interrupts with an active rising edge, an active falling edge, or both edges being active.

NOTE

Writing a '0' to both IREE[x] and IFEE[x] disables the external interrupt functionality for that pad completely (that is, no system wakeup or interrupt is generated on any activity of that pad).

The active IRQ edge is controlled by users through the configuration of the registers WIREER and WIFEER.

Each external interrupt supports an individual flag, which is held in the flag register, WISR. This register is a clear-by-write-1 register type, preventing inadvertent overwriting of other flags in the same register.

43.3.4 External Signals

This module has no external signals.

43.4 Initialization

This section discusses initialization for the following features:

- Glitch filter and pad configuration

- Non-maskable interrupts

43.4.1 Glitch filter and pad configuration

Glitch filter control and pad configuration should be performed when the NMI is disabled. This is to avoid erroneous triggering by glitches caused by the configuration process.

When enabling the glitch filter, do not enable the rising-/falling-edge events bits, i.e., the NCR[NREE], NCR[NFEE], NCR[RREE], and NCR[RFEE] bits in the same register write.

43.4.2 Non-maskable interrupts

If the IBE of NMI is tied off to 1, no false interrupt is expected.

43.5 WKPU memory map and registers

43.5.1 WKPU register descriptions

This section provides a detailed description of all the registers accessible in the WKPU module.

NOTE

Reserved registers read as zero and writes have no effect. A transfer error is generated when trying to access a completely reserved register space. The field length of external pad control registers depends on the number of WKPU channels implemented in a chip.

43.5.1.1 WKPU memory map

WKPU base address: 402B_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	NMI Status Flag Register (NSR)	32	RW	0000_0000h
8h	NMI Configuration Register (NCR)	32	RW	6060_6000h
14h	Wakeup/Interrupt Status Flag Register (WISR)	32	RW	0000_0000h
18h	Interrupt Request Enable Register (IRER)	32	RW	0000_0000h
1Ch	Wakeup Request Enable Register (WRER)	32	RW	0000_0000h
28h	Wakeup/Interrupt Rising-Edge Event Enable Register (WIREER)	32	RW	0000_0000h
2Ch	Wakeup/Interrupt Falling-Edge Event Enable Register (WIFEER)	32	RW	0000_0000h
30h	Wakeup/Interrupt Filter Enable Register (WIFER)	32	RW	0000_0000h
54h	Wakeup/Interrupt Status Flag Register (WISR_64)	32	RW	0000_0000h
58h	Interrupt Request Enable Register (IRER_64)	32	RW	0000_0000h
5Ch	Wakeup Request Enable Register (WRER_64)	32	RW	0000_0000h
68h	Wakeup/Interrupt Rising-Edge Event Enable Register (WIREER_64)	32	RW	0000_0000h
6Ch	Wakeup/Interrupt Falling-Edge Event Enable Register (WIFEER_64)	32	RW	0000_0000h
70h	Wakeup/Interrupt Filter Enable Register (WIFER_64)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
120h	Wakeup/Interrupt Filter Enable Register (WIFER_96)	32	RW	0000_0000h
150h	Wakeup/Interrupt Filter Enable Register (WIFER_128)	32	RW	0000_0000h

43.5.1.2 NMI Status Flag Register (NSR)

Offset

Register	Offset
NSR	0h

Function

This register holds the non-maskable interrupt status flags.

NOTE

This register is accessible by 8-, 16-, and 32-bit read/write operations.

Access: User read/write

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	NIF0	NOVF 0	Reserved						NIF1	NOVF 1	Reserved					
W	W1C	W1C							W1C	W1C						
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NIF2	NOVF 2	Reserved						Reserved		Reserved					
W	W1C	W1C														
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 NIF0	NMI Status Flag 0 This flag can be cleared only by writing 1. Writing 0 has no effect. If enabled (NREE0 or NFEE0 set), NIF0 causes an interrupt request.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No event has occurred on the pad 1b - An event as defined by NREE0 and NFEE0 has occurred
30 NOVF0	NMI Overrun Status Flag 0 This flag can be cleared only by writing 1. Writing 0 has no effect. It will be a copy of the current NIF0 value whenever an NMI event occurs, thereby indicating to the software that the NMI occurred when the last one was not yet serviced. If enabled (NREE0 or NFEE0 set), NOVF0 causes an interrupt request. 0b - No overrun has occurred on NMI input 0 1b - An overrun has occurred on NMI input 0
29-24 —	Reserved
23 NIF1	NMI Status Flag 1 This flag can be cleared only by writing 1. Writing 0 has no effect. If enabled (NREE1 or NFEE1 set), NIF1 causes an interrupt request. 0b - No event has occurred on the pad 1b - An event as defined by NREE1 and NFEE1 has occurred
22 NOVF1	NMI Overrun Status Flag 1 This flag can be cleared only by writing 1. Writing 0 has no effect. It will be a copy of the current NIF1 value whenever an NMI event occurs, thereby indicating to the software that the NMI occurred when the last one was not yet serviced. If enabled (NREE1 or NFEE1 set), NOVF1 causes an interrupt request. 0b - No overrun has occurred on NMI input 1 1b - An overrun has occurred on NMI input 1
21-16 —	Reserved
15 NIF2	NMI Status Flag 2 This flag can be cleared only by writing 1. Writing 0 has no effect. If enabled (NREE2 or NFEE2 set), NIF2 causes an interrupt request. 0b - No event has occurred on the pad 1b - An event as defined by NREE2 and NFEE2 has occurred
14 NOVF2	NMI Overrun Status Flag 2 This flag can be cleared only by writing 1. Writing 0 has no effect. It will be a copy of the current NIF2 value whenever an NMI event occurs, thereby indicating to the software that an NMI occurred while the last one was not yet serviced. If enabled (NREE2 or NFEE2 set), NOVF2 causes an interrupt request. 0b - No overrun has occurred on NMI input 2 1b - An overrun has occurred on NMI input 2

Table continues on the next page...

Table continued from the previous page...

Field	Function
13-8 —	Reserved
7-6 —	Reserved
5-0 —	Reserved

43.5.1.3 NMI Configuration Register (NCR)

Offset

Register	Offset
NCR	8h

Function

This register holds the configuration bits for the non-maskable interrupt settings.

NOTE

- This register is accessible by 8-, 16-, and 32-bit read/write operations.
- Writing 0 to both NREE[*n*] and NFEE[*n*] disables the NMI functionality completely (that is, no non-maskable interrupt is generated on any pad activity).

Access: User read/write

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	NLOCK0	NDSS0		NWRE0	0	NREE0	NFEE0	NFE0	NLOCK1	NDSS1		NWRE1	0	NREE1	NFEE1	NFE1
W																
Reset	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NLOCK2	NDSS2		NWRE2	0	NREE2	NFEE2	NFE2	Reserved							
W																
Reset	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 NLOCK0	NMI Configuration Lock Register 0 Writing 1 to this bit locks the configuration for the NMI until it is unlocked by a system reset or STANDBY0 mode exit. Writing 0 has no effect.
30-29 NDSS0	NMI Destination Source Select 0 **NOTE** As wakeup does not support another interrupt than NMI, the destination source select signal bits are reserved and always retain their reset value. This means no other request other than NMI can be generated. 00b - Non-maskable interrupt 01b - Reserved 10b - Reserved 11b - Reserved
28 NWRE0	NMI Wakeup Request Enable 0 0b - System wakeup requests from the corresponding NIF0 field are disabled 1b - Causes a system wakeup request when NIF0 = 1 or NOVF0 = 1
27 —	Reserved
26 NREE0	NMI Rising-Edge Events Enable 0 0b - Rising-edge event is disabled 1b - Rising-edge event is enabled
25 NFEE0	NMI Falling-edge Events Enable 0 0b - Falling-edge event is disabled 1b - Falling-edge event is enabled
24 NFE0	NMI Filter Enable 0 Enable analog glitch filter on the NMI pad input. 0b - Filter is disabled 1b - Filter is enabled
23 NLOCK1	NMI Configuration Lock Register 1 Writing 1 to this bit locks the configuration for the NMI until it is unlocked by a system reset or STANDBY0 mode exit . Writing 0 has no effect.
22-21	NMI Destination Source Select 1

Table continues on the next page...

Table continued from the previous page...

Field	Function
NDSS1	**NOTE** As wakeup does not support another interrupt than NMI, the destination source select signal bits are reserved and always retain their reset value. This means no other request other than NMI can be generated. 00b - Non-maskable interrupt 01b - Reserved 10b - Reserved 11b - Reserved
20 NWRE1	NMI Wakeup Request Enable 1 0b - System wakeup requests from the corresponding NIF1 field are disabled 1b - Causes a system wakeup request when NIF1 = 1 or NOVF1 = 1
19 —	Reserved
18 NREE1	NMI Rising-Edge Events Enable 1 0b - Rising-edge event is disabled 1b - Rising-edge event is enabled
17 NFEE1	NMI Falling-Edge Events Enable 1 0b - Falling-edge event is disabled 1b - Falling-edge event is enabled
16 NFE1	NMI Filter Enable 1 Enable analog glitch filter on the NMI pad input. 0b - Filter is disabled 1b - Filter is enabled
15 NLOCK2	NMI Configuration Lock Register 2 Writing 1 to this bit locks the configuration for the NMI until it is unlocked by a system reset. Writing 0 has no effect.
14-13 NDSS2	NMI Destination Source Select 2 **NOTE** Since wakeup does not support any other interrupt other than NMI, the destination source select signal bits are reserved and will always retain their reset value. This means no other request other than NMI can be generated.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	00b - Non-maskable interrupt 01b - Reserved 10b - Reserved 11b - Reserved
12 NWRE2	NMI Wakeup Request Enable 2 0b - System wakeup requests from the corresponding NIF2 field are disabled 1b - Causes a system wakeup request when NIF2 = 1 or NOVF2 = 1
11 —	Reserved
10 NREE2	NMI Rising-Edge Events Enable 2 0b - Rising-edge event is disabled 1b - Rising-edge event is enabled
9 NFEE2	NMI Falling-Edge Events Enable 2 0b - Falling-edge event is disabled 1b - Falling-edge event is enabled
8 NFE2	NMI Filter Enable 2 Enable analog glitch filter on the NMI pad input. 0b - Filter is disabled 1b - Filter is enabled
7-0 —	Reserved

43.5.1.4 Wakeup/Interrupt Status Flag Register (WISR)

Offset

Register	Offset
WISR	14h

Function

This register holds the wakeup/interrupt flags.

NOTE

- This register is accessible only by 32-bit read/write operations.
- Status bits associated with on-chip wakeup sources are located at the left of the external wakeup/interrupt status bits and are read-only. The wakeup for these sources must be configured and cleared at the on-chip wakeup source. Also, the configuration registers for the external interrupts/wakeups do not have corresponding bits.

Access: User read/write

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EIF															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	EIF															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 EIF	External Wakeup/Interrupt Status Flag x This flag can be cleared only by writing 1. Writing 0 has no effect. If enabled (IRER[x]), EIF[x] causes an interrupt request. 0b - No event has occurred on the pad 1b - An event as defined by WIREER and WIFEER has occurred

43.5.1.5 Interrupt Request Enable Register (IRER)

Offset

Register	Offset
IRER	18h

Function

This register is used to enable the interrupt messaging from the wakeup/interrupt pads to the interrupt controller.

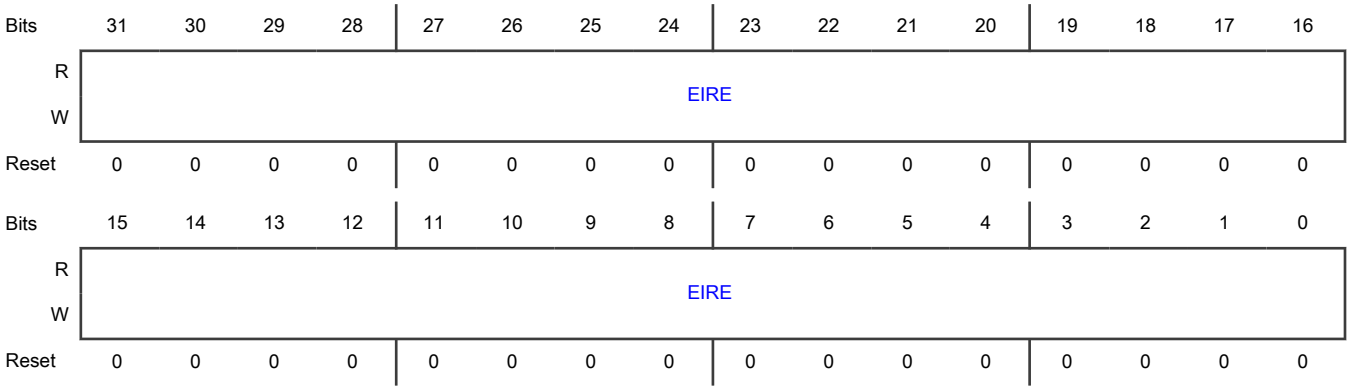
NOTE

This register is accessible only by 32-bit read/write operations.

If a pin is disabled through this register, the corresponding bits in the WIFEER and WIREER registers must be written to 0 to ensure that the pin does not respond to any change.

Access: User read/write

Diagram



Fields

Field	Function
31-0 EIRE	External Interrupt Request Enable x 0b - Interrupt requests from the corresponding EIF[x] bit are disabled 1b - A set EIF[x] bit causes an interrupt request

43.5.1.6 Wakeup Request Enable Register (WRER)

Offset

Register	Offset
WRER	1Ch

Function

This register is used to enable the system wakeup messaging from the wakeup/interrupt pads to the mode entry and power control modules.

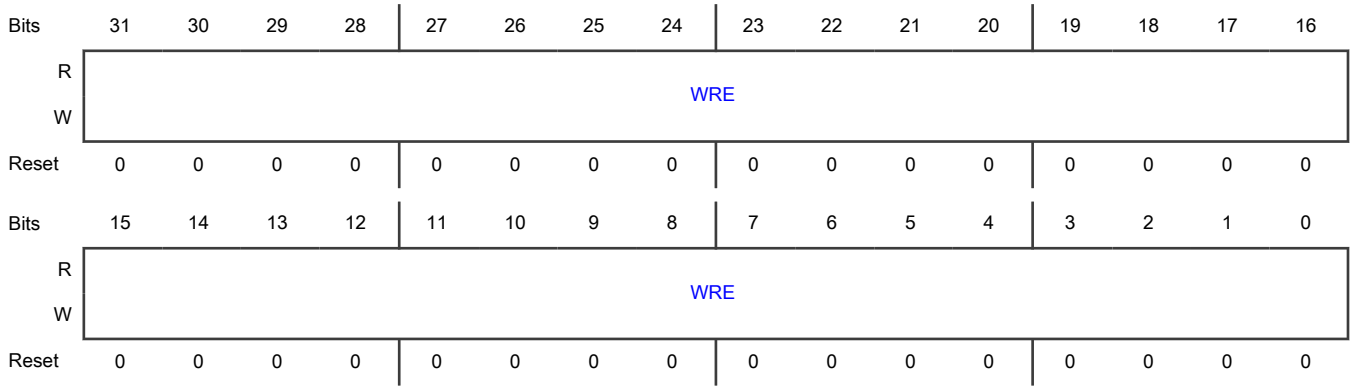
NOTE

This register is accessible only by 32-bit read/write operations.

If a pin is disabled through this register, the corresponding bits in the WIFEER and WIREER registers must be written to 0 to ensure that the pin does not respond to any change.

Access: User read/write

Diagram



Fields

Field	Function
31-0 WRE	External Wakeup Request Enable x 0b - System wakeup requests from corresponding EIF[x] bit are disabled 1b - A set EIF[x] bit causes a system wakeup request

43.5.1.7 Wakeup/Interrupt Rising-Edge Event Enable Register (WIREER)

Offset

Register	Offset
WIREER	28h

Function

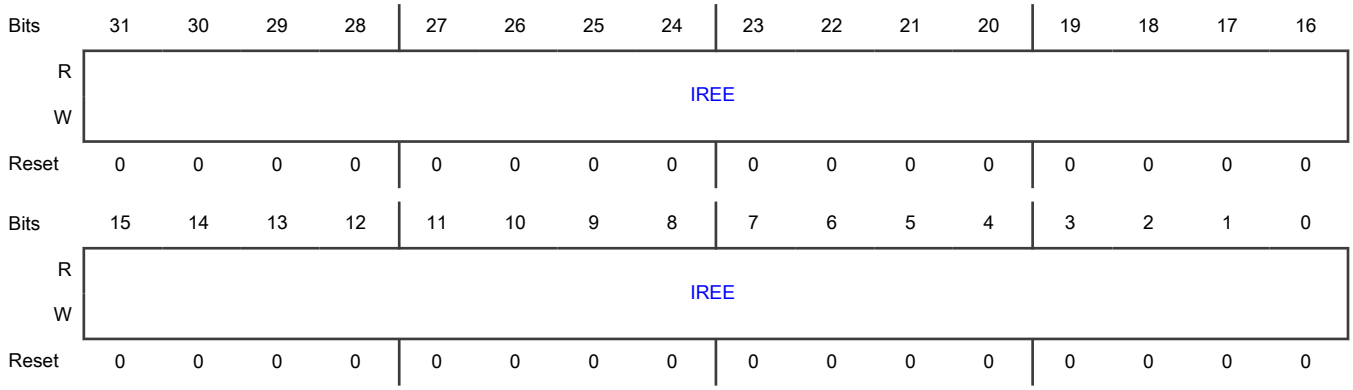
This register is used to enable rising-edge triggered events on the corresponding wakeup/interrupt pads.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IREE	External Interrupt Rising-edge Events Enable x 0b - Rising-edge event is disabled 1b - Rising-edge event is enabled

43.5.1.8 Wakeup/Interrupt Falling-Edge Event Enable Register (WIFEER)

Offset

Register	Offset
WIFEER	2Ch

Function

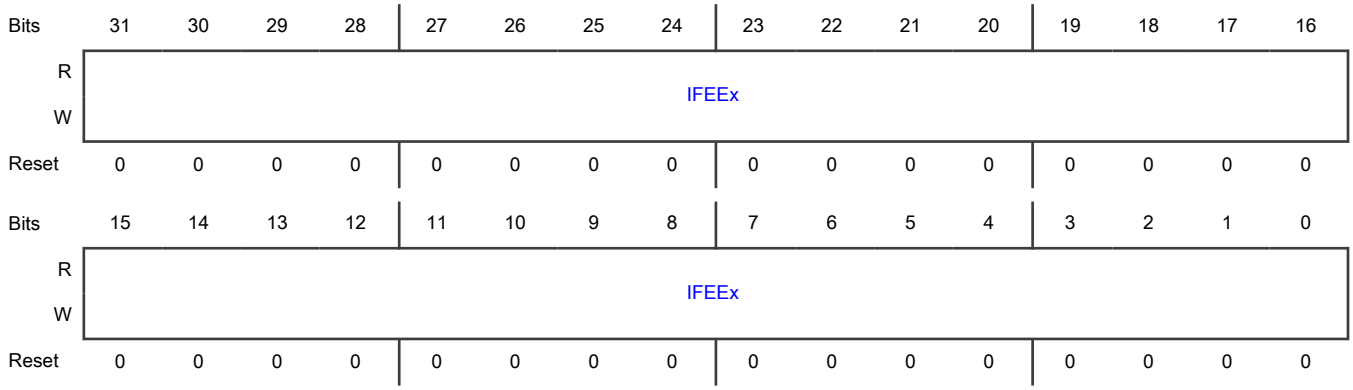
This register is used to enable falling-edge triggered events on the corresponding wakeup/interrupt pads.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IFEEx	External Interrupt Falling-edge Events Enable x 0b - Falling-edge event is disabled 1b - Falling-edge event is enabled

43.5.1.9 Wakeup/Interrupt Filter Enable Register (WIFER)

Offset

Register	Offset
WIFER	30h

Function

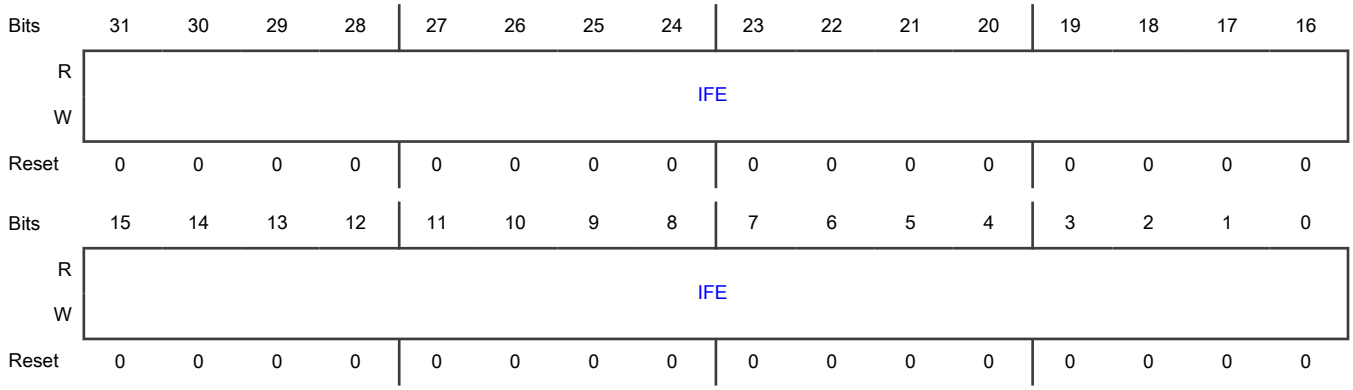
This register is used to enable an analog filter on the corresponding interrupt pads to filter out glitches on the inputs.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IFE	External Interrupt Filter Enable x Enable analog glitch filter on the external interrupt pad input. 0b - Filter is disabled 1b - Filter is enabled

43.5.1.10 Wakeup/Interrupt Status Flag Register (WISR_64)

Offset

Register	Offset
WISR_64	54h

Function

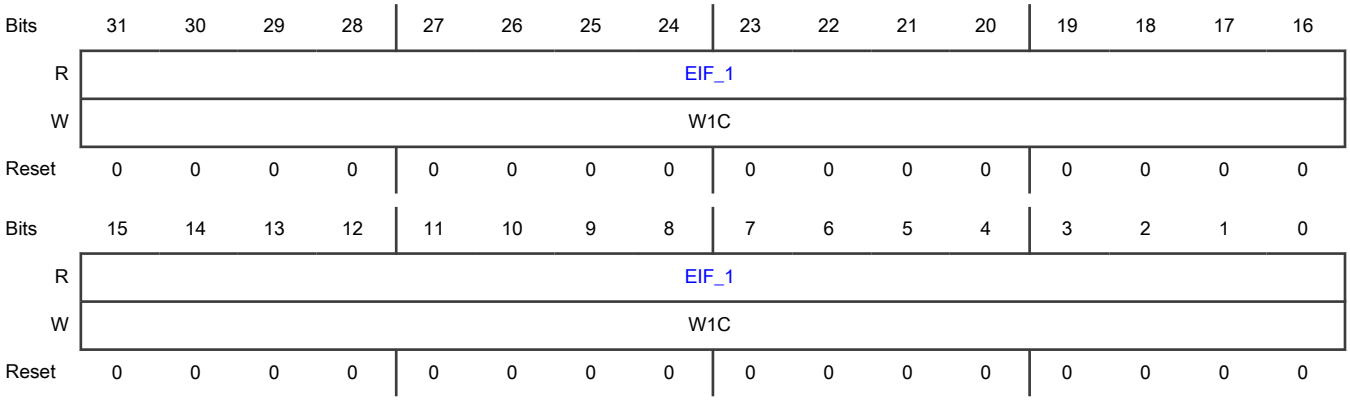
This register holds the wakeup/interrupt flags.

NOTE

- This register is accessible only by 32-bit read/write operations.
- Status bits associated with on-chip wakeup sources are located to the left of the external wakeup/interrupt status bits and are read-only. The wakeup for these sources must be configured and cleared at the on-chip wakeup source. Also, the configuration registers for the external interrupts/wakeups do not have corresponding bits.

Access: User read/write

Diagram



Fields

Field	Function
31-0 EIF_1	External Wakeup/Interrupt Status Flag x This flag can be cleared only by writing 1. Writing 0 has no effect. If enabled (IRER[x]), EIF[x] causes an interrupt request. 0b - No event has occurred on the pad 1b - An event as defined by WIREER and WIFEER has occurred

43.5.1.11 Interrupt Request Enable Register (IRER_64)

Offset

Register	Offset
IRER_64	58h

Function

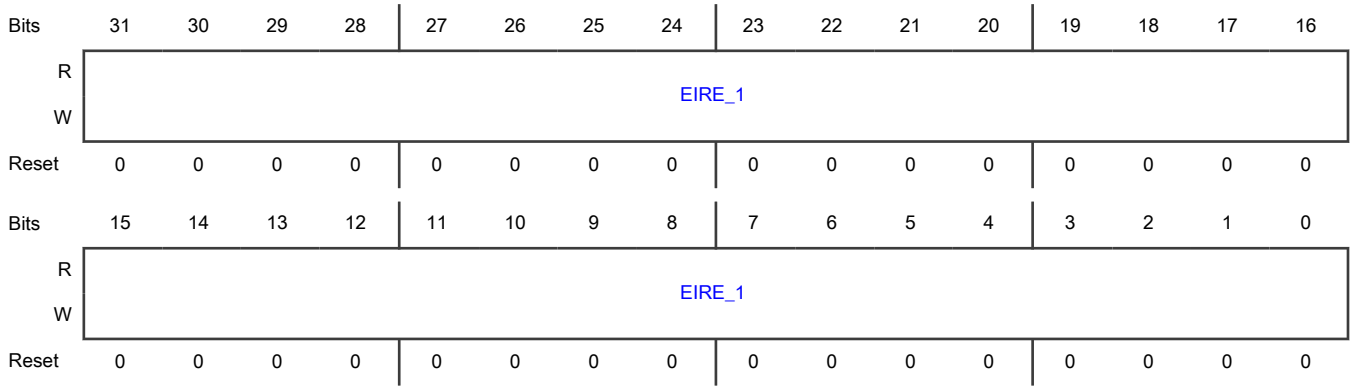
This register is used to enable interrupt messaging from the wakeup/interrupt pads to the interrupt controller.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 EIRE_1	External Interrupt Request Enable x 0b - Interrupt requests from the corresponding EIF[x] bit are disabled 1b - A set EIF[x] bit causes an interrupt request

43.5.1.12 Wakeup Request Enable Register (WRER_64)

Offset

Register	Offset
WRER_64	5Ch

Function

This register is used to enable system wakeup messaging from the wakeup/interrupt pads to the mode entry and power control modules.

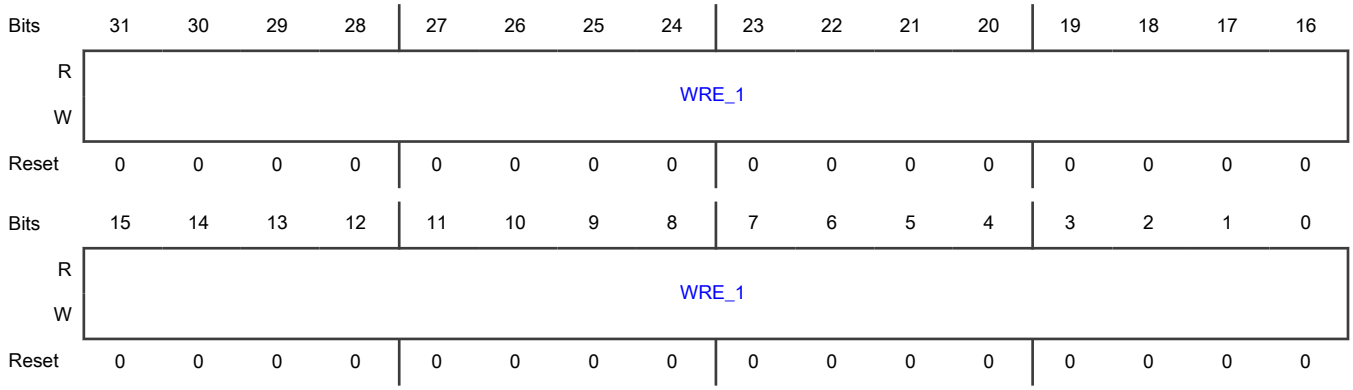
NOTE

This register is accessible only by 32-bit read/write operations.

If a pin is disabled through this register, the corresponding bits in the WIFEER and WIREER registers must be written to 0 to ensure that the pin does not respond to any change.

Access: User read/write

Diagram



Fields

Field	Function
31-0 WRE_1	External Wakeup Request Enable x 0b - System wakeup requests from corresponding EIF[x] bit are disabled 1b - A set EIF[x] bit causes a system wakeup request

43.5.1.13 Wakeup/Interrupt Rising-Edge Event Enable Register (WIREER_64)

Offset

Register	Offset
WIREER_64	68h

Function

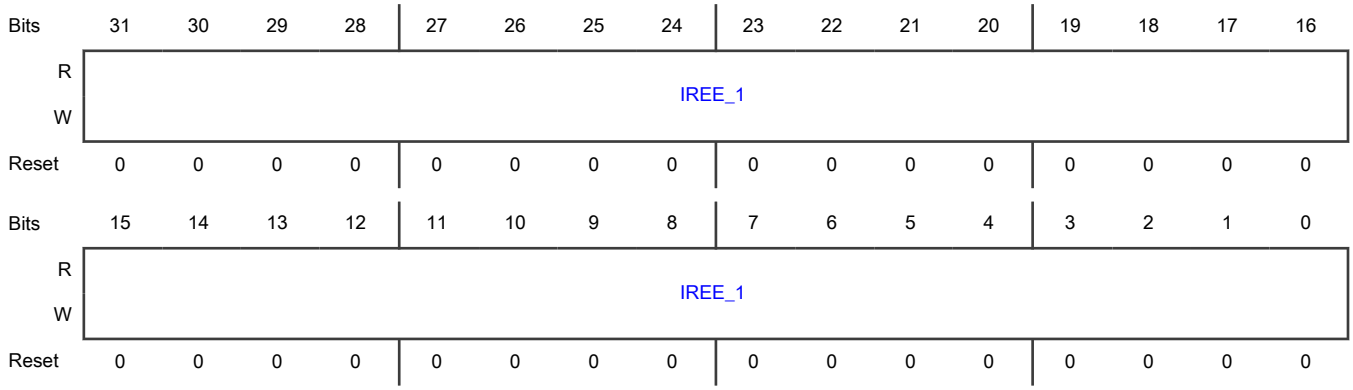
This register is used to enable rising-edge triggered events on the corresponding wakeup/interrupt pads.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IREE_1	External Interrupt Rising-edge Events Enable x 0b - Rising-edge event is disabled 1b - Rising-edge event is enabled

43.5.1.14 Wakeup/Interrupt Falling-Edge Event Enable Register (WIFEER_64)

Offset

Register	Offset
WIFEER_64	6Ch

Function

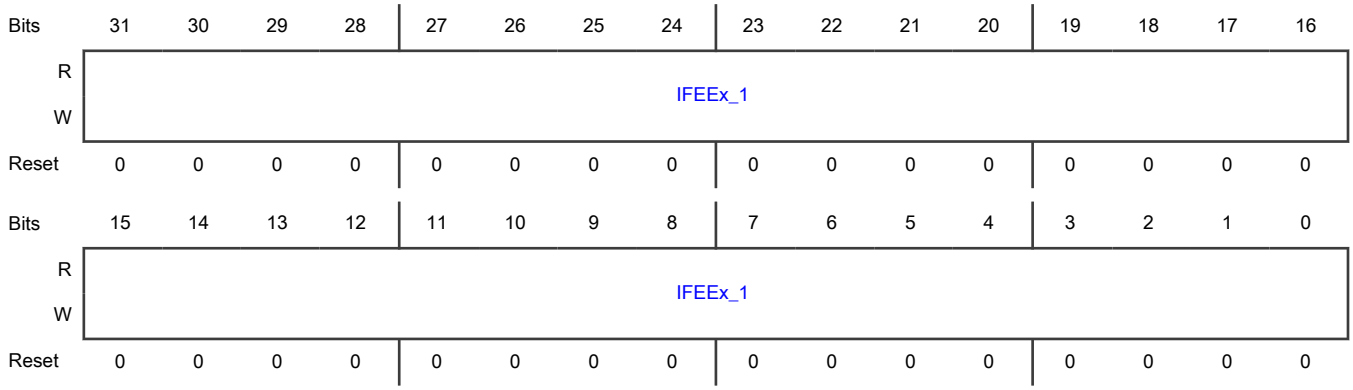
This register is used to enable falling-edge triggered events on the corresponding wakeup/interrupt pads.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IFEEx_1	External Interrupt Falling-edge Events Enable x 0b - Falling-edge event is disabled 1b - Falling-edge event is enabled

43.5.1.15 Wakeup/Interrupt Filter Enable Register (WIFER_64)

Offset

Register	Offset
WIFER_64	70h

Function

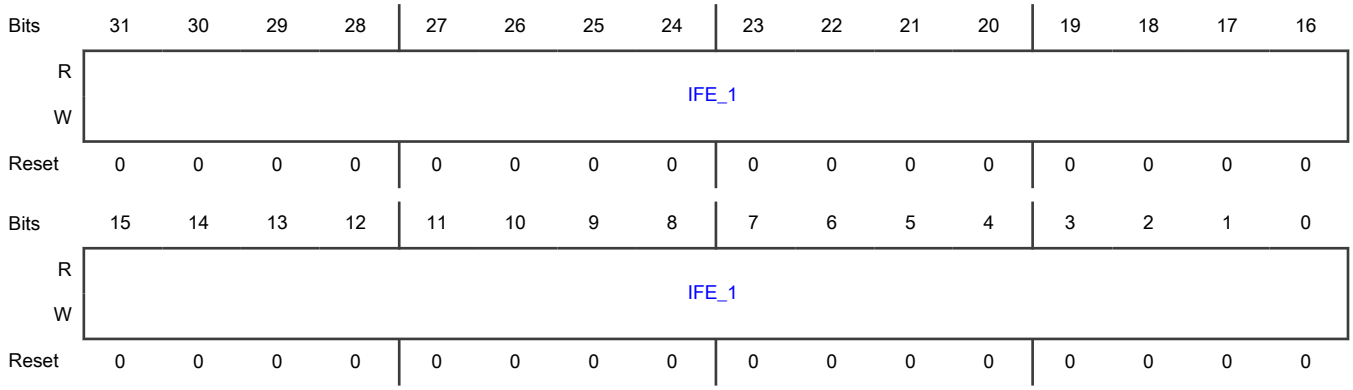
This register is used to enable an analog filter on the corresponding interrupt pads to filter out glitches on the inputs.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IFE_1	External Interrupt Filter Enable x Enable analog glitch filter on the external interrupt pad input. 0b - Filter is disabled 1b - Filter is enabled

43.5.1.16 Wakeup/Interrupt Filter Enable Register (WIFER_96)

Offset

Register	Offset
WIFER_96	120h

Function

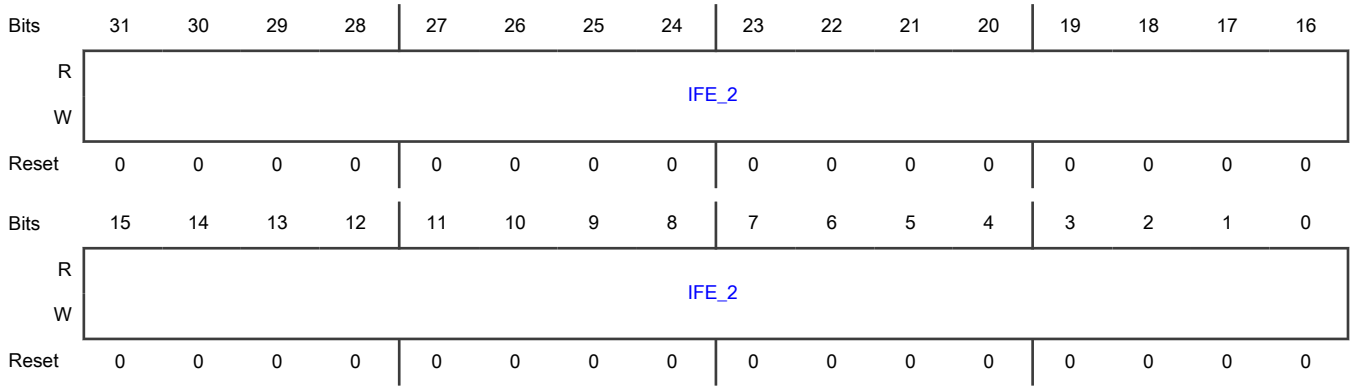
This register is used to enable an analog filter on the corresponding interrupt pads to filter out glitches on the inputs.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IFE_2	External Interrupt Filter Enable x Enable analog glitch filter on the external interrupt pad input. 0b - Filter is disabled 1b - Filter is enabled

43.5.1.17 Wakeup/Interrupt Filter Enable Register (WIFER_128)

Offset

Register	Offset
WIFER_128	150h

Function

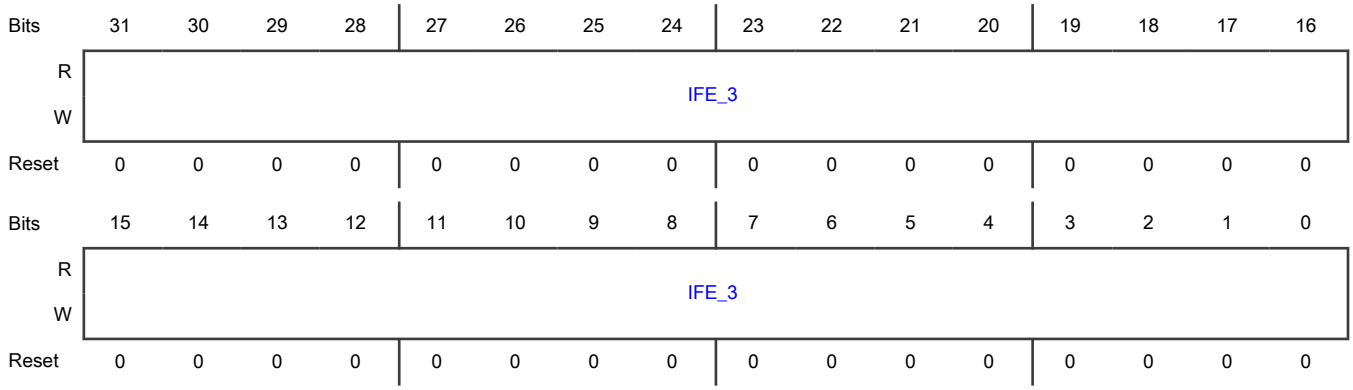
This register is used to enable an analog filter on the corresponding interrupt pads to filter out glitches on the inputs.

NOTE

This register is accessible only by 32-bit read/write operations.

Access: User read/write

Diagram



Fields

Field	Function
31-0 IFE_3	External Interrupt Filter Enable x Enable analog glitch filter on the external interrupt pad input. 0b - Filter is disabled 1b - Filter is enabled

43.6 Glossary

NMI Non-maskable interrupts

Chapter 44
Safety Overview

44.1 Safety Concept

This chip is developed following the ISO 26262-2:2018 standard, intended to be used in an automotive safety-related system that fulfills the requirements of the ASIL D safety integrity levels.

The ASIL level targets the safety processing, which means the software functions are executed as intended:

1. Read instructions from memory.
2. Execute instructions.
3. Read data from memory.
4. Process data.
5. Write back the result data into memory.

Motor Control is the primary application for this chip and the safety concept of applicable I/O and peripherals has been developed in-context of the motor control application. Thus, the peripherals that are part of motor control application have been classified as SR (safety-related) in the safety concept. Some elements of the safety concept are based on the assumption that the chip is connected to an external SBC or PMIC. The SBC or PMIC performs observations and control functionalities that are essential to fulfill some related functional safety requirements. If you do not use an SBC or PMIC, you must ensure that the chip provides an equivalent functionality that properly manages the corresponding interface(s).

The following figure illustrates the safety interface between the chip and the SBC or PMIC.

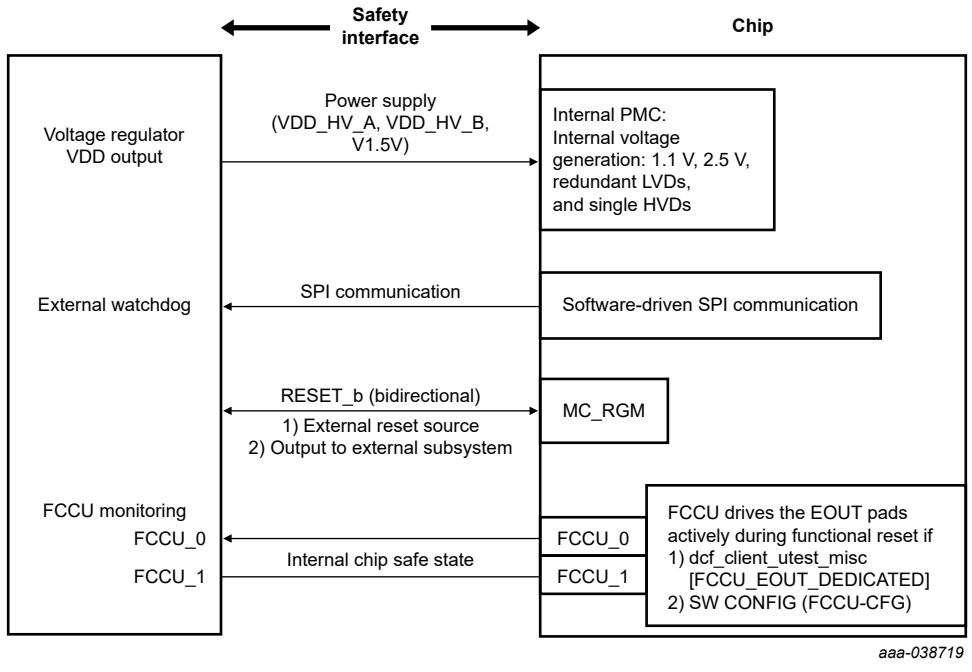


Figure 178. Safety interface between the chip and the SBC or PMIC

In the safety context, the chip interfaces can be classified into the groups shown in the table.

Table 209. Chip interface groups

Interface	Description
Power supply	This interface is between the SBC and the chip. It ensures that the supply to the chip is in the correct range. In case of any low-voltage event, the chip has POR, LVR, and LVD circuits in place and in case of any HVD event, the chip raises an interrupt. The SBC must ensure that the voltage regulator outputs never exceed the allowed range (more specifically for HVD range). In case the power supply to the chip is exceeding the allowed range, the SBC switches off the power supply.
Communication	Responsible for communication between the SBC and the chip. Though the chip supports multiple communication protocols (UART, LIN, SPI, I2C, FlexCAN, and so on), SPI is the preferred communication with SBC. This is relevant to program the SBC or PMIC registers during boot and to service the external watchdog periodically during runtime.
Reset	The chip consists of a reset bidirectional pin interfaced with SBC. The SBC can initiate a chip reset via this pin as a safety reaction in case of: • Extreme critical faults • An inoperative chip • Stuck cases based on the criticality and the application requirements The SBC also samples the reset pin state to identify the chip condition (whether in running state or in reset).
FCCU	The chip indicates the chip faults to the SBC via FCCU EOUT pins through this interface.

The interfaces in Table 209 ensure the chip's operational safety and integrity. Upon detecting an unrecoverable failure (one that can't be resolved by the application), the SBC must ensure the chip enters an appropriate safe state as defined in the chip safety manual. The SBC ensures that the system transitions to a safe state when the chip can no longer perform a safety function.

44.2 Safety architecture elements

The chip safety architecture consists of following elements that operate in an interconnected way to meet the ASIL requirements:

- Cortex-M7 core complex (including the cache controllers) operating in delayed lockstep (ASIL D only)
- eDMA controller operating in delayed lockstep
- Structural core self-test
- Internal windowed watchdogs with independent clock sources
- Power supply monitoring with redundant low-voltage detectors, single high-voltage detectors, and internal ADC connection to check the internal voltages during application
- Robust clock monitoring, including PLL loss of lock detection
- Embedded flash memory with ECC (single-bit data correction, double-bit data detection) and address encoding (parallel address path check)
- System RAM with ECC

  - Single-bit data correction
  - Double-bit data detection
  - Address detection
- Cortex-M7 cache memories with ECC (single-bit data correction, double-bit data detection)
- Peripherals memories (EMAC, FlexCAN, ETPU, Coolflux) with ECC (single-bit data correction, double-bit data detection).
- End-to-End EDC (E2E EDC), with address encoding and monitoring of the control signals done by a dedicated module (XBIC). This ensures the safety of storage and of the data path to the internal storage (RAM, flash memory, core cache) and peripherals across the crossbar switch. See the XBIC chapter for details.
- Hardware CRC module that supports end-to-end data check integrity for any data transfer in the system (SRAM to peripherals via DMA transfer, external interfaces to SRAM/peripherals, and so on)
- Cortex-M7 MPUs
- XRDC for memory and peripheral protection
- AIPS_Lite peripheral protection with trusted master-slave connection
- Register protection mechanism for safety-critical registers
- On-chip temperature sensor for temperature monitoring
- Self-test:
  - LBIST to detect latent faults in functional logic as well as in safety integrity mechanisms
  - MBIST to ensure integrity of the memories in the chip (SRAM, ITCM, DTCM, peripheral memories, and so on)
  - Check-the-checker software library
  - ADC self-test
  - SD-ADC BIST
  - Flash array integrity self check
- FCCU for error collection and reaction, including reporting error status to system; FCCU supports these programmable reaction types:
  - Interrupt
  - Functional reset
- Error pads indicate the chip's internal state to the external chip interface or SBC.
- EIM to inject errors into the memories and interface gaskets to verify the error-detection features of the memory controllers and the interface gaskets
- ERM to collect diagnostic information from memory controllers in case of an error event

44.3 I/O peripherals

Some peripherals on the chip are classified as SR-AD (safety-related; application-dependent) as their usage is highly system dependent. The integrity of such functional safety-relevant peripherals has to be ensured by application level measures (for example—connecting one sensor to different I/O modules, sensor validation by sensor redundancy).

The arrangement of I/O peripherals across peripheral bridges allows redundant use of peripherals while limiting possible causes of CCF. Redundant use includes using equivalent peripherals in a replicated way as well as using functionally different peripherals in, for example, feedback measurement loops. Comparison of redundant operation is the responsibility of the application software, not the safety hardware mechanism.

The peripherals are distributed evenly across the peripheral bridges (AIPS*n*), except for singular modules like EMAC, QuadSPI, and so on.

Some peripherals on the chip are classified as SR (safety-related) as they have been analyzed as part of the motor control application and their safety concept has been developed in-context of this application. The integrity of such functional safety-relevant peripherals is ensured by on-chip hardware and software safety mechanisms developed by NXP. The details of these safety mechanisms are available in the chip safety manual.

44.4 Latent Fault Checks

The chip supports BIST to fulfill the requirements of ISO 26262-2:2018 standard to check for latent faults. Your safety software must initiate self-test by configuring STCU2; the chip does not initiate it. STCU2 then controls the self-test operation. Self-test supports both MBIST and LBIST. After the self-test operation completes, the chip enters a reset sequence. Self-test results are stored in STCU2 and your safety software can read the results after the reset sequence.

Figure 179 depicts the processing steps related to the self-test operation, and its linkage to the chip reset and an application start. You decide whether to run a self-test or to skip it before starting an application. You must also specify the self-test configuration before relinquishing control to STCU2 for performing the self-test operation. This processing finishes by reentering the chip reset sequence, depending on whether the chip encountered an unrecoverable fault during the self-test operation. When an unrecoverable fault is encountered during the self-test operation, the chip enters a reset sequence by performing a destructive reset. When no such fault is encountered, the self-test operation completes by entering the chip sequence with a functional reset sequence. You can prevent reset cycling by limiting the amount of resets permitted; the chip shuts down when this limit has been reached. See the "Functional reset escalation" and "Destructive reset escalation" sections in the MC_RGM chapter.

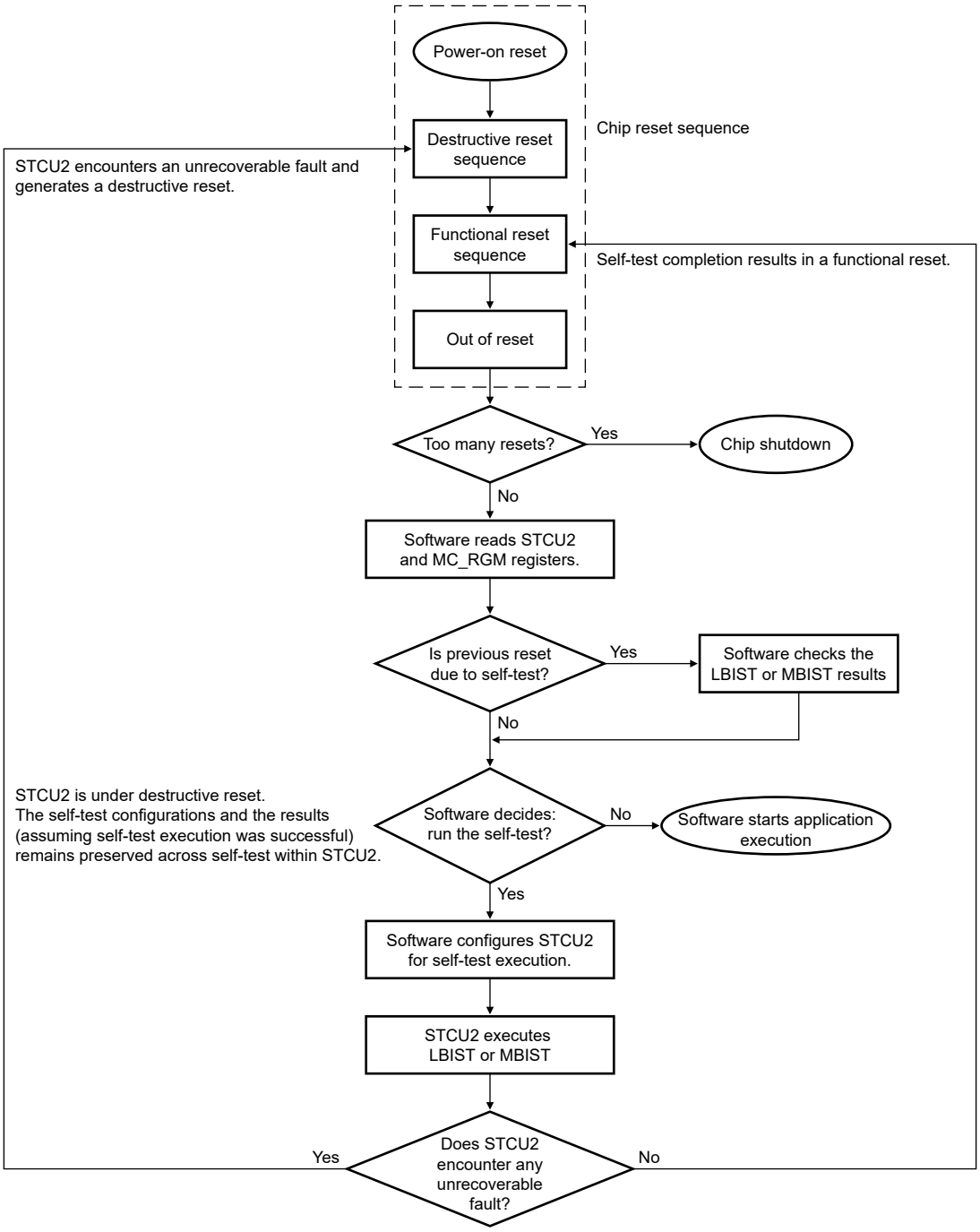


Figure 179. LBIST/MBIST execution

Figure 180 visualizes the top-level partitioning of the chip. The chip consists of two partitions, Run and Standby.

- Run: This partition consists of logic which is present in switchable domain and is shut off (has no supply) while the chip operates in low-power (Standby) mode.
- Standby: This partition consists of always-on logic which is functional even while the chip operates In low-power (Standby) mode.

The Run partition also contains the control logic that is essential for the chip self-test operation, as well as blocks that undergo self-test. The chip consists of a single LBIST partition, which is a subpartition within the Run partition. The LBIST subpartition

contains the logic over which self-test is executed. The logic outside the LBIST subpartition and within the Run partition consists of the LBIST control logic as well as logic which does not undergo LBIST.

The components within these different partitions are listed below the figure (they are not indicated in the figure for clarity).

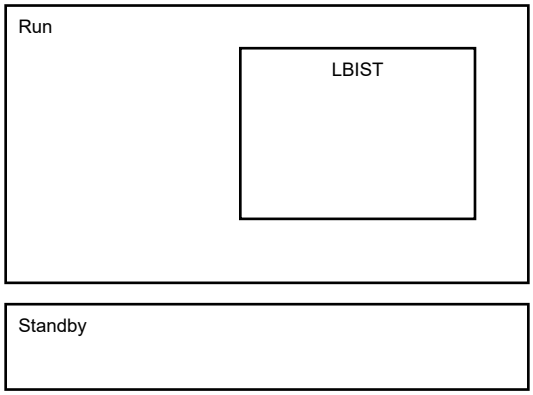


Figure 180. S32K396 chip top-level partition view

The following list specifies the content of the LBIST partition and both power domains related to their participation in the self-test operation:

- Modules participating in the LBIST operation:
  - eMIOS0
  - eDMA
  - EIM2
  - ERM0
  - ERM1
  - XRDC
    - MDAC0
    - MDAC1
    - MDAC2
    - MDAC3
    - MDAC4
    - MDAC5
    - MDAC6
    - MDAC7
    - MDAC8
    - MRC0
    - MRC1
    - MRC2
    - MRC3
    - PDAC1
    - PDAC2
  - CRC

- FCCU
- FOSU
- PFLASH_CTL
- PRAM_C0
- PRAM_C1
- SWT_1
- SWT_2
- CMU
  - CMU_FC_0
  - CMU_FM_1
  - CMU_FM_2
  - CMU_FC_3
  - CMU_FC_4
  - CMU_FC_5
  - CMU_FC_6
- IAHB gaskets

NOTE

An IAHB gasket is a frequency translation gasket in the system. These gaskets are used to add register walls and synchronize the timing domain across different operating frequencies. See the configurable gaskets in the 'Block diagram' in 'Introduction' chapter for the locations of the IAHB_GASKETs in the chip.

  - DMA1_GSKT
  - HSE_GSKT
  - QSPI_GSKT
  - ENET_GSKT
  - TCM_GSKT
  - Zipwire_GSKT
  - CM7_0_AHBP_GSKT
  - CM7_0_AHBM_GSKT
  - CM7_1_AHBP_GSKT
  - CM7_1_AHBM_GSKT
  - CM7_2_AHBP_GSKT
  - CM7_2_AHBM_GSKT
  - EDC master checker gaskets (See block diagram in Introduction chapter for details)
  - EDC slave checker gasket (See block diagram in Introduction chapter for details)
- Crossbar switches and bridges
  - AXBS_0
  - DMA1_AXBS
  - HSE_AXBS

    - PERIPHERAL_AXBS
    - TCM_AXBS
    - ZIPWIRE_AXBS
- Modules within the Standby domain (not participating in the LBIST operation):
  - 64 KB standby SRAM
  - LPCMP_0–LPCMP_1
  - Reset generation
    - MC_RGM
    - POR_WDG
  - Power management
    - PMC
    - MC_PCU
    - WKPU
    - Chip standby pins
  - Clock sources
    - FIRC
    - SIRC
    - FXOSC
  - Timers
    - PIT_0
    - RTC
    - SWT_0
- Modules not participating in the LBIST operation (in the Run domain):
  - HSE subsystem
    - Engine
    - Memories
  - Cortex-M7_0
    - Core
    - I-cache
    - D-cache
    - ITCM
    - DTCM
  - Cortex-M7_1
    - Core
    - I-cache
    - D-cache
    - ITCM
    - DTCM

- Cortex-M7_2
  - Core
  - I-cache
  - D-cache
  - ITCM
  - DTCM
- CMUs
  - CMU0
  - CMU3
- Analog blocks
  - ADC_0–ADC_6
  - TempSense
  - SDADC_0-SDADC_3
  - SGEN_0, SGEN_1
  - eFlexPWM_0, eFlexPWM_1
- Communication modules
  - LPSPI_0–LPSPI_5
  - LPI2C_0
  - LPI2C_1
  - LPUART_0–LPUART_3
  - FlexCAN_0–FlexCAN_5
- Timers
  - PIT_1
  - PIT_2
  - BCTU, BCTU_1
  - STM_0
  - STM_1
- TRGMUX, TRGMUX_1
- PLLDIG
- SIUL2
- LCU_0
- LCU_1
- STCU2
- DMAMUX
- MCM
- MCSM
- INTM
- SEMA42

— MU

— ETPU

NOTE

REG_PROT of an IP undergoes (or does not undergo) LBIST in conjunction with the protected module that undergoes (or does not undergo) LBIST.

The modules that are vital to the self-test operation are excluded from LBIST regions to allow LBIST to execute successfully.

You must run self-test with PLLDIG configured as the system clock. The LBIST clock controller controls the clock during serial shift, but returns clock control to the functional nodes during the self-test.

NXP also provides a check-the-checker software library as part of SAF software package to test the on-chip hardware safety mechanisms during start-up or shutdown. For details, see the SquareCheck (sCheck) component in the S32 SAF documentation.

The complete details of the safety concept, including assumptions of use and the implementation of safety mechanisms are available in the chip safety manual.

44.5 Glossary

ASIL Automotive safety integrity level. This is a risk classification scheme as defined by ISO 26262 for automotive standard.

CCF Common cause failure

DTCM Data tightly coupled memory

ECC Error correction code

ITCM Instruction tightly coupled memory

LBIST Logic built-in self-test

MBIST Memory built-in self-test

PLL Phase-locked loop oscillator

PMIC Power management integrated chip

SBC System basis chip

Chapter 45
Error Injection Module (EIM)

45.1 Chip-specific EIM information

45.1.1 EIM instances

This chip supports three instances of EIM:

- EIM_0
- EIM_1
- EIM_2

45.1.2 EIM channel mapping

EIM integrates with the memory controller and memory array to enable error injection in a controlled way. Each memory controller has its own EIM channel.

Table 210. ACP_EIM_0

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
0	cm7_0 ic tag	[43:22] - cm7_0 ic tag read data1[28:7] [21:0] - cm7_0 ic tag read data0[28:7]	[13:7] - cm7_0 ic tag read data1[6:0] [6:0] - cm7_0 ic tag read data0[6:0]	44	14
1	cm7_0 ic data	[127:64] - cm7_0 ic data read data1[71:8] [63:0] - cm7_0 ic data read data0[71:8]	[15:8] - cm7_0 ic data read data1[7:0] [7:0] - cm7_0 ic data read data0[7:0]	128	16
2	cm7_0 dc tag	[103:78] - cm7_0 dc tag read data3[32:7] [77:52] - cm7_0 dc tag read data2[32:7] [51:26] - cm7_0 dc tag read data1[32:7] [25:0] - cm7_0 dc tag read data0[32:7]	[27:21] - cm7_0 dc tag read data3[6:0] [20:14] - cm7_0 dc tag read data2[6:0] [13:7] - cm7_0 dc tag read data1[6:0] [6:0] - cm7_0 dc tag read data0[6:0]	104	28
3	cm7_0 dc data0	[127:96] - cm7_0 dc data0 read data3[38:7] [95:64] - cm7_0 dc data0 read data2[38:7] [63:32] - cm7_0 dc data0 read data1[38:7]	[27:21] - cm7_0 dc data0 read data3[6:0] [20:14] - cm7_0 dc data0 read data2[6:0] [13:7] - cm7_0 dc data0 read data1[6:0]	128	28

Table continues on the next page...

Table 210. ACP_EIM_0 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
		[31:0] - cm7_0 dc data0 read data0[38:7]	[6:0] - cm7_0 dc data0 read data0[6:0]		
4	cm7_0 dc data1	[127:96] - cm7_0 dc data1 read data3[38:7] [95:64] - cm7_0 dc data1 read data2[38:7] [63:32] - cm7_0 dc data1 read data1[38:7] [31:0] - cm7_0 dc data1 read data0[38:7]	[27:21] - cm7_0 dc data1 read data3[6:0] [20:14] - cm7_0 dc data1 read data2[6:0] [13:7] - cm7_0 dc data1 read data1[6:0] [6:0] - cm7_0 dc data1 read data0[6:0]	128	28
5	cm7_1 ic tag	[43:22] - cm7_1 ic tag read data1[28:7] [21:0] - cm7_1 ic tag read data0[28:7]	[13:7] - cm7_1 ic tag read data1[6:0] [6:0] - cm7_1 ic tag read data0[6:0]	44	14
6	cm7_1 ic data	[127:64] - cm7_1 ic data read data1[71:8] [63:0] - cm7_1 ic data read data0[71:8]	[15:8] - cm7_1 ic data read data1[7:0] [7:0] - cm7_1 ic data read data0[7:0]	128	16
7	cm7_1 dc tag	[103:76] - cm7_1 dc tag read data3[32:7] [75:52] - cm7_1 dc tag read data2[32:7] [51:26] - cm7_1 dc tag read data1[32:7] [25:0] - cm7_1 dc tag read data0[32:7]	[27:21] - cm7_1 dc tag read data3[6:0] [20:14] - cm7_1 dc tag read data2[6:0] [13:7] - cm7_1 dc tag read data1[6:0] [6:0] - cm7_1 dc tag read data0[6:0]	104	28
8	cm7_1 dc data0	[127:96] - cm7_1 dc data0 read data3[38:7] [95:64] - cm7_1 dc data0 read data2[38:7] [63:32] - cm7_1 dc data0 read data1[38:7] [31:0] - cm7_1 dc data0 read data0[38:7]	[27:21] - cm7_1 dc data0 read data3[6:0] [20:14] - cm7_1 dc data0 read data2[6:0] [13:7] - cm7_1 dc data0 read data1[6:0] [6:0] - cm7_1 dc data0 read data0[6:0]	128	28
9	cm7_1 dc data1	[127:96] - cm7_1 dc data1 read data3[38:7] [95:64] - cm7_1 dc data1 read data2[38:7]	[27:21] - cm7_1 dc data1 read data3[6:0] [20:14] - cm7_1 dc data1 read data2[6:0]	128	28

Table continues on the next page...

Table 210. ACP_EIM_0 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
		[63:32] - cm7_1 dc data1 read data1[38:7] [31:0] - cm7_1 dc data1 read data0[38:7]	[13:7] - cm7_1 dc data1 read data1[6:0] [6:0] - cm7_1 dc data1 read data0[6:0]		
10	cm7_0 itcm	[63:0] - cm7_0 itcm read data [63:0]	[7:0] - cm7_0 itcm read data ecc[7:0]	64	8
11	cm7_0 d0tcm	[31:0] - cm7_0 d0tcm read data [31:0]	[7:0] - cm7_0 d0tcm read data ecc[7:0]	32	8
12	cm7_0 d1tcm	[31:0] - cm7_0 d1tcm read data [31:0]	[7:0] - cm7_0 d1tcm read data ecc[7:0]	32	8
13	cm7_1 itcm	[63:0] - cm7_1 itcm read data [63:0]	[7:0] - cm7_1 itcm read data ecc[7:0]	64	8
14	cm7_1 d0tcm	[31:0] - cm7_1 d0tcm read data [31:0]	[7:0] - cm7_1 d0tcm read data ecc[7:0]	32	8
15	cm7_1 d1tcm	[31:0] - cm7_1 d1tcm read data [31:0]	[7:0] - cm7_1 d1tcm read data ecc[7:0]	32	8
16	cm7 lockstep	[29:0] - cm7 error injection[29:0]		30	0
17	cm7_0_ahbs gasket	[59:0] - cm7_0_ahbs_gskt_mon_err_inj[59:0]		60	0
18	cm7_1_ahbs gasket	[59:0] - cm7_1_ahbs_gskt_mon_err_inj[59:0]		60	0
19				0	0
20				0	0
21				0	0
22				0	0
23				0	0
24				0	0
25				0	0
26				0	0
27				0	0
28				0	0
29				0	0
30				0	0
31				0	0

Table 211. ACP_EIM_1

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
0	cm7_2 ic tag	[43:22] - cm7_2 ic tag read data1[28:7] [21:0] - cm7_2 ic tag read data0[28:7]	[13:7] - cm7_2 ic tag read data1[6:0] [6:0] - cm7_2 ic tag read data0[6:0]	44	14
1	cm7_2 ic data	[127:64] - cm7_2 ic data read data1[71:8] [63:0] - cm7_2 ic data read data0[71:8]	[15:8] - cm7_2 ic data read data1[7:0] [7:0] - cm7_2 ic data read data0[7:0]	128	16
2	cm7_2 dc tag	[103:76] - cm7_2 dc tag read data3[32:7] [75:52] - cm7_2 dc tag read data2[32:7] [51:26] - cm7_2 dc tag read data1[32:7] [25:0] - cm7_2 dc tag read data0[32:7]	[27:21] - cm7_2 dc tag read data3[6:0] [20:14] - cm7_2 dc tag read data2[6:0] [13:7] - cm7_2 dc tag read data1[6:0] [6:0] - cm7_2 dc tag read data0[6:0]	104	28
3	cm7_2 dc data0	[127:96] - cm7_2 dc data0 read data3[38:7] [95:64] - cm7_2 dc data0 read data2[38:7] [63:32] - cm7_2 dc data0 read data1[38:7] [31:0] - cm7_2 dc data0 read data0[38:7]	[27:21] - cm7_2 dc data0 read data3[6:0] [20:14] - cm7_2 dc data0 read data2[6:0] [13:7] - cm7_2 dc data0 read data1[6:0] [6:0] - cm7_2 dc data0 read data0[6:0]	128	28
4	cm7_2 dc data1	[127:96] - cm7_2 dc data1 read data3[38:7] [95:64] - cm7_2 dc data1 read data2[38:7]	[27:21] - cm7_2 dc data1 read data3[6:0] [20:14] - cm7_2 dc data1 read data2[6:0]	128	28

Table continues on the next page...

Table 211. ACP_EIM_1 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
		[63:32] - cm7_2 dc data1 read data1[38:7] [31:0] - cm7_2 dc data1 read data0[38:7]	[13:7] - cm7_2 dc data1 read data1[6:0] [6:0] - cm7_2 dc data1 read data0[6:0]		
5				0	0
6				0	0
7				0	0
8				0	0
9				0	0
10	cm7_2 itcm	[63:0] - cm7_2 itcm read data [63:0]	[7:0] - cm7_2 itcm read data ecc[7:0]	64	8
11	cm7_2 d0tcm	[31:0] - cm7_2 d0tcm read data [31:0]	[7:0] - cm7_2 d0tcm read data ecc[7:0]	32	8
12	cm7_2 d1tcm	[31:0] - cm7_2 d1tcm read data [31:0]	[7:0] - cm7_2 d1tcm read data ecc[7:0]	32	8
13				0	0
14				0	0
15				0	0
16	cm7_2 lockstep	[29:0] - cm7_2 error injection[29:0]		30	0
17	cm7_2_ahbs gasket	[59:0] - cm7_2_ahbs_gskt_mon_err_inj[59:0]		60	0
18				0	0
19				0	0
20				0	0
21				0	0
22				0	0
23				0	0
24				0	0
25				0	0
26				0	0

Table continues on the next page...

Table 211. ACP_EIM_1 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
27				0	0
28				0	0
29				0	0
30				0	0
31				0	0

Table 212. ACP_EIM_2

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
0	sram0	[63:0] - sram0 read data[63:0]	[7:0] sram0 read data ecc[7:0]	64	8
1	sram1	[63:0] - sram1 read data[63:0]	[7:0] sram1 read data ecc[7:0]	64	8
2				0	0
3	dma tcd	[63:0] - dma tcd ram read data[63:0]	[7:0] dma tcd ram read data checkbits[7:0]	64	8
4	edma1 TCD	[63:0] - dma1 tcd ram read data[63:0]	[7:0] dma1 tcd ram read data checkbits[7:0]	64	8
5	enet gasket	[187:124] EMAC AHB WRITE DATA[63:0] [123:60] EMAC AHB READ DATA[63:0] [59:0] EMAC AHB Gasket Mon Error Injection data[59:0]		188	0
6	CM7 TCM gasket	[187:124] TCM AHB WRITE DATA[63:0] [123:60] TCM AHB READ DATA[63:0] [59:0] TCM AHB Gasket Mon Error Injection data[59:0]		188	0
7	dma axbs s0 gasket	[59:0] DMA Axbs s0 Gasket Mon Error Injection data[59:0]		60	0

Table continues on the next page...

Table 212. ACP_EIM_2 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
8	dma axbs s1 gasket	[59:0] DMA Axbs s1 Gasket Mon Error Injection data[59:0]		60	0
9	dma1 axbs S0 gasket	[59:0] DMA1 Axbs s0 Gasket Mon Error Injection data[59:0]		60	0
10	dma1 axbs S1 gasket	[59:0] DMA1 Axbs s1 Gasket Mon Error Injection data[59:0]		60	0
11	cm7_0_ahbp	[59:0] CM7_0 AHBP Gasket Mon Error Injection data[59:0]		60	0
12	cm7_0_ahbm	[59:0] CM7_0 AHBM Gasket Mon Error Injection data[59:0]		60	0
13	cm7_1_ahbp	[59:0] CM7_1 AHBP Gasket Mon Error Injection data[59:0]		60	0
14	cm7_1_ahbm	[59:0] CM7_1 AHBM Gasket Mon Error Injection data[59:0]		60	0
15	cm7_2_ahbp	[59:0] CM7)2 AHBP Gasket Mon Error Injection data[59:0]		60	0
16	cm7_2_ahbm	[59:0] CM7_2 AHBM Gasket Mon Error Injection data[59:0]		60	0
17	hse gasket	[59:0] HSE Gasket Mon Error Injection data[59:0]		60	0
18	qspi gasket	[59:0] QSPI Gasket Mon Error Injection data[59:0]		60	0
19				0	0

Table continues on the next page...

Table 212. ACP_EIM_2 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
20				0	0
21	edma1 CHK	[7:0] DMA1 Error Injection [7:0]		8	0
22	Zipwire	[187:124] Zipwire WRITE DATA[63:0] [123:60] Zipwire READ DATA[63:0] [59:0] Zipwire Gasket Mon Error Injection data[59:0]		188	0
23	dspss_pmem	[31:0] dspss pram error injection bus[31:0]	[6:0] dspss pram ecc error injection bus[6:0]	32	7
24	dspss_xmem_even	[15:0] dspss xmem even error injection bus[15:0]	[5:0] dspss xmem odd ecc error injection bus[5:0]	16	6
25	dspss_xmem_odd	[15:0] dspss xmem odd error injection bus[15:0]	[5:0] dspss xmem even ecc error injection bus[5:0]	16	6
26	edc1 gaskets addr	[1:0] Inject error on flash controller 3 port address checker [3:2] Inject error on 32 bit CM7_2 TCM path address checker [5:4] Inject error on AIPS3 address checker [7:6] Inject error on DMA1 S0 address checker [9:8] Inject error on DMA1 S1 address checker		10	0
27	edc1 gaskets wdata	[1:0] Inject error on CM7_2 TCM path write data checker		4	0

Table continues on the next page...

Table 212. ACP_EIM_2 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
		[3:2] Inject error on AIPS3 write data checker			
28	edc1 gaskets rdata	[1:0] Inject error on CM7_2 AHBM read data checker [3:2] Inject error on CM7_2 AHBP read data checker [5:4] Inject error on zipwire read data checker [7:6] Inject error on DMA1 read data checker		8	0
29	edc gaskets addr	[1:0] Inject error on flash controller 0 port address checker [3:2] Inject error on flash controller 1 port address checker [5:4] Inject error on flash controller 2 port address checker [7:6] Inject error on PRAM0 address checker [9:8] Inject error on PRAM1 address checker [11:10] Inject error on 64 bit TCM address checker [13:12] Inject error on QSPI address checker [15:14] Inject error on AIPS0 address checker		28	0

Table continues on the next page...

Table 212. ACP_EIM_2 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
		[17:16] Inject error on AIPS1 address checker [19:18] Inject error on AIPS2 address checker [21:20] Inject error on 32 bit CM2_0 TCM address checker [23:22] Inject error on 32 bit CM7_1 TCM path address checker [25:24] Inject error on DMA S0 address checker [27:26] Inject error on DMA S1 address checker			
30	edc gaskets wdata	[1:0] Inject error on PRAM0 write data checker [3:2] Inject error on PRAM1 write data checker [5:4] Inject error on 64 bit TCM write data checker [7:6] Inject error on QSPI write data checker [9:8] Inject error on AIPS0 write data checker [11:10] Inject error on AIPS1 write data checker [13:12] Inject error on AIPS2 write data checker [15:14] Inject error on CM7_0		18	0

Table continues on the next page...

Table 212. ACP_EIM_2 (continued)

Channel Number	Target	Data bits	Check bits	Num of data bits	Num of check bits
		TCM path write data checker [17:16] Inject error on CM7_1 TCM path write data checker			
31	edc gaskets rdata	[1:0] Inject error on CM7_0 AHBM read data checker [3:2] Inject error on CM7_0 AHBP read data checker [5:4] Inject error on DMA read data checker [9:8] Inject error on HSE read data checker [11:10] Inject error on ENET read data checker [13:12] Inject error on CM7_1 AHBM read data checker [15:14] Inject error on CM7_1 AHBP read data checker [17:16] Inject error on 32 bit TCM read data checker		18	0

The two enables, GEIEN and EICHEN*n*, enable the error injection functionality. The former enables it globally and the latter does it for a particular channel. This double-layer enable provides protection against accidental enabling and reconfiguration of the error injection function for each channel.

EIM provides support for inducing single-bit and multi-bit inversions on read data when accessing peripheral RAMs through its data mask registers.

NOTE

For enabling error injection on EDC gaskets (corresponding to channel 28, channel 29, and channel 30), you must also enable the fields corresponding to the required EDC gasket in the MSCM_ENEDC register before enabling the EIM channel.

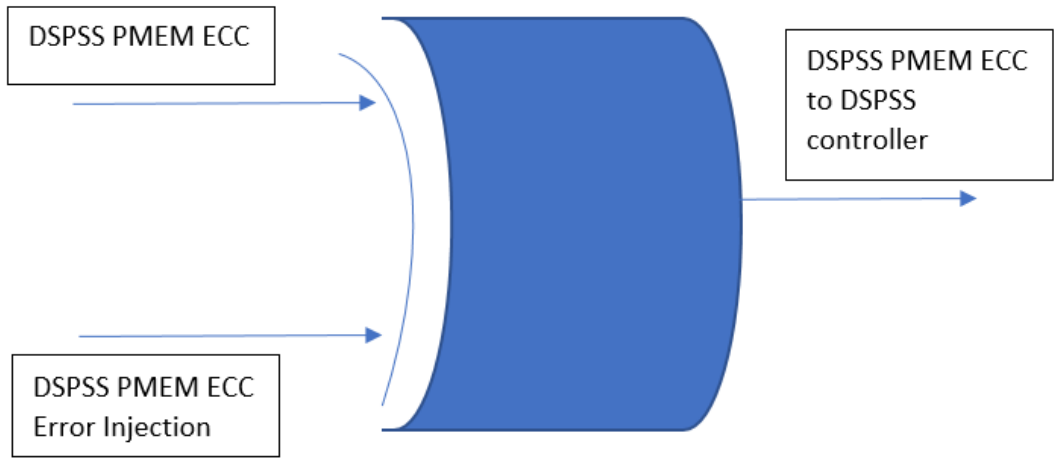
45.1.3 Coolflux

The Core and DSP PMEM and XMEM error injection signals are generated by EIM and then forwarded to DSPSS. The error injection is done on both RDATA and ECC. For PMEM, the RDATA and ECC error injections are symmetrical to RDATA and ECC but in case of XMEM.

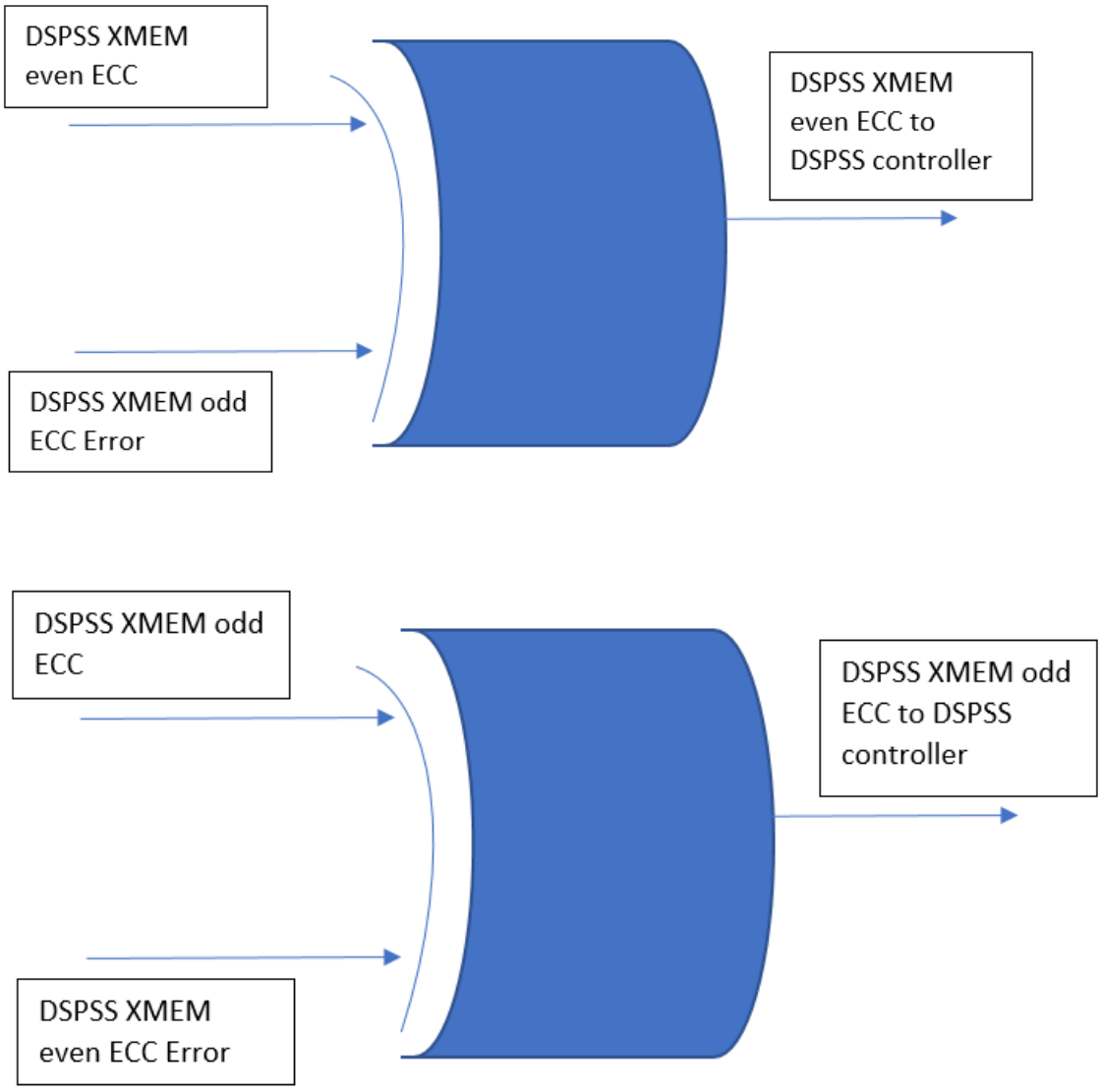
The ECC error injection of XMEM even is used with ECC of XMEM odd ECC and vice versa.

This can be explained with the help of following diagram:

In case of ECC, FOR PMEM, PMEM ECC is xored with PMEM Error Injection bus and then provided to DSPSS controller.



In case of ECC, FOR XMEM, XMEM odd ECC is xored with XMEM even ECC Error Injection bus and then provided to DSPSS controller. And vice versa.



45.1.4 Constraints to use EIM on CM7 cache memories

The Cortex-M7 processor has Error Correcting Code (ECC) functionality for error detection and correction which is included in the data and instruction caches when implemented. If hard, or permanent, errors occur on the cache RAM, the clean, invalidate and retry scheme might cause a deadlock, and the access is continuously replayed. To prevent this, error bank registers are provided to mask the faulty locations as unusable and invalid. To ensure such a deadlock scenario doesn't occur while testing the cache memory using EIM module, you should take care of the following points:

- Inject one single-bit error on a cache line at a time.
- Ensure that at least one error bank register of the tested cache is free before injecting any faults. This is to make sure that the fault recovery mechanism of the M7 core will work.

For further details, refer to 'Cache RAM protection' section in Arm Cortex-M7 Processor Technical Reference Manual.

NOTE

Error injection on 0th and 1st bit for Icache and Dcache is invalid for S32K396 since the Icache and Dcache size is 16KB.

45.2 Overview

The Error Injection Module (EIM) is mainly used for diagnostic purposes. It provides a method to test the diagnostics (memory ECC, interconnect parity) by error injection in the field. See the chip-specific EIM information to determine which functional safety features are supported by this method.

EIM enables you to inject artificial errors on error-checking mechanisms of a system, such as ECC for RAM read data and parity bits. For each such mechanism that EIM supports on the chip, EIM can inject single-bit and multi-bit inversions on data in the applicable target bus. Injecting faults on memory accesses can be used to exercise the SEC-DED ECC function of the related system.

45.2.1 Features

The EIM includes these features:

- Supports 19 error injection channels. See the chip-specific EIM information for channel assignment details.
- Protection against accidental enable and reconfiguration error injection function via two-stage enable mechanism

45.2.2 Block diagram

The following diagram shows an example of EIM implementation with a 64-bit read data bus and an 8-bit checkbit bus.

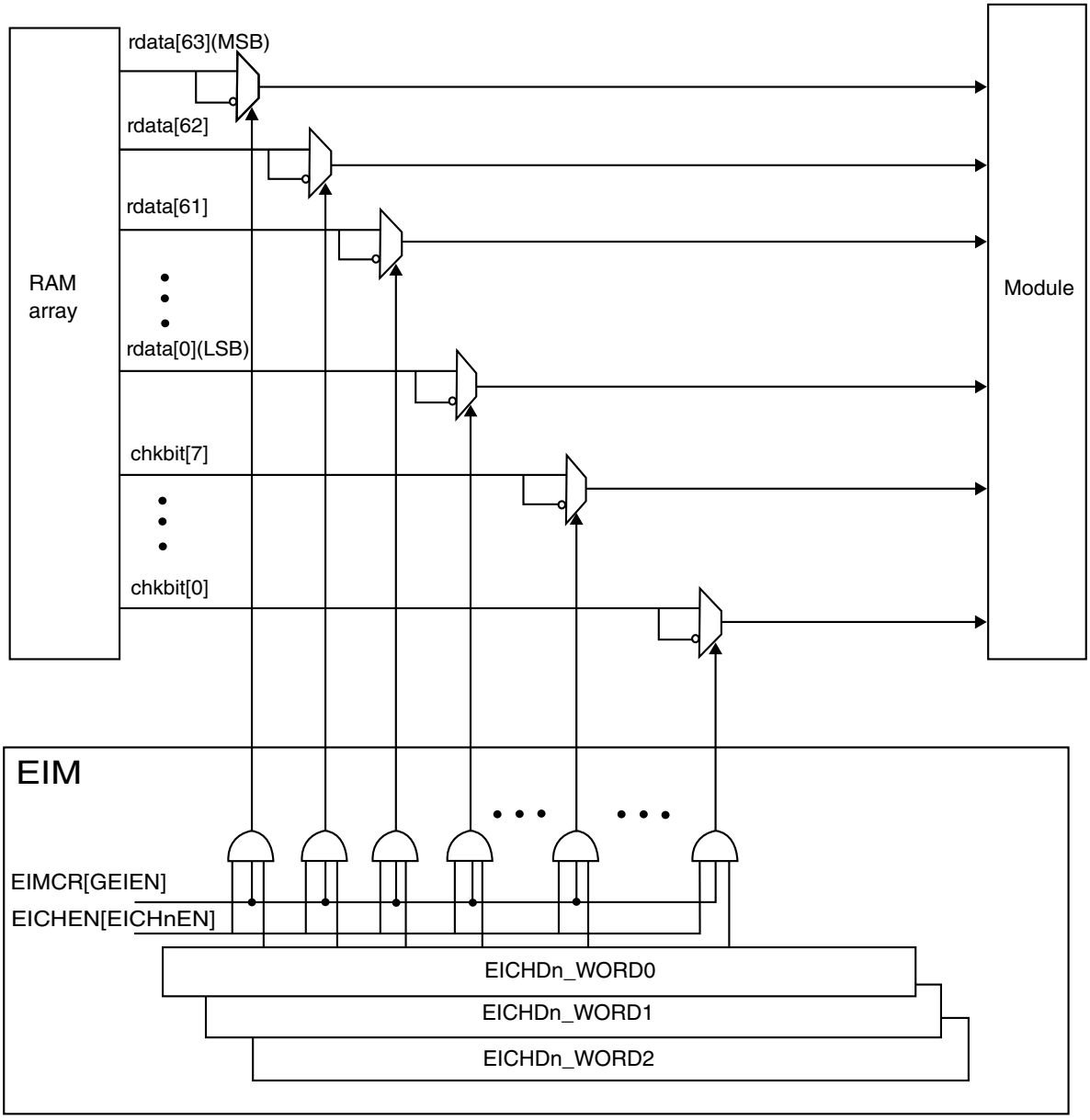


Figure 181. EIM functional block diagram (64-bit read data bus and 8-bit check bit bus)

Several memory elements are implemented within a device, which may not only be the large memory blocks (Flash and SRAM) but also smaller memories like caches, the TCD blocks, and the embedded peripheral memories. Some larger memories may actually be built from multiple memory elements, dependent on their size or function. Each of these memory elements implements its own control logic, the memory controller, that performs the accesses to the actual memory, the memory array. An EIM channel is associated with a memory controller and provides the capability to alter one or multiple signals in the read access path from the corresponding memory array(s). Only memory controllers controlling a safety related memory may be associated with an EIM channel.

45.3 Functional description

The EIM provides protection against accidental enabling and reconfiguration of the error injection function by enforcing a two-stage enablement mechanism. To properly enable the error injection mechanism for a channel:

- Write 1 to the EICHEN[EICH*n*EN] field, where *n* denotes the channel number.

- Write 1 to EIMCR[GEIEN].

NOTE

When the use case for a channel requires writing any EICHD*n*_WORD register, write the EICHD*n*_WORD register before executing the two-stage enablement mechanism. A successful write to any EICHD*n*_WORD register clears the corresponding EICHEN[EICH*n*EN] field.

The EIM supports 19 error injection channels. See the chip-specific EIM information for channel assignment details. Each channel:

- Can be assigned to a single memory array interface by intercepting the assigned memory read data bus and checkbit bus, and injects errors by inverting the value transmitted for selected bits on each bus line.
- Can be assigned to a redundant comparison unit by intercepting the signals being compared, and injecting errors by inverting the value transmitted for selected bits on each bus line.

On a memory read access, the applicable EICHD*n*_WORD registers define which bits of the read data and/or checkbit bus to invert.

Figure 181 depicts the interception and override of a 64-bit read data bus and an 8-bit checkbit data bus for an example memory array.

Error injection scenarios

The EIM supports these cases of error injection:

- To generate a single-bit error, invert only 1 bit of the CHKBIT_MASK or DATA_MASK in the EICHD*n*_WORD registers.
- To generate a multi-bit error, invert only 2 bits of the CHKBIT_MASK or DATA_MASK in the EICHD*n*_WORD registers.

NOTE

An attempt to invert more than 2 bits in one operation might result in undefined behavior.

To enable error injection:

1. Set the EICHD*n*_WORD*m*[CHKBIT_MASK] and EICHD*n*_WORD*m*[B*a*_*b*DATA_MASK] fields for each channel that will be driving an injection.
2. Program the EICHEN register to enable the channels that will be injecting errors.
3. Set the EIMCR[GEIEN] field to globally allow all enabled channels to actively inject errors.

To disable error injection, either disable the EIMCR[GEIEN] field or disable the individual channel enable fields of the EICHEN register.

45.4 Initialization

This module does not require initialization.

45.6 EIM_0 register descriptions

The EIM provides a programming model mapped to an on-platform peripheral slot.

Programming model access

All system bus masters can access the programming model:

- Only in supervisor mode
- Using only 32-bit (word) accesses

Any of the following attempted references to the programming model generates an error termination:

- In user mode
- Using non-32-bit access sizes

- To undefined (reserved) addresses

Attempted updates to the programming model while the EIM is in the midst of an operation result in non-deterministic behavior.

Error injection channel descriptor: function and structure

Each error injection channel descriptor:

- Specifies a mask that defines which bits of the read data and/or checkbit bus from target RAM are inverted on a read access.
- Consists of a 288-bit (36-byte) structure, composed of nine 32-bit words, in the EIM programming model. Unused words are not documented.
  - Word0 (EICHD*n*_WORD0), if present, defines the checkbit mask.
  - Word1 (EICHD*n*_WORD1) and additional words, if present, define the data mask. Word registers subsequent to Word1 are present only when required by the total width of the channel's data mask. Error injection channel descriptor: DATA_MASK details.

The multiple channel descriptors are organized sequentially.

Error injection channel descriptor: DATA_MASK details

For each channel: The following tables show the distribution of DATA_MASK's bits across the WORD registers. The first table shows the total width of DATA_MASK and the distribution of its bits across WORD1, WORD2, and WORD3. The second table shows the distribution of DATA_MASK's bits across WORD4 and subsequent registers.

Table 213. Error injection channel descriptor: DATA_MASK details

Channel	DATA_MASK total width (bits)	Specific bits of DATA_MASK in		
		WORD1	WORD2	WORD3
0	44	43-32	31-0	—
1	128	127-96	95-64	63-32
2	104	103-96	95-64	63-32
3	128	127-96	95-64	63-32
4	128	127-96	95-64	63-32
5	44	43-32	31-0	—
6	128	127-96	95-64	63-32
7	104	103-96	95-64	63-32
8	128	127-96	95-64	63-32
9	128	127-96	95-64	63-32
10	64	63-32	31-0	—
11	32	31-0	—	—
12	32	31-0	—	—
13	64	63-32	31-0	—

Table continues on the next page...

Table 213. Error injection channel descriptor: DATA_MASK details (continued)

Channel	DATA_MASK total width (bits)	Specific bits of DATA_MASK in		
		WORD1	WORD2	WORD3
14	32	31-0	—	—
15	32	31-0	—	—
16	30	29-0	—	—
17	60	59-32	31-0	—
18	60	59-32	31-0	—

Table 214. DATA_MASK bit: Channel-word mapping

Channel	Specific bits of DATA_MASK in				
	WORD4	WORD5	WORD6	WORD7	WORD8
1	31-0	—	—	—	—
2	31-0	—	—	—	—
3	31-0	—	—	—	—
4	31-0	—	—	—	—
6	31-0	—	—	—	—
7	31-0	—	—	—	—
8	31-0	—	—	—	—
9	31-0	—	—	—	—

45.6.1 EIM_0 memory map

EIM_0 base address: 4050_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Error Injection Module Configuration Register (EIMCR)	32	RW	0000_0000h
4h	Error Injection Channel Enable register (EICHEN)	32	RW	0000_0000h
100h	Error Injection Channel Descriptor 0, Word0 (EICHD0_WORD0)	32	RW	0000_0000h
104h	Error Injection Channel Descriptor 0, Word1 (EICHD0_WORD1)	32	RW	0000_0000h
108h	Error Injection Channel Descriptor 0, Word2 (EICHD0_WORD2)	32	RW	0000_0000h
140h	Error Injection Channel Descriptor 1, Word0 (EICHD1_WORD0)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
144h	Error Injection Channel Descriptor 1, Word1 (EICHD1_WORD1)	32	RW	0000_0000h
148h	Error Injection Channel Descriptor 1, Word2 (EICHD1_WORD2)	32	RW	0000_0000h
14Ch	Error Injection Channel Descriptor 1, Word3 (EICHD1_WORD3)	32	RW	0000_0000h
150h	Error Injection Channel Descriptor 1, Word4 (EICHD1_WORD4)	32	RW	0000_0000h
180h	Error Injection Channel Descriptor 2, Word0 (EICHD2_WORD0)	32	RW	0000_0000h
184h	Error Injection Channel Descriptor 2, Word1 (EICHD2_WORD1)	32	RW	0000_0000h
188h	Error Injection Channel Descriptor 2, Word2 (EICHD2_WORD2)	32	RW	0000_0000h
18Ch	Error Injection Channel Descriptor 2, Word3 (EICHD2_WORD3)	32	RW	0000_0000h
190h	Error Injection Channel Descriptor 2, Word4 (EICHD2_WORD4)	32	RW	0000_0000h
1C0h	Error Injection Channel Descriptor 3, Word0 (EICHD3_WORD0)	32	RW	0000_0000h
1C4h	Error Injection Channel Descriptor 3, Word1 (EICHD3_WORD1)	32	RW	0000_0000h
1C8h	Error Injection Channel Descriptor 3, Word2 (EICHD3_WORD2)	32	RW	0000_0000h
1CCh	Error Injection Channel Descriptor 3, Word3 (EICHD3_WORD3)	32	RW	0000_0000h
1D0h	Error Injection Channel Descriptor 3, Word4 (EICHD3_WORD4)	32	RW	0000_0000h
200h	Error Injection Channel Descriptor 4, Word0 (EICHD4_WORD0)	32	RW	0000_0000h
204h	Error Injection Channel Descriptor 4, Word1 (EICHD4_WORD1)	32	RW	0000_0000h
208h	Error Injection Channel Descriptor 4, Word2 (EICHD4_WORD2)	32	RW	0000_0000h
20Ch	Error Injection Channel Descriptor 4, Word3 (EICHD4_WORD3)	32	RW	0000_0000h
210h	Error Injection Channel Descriptor 4, Word4 (EICHD4_WORD4)	32	RW	0000_0000h
240h	Error Injection Channel Descriptor 5, Word0 (EICHD5_WORD0)	32	RW	0000_0000h
244h	Error Injection Channel Descriptor 5, Word1 (EICHD5_WORD1)	32	RW	0000_0000h
248h	Error Injection Channel Descriptor 5, Word2 (EICHD5_WORD2)	32	RW	0000_0000h
280h	Error Injection Channel Descriptor 6, Word0 (EICHD6_WORD0)	32	RW	0000_0000h
284h	Error Injection Channel Descriptor 6, Word1 (EICHD6_WORD1)	32	RW	0000_0000h
288h	Error Injection Channel Descriptor 6, Word2 (EICHD6_WORD2)	32	RW	0000_0000h
28Ch	Error Injection Channel Descriptor 6, Word3 (EICHD6_WORD3)	32	RW	0000_0000h
290h	Error Injection Channel Descriptor 6, Word4 (EICHD6_WORD4)	32	RW	0000_0000h
2C0h	Error Injection Channel Descriptor 7, Word0 (EICHD7_WORD0)	32	RW	0000_0000h
2C4h	Error Injection Channel Descriptor 7, Word1 (EICHD7_WORD1)	32	RW	0000_0000h
2C8h	Error Injection Channel Descriptor 7, Word2 (EICHD7_WORD2)	32	RW	0000_0000h
2CCh	Error Injection Channel Descriptor 7, Word3 (EICHD7_WORD3)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
2D0h	Error Injection Channel Descriptor 7, Word4 (EICHD7_WORD4)	32	RW	0000_0000h
300h	Error Injection Channel Descriptor 8, Word0 (EICHD8_WORD0)	32	RW	0000_0000h
304h	Error Injection Channel Descriptor 8, Word1 (EICHD8_WORD1)	32	RW	0000_0000h
308h	Error Injection Channel Descriptor 8, Word2 (EICHD8_WORD2)	32	RW	0000_0000h
30Ch	Error Injection Channel Descriptor 8, Word3 (EICHD8_WORD3)	32	RW	0000_0000h
310h	Error Injection Channel Descriptor 8, Word4 (EICHD8_WORD4)	32	RW	0000_0000h
340h	Error Injection Channel Descriptor 9, Word0 (EICHD9_WORD0)	32	RW	0000_0000h
344h	Error Injection Channel Descriptor 9, Word1 (EICHD9_WORD1)	32	RW	0000_0000h
348h	Error Injection Channel Descriptor 9, Word2 (EICHD9_WORD2)	32	RW	0000_0000h
34Ch	Error Injection Channel Descriptor 9, Word3 (EICHD9_WORD3)	32	RW	0000_0000h
350h	Error Injection Channel Descriptor 9, Word4 (EICHD9_WORD4)	32	RW	0000_0000h
380h	Error Injection Channel Descriptor 10, Word0 (EICHD10_WORD0)	32	RW	0000_0000h
384h	Error Injection Channel Descriptor 10, Word1 (EICHD10_WORD1)	32	RW	0000_0000h
388h	Error Injection Channel Descriptor 10, Word2 (EICHD10_WORD2)	32	RW	0000_0000h
3C0h	Error Injection Channel Descriptor 11, Word0 (EICHD11_WORD0)	32	RW	0000_0000h
3C4h	Error Injection Channel Descriptor 11, Word1 (EICHD11_WORD1)	32	RW	0000_0000h
400h	Error Injection Channel Descriptor 12, Word0 (EICHD12_WORD0)	32	RW	0000_0000h
404h	Error Injection Channel Descriptor 12, Word1 (EICHD12_WORD1)	32	RW	0000_0000h
440h	Error Injection Channel Descriptor 13, Word0 (EICHD13_WORD0)	32	RW	0000_0000h
444h	Error Injection Channel Descriptor 13, Word1 (EICHD13_WORD1)	32	RW	0000_0000h
448h	Error Injection Channel Descriptor 13, Word2 (EICHD13_WORD2)	32	RW	0000_0000h
480h	Error Injection Channel Descriptor 14, Word0 (EICHD14_WORD0)	32	RW	0000_0000h
484h	Error Injection Channel Descriptor 14, Word1 (EICHD14_WORD1)	32	RW	0000_0000h
4C0h	Error Injection Channel Descriptor 15, Word0 (EICHD15_WORD0)	32	RW	0000_0000h
4C4h	Error Injection Channel Descriptor 15, Word1 (EICHD15_WORD1)	32	RW	0000_0000h
504h	Error Injection Channel Descriptor 16, Word1 (EICHD16_WORD1)	32	RW	0000_0000h
544h	Error Injection Channel Descriptor 17, Word1 (EICHD17_WORD1)	32	RW	0000_0000h
548h	Error Injection Channel Descriptor 17, Word2 (EICHD17_WORD2)	32	RW	0000_0000h
584h	Error Injection Channel Descriptor 18, Word1 (EICHD18_WORD1)	32	RW	0000_0000h
588h	Error Injection Channel Descriptor 18, Word2 (EICHD18_WORD2)	32	RW	0000_0000h

45.6.2 Error Injection Module Configuration Register (EIMCR)

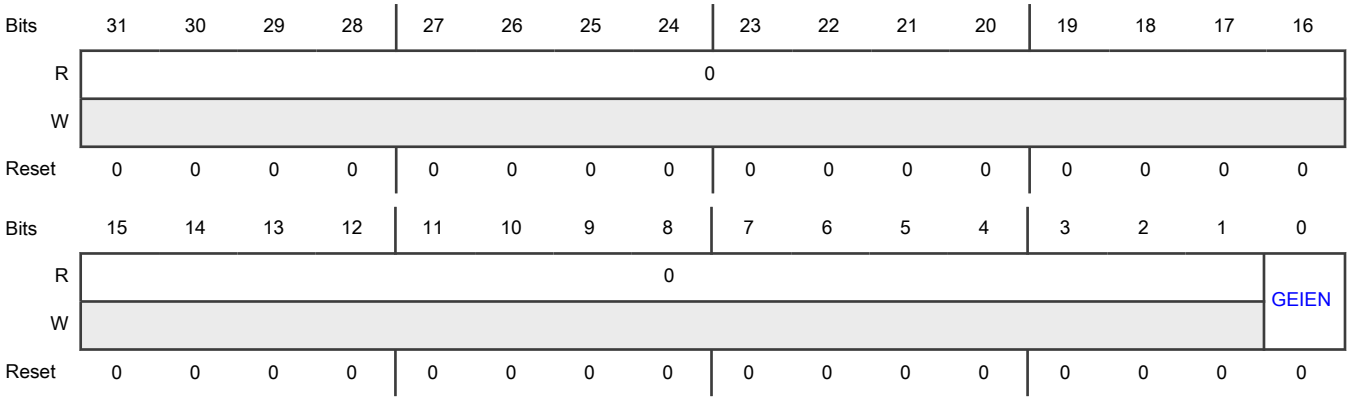
Offset

Register	Offset
EIMCR	0h

Function

The EIM Configuration Register is used to globally enable/disable the error injection function.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 GEIEN	Global Error Injection Enable This bit globally enables or disables the error injection function of the EIM. This field is initialized by hardware reset. 0b - Disabled 1b - Enabled

45.6.3 Error Injection Channel Enable register (EICHEN)

Offset

Register	Offset
EICHEN	4h

Function

Each field of the Error Injection Channel Enable register (EICHEN) is used to enable or disable the corresponding error injection channel.

NOTE

To enable an error injection channel, the Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EICH0EN	EICH1EN	EICH2EN	EICH3EN	EICH4EN	EICH5EN	EICH6EN	EICH7EN	EICH8EN	EICH9EN	EICH10EN	EICH11EN	EICH12EN	EICH13EN	EICH14EN	EICH15EN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	EICH16EN	EICH17EN	EICH18EN	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EICH0EN	Error Injection Channel 0 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 0 1b - Error injection is enabled on Error Injection Channel 0
30 EICH1EN	Error Injection Channel 1 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 1

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Field	Function
	1b - Error injection is enabled on Error Injection Channel 1
29 EICH2EN	Error Injection Channel 2 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 2 1b - Error injection is enabled on Error Injection Channel 2
28 EICH3EN	Error Injection Channel 3 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 3 1b - Error injection is enabled on Error Injection Channel 3
27 EICH4EN	Error Injection Channel 4 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 4 1b - Error injection is enabled on Error Injection Channel 4
26 EICH5EN	Error Injection Channel 5 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software.

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Field	Function
	Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 5 1b - Error injection is enabled on Error Injection Channel 5
25 EICH6EN	Error Injection Channel 6 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 6 1b - Error injection is enabled on Error Injection Channel 6
24 EICH7EN	Error Injection Channel 7 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 7 1b - Error injection is enabled on Error Injection Channel 7
23 EICH8EN	Error Injection Channel 8 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 8 1b - Error injection is enabled on Error Injection Channel 8
22 EICH9EN	Error Injection Channel 9 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection.

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Field	Function
	After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 9 1b - Error injection is enabled on Error Injection Channel 9
21 EICH10EN	Error Injection Channel 10 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 10 1b - Error injection is enabled on Error Injection Channel 10
20 EICH11EN	Error Injection Channel 11 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 11 1b - Error injection is enabled on Error Injection Channel 11
19 EICH12EN	Error Injection Channel 12 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 12 1b - Error injection is enabled on Error Injection Channel 12

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Field	Function
18 EICH13EN	Error Injection Channel 13 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 13 1b - Error injection is enabled on Error Injection Channel 13
17 EICH14EN	Error Injection Channel 14 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 14 1b - Error injection is enabled on Error Injection Channel 14
16 EICH15EN	Error Injection Channel 15 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 15 1b - Error injection is enabled on Error Injection Channel 15
15 EICH16EN	Error Injection Channel 16 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel.

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Field	Function
	0b - Error injection is disabled on Error Injection Channel 16 1b - Error injection is enabled on Error Injection Channel 16
14 EICH17EN	Error Injection Channel 17 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 17 1b - Error injection is enabled on Error Injection Channel 17
13 EICH18EN	Error Injection Channel 18 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 18 1b - Error injection is enabled on Error Injection Channel 18
12 —	Reserved
11 —	Reserved
10 —	Reserved
9 —	Reserved
8 —	Reserved
7	Reserved

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Field	Function
—	
6 —	Reserved
5 —	Reserved
4 —	Reserved
3 —	Reserved
2 —	Reserved
1 —	Reserved
0 —	Reserved

45.6.4 Error Injection Channel Descriptor 0, Word0 (EICHD0_WORD0)

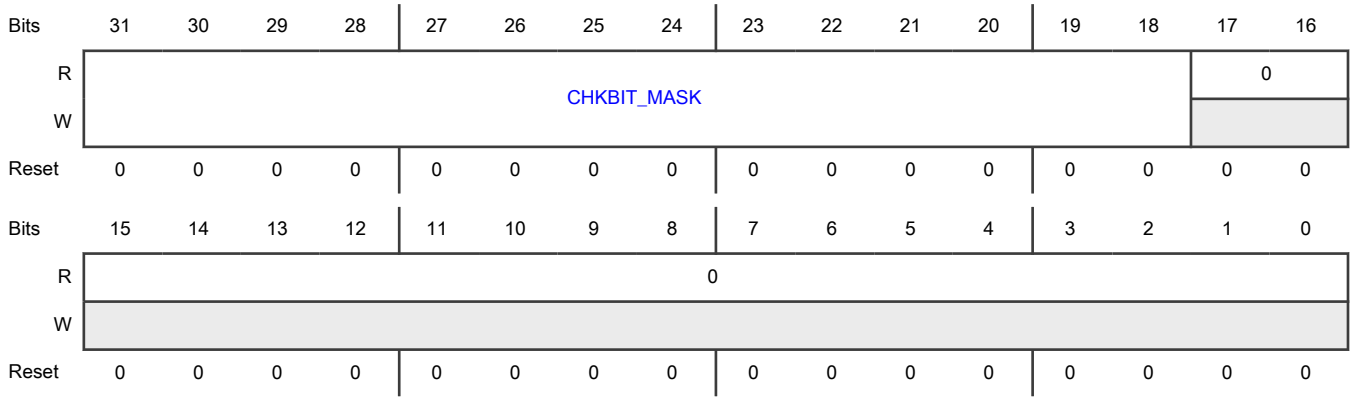
Offset

Register	Offset
EICHD0_WORD0	100h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-18 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[13:0] (14 bits wide), CHKBIT_MASK[13] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
17-0 —	Reserved

45.6.5 Error Injection Channel Descriptor 0, Word1 (EICHD0_WORD1)

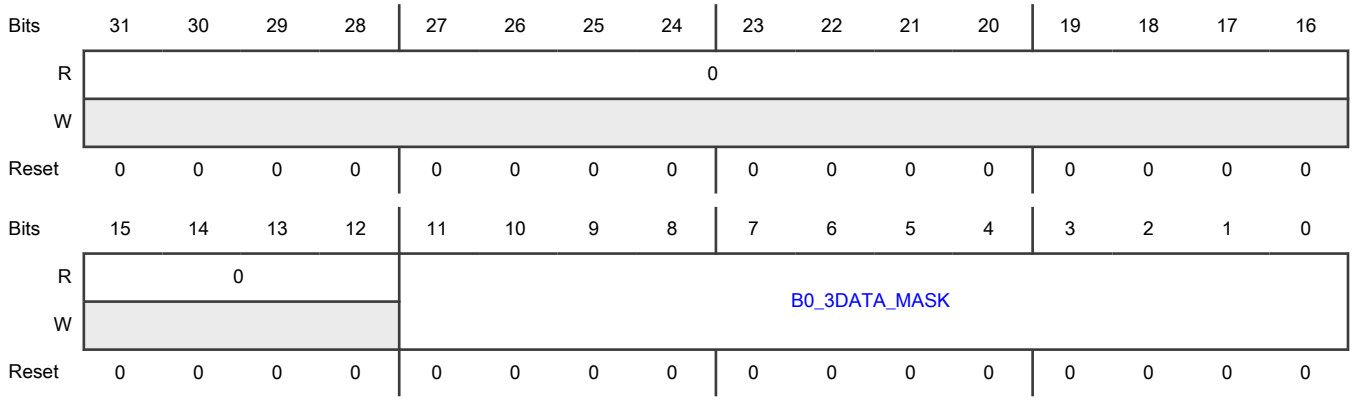
Offset

Register	Offset
EICHD0_WORD1	104h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.6 Error Injection Channel Descriptor n, Word2 (EICHD0_WORD2 - EICHD18_WORD2)

Offset

Register	Offset
EICHD0_WORD2	108h
EICHD1_WORD2	148h
EICHD2_WORD2	188h
EICHD3_WORD2	1C8h
EICHD4_WORD2	208h
EICHD5_WORD2	248h
EICHD6_WORD2	288h
EICHD7_WORD2	2C8h

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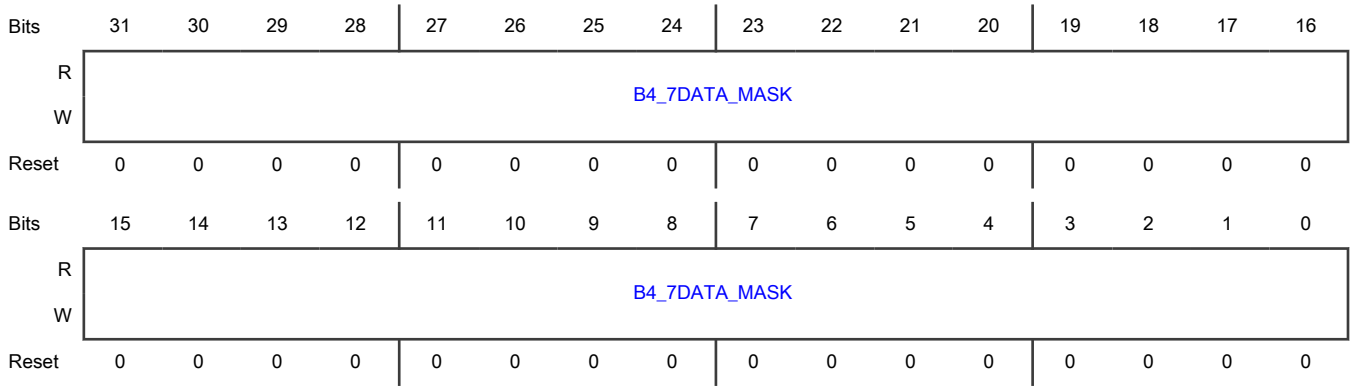
Register	Offset
EICHD8_WORD2	308h
EICHD9_WORD2	348h
EICHD10_WORD2	388h
EICHD13_WORD2	448h
EICHD17_WORD2	548h
EICHD18_WORD2	588h

Function

The third word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B4_7DATA_MASK correspond to bytes 4–7 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B4_7DATA_MASK	Data Mask Bytes 4-7 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B4_7DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 4-7 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 4-7 on the read data bus is inverted.

45.6.7 Error Injection Channel Descriptor 1, Word0 (EICHD1_WORD0)

Offset

Register	Offset
EICHD1_WORD0	140h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CHKBIT_MASK															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[15:0] (16 bits wide), CHKBIT_MASK[15] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
15-0 —	Reserved

45.6.8 Error Injection Channel Descriptor 1, Word1 (EICHD1_WORD1)

Offset

Register	Offset
EICHD1_WORD1	144h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	B0_3DATA_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	B0_3DATA_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.9 Error Injection Channel Descriptor n, Word3 (EICHD1_WORD3 - EICHD9_WORD3)

Offset

Register	Offset
EICHD1_WORD3	14Ch
EICHD2_WORD3	18Ch
EICHD3_WORD3	1CCh
EICHD4_WORD3	20Ch
EICHD6_WORD3	28Ch
EICHD7_WORD3	2CCh
EICHD8_WORD3	30Ch
EICHD9_WORD3	34Ch

Function

The fourth word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B8_11DATA_MASK correspond to bytes 8–11 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	B8_11DATA_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	B8_11DATA_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 B8_11DATA_MASK	Data Mask Bytes 8-11 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B8_11DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details.

Table continues on the next page...

Field	Function
	0b - The corresponding bit of bytes 8-11 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 8-11 on the read data bus is inverted.

45.6.10 Error Injection Channel Descriptor n, Word4 (EICHD1_WORD4 - EICHD9_WORD4)

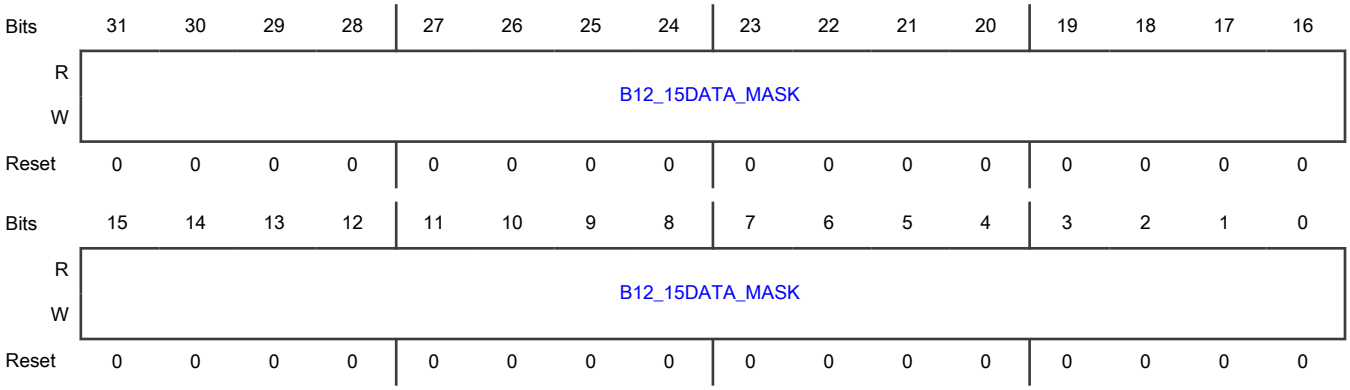
Offset

Register	Offset
EICHD1_WORD4	150h
EICHD2_WORD4	190h
EICHD3_WORD4	1D0h
EICHD4_WORD4	210h
EICHD6_WORD4	290h
EICHD7_WORD4	2D0h
EICHD8_WORD4	310h
EICHD9_WORD4	350h

Function

The fifth word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B12_15DATA_MASK correspond to bytes 12–15 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B12_15DATA_MASK	Data Mask Bytes 12-15 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B12_15DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 12-15 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 12-15 on the read data bus is inverted.

45.6.11 Error Injection Channel Descriptor n, Word0 (EICHD2_WORD0 - EICHD4_WORD0)

Offset

Register	Offset
EICHD2_WORD0	180h
EICHD3_WORD0	1C0h
EICHD4_WORD0	200h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CHKBIT_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CHKBIT_MASK												0			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[27:0] (28 bits wide), CHKBIT_MASK[27] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
3-0 —	Reserved

45.6.12 Error Injection Channel Descriptor 2, Word1 (EICHD2_WORD1)

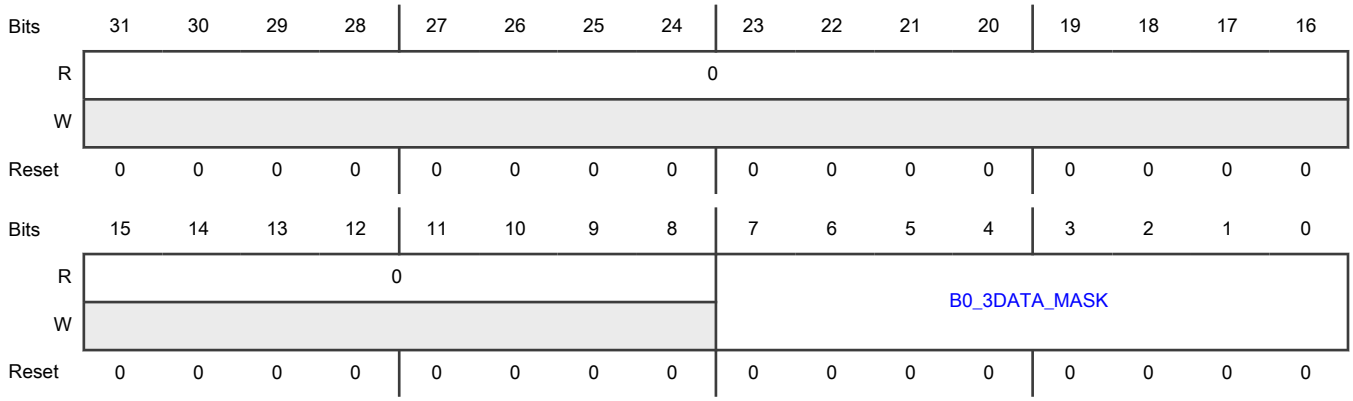
Offset

Register	Offset
EICHD2_WORD1	184h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.13 Error Injection Channel Descriptor n, Word1 (EICHD3_WORD1 - EICHD4_WORD1)

Offset

Register	Offset
EICHD3_WORD1	1C4h
EICHD4_WORD1	204h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	B0_3DATA_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	B0_3DATA_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.14 Error Injection Channel Descriptor 5, Word0 (EICHD5_WORD0)

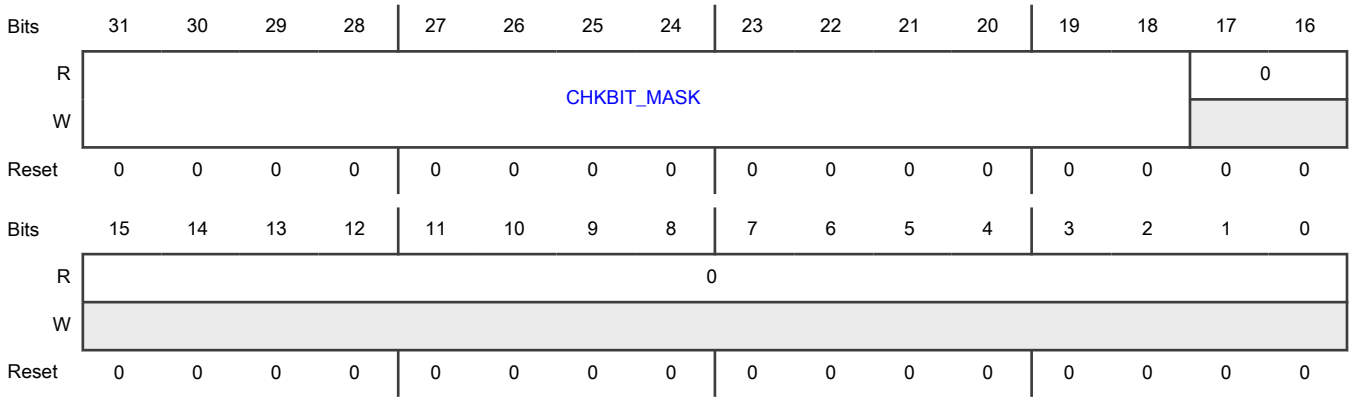
Offset

Register	Offset
EICHD5_WORD0	240h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-18	Checkbit Mask

Table continues on the next page...

Table continued from the previous page...

Field	Function
CHKBIT_MASK	This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[13:0] (14 bits wide), CHKBIT_MASK[13] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
17-0 —	Reserved

45.6.15 Error Injection Channel Descriptor 5, Word1 (EICHD5_WORD1)

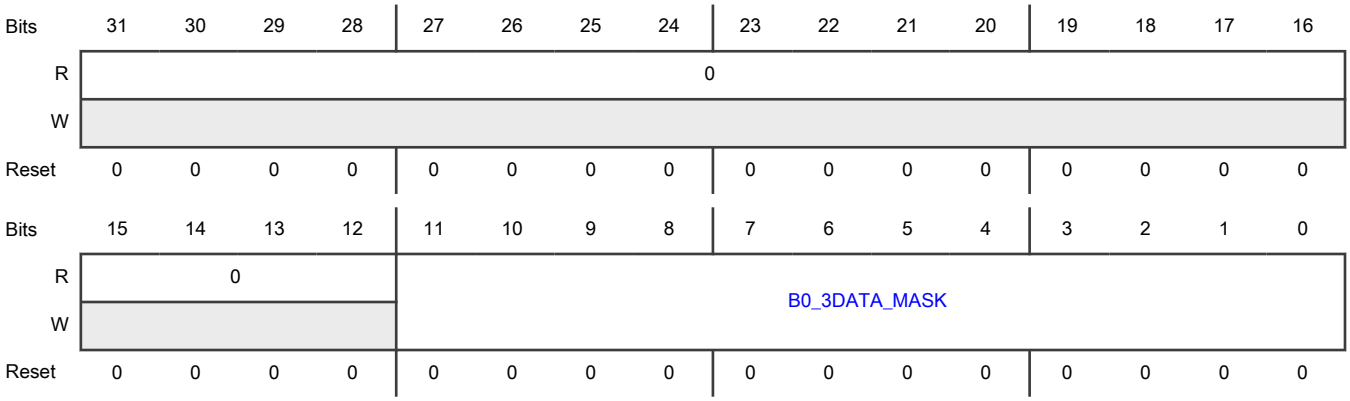
Offset

Register	Offset
EICHD5_WORD1	244h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.16 Error Injection Channel Descriptor 6, Word0 (EICHD6_WORD0)

Offset

Register	Offset
EICHD6_WORD0	280h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CHKBIT_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[15:0] (16 bits wide), CHKBIT_MASK[15] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
15-0 —	Reserved

45.6.17 Error Injection Channel Descriptor 6, Word1 (EICHD6_WORD1)

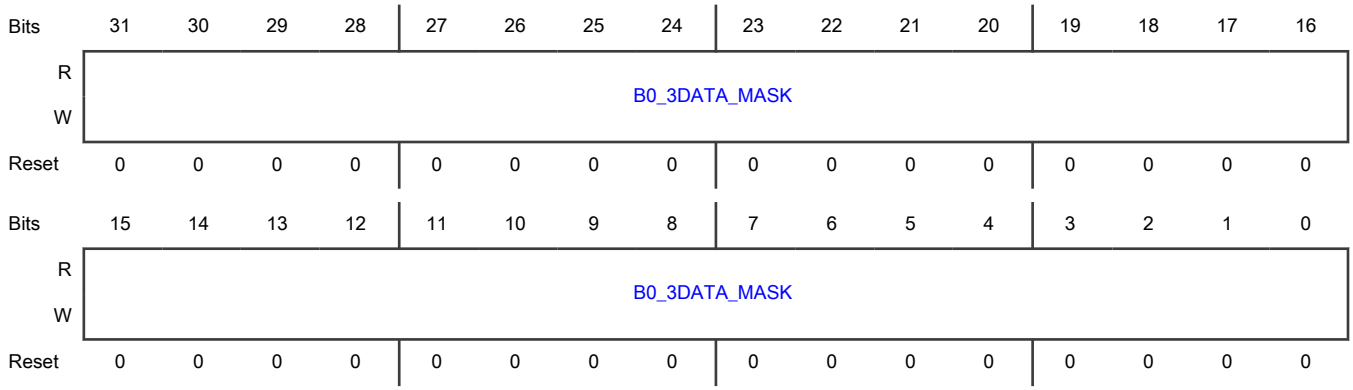
Offset

Register	Offset
EICHD6_WORD1	284h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.18 Error Injection Channel Descriptor n, Word0 (EICHD7_WORD0 - EICHD9_WORD0)

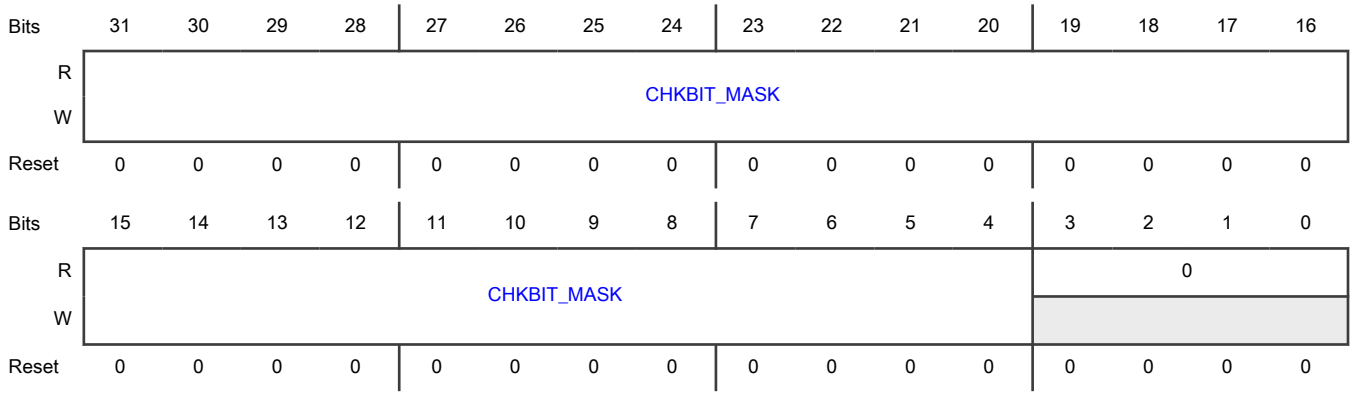
Offset

Register	Offset
EICHD7_WORD0	2C0h
EICHD8_WORD0	300h
EICHD9_WORD0	340h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-4 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[27:0] (28 bits wide), CHKBIT_MASK[27] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
3-0 —	Reserved

45.6.19 Error Injection Channel Descriptor 7, Word1 (EICHD7_WORD1)

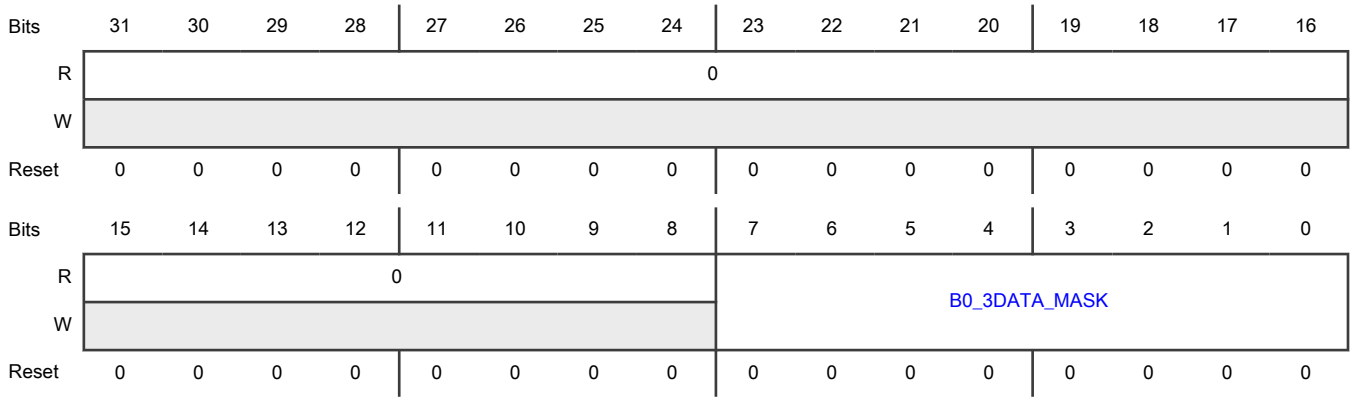
Offset

Register	Offset
EICHD7_WORD1	2C4h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.20 Error Injection Channel Descriptor n, Word1 (EICHD8_WORD1 - EICHD15_WORD1)

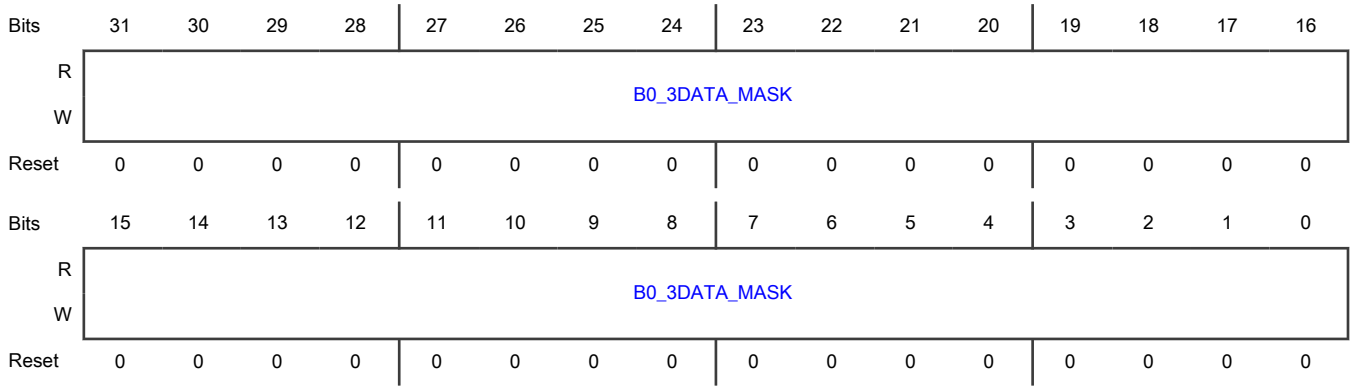
Offset

Register	Offset
EICHD8_WORD1	304h
EICHD9_WORD1	344h
EICHD10_WORD1	384h
EICHD11_WORD1	3C4h
EICHD12_WORD1	404h
EICHD13_WORD1	444h
EICHD14_WORD1	484h
EICHD15_WORD1	4C4h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.21 Error Injection Channel Descriptor n, Word0 (EICHD10_WORD0 - EICHD15_WORD0)

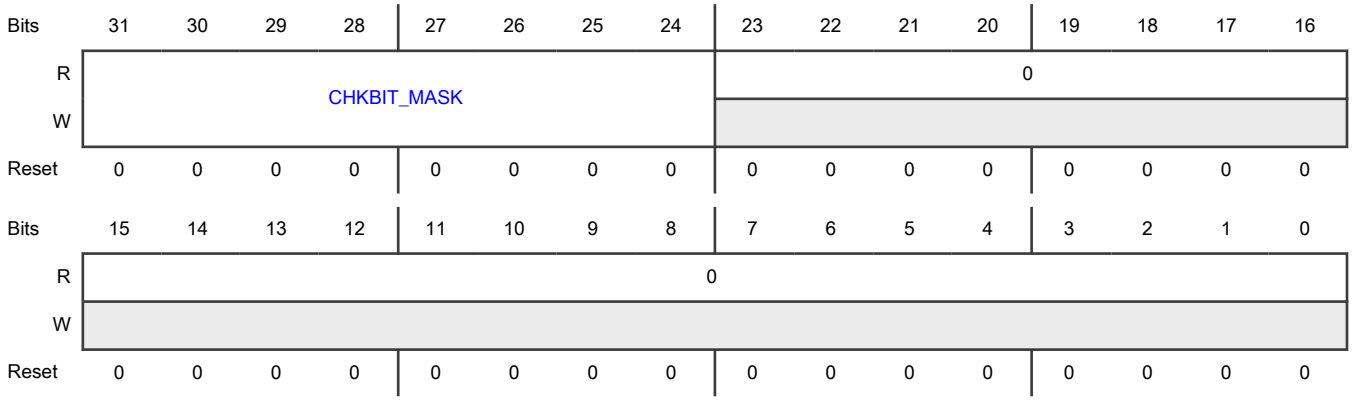
Offset

Register	Offset
EICHD10_WORD0	380h
EICHD11_WORD0	3C0h
EICHD12_WORD0	400h
EICHD13_WORD0	440h
EICHD14_WORD0	480h
EICHD15_WORD0	4C0h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-24 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[7:0] (8 bits wide), CHKBIT_MASK[7] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
23-0 —	Reserved

45.6.22 Error Injection Channel Descriptor 16, Word1 (EICHD16_WORD1)

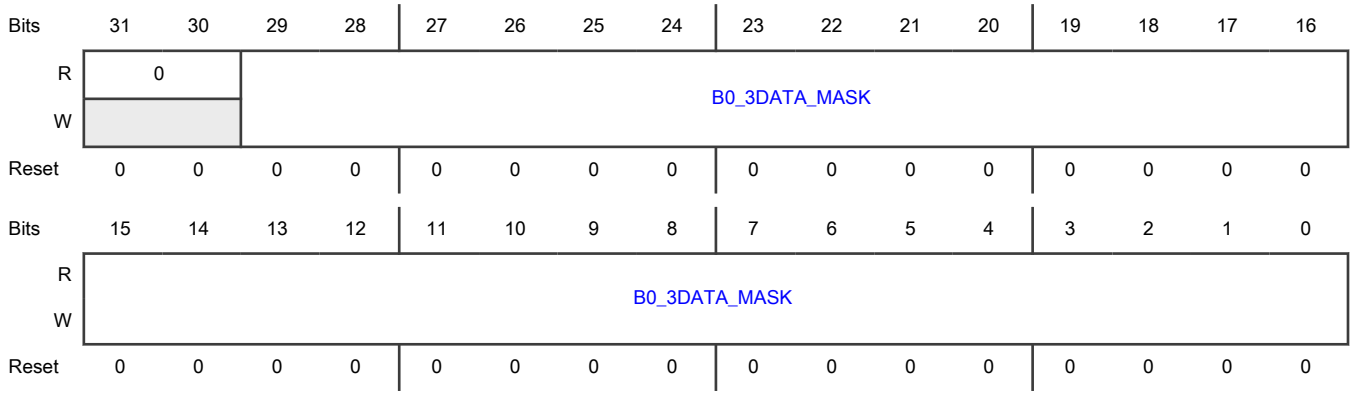
Offset

Register	Offset
EICHD16_WORD1	504h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-30 —	Reserved
29-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.6.23 Error Injection Channel Descriptor n, Word1 (EICHD17_WORD1 - EICHD18_WORD1)

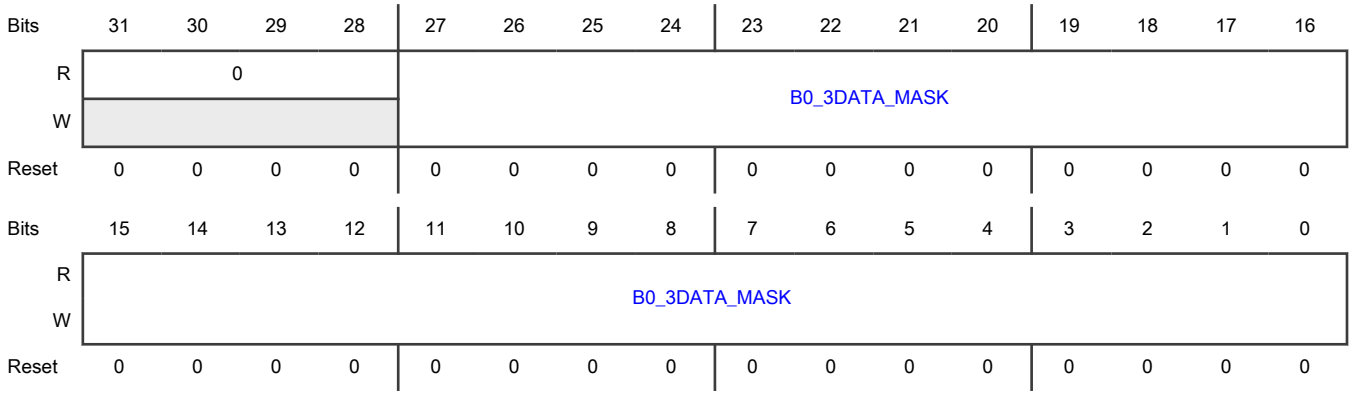
Offset

Register	Offset
EICHD17_WORD1	544h
EICHD18_WORD1	584h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-28 —	Reserved
27-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.7 EIM_1 register descriptions

The EIM provides a programming model mapped to an on-platform peripheral slot.

Programming model access

All system bus masters can access the programming model:

- Only in supervisor mode
- Using only 32-bit (word) accesses

Any of the following attempted references to the programming model generates an error termination:

- In user mode
- Using non-32-bit access sizes
- To undefined (reserved) addresses

Attempted updates to the programming model while the EIM is in the midst of an operation result in non-deterministic behavior.

Error injection channel descriptor: function and structure

Each error injection channel descriptor:

- Specifies a mask that defines which bits of the read data and/or checkbit bus from target RAM are inverted on a read access.
- Consists of a 288-bit (36-byte) structure, composed of nine 32-bit words, in the EIM programming model. Unused words are not documented.
  - Word0 (EICHD*n*_WORD0), if present, defines the checkbit mask.
  - Word1 (EICHD*n*_WORD1) and additional words, if present, define the data mask. Word registers subsequent to Word1 are present only when required by the total width of the channel's data mask. Error injection channel descriptor: DATA_MASK details.

The multiple channel descriptors are organized sequentially.

Error injection channel descriptor: DATA_MASK details

For each channel: The following tables show the distribution of DATA_MASK's bits across the WORD registers. The first table shows the total width of DATA_MASK and the distribution of its bits across WORD1, WORD2, and WORD3. The second table shows the distribution of DATA_MASK's bits across WORD4 and subsequent registers.

Table 215. Error injection channel descriptor: DATA_MASK details

Channel	DATA_MASK total width (bits)	Specific bits of DATA_MASK in		
		WORD1	WORD2	WORD3
0	44	43-32	31-0	—
1	128	127-96	95-64	63-32
2	104	103-96	95-64	63-32
3	128	127-96	95-64	63-32
4	128	127-96	95-64	63-32
10	64	63-32	31-0	—
11	32	31-0	—	—
12	32	31-0	—	—
16	30	29-0	—	—
17	60	59-32	31-0	—

Table 216. DATA_MASK bit: Channel-word mapping

Channel	Specific bits of DATA_MASK in				
	WORD4	WORD5	WORD6	WORD7	WORD8
1	31-0	—	—	—	—
2	31-0	—	—	—	—
3	31-0	—	—	—	—
4	31-0	—	—	—	—

45.7.1 EIM_1 memory map

EIM_1 base address: 4051_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Error Injection Module Configuration Register (EIMCR)	32	RW	0000_0000h
4h	Error Injection Channel Enable register (EICHEN)	32	RW	0000_0000h
100h	Error Injection Channel Descriptor 0, Word0 (EICHD0_WORD0)	32	RW	0000_0000h
104h	Error Injection Channel Descriptor 0, Word1 (EICHD0_WORD1)	32	RW	0000_0000h
108h	Error Injection Channel Descriptor 0, Word2 (EICHD0_WORD2)	32	RW	0000_0000h
140h	Error Injection Channel Descriptor 1, Word0 (EICHD1_WORD0)	32	RW	0000_0000h
144h	Error Injection Channel Descriptor 1, Word1 (EICHD1_WORD1)	32	RW	0000_0000h
148h	Error Injection Channel Descriptor 1, Word2 (EICHD1_WORD2)	32	RW	0000_0000h
14Ch	Error Injection Channel Descriptor 1, Word3 (EICHD1_WORD3)	32	RW	0000_0000h
150h	Error Injection Channel Descriptor 1, Word4 (EICHD1_WORD4)	32	RW	0000_0000h
180h	Error Injection Channel Descriptor 2, Word0 (EICHD2_WORD0)	32	RW	0000_0000h
184h	Error Injection Channel Descriptor 2, Word1 (EICHD2_WORD1)	32	RW	0000_0000h
188h	Error Injection Channel Descriptor 2, Word2 (EICHD2_WORD2)	32	RW	0000_0000h
18Ch	Error Injection Channel Descriptor 2, Word3 (EICHD2_WORD3)	32	RW	0000_0000h
190h	Error Injection Channel Descriptor 2, Word4 (EICHD2_WORD4)	32	RW	0000_0000h
1C0h	Error Injection Channel Descriptor 3, Word0 (EICHD3_WORD0)	32	RW	0000_0000h
1C4h	Error Injection Channel Descriptor 3, Word1 (EICHD3_WORD1)	32	RW	0000_0000h
1C8h	Error Injection Channel Descriptor 3, Word2 (EICHD3_WORD2)	32	RW	0000_0000h
1CCh	Error Injection Channel Descriptor 3, Word3 (EICHD3_WORD3)	32	RW	0000_0000h
1D0h	Error Injection Channel Descriptor 3, Word4 (EICHD3_WORD4)	32	RW	0000_0000h
200h	Error Injection Channel Descriptor 4, Word0 (EICHD4_WORD0)	32	RW	0000_0000h
204h	Error Injection Channel Descriptor 4, Word1 (EICHD4_WORD1)	32	RW	0000_0000h
208h	Error Injection Channel Descriptor 4, Word2 (EICHD4_WORD2)	32	RW	0000_0000h
20Ch	Error Injection Channel Descriptor 4, Word3 (EICHD4_WORD3)	32	RW	0000_0000h
210h	Error Injection Channel Descriptor 4, Word4 (EICHD4_WORD4)	32	RW	0000_0000h
380h	Error Injection Channel Descriptor 10, Word0 (EICHD10_WORD0)	32	RW	0000_0000h
384h	Error Injection Channel Descriptor 10, Word1 (EICHD10_WORD1)	32	RW	0000_0000h
388h	Error Injection Channel Descriptor 10, Word2 (EICHD10_WORD2)	32	RW	0000_0000h
3C0h	Error Injection Channel Descriptor 11, Word0 (EICHD11_WORD0)	32	RW	0000_0000h
3C4h	Error Injection Channel Descriptor 11, Word1 (EICHD11_WORD1)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
400h	Error Injection Channel Descriptor 12, Word0 (EICHD12_WORD0)	32	RW	0000_0000h
404h	Error Injection Channel Descriptor 12, Word1 (EICHD12_WORD1)	32	RW	0000_0000h
504h	Error Injection Channel Descriptor 16, Word1 (EICHD16_WORD1)	32	RW	0000_0000h
544h	Error Injection Channel Descriptor 17, Word1 (EICHD17_WORD1)	32	RW	0000_0000h
548h	Error Injection Channel Descriptor 17, Word2 (EICHD17_WORD2)	32	RW	0000_0000h

45.7.2 Error Injection Module Configuration Register (EIMCR)

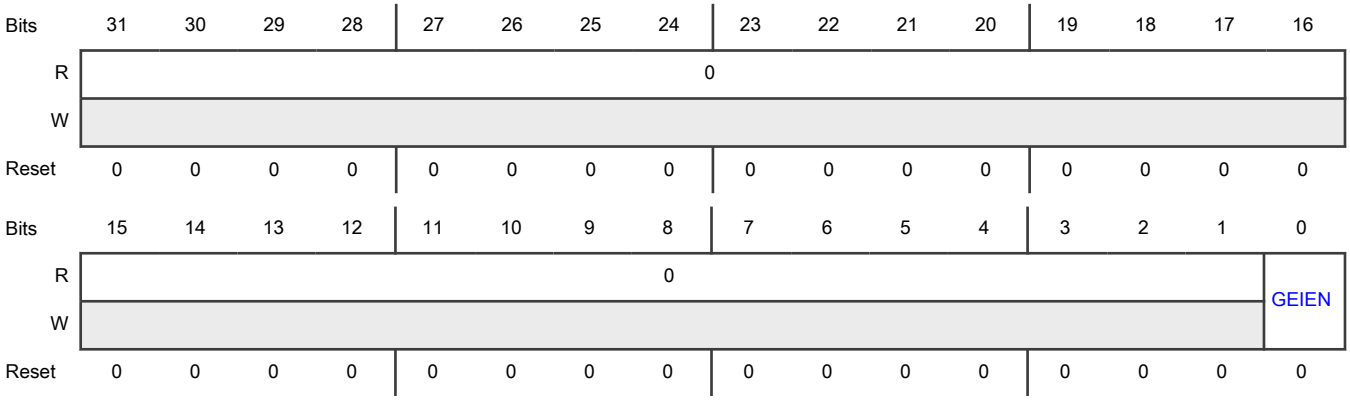
Offset

Register	Offset
EIMCR	0h

Function

The EIM Configuration Register is used to globally enable/disable the error injection function.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 GEIEN	Global Error Injection Enable This bit globally enables or disables the error injection function of the EIM. This field is initialized by hardware reset.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled

45.7.3 Error Injection Channel Enable register (EICHEN)

Offset

Register	Offset
EICHEN	4h

Function

Each field of the Error Injection Channel Enable register (EICHEN) is used to enable or disable the corresponding error injection channel.

NOTE

To enable an error injection channel, the Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EICH0EN	EICH1EN	EICH2EN	EICH3EN	EICH4EN	0	0	0	0	0	EICH10EN	EICH11EN	EICH12EN	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	EICH16EN	EICH17EN	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EICH0EN	Error Injection Channel 0 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 0 1b - Error injection is enabled on Error Injection Channel 0
30 EICH1EN	Error Injection Channel 1 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 1 1b - Error injection is enabled on Error Injection Channel 1
29 EICH2EN	Error Injection Channel 2 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 2 1b - Error injection is enabled on Error Injection Channel 2
28 EICH3EN	Error Injection Channel 3 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 3 1b - Error injection is enabled on Error Injection Channel 3
27 EICH4EN	Error Injection Channel 4 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection.

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Field	Function
	After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 4 1b - Error injection is enabled on Error Injection Channel 4
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 —	Reserved
22 —	Reserved
21 EICH10EN	Error Injection Channel 10 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 10 1b - Error injection is enabled on Error Injection Channel 10
20 EICH11EN	Error Injection Channel 11 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel.

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Field	Function
	0b - Error injection is disabled on Error Injection Channel 11 1b - Error injection is enabled on Error Injection Channel 11
19 EICH12EN	Error Injection Channel 12 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 12 1b - Error injection is enabled on Error Injection Channel 12
18 —	Reserved
17 —	Reserved
16 —	Reserved
15 EICH16EN	Error Injection Channel 16 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 16 1b - Error injection is enabled on Error Injection Channel 16
14 EICH17EN	Error Injection Channel 17 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software.

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Field	Function
	Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 17 1b - Error injection is enabled on Error Injection Channel 17
13 —	Reserved
12 —	Reserved
11 —	Reserved
10 —	Reserved
9 —	Reserved
8 —	Reserved
7 —	Reserved
6 —	Reserved
5 —	Reserved
4 —	Reserved
3 —	Reserved
2 —	Reserved
1	Reserved

Table continues on the next page...

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Field	Function
—	
0 —	Reserved

45.7.4 Error Injection Channel Descriptor 0, Word0 (EICHD0_WORD0)

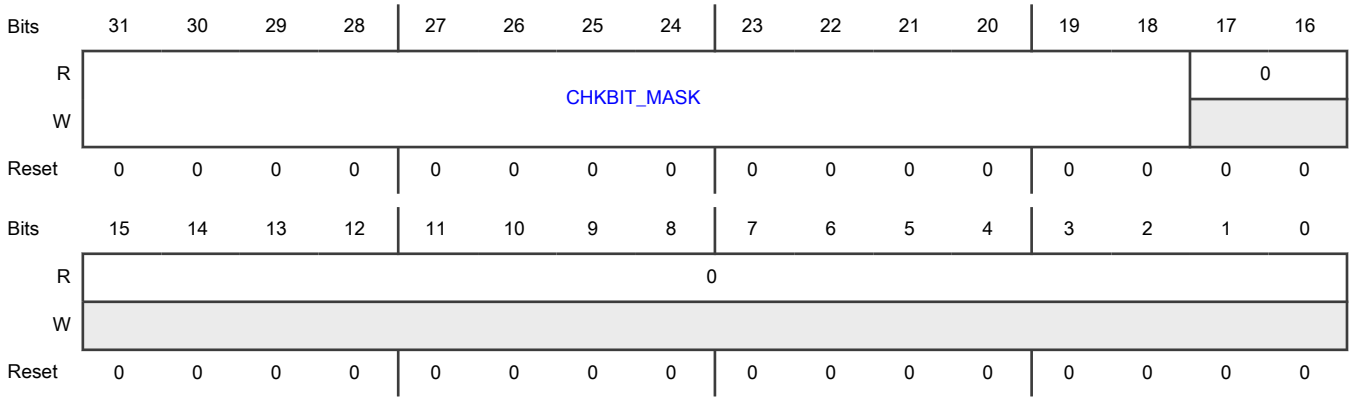
Offset

Register	Offset
EICHD0_WORD0	100h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-18 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information.

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Field	Function
	NOTE Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[13:0] (14 bits wide), CHKBIT_MASK[13] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
17-0 —	Reserved

45.7.5 Error Injection Channel Descriptor 0, Word1 (EICHD0_WORD1)

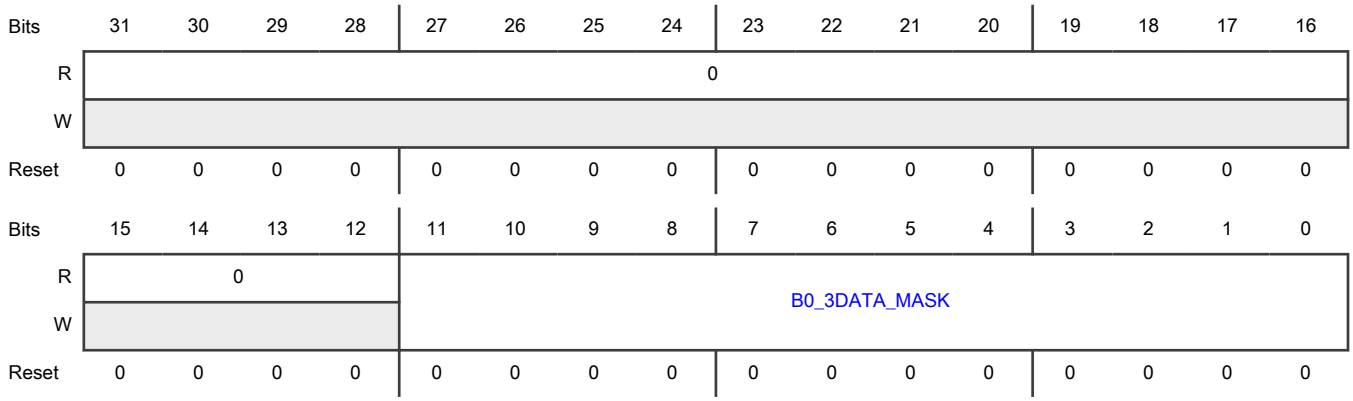
Offset

Register	Offset
EICHD0_WORD1	104h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-12	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
11-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.7.6 Error Injection Channel Descriptor n, Word2 (EICHD0_WORD2 - EICHD17_WORD2)

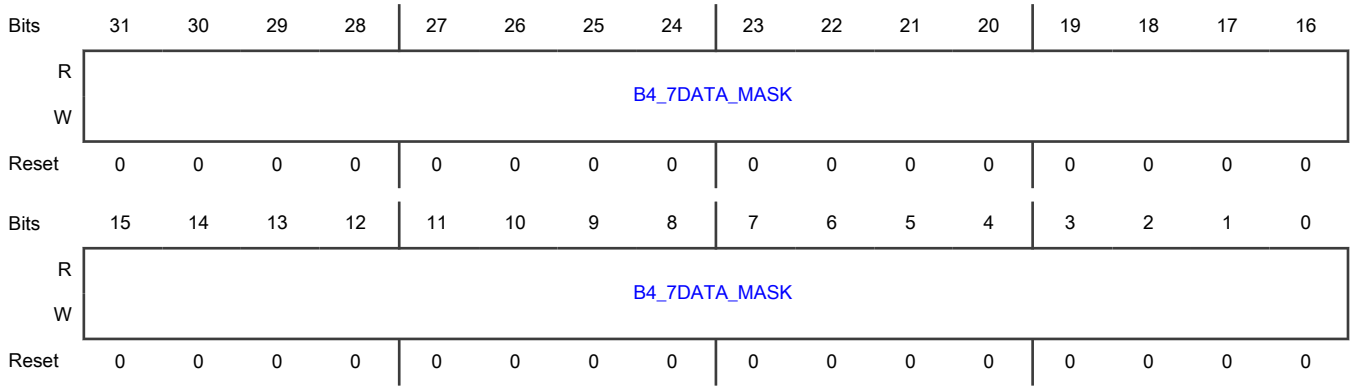
Offset

Register	Offset
EICHD0_WORD2	108h
EICHD1_WORD2	148h
EICHD2_WORD2	188h
EICHD3_WORD2	1C8h
EICHD4_WORD2	208h
EICHD10_WORD2	388h
EICHD17_WORD2	548h

Function

The third word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B4_7DATA_MASK correspond to bytes 4–7 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B4_7DATA_MASK	Data Mask Bytes 4-7 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B4_7DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 4-7 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 4-7 on the read data bus is inverted.

45.7.7 Error Injection Channel Descriptor 1, Word0 (EICHD1_WORD0)

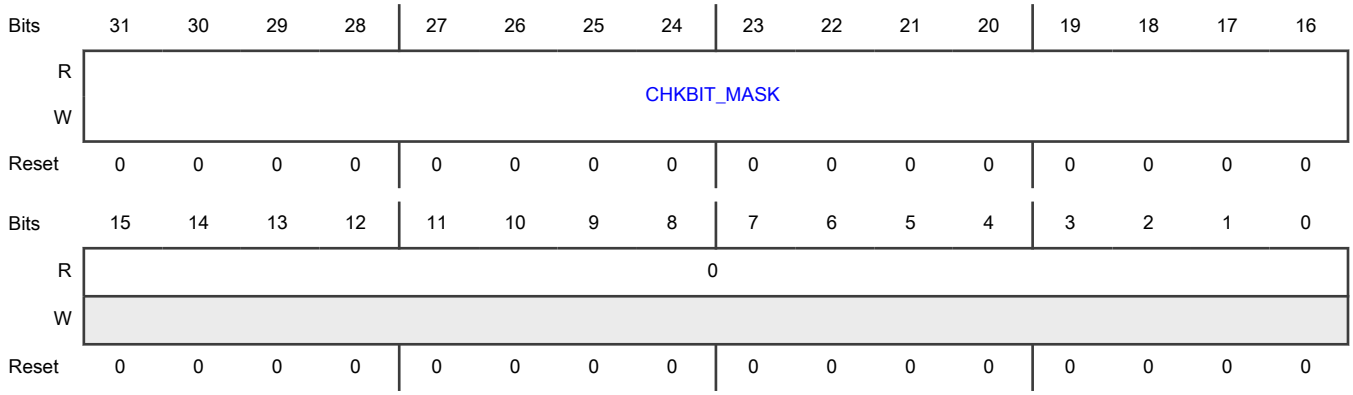
Offset

Register	Offset
EICHD1_WORD0	140h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-16 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[15:0] (16 bits wide), CHKBIT_MASK[15] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
15-0 —	Reserved

45.7.8 Error Injection Channel Descriptor 1, Word1 (EICHD1_WORD1)

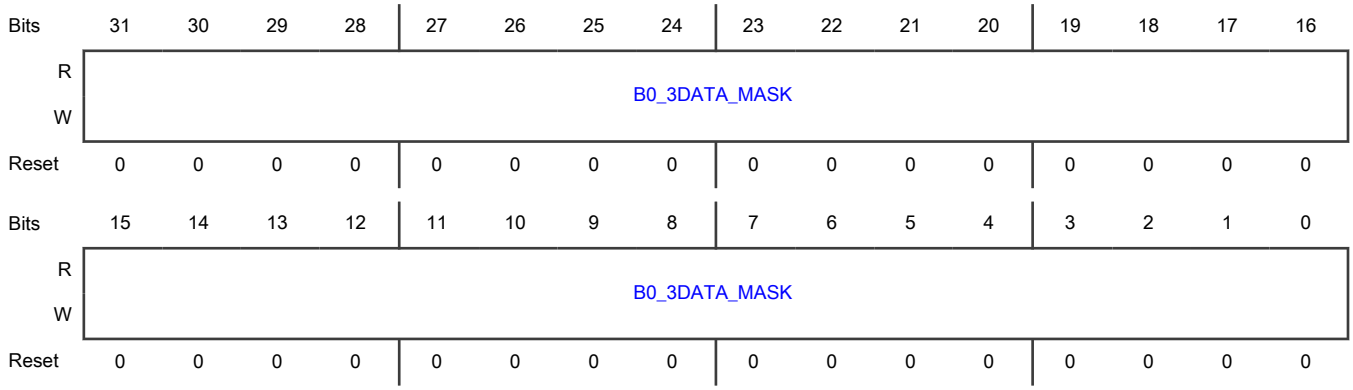
Offset

Register	Offset
EICHD1_WORD1	144h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.7.9 Error Injection Channel Descriptor n, Word3 (EICHD1_WORD3 - EICHD4_WORD3)

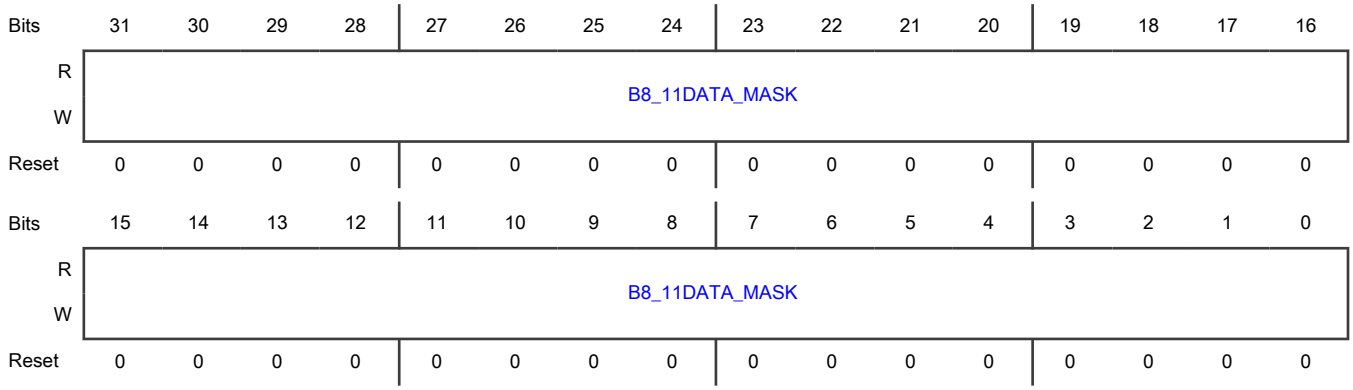
Offset

Register	Offset
EICHD1_WORD3	14Ch
EICHD2_WORD3	18Ch
EICHD3_WORD3	1CCh
EICHD4_WORD3	20Ch

Function

The fourth word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B8_11DATA_MASK correspond to bytes 8–11 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B8_11DATA_MASK	Data Mask Bytes 8-11 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B8_11DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 8-11 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 8-11 on the read data bus is inverted.

45.7.10 Error Injection Channel Descriptor n, Word4 (EICHD1_WORD4 - EICHD4_WORD4)

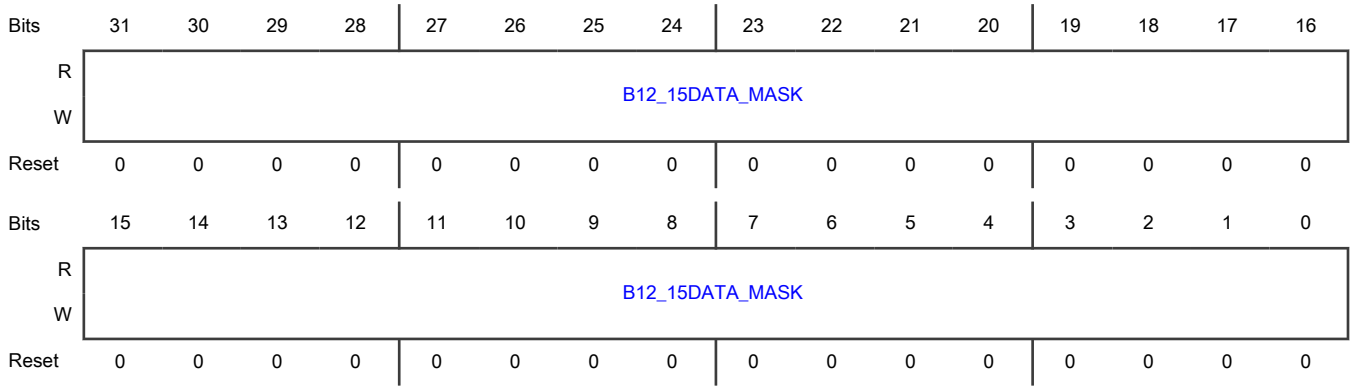
Offset

Register	Offset
EICHD1_WORD4	150h
EICHD2_WORD4	190h
EICHD3_WORD4	1D0h
EICHD4_WORD4	210h

Function

The fifth word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B12_15DATA_MASK correspond to bytes 12–15 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B12_15DATA_MASK	Data Mask Bytes 12-15 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B12_15DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 12-15 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 12-15 on the read data bus is inverted.

45.7.11 Error Injection Channel Descriptor n, Word0 (EICHD2_WORD0 - EICHD4_WORD0)

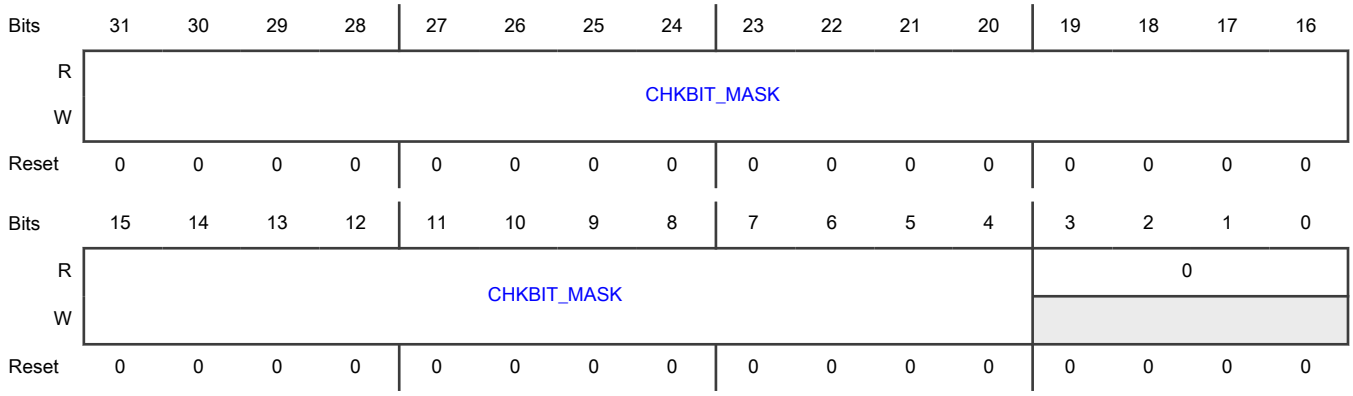
Offset

Register	Offset
EICHD2_WORD0	180h
EICHD3_WORD0	1C0h
EICHD4_WORD0	200h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-4 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[27:0] (28 bits wide), CHKBIT_MASK[27] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
3-0 —	Reserved

45.7.12 Error Injection Channel Descriptor 2, Word1 (EICHD2_WORD1)

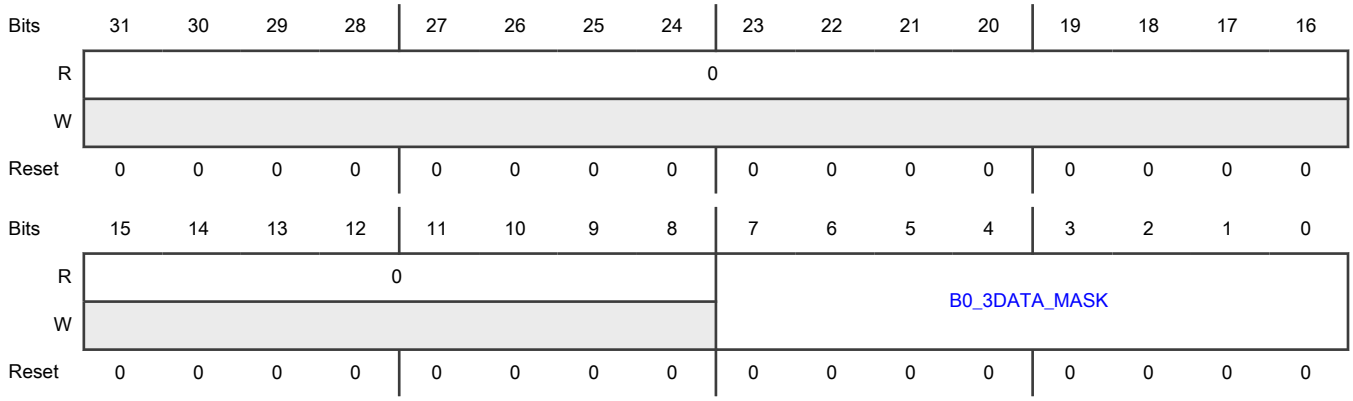
Offset

Register	Offset
EICHD2_WORD1	184h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.7.13 Error Injection Channel Descriptor n, Word1 (EICHD3_WORD1 - EICHD12_WORD1)

Offset

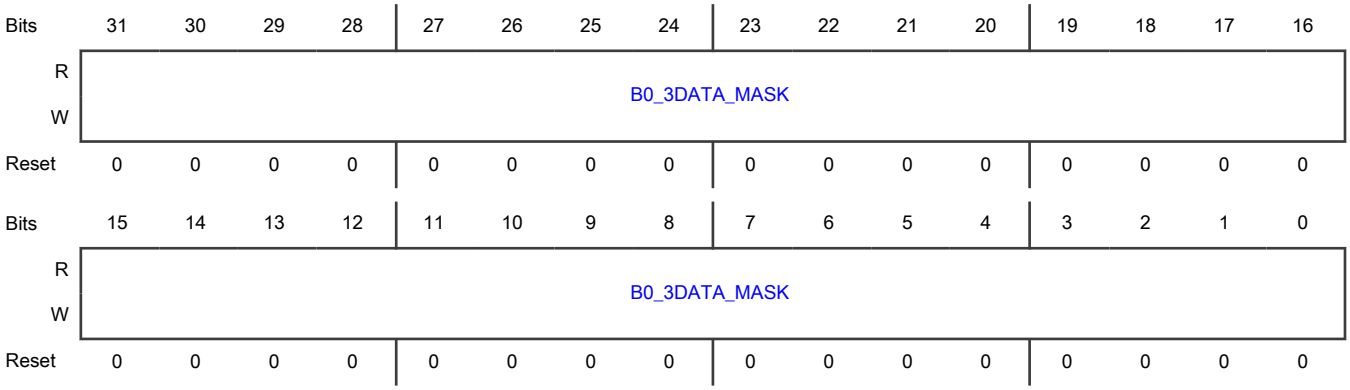
Register	Offset
EICHD3_WORD1	1C4h
EICHD4_WORD1	204h
EICHD10_WORD1	384h
EICHD11_WORD1	3C4h
EICHD12_WORD1	404h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted

or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.7.14 Error Injection Channel Descriptor n, Word0 (EICHD10_WORD0 - EICHD12_WORD0)

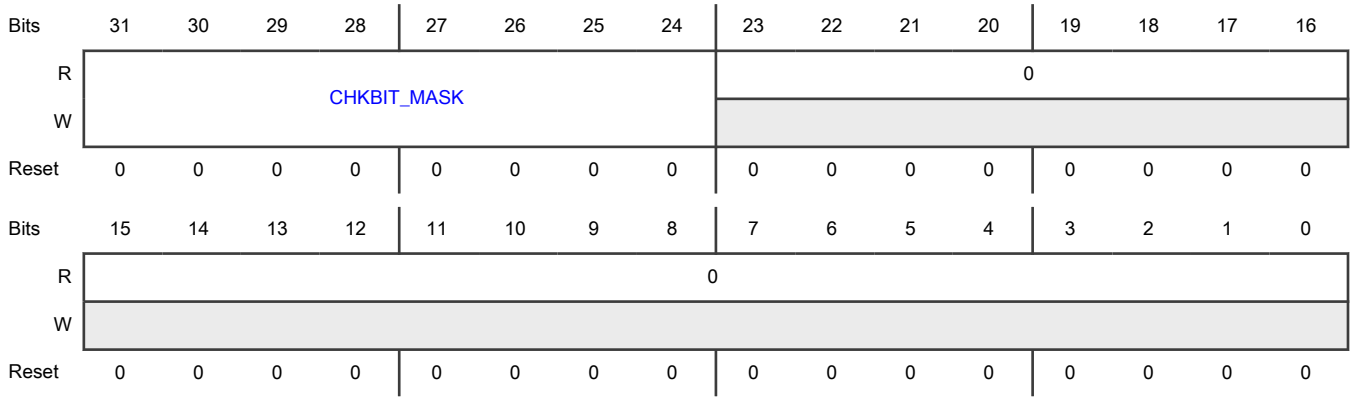
Offset

Register	Offset
EICHD10_WORD0	380h
EICHD11_WORD0	3C0h
EICHD12_WORD0	400h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-24 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[7:0] (8 bits wide), CHKBIT_MASK[7] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
23-0 —	Reserved

45.7.15 Error Injection Channel Descriptor 16, Word1 (EICHD16_WORD1)

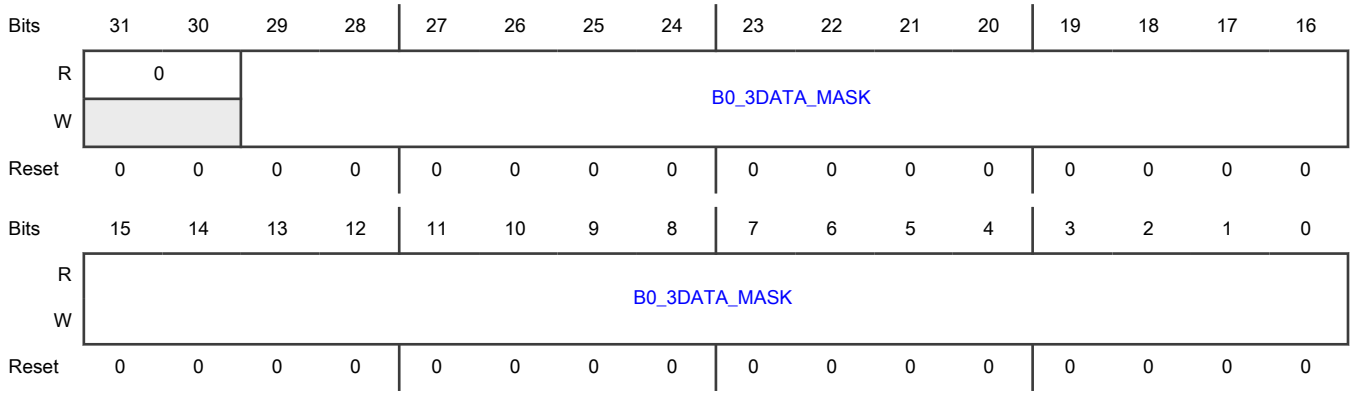
Offset

Register	Offset
EICHD16_WORD1	504h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-30 —	Reserved
29-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.7.16 Error Injection Channel Descriptor 17, Word1 (EICHD17_WORD1)

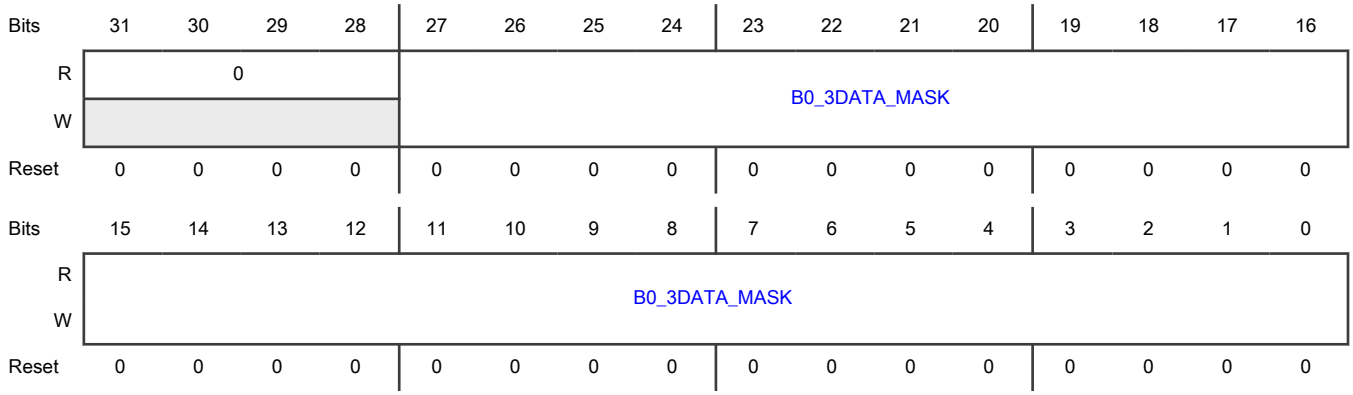
Offset

Register	Offset
EICHD17_WORD1	544h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-28 —	Reserved
27-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8 EIM_2 register descriptions

The EIM provides a programming model mapped to an on-platform peripheral slot.

Programming model access

All system bus masters can access the programming model:

- Only in supervisor mode
- Using only 32-bit (word) accesses

Any of the following attempted references to the programming model generates an error termination:

- In user mode
- Using non-32-bit access sizes
- To undefined (reserved) addresses

Attempted updates to the programming model while the EIM is in the midst of an operation result in non-deterministic behavior.

Error injection channel descriptor: function and structure

Each error injection channel descriptor:

- Specifies a mask that defines which bits of the read data and/or checkbit bus from target RAM are inverted on a read access.
- Consists of a 288-bit (36-byte) structure, composed of nine 32-bit words, in the EIM programming model. Unused words are not documented.
  - Word0 (EICHD*n*_WORD0), if present, defines the checkbit mask.
  - Word1 (EICHD*n*_WORD1) and additional words, if present, define the data mask. Word registers subsequent to Word1 are present only when required by the total width of the channel's data mask. Error injection channel descriptor: DATA_MASK details.

The multiple channel descriptors are organized sequentially.

Error injection channel descriptor: DATA_MASK details

For each channel: The following tables show the distribution of DATA_MASK's bits across the WORD registers. The first table shows the total width of DATA_MASK and the distribution of its bits across WORD1, WORD2, and WORD3. The second table shows the distribution of DATA_MASK's bits across WORD4 and subsequent registers.

Table 217. Error injection channel descriptor: DATA_MASK details

Channel	DATA_MASK total width (bits)	Specific bits of DATA_MASK in		
		WORD1	WORD2	WORD3
0	64	63-32	31-0	—
1	64	63-32	31-0	—
3	64	63-32	31-0	—
4	64	63-32	31-0	—
5	188	187-160	159-128	127-96
6	188	187-160	159-128	127-96
7	60	59-32	31-0	—
8	60	59-32	31-0	—
9	60	59-32	31-0	—
10	60	59-32	31-0	—
11	60	59-32	31-0	—
12	60	59-32	31-0	—
13	60	59-32	31-0	—
14	60	59-32	31-0	—
15	60	59-32	31-0	—
16	60	59-32	31-0	—
17	60	59-32	31-0	—

Table continues on the next page...

Table 217. Error injection channel descriptor: DATA_MASK details (continued)

Channel	DATA_MASK total width (bits)	Specific bits of DATA_MASK in		
		WORD1	WORD2	WORD3
18	60	59-32	31-0	—
21	8	7-0	—	—
22	188	187-160	159-128	127-96
23	32	31-0	—	—
24	16	15-0	—	—
25	16	15-0	—	—
26	10	9-0	—	—
27	4	3-0	—	—
28	8	7-0	—	—
29	28	27-0	—	—
30	18	17-0	—	—
31	18	17-0	—	—

Table 218. DATA_MASK bit: Channel-word mapping

Channel	Specific bits of DATA_MASK in				
	WORD4	WORD5	WORD6	WORD7	WORD8
5	95-64	63-32	31-0	—	—
6	95-64	63-32	31-0	—	—
22	95-64	63-32	31-0	—	—

45.8.1 EIM_2 memory map

EIM_2 base address: 4051_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Error Injection Module Configuration Register (EIMCR)	32	RW	0000_0000h
4h	Error Injection Channel Enable register (EICHEN)	32	RW	0000_0000h
100h	Error Injection Channel Descriptor 0, Word0 (EICHD0_WORD0)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
104h	Error Injection Channel Descriptor 0, Word1 (EICHD0_WORD1)	32	RW	0000_0000h
108h	Error Injection Channel Descriptor 0, Word2 (EICHD0_WORD2)	32	RW	0000_0000h
140h	Error Injection Channel Descriptor 1, Word0 (EICHD1_WORD0)	32	RW	0000_0000h
144h	Error Injection Channel Descriptor 1, Word1 (EICHD1_WORD1)	32	RW	0000_0000h
148h	Error Injection Channel Descriptor 1, Word2 (EICHD1_WORD2)	32	RW	0000_0000h
1C0h	Error Injection Channel Descriptor 3, Word0 (EICHD3_WORD0)	32	RW	0000_0000h
1C4h	Error Injection Channel Descriptor 3, Word1 (EICHD3_WORD1)	32	RW	0000_0000h
1C8h	Error Injection Channel Descriptor 3, Word2 (EICHD3_WORD2)	32	RW	0000_0000h
200h	Error Injection Channel Descriptor 4, Word0 (EICHD4_WORD0)	32	RW	0000_0000h
204h	Error Injection Channel Descriptor 4, Word1 (EICHD4_WORD1)	32	RW	0000_0000h
208h	Error Injection Channel Descriptor 4, Word2 (EICHD4_WORD2)	32	RW	0000_0000h
244h	Error Injection Channel Descriptor 5, Word1 (EICHD5_WORD1)	32	RW	0000_0000h
248h	Error Injection Channel Descriptor 5, Word2 (EICHD5_WORD2)	32	RW	0000_0000h
24Ch	Error Injection Channel Descriptor 5, Word3 (EICHD5_WORD3)	32	RW	0000_0000h
250h	Error Injection Channel Descriptor 5, Word4 (EICHD5_WORD4)	32	RW	0000_0000h
254h	Error Injection Channel Descriptor 5, Word5 (EICHD5_WORD5)	32	RW	0000_0000h
258h	Error Injection Channel Descriptor 5, Word6 (EICHD5_WORD6)	32	RW	0000_0000h
284h	Error Injection Channel Descriptor 6, Word1 (EICHD6_WORD1)	32	RW	0000_0000h
288h	Error Injection Channel Descriptor 6, Word2 (EICHD6_WORD2)	32	RW	0000_0000h
28Ch	Error Injection Channel Descriptor 6, Word3 (EICHD6_WORD3)	32	RW	0000_0000h
290h	Error Injection Channel Descriptor 6, Word4 (EICHD6_WORD4)	32	RW	0000_0000h
294h	Error Injection Channel Descriptor 6, Word5 (EICHD6_WORD5)	32	RW	0000_0000h
298h	Error Injection Channel Descriptor 6, Word6 (EICHD6_WORD6)	32	RW	0000_0000h
2C4h	Error Injection Channel Descriptor 7, Word1 (EICHD7_WORD1)	32	RW	0000_0000h
2C8h	Error Injection Channel Descriptor 7, Word2 (EICHD7_WORD2)	32	RW	0000_0000h
304h	Error Injection Channel Descriptor 8, Word1 (EICHD8_WORD1)	32	RW	0000_0000h
308h	Error Injection Channel Descriptor 8, Word2 (EICHD8_WORD2)	32	RW	0000_0000h
344h	Error Injection Channel Descriptor 9, Word1 (EICHD9_WORD1)	32	RW	0000_0000h
348h	Error Injection Channel Descriptor 9, Word2 (EICHD9_WORD2)	32	RW	0000_0000h
384h	Error Injection Channel Descriptor 10, Word1 (EICHD10_WORD1)	32	RW	0000_0000h
388h	Error Injection Channel Descriptor 10, Word2 (EICHD10_WORD2)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
3C4h	Error Injection Channel Descriptor 11, Word1 (EICHD11_WORD1)	32	RW	0000_0000h
3C8h	Error Injection Channel Descriptor 11, Word2 (EICHD11_WORD2)	32	RW	0000_0000h
404h	Error Injection Channel Descriptor 12, Word1 (EICHD12_WORD1)	32	RW	0000_0000h
408h	Error Injection Channel Descriptor 12, Word2 (EICHD12_WORD2)	32	RW	0000_0000h
444h	Error Injection Channel Descriptor 13, Word1 (EICHD13_WORD1)	32	RW	0000_0000h
448h	Error Injection Channel Descriptor 13, Word2 (EICHD13_WORD2)	32	RW	0000_0000h
484h	Error Injection Channel Descriptor 14, Word1 (EICHD14_WORD1)	32	RW	0000_0000h
488h	Error Injection Channel Descriptor 14, Word2 (EICHD14_WORD2)	32	RW	0000_0000h
4C4h	Error Injection Channel Descriptor 15, Word1 (EICHD15_WORD1)	32	RW	0000_0000h
4C8h	Error Injection Channel Descriptor 15, Word2 (EICHD15_WORD2)	32	RW	0000_0000h
504h	Error Injection Channel Descriptor 16, Word1 (EICHD16_WORD1)	32	RW	0000_0000h
508h	Error Injection Channel Descriptor 16, Word2 (EICHD16_WORD2)	32	RW	0000_0000h
544h	Error Injection Channel Descriptor 17, Word1 (EICHD17_WORD1)	32	RW	0000_0000h
548h	Error Injection Channel Descriptor 17, Word2 (EICHD17_WORD2)	32	RW	0000_0000h
584h	Error Injection Channel Descriptor 18, Word1 (EICHD18_WORD1)	32	RW	0000_0000h
588h	Error Injection Channel Descriptor 18, Word2 (EICHD18_WORD2)	32	RW	0000_0000h
644h	Error Injection Channel Descriptor 21, Word1 (EICHD21_WORD1)	32	RW	0000_0000h
684h	Error Injection Channel Descriptor 22, Word1 (EICHD22_WORD1)	32	RW	0000_0000h
688h	Error Injection Channel Descriptor 22, Word2 (EICHD22_WORD2)	32	RW	0000_0000h
68Ch	Error Injection Channel Descriptor 22, Word3 (EICHD22_WORD3)	32	RW	0000_0000h
690h	Error Injection Channel Descriptor 22, Word4 (EICHD22_WORD4)	32	RW	0000_0000h
694h	Error Injection Channel Descriptor 22, Word5 (EICHD22_WORD5)	32	RW	0000_0000h
698h	Error Injection Channel Descriptor 22, Word6 (EICHD22_WORD6)	32	RW	0000_0000h
6C0h	Error Injection Channel Descriptor 23, Word0 (EICHD23_WORD0)	32	RW	0000_0000h
6C4h	Error Injection Channel Descriptor 23, Word1 (EICHD23_WORD1)	32	RW	0000_0000h
700h	Error Injection Channel Descriptor 24, Word0 (EICHD24_WORD0)	32	RW	0000_0000h
704h	Error Injection Channel Descriptor 24, Word1 (EICHD24_WORD1)	32	RW	0000_0000h
740h	Error Injection Channel Descriptor 25, Word0 (EICHD25_WORD0)	32	RW	0000_0000h
744h	Error Injection Channel Descriptor 25, Word1 (EICHD25_WORD1)	32	RW	0000_0000h
784h	Error Injection Channel Descriptor 26, Word1 (EICHD26_WORD1)	32	RW	0000_0000h
7C4h	Error Injection Channel Descriptor 27, Word1 (EICHD27_WORD1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
804h	Error Injection Channel Descriptor 28, Word1 (EICHD28_WORD1)	32	RW	0000_0000h
844h	Error Injection Channel Descriptor 29, Word1 (EICHD29_WORD1)	32	RW	0000_0000h
884h	Error Injection Channel Descriptor 30, Word1 (EICHD30_WORD1)	32	RW	0000_0000h
8C4h	Error Injection Channel Descriptor 31, Word1 (EICHD31_WORD1)	32	RW	0000_0000h

45.8.2 Error Injection Module Configuration Register (EIMCR)

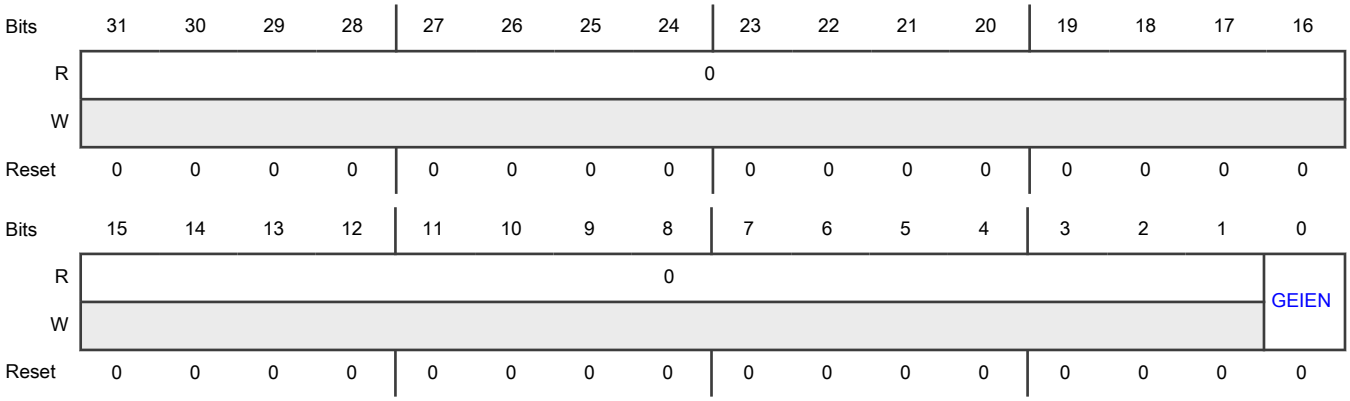
Offset

Register	Offset
EIMCR	0h

Function

The EIM Configuration Register is used to globally enable/disable the error injection function.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 GEIEN	Global Error Injection Enable This bit globally enables or disables the error injection function of the EIM. This field is initialized by hardware reset.

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Field	Function
	0b - Disabled 1b - Enabled

45.8.3 Error Injection Channel Enable register (EICHEN)

Offset

Register	Offset
EICHEN	4h

Function

Each field of the Error Injection Channel Enable register (EICHEN) is used to enable or disable the corresponding error injection channel.

NOTE

To enable an error injection channel, the Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EICH0EN	EICH1EN	0	EICH3EN	EICH4EN	EICH5EN	EICH6EN	EICH7EN	EICH8EN	EICH9EN	EICH10EN	EICH11EN	EICH12EN	EICH13EN	EICH14EN	EICH15EN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	EICH16EN	EICH17EN	EICH18EN	0	0	EICH21EN	EICH22EN	EICH23EN	EICH24EN	EICH25EN	EICH26EN	EICH27EN	EICH28EN	EICH29EN	EICH30EN	EICH31EN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EICH0EN	Error Injection Channel 0 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software.

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Field	Function
	Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 0 1b - Error injection is enabled on Error Injection Channel 0
30 EICH1EN	Error Injection Channel 1 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 1 1b - Error injection is enabled on Error Injection Channel 1
29 —	Reserved
28 EICH3EN	Error Injection Channel 3 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 3 1b - Error injection is enabled on Error Injection Channel 3
27 EICH4EN	Error Injection Channel 4 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 4 1b - Error injection is enabled on Error Injection Channel 4

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Field	Function
26 EICH5EN	Error Injection Channel 5 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 5 1b - Error injection is enabled on Error Injection Channel 5
25 EICH6EN	Error Injection Channel 6 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 6 1b - Error injection is enabled on Error Injection Channel 6
24 EICH7EN	Error Injection Channel 7 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 7 1b - Error injection is enabled on Error Injection Channel 7
23 EICH8EN	Error Injection Channel 8 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel.

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Field	Function
	0b - Error injection is disabled on Error Injection Channel 8 1b - Error injection is enabled on Error Injection Channel 8
22 EICH9EN	Error Injection Channel 9 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 9 1b - Error injection is enabled on Error Injection Channel 9
21 EICH10EN	Error Injection Channel 10 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 10 1b - Error injection is enabled on Error Injection Channel 10
20 EICH11EN	Error Injection Channel 11 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 11 1b - Error injection is enabled on Error Injection Channel 11
19 EICH12EN	Error Injection Channel 12 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection.

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Field	Function
	After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 12 1b - Error injection is enabled on Error Injection Channel 12
18 EICH13EN	Error Injection Channel 13 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 13 1b - Error injection is enabled on Error Injection Channel 13
17 EICH14EN	Error Injection Channel 14 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 14 1b - Error injection is enabled on Error Injection Channel 14
16 EICH15EN	Error Injection Channel 15 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 15 1b - Error injection is enabled on Error Injection Channel 15

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Field	Function
15 EICH16EN	Error Injection Channel 16 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 16 1b - Error injection is enabled on Error Injection Channel 16
14 EICH17EN	Error Injection Channel 17 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 17 1b - Error injection is enabled on Error Injection Channel 17
13 EICH18EN	Error Injection Channel 18 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 18 1b - Error injection is enabled on Error Injection Channel 18
12 —	Reserved
11 —	Reserved
10 EICH21EN	Error Injection Channel 21 Enable

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Field	Function
	This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 21 1b - Error injection is enabled on Error Injection Channel 21
9 EICH22EN	Error Injection Channel 22 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 22 1b - Error injection is enabled on Error Injection Channel 22
8 EICH23EN	Error Injection Channel 23 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 23 1b - Error injection is enabled on Error Injection Channel 23
7 EICH24EN	Error Injection Channel 24 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel.

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Field	Function
	0b - Error injection is disabled on Error Injection Channel 24 1b - Error injection is enabled on Error Injection Channel 24
6 EICH25EN	Error Injection Channel 25 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 25 1b - Error injection is enabled on Error Injection Channel 25
5 EICH26EN	Error Injection Channel 26 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 26 1b - Error injection is enabled on Error Injection Channel 26
4 EICH27EN	Error Injection Channel 27 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 27 1b - Error injection is enabled on Error Injection Channel 27
3 EICH28EN	Error Injection Channel 28 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection.

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Field	Function
	After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 28 1b - Error injection is enabled on Error Injection Channel 28
2 EICH29EN	Error Injection Channel 29 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 29 1b - Error injection is enabled on Error Injection Channel 29
1 EICH30EN	Error Injection Channel 30 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Optionally, a hardware error event from the logic being injected by this channel can also disable the injection if that feature is utilized at the instantiation of the EIM. Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 30 1b - Error injection is enabled on Error Injection Channel 30
0 EICH31EN	Error Injection Channel 31 Enable This field enables the corresponding error injection channel. The Global Error Injection Enable (EIMCR[GEIEN]) field must also be asserted to enable error injection. After error injection is enabled, all subsequent read accesses incur one or more bit inversions as defined in the corresponding EICHD*n*_WORD registers. Error injection remains in effect until the error injection channel is manually disabled via software. Optionally, a hardware error event from the logic being injected by this channel can also disable the injection if that feature is utilized at the instantiation of the EIM.

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Field	Function
	Any write to the corresponding EICHD*n*_WORD registers clears the corresponding EICHEN[EICH*n*EN] field, disabling the error injection channel. 0b - Error injection is disabled on Error Injection Channel 31 1b - Error injection is enabled on Error Injection Channel 31

45.8.4 Error Injection Channel Descriptor n, Word0 (EICHD0_WORD0 - EICHD4_WORD0)

Offset

Register	Offset
EICHD0_WORD0	100h
EICHD1_WORD0	140h
EICHD3_WORD0	1C0h
EICHD4_WORD0	200h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CHKBIT_MASK								0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24	Checkbit Mask

Table continues on the next page...

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Field	Function
CHKBIT_MASK	This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[7:0] (8 bits wide), CHKBIT_MASK[7] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
23-0 —	Reserved

45.8.5 Error Injection Channel Descriptor n, Word1 (EICHD0_WORD1 - EICHD4_WORD1)

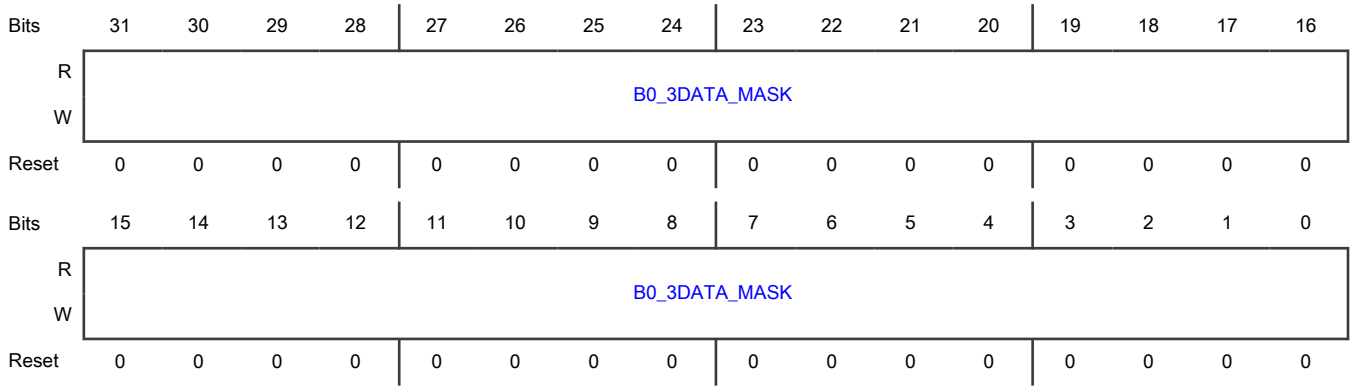
Offset

Register	Offset
EICHD0_WORD1	104h
EICHD1_WORD1	144h
EICHD3_WORD1	1C4h
EICHD4_WORD1	204h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.6 Error Injection Channel Descriptor n, Word2 (EICHD0_WORD2 - EICHD22_WORD2)

Offset

Register	Offset
EICHD0_WORD2	108h
EICHD1_WORD2	148h
EICHD3_WORD2	1C8h
EICHD4_WORD2	208h
EICHD5_WORD2	248h
EICHD6_WORD2	288h
EICHD7_WORD2	2C8h
EICHD8_WORD2	308h
EICHD9_WORD2	348h
EICHD10_WORD2	388h

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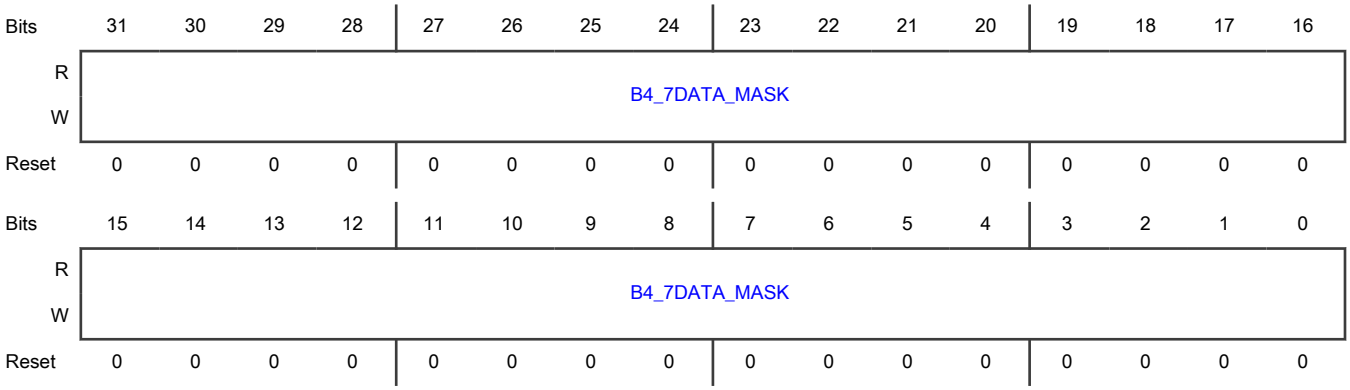
Register	Offset
EICHD11_WORD2	3C8h
EICHD12_WORD2	408h
EICHD13_WORD2	448h
EICHD14_WORD2	488h
EICHD15_WORD2	4C8h
EICHD16_WORD2	508h
EICHD17_WORD2	548h
EICHD18_WORD2	588h
EICHD22_WORD2	688h

Function

The third word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B4_7DATA_MASK correspond to bytes 4–7 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B4_7DATA_MASK	Data Mask Bytes 4-7 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B4_7DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details.

Table continues on the next page...

Field	Function
	0b - The corresponding bit of bytes 4-7 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 4-7 on the read data bus is inverted.

45.8.7 Error Injection Channel Descriptor n, Word1 (EICHD5_WORD1 - EICHD18_WORD1)

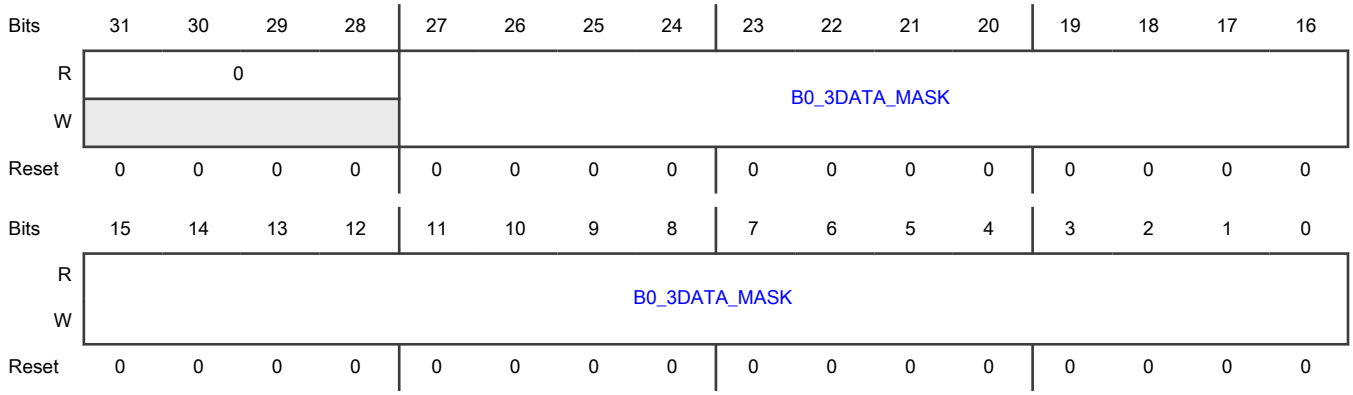
Offset

Register	Offset
EICHD5_WORD1	244h
EICHD6_WORD1	284h
EICHD7_WORD1	2C4h
EICHD8_WORD1	304h
EICHD9_WORD1	344h
EICHD10_WORD1	384h
EICHD11_WORD1	3C4h
EICHD12_WORD1	404h
EICHD13_WORD1	444h
EICHD14_WORD1	484h
EICHD15_WORD1	4C4h
EICHD16_WORD1	504h
EICHD17_WORD1	544h
EICHD18_WORD1	584h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-28 —	Reserved
27-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.8 Error Injection Channel Descriptor n, Word3 (EICHD5_WORD3 - EICHD22_WORD3)

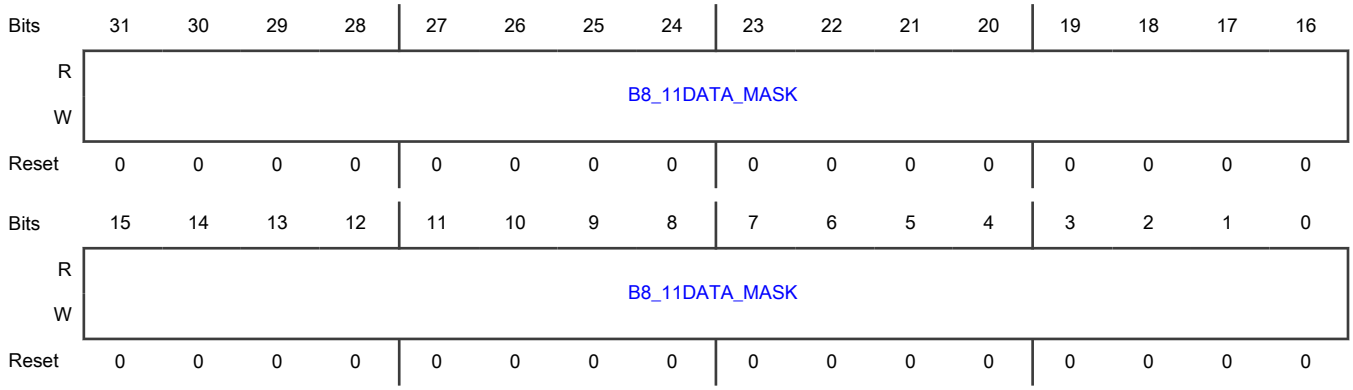
Offset

Register	Offset
EICHD5_WORD3	24Ch
EICHD6_WORD3	28Ch
EICHD22_WORD3	68Ch

Function

The fourth word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B8_11DATA_MASK correspond to bytes 8–11 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B8_11DATA_MASK	Data Mask Bytes 8-11 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B8_11DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 8-11 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 8-11 on the read data bus is inverted.

45.8.9 Error Injection Channel Descriptor n, Word4 (EICHD5_WORD4 - EICHD22_WORD4)

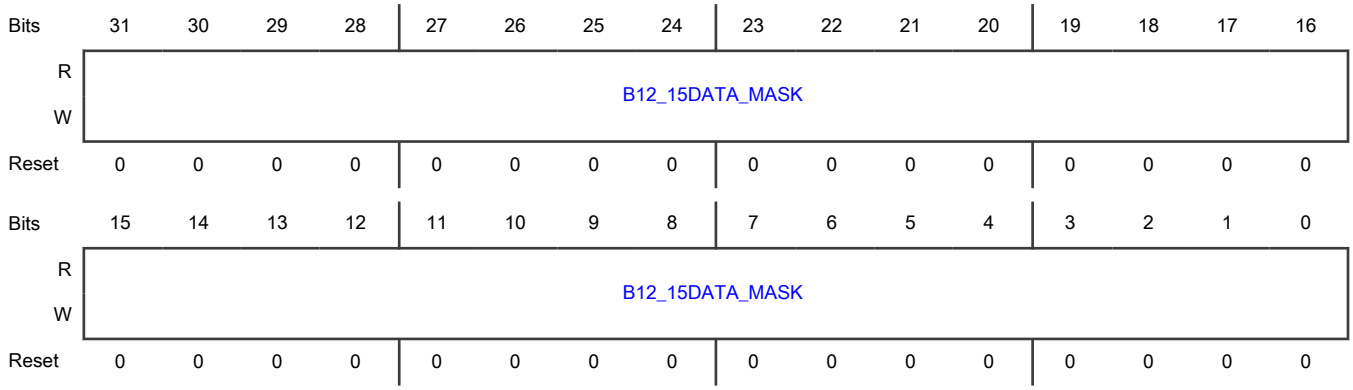
Offset

Register	Offset
EICHD5_WORD4	250h
EICHD6_WORD4	290h
EICHD22_WORD4	690h

Function

The fifth word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B12_15DATA_MASK correspond to bytes 12–15 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B12_15DATA_MASK	Data Mask Bytes 12-15 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B12_15DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 12-15 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 12-15 on the read data bus is inverted.

45.8.10 Error Injection Channel Descriptor n, Word5 (EICHD5_WORD5 - EICHD22_WORD5)

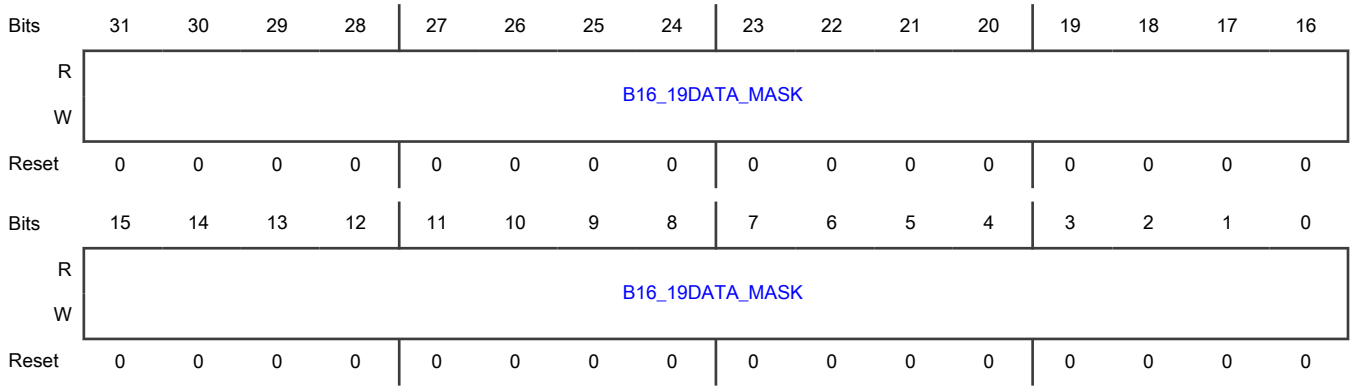
Offset

Register	Offset
EICHD5_WORD5	254h
EICHD6_WORD5	294h
EICHD22_WORD5	694h

Function

The sixth word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B16_19DATA_MASK correspond to bytes 16–19 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B16_19DATA_MASK	Data Mask Bytes 16-19 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B16_19DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 16-19 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 16-19 on the read data bus is inverted.

45.8.11 Error Injection Channel Descriptor n, Word6 (EICHD5_WORD6 - EICHD22_WORD6)

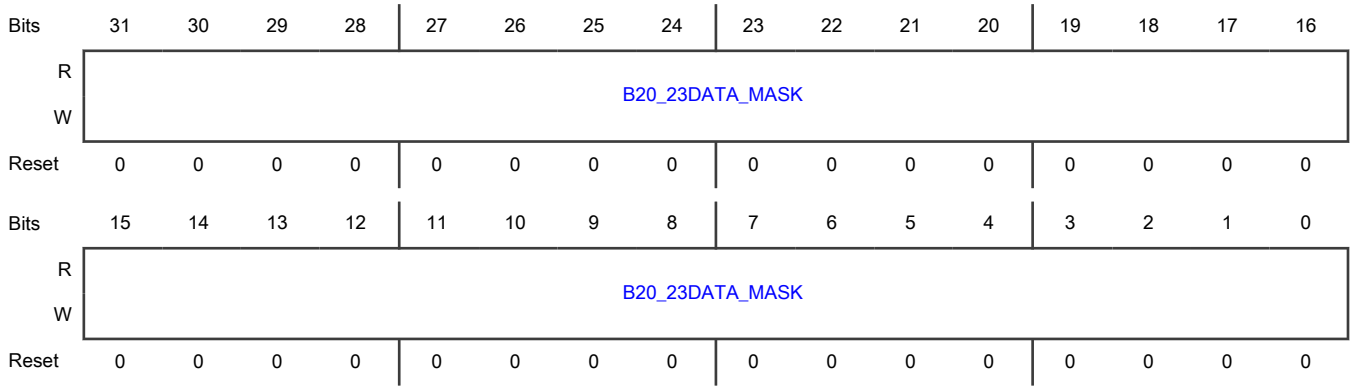
Offset

Register	Offset
EICHD5_WORD6	258h
EICHD6_WORD6	298h
EICHD22_WORD6	698h

Function

The seventh word of the Error Injection Channel Descriptor, when present, defines a right-justified mask field. The bits in B20_23DATA_MASK correspond to bytes 20–23 of the read data bus. Each bit specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B20_23DATA_MASK	Data Mask Bytes 20-23 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. **NOTE** For each channel: For the specific DATA_MASK bits to which B20_23DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 20-23 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 20-23 on the read data bus is inverted.

45.8.12 Error Injection Channel Descriptor 21, Word1 (EICHD21_WORD1)

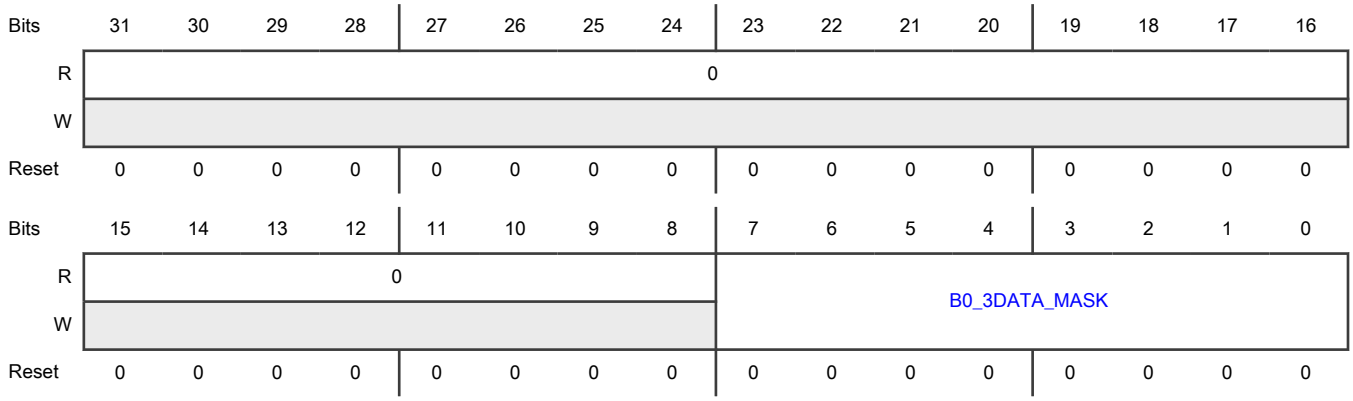
Offset

Register	Offset
EICHD21_WORD1	644h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.13 Error Injection Channel Descriptor 22, Word1 (EICHD22_WORD1)

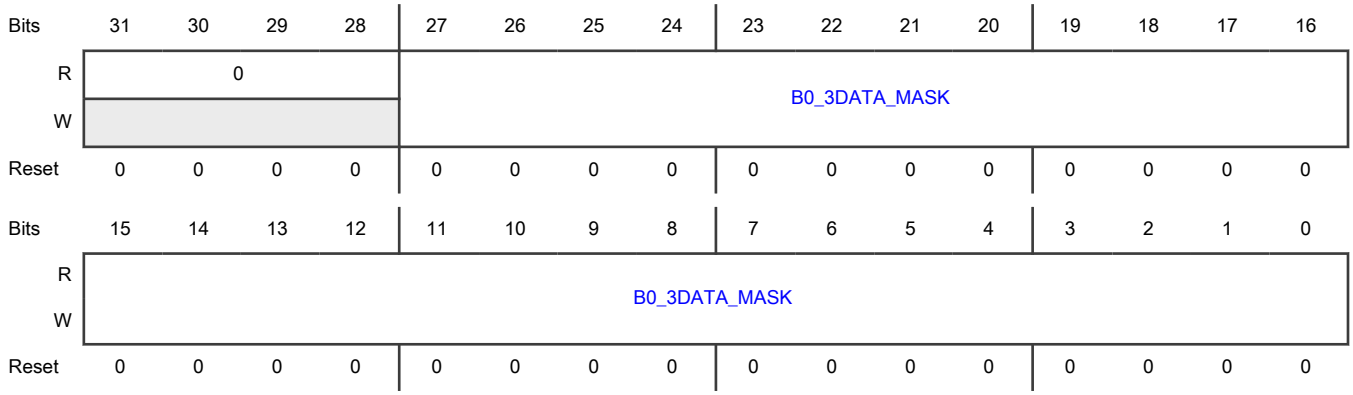
Offset

Register	Offset
EICHD22_WORD1	684h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-28 —	Reserved
27-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.14 Error Injection Channel Descriptor 23, Word0 (EICHD23_WORD0)

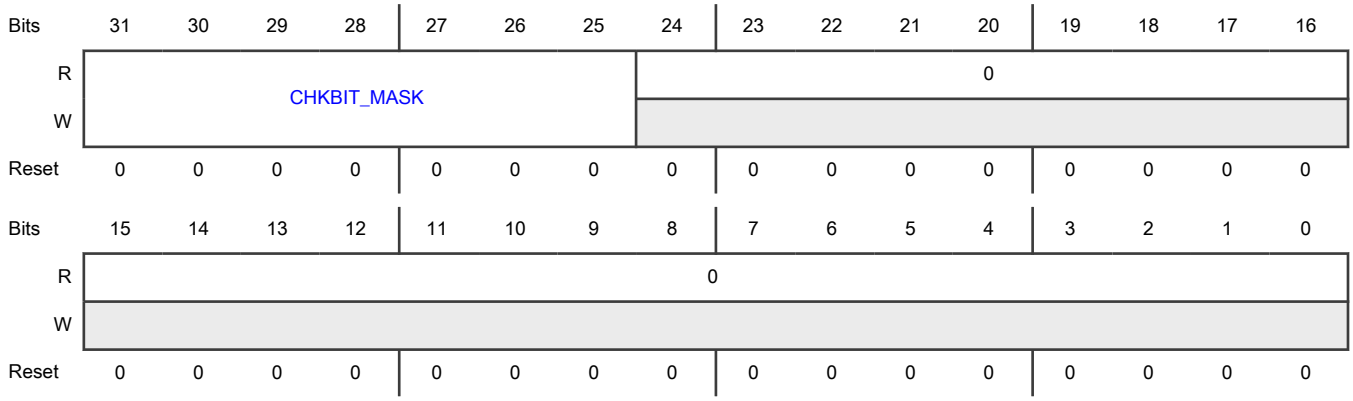
Offset

Register	Offset
EICHD23_WORD0	6C0h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-25 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[6:0] (7 bits wide), CHKBIT_MASK[6] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
24-0 —	Reserved

45.8.15 Error Injection Channel Descriptor 23, Word1 (EICHD23_WORD1)

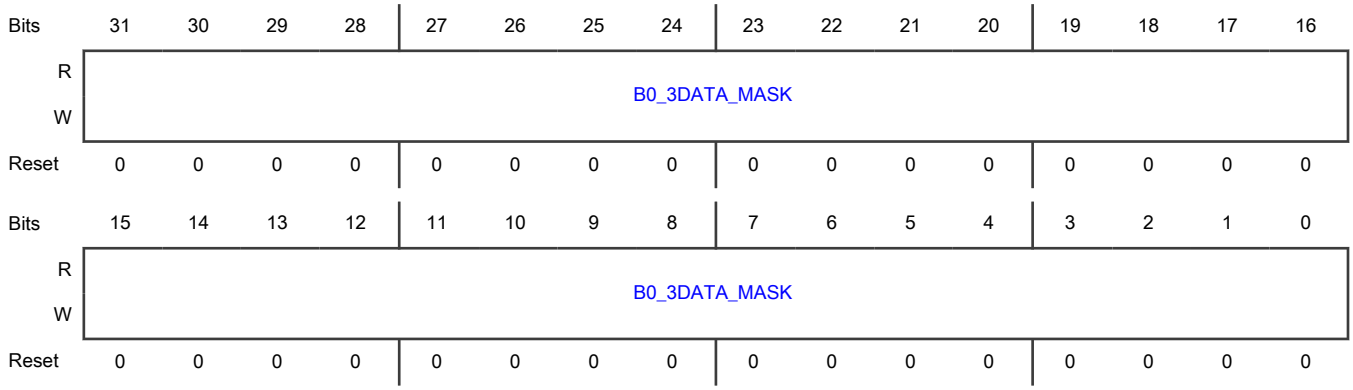
Offset

Register	Offset
EICHD23_WORD1	6C4h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.16 Error Injection Channel Descriptor n, Word0 (EICHD24_WORD0 - EICHD25_WORD0)

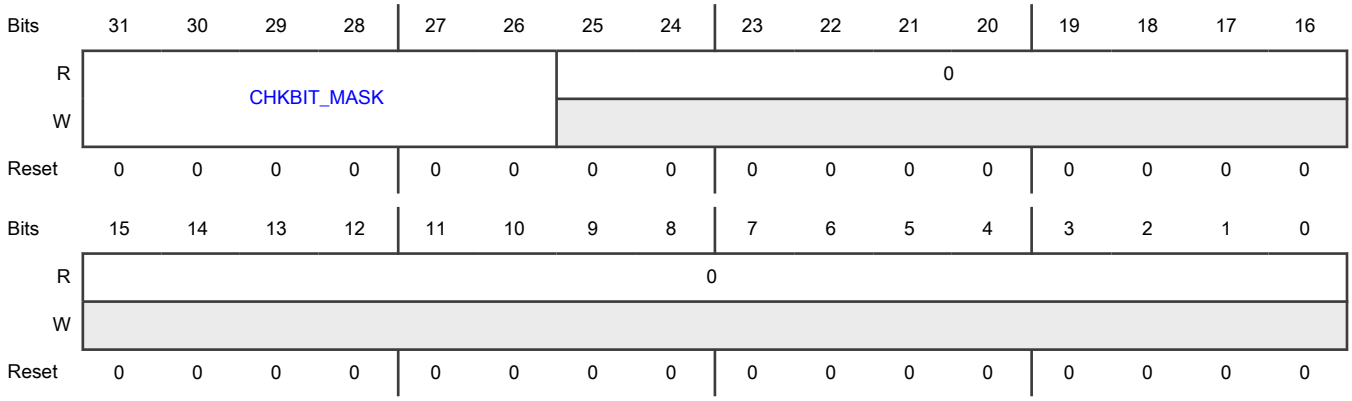
Offset

Register	Offset
EICHD24_WORD0	700h
EICHD25_WORD0	740h

Function

The first word of the Error Injection Channel Descriptor defines a left-justified mask field: CHKBIT_MASK. Each bit of CHKBIT_MASK specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified on read accesses. Successful write to this field clears the corresponding error injection channel valid bit, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-26 CHKBIT_MASK	Checkbit Mask This field defines a bit-mapped mask that specifies whether the corresponding bit of the checkbit bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. For any unique details about the mapping of CHKBIT_MASK's bits to a channel's target RAM, see the chip-specific EIM information. **NOTE** Because CHKBIT_MASK is left-justified, the highest bit in the bit range is always in the position of the most significant bit. For CHKBIT_MASK[5:0] (6 bits wide), CHKBIT_MASK[5] is in the position of the most significant bit. 0b - The corresponding bit of the checkbit bus remains unmodified. 1b - The corresponding bit of the checkbit bus is inverted.
25-0 —	Reserved

45.8.17 Error Injection Channel Descriptor n, Word1 (EICHD24_WORD1 - EICHD25_WORD1)

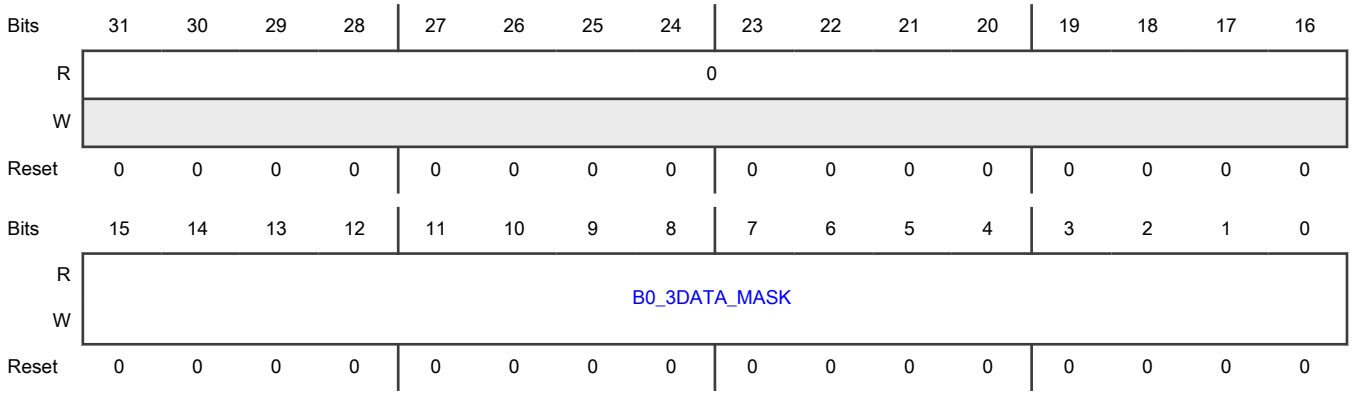
Offset

Register	Offset
EICHD24_WORD1	704h
EICHD25_WORD1	744h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.18 Error Injection Channel Descriptor 26, Word1 (EICHD26_WORD1)

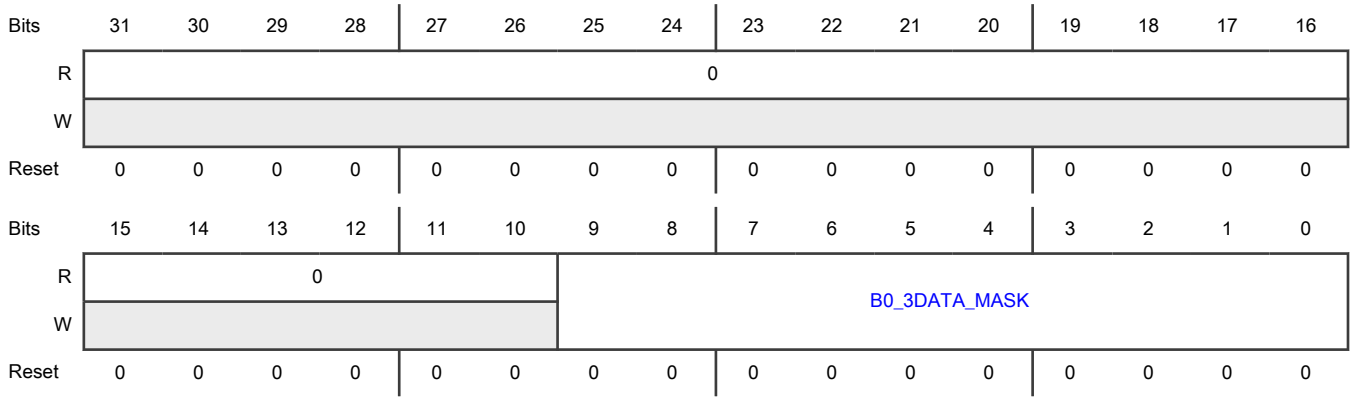
Offset

Register	Offset
EICHD26_WORD1	784h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-10 —	Reserved
9-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.19 Error Injection Channel Descriptor 27, Word1 (EICHD27_WORD1)

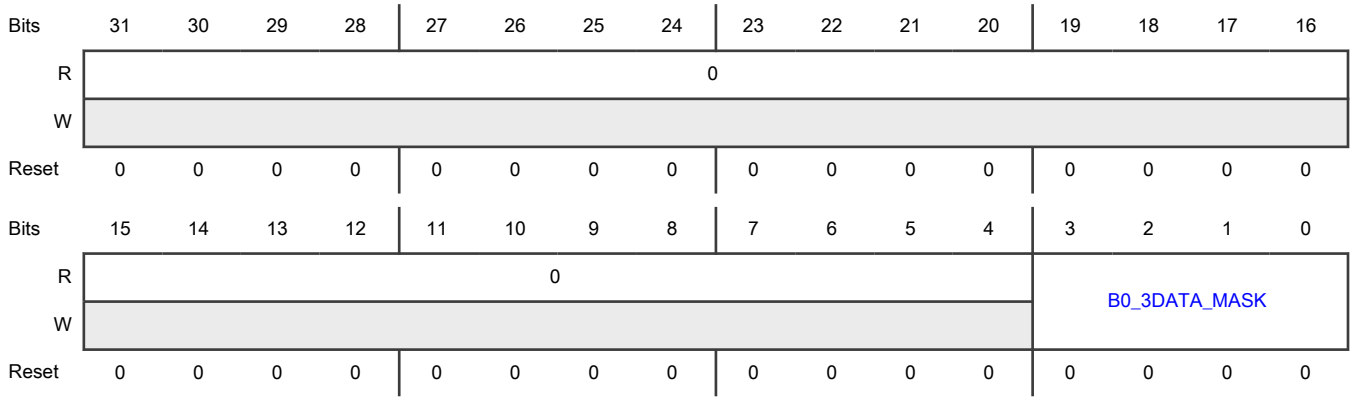
Offset

Register	Offset
EICHD27_WORD1	7C4h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.20 Error Injection Channel Descriptor 28, Word1 (EICHD28_WORD1)

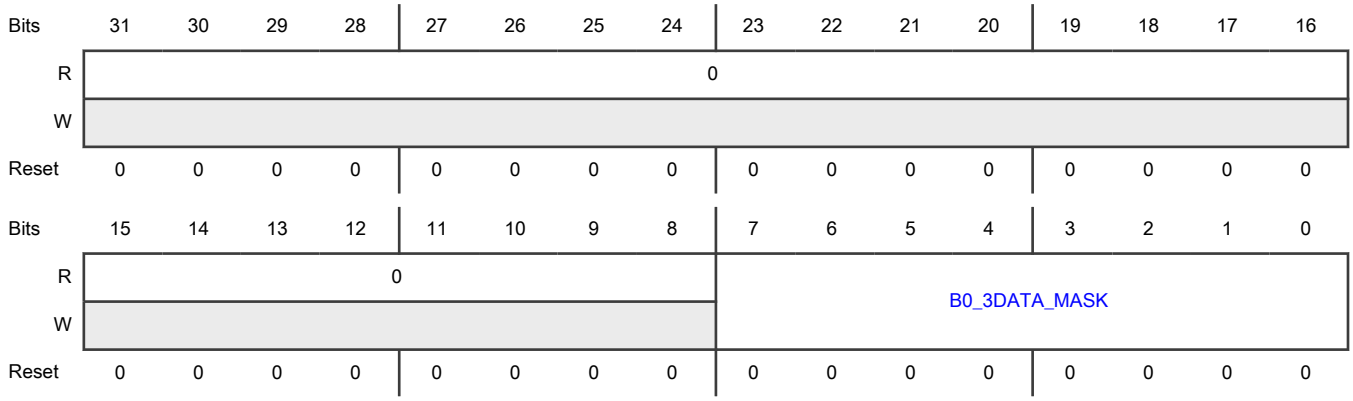
Offset

Register	Offset
EICHD28_WORD1	804h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.21 Error Injection Channel Descriptor 29, Word1 (EICHD29_WORD1)

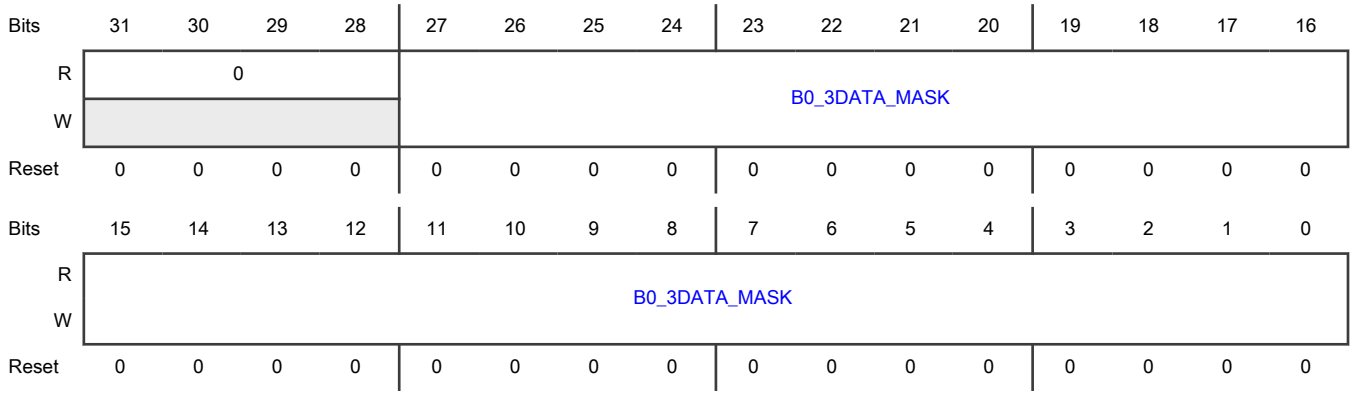
Offset

Register	Offset
EICHD29_WORD1	844h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-28 —	Reserved
27-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.8.22 Error Injection Channel Descriptor n, Word1 (EICHD30_WORD1 - EICHD31_WORD1)

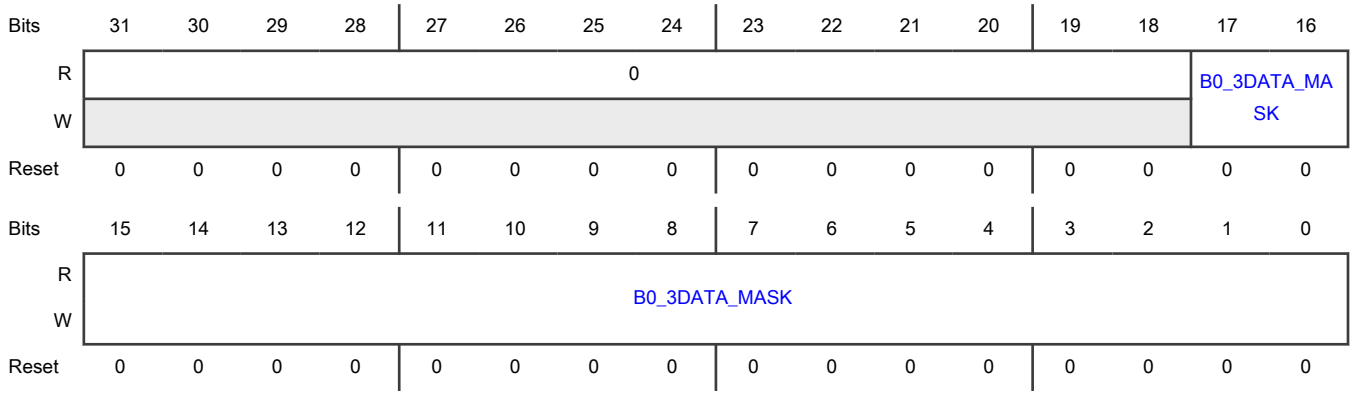
Offset

Register	Offset
EICHD30_WORD1	884h
EICHD31_WORD1	8C4h

Function

The second word of the Error Injection Channel Descriptor defines a right-justified mask field. The bits in B0_3DATA_MASK correspond to bytes 0–3 of the target bus. Each bit specifies whether the corresponding bit of the target bus should be inverted or remain unmodified on read accesses. A successful write to this field clears the corresponding error injection channel valid field, EICHEN[EICH*n*EN].

Diagram



Fields

Field	Function
31-18 —	Reserved
17-0 B0_3DATA_MASK	Data Mask Bytes 0-3 This field defines a bit-mapped mask that specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified. Writes to unimplemented bits are ignored. **NOTE** For the specific DATA_MASK bits to which B0_3DATA_MASK corresponds, See Error injection channel descriptor: DATA_MASK details. 0b - The corresponding bit of bytes 0-3 on the read data bus remains unmodified. 1b - The corresponding bit of bytes 0-3 on the read data bus is inverted.

45.9 Glossary

SEC-DED	Single error correction – double error detection
ECC	Error correction code

Chapter 46
Error Reporting Module (ERM)

46.1 Chip-specific ERM information

46.1.1 ERM channel mapping

ERM provides information on memory events associated with ECC and parity. It also provides you an option to enable interrupt notification for these events.

Table 219. ACP_ERM_0 channel mapping

CHANNEL NUMBER	MODULE	CAPTURED STATUS
0	SRAM0	single-bit error, multi-bit error, syndrome, absolute error address aligned to double, word (64-bit) boundary
1	SRAM1	single-bit error, multi-bit error, syndrome, absolute error address aligned to double, word (64-bit) boundary
2	CM7_0 I-cache tag RAM	single-bit error, multi-bit error
3	CM7_0 I-cache data RAM	single-bit error, multi-bit error
4	CM7_0 D-cache tag RAM	single-bit error, multi-bit error
5	CM7_0 D-cache data RAM	single-bit error, multi-bit error
6	CM7_1 I-cache tag RAM	single-bit error, multi-bit error
7	CM7_1 I-cache data RAM	single-bit error, multi-bit error
8	CM7_1 D-cache tag RAM	single-bit error, multi-bit error
9	CM7_1 D-cache data RAM	single-bit error, multi-bit error
10	CM7_0 ITCM	single-bit error, multi-bit error, syndrome, offset error address
11	CM7_0 D0TCM	single-bit error, multi-bit error, syndrome, offset error address
12	CM7_0 D1TCM	Single-bit error, multi-bit error, syndrome, offset error address[1]
13	CM7_1 ITCM	single-bit error, multi-bit error, syndrome, offset error address
14	CM7_1 D0TCM	single-bit error, multi-bit error, syndrome, offset error address
15	CM7_1 D1TCM	Single-bit error, multi-bit error, syndrome, offset error address[1]
16	DMA TCD	single-bit error, multi-bit error, syndrome, offset error address

Table continues on the next page...

Table 219. ACP_ERM_0 channel mapping (continued)

CHANNEL NUMBER	MODULE	CAPTURED STATUS
17	flash memory port p0	single-bit error, multi-bit error, absolute error address
18	flash memory port p1	single-bit error, multi-bit error, absolute error address
19	flash memory port p2	single-bit error, multi-bit error, absolute error address
20	-	
21	-	
22	-	
23	-	

1. For address reporting, bit 2 of the address is masked because this bit decides whether the access (read or write) is for D0TCM or D1TCM. For example, if the offset address is 0h or 8h, it is routed to D0TCM, but if the offset address is 4h or Ch, it is routed to D1TCM. The errors that are latched for these offset addresses are as follows:
   - Offset 0h : Address 0h is latched into the ERM channel corresponding to D0TCM.
   - Offset 4h : Address 0h is latched into the ERM channel corresponding to D1TCM.
   - Offset 8h : Address 8h is latched into the ERM channel corresponding to D0TCM.
   - Offset Ch : Address 8h is latched into the ERM channel corresponding to D1TCM.

Table 220. ACP_ERM_1 channel mapping

CHANNEL NUMBER	MODULE	CAPTURED STATUS
0	-	
1	-	
2	CM7_2 I-cache tag RAM	single-bit error, multi-bit error
3	CM7_2 I-cache data RAM	single-bit error, multi-bit error
4	CM7_2 D-cache tag RAM	single-bit error, multi-bit error
5	CM7_2 D-cache data RAM	single-bit error, multi-bit error
6	-	
7	-	
8	-	
9	-	
10	CM7_2 ITCM	single-bit error, multi-bit error, syndrome, offset error address
11	CM7_2 D0TCM	single-bit error, multi-bit error, syndrome, offset error address
12	CM7_2 D1TCM	single-bit error, multi-bit error, syndrome, offset error address

Table continues on the next page...

Table 220. ACP_ERM_1 channel mapping (continued)

CHANNEL NUMBER	MODULE	CAPTURED STATUS
13	-	
14	-	
15	-	
16	DMA1 TCD	single-bit error, multi-bit error, syndrome, offset error address
17	flash memory port p3	single-bit error, multi-bit error, absolute error address
18	dspss pmem core	single-bit error, multi-bit error, syndrome, offset error address (address is aligned to 32 bit offset memory address)
19	dspss pmem dsp	single-bit error, multi-bit error, syndrome, offset error address (address is aligned to 32 bit offset memory address)
20	dspss xmem even core	single-bit error, multi-bit error, syndrome, offset error address (address is aligned to 32 bit offset memory address)
21	dspss xmem even dsp	single-bit error, multi-bit error, syndrome, offset error address (address is aligned to 32 bit offset memory address)
22	dspss xmem odd core	single-bit error, multi-bit error, syndrome, offset error address (address is aligned to 32 bit offset memory address)
23	dspss xmem odd dsp	single-bit error, multi-bit error, syndrome, offset error address (address is aligned to 32 bit offset memory address)

NOTE

The eTPU ECC errors are not under ERM control. It needs to be reported separately.

46.1.2 Coolflux

COOLFLUX have Core and DSP. Both the components have two memories:

- PMEM : Program Memory
- XMEM: Data Memory

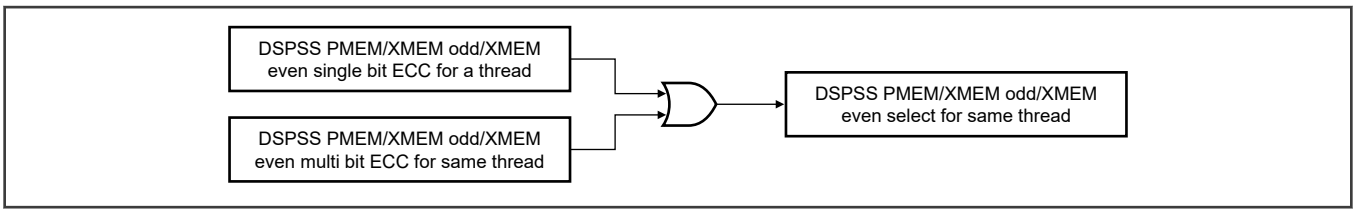
The XMEM memory is further divided into odd and even memory.

For PMEM and XMEM(both even and odd), single bit, multi bit and address ecc error (offset error address) and syndrome are generated.

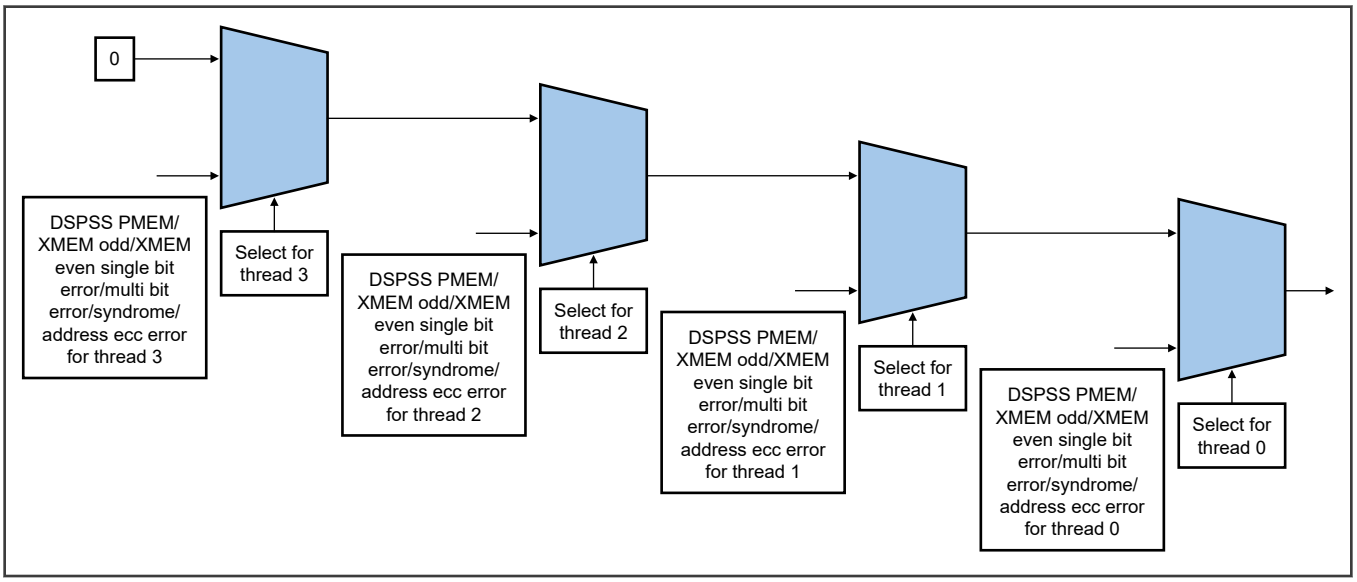
The single bit error, multi-bit error, syndrome and address ECC for both the memories from the CORE are directly connected to the ERM.

But DSP consist of 4 threads for each. All the data will be generated for all 4 threads. So, before connecting it to ERM the data from each thread is manipulated to generate single set of data to be connected to ERM. Along with that the information about that which thread is generating the error is provided to ERM with address ecc error for DSP. The data is manipulated the following way:

First for select to inform that which thread has been selected:



The single bit error, multi bit error, syndrome and address ecc for each thread is selected on the basis of select for each thread. A priority mux is used where 0 thread is at highest priority and 3 at lowest priority.



The output for the above priority mux will be connected to erm for all three single bit error, multi bit error and syndrome. For address ecc bit, the select bits will be concatenated from low to high priority level with the address and then provided to ERM.

[Select for thread 3, Select for thread 2, select for thread 1, select for thread 0, address ECC]

NOTE

The single bit errors for DSP are only connected to ERM but multi bit ones are connected to ERM as well as ported out to FCCU.

46.1.3 PMEM syndrome

The table below contains the ECC syndrome information for DSPSS PMEM (code memory). For an ECC error, the index of the bit equal to 1’b1 is equal to the index of the bit with error. For example if syndrome[2] = 1’b1 and other bits are 0, then bit 2 of the ECC has error.

The same is true for other ECC bits. This is valid for single bit error scenarios only.

For multibit error position/syndrome decoding is not useful.

Syndrome	Error bit position
7'b0000111	0
7'b0001011	1
7'b0001101	2

Table continues on the next page...

Table continued from the previous page...

Syndrome	Error bit position
7'b0001110	3
7'b0010011	4
7'b0010101	5
7'b0010110	6
7'b0011001	7
7'b0011010	8
7'b0011100	9
7'b0100011	10
7'b0100101	11
7'b0100110	12
7'b0101001	13
7'b0101010	14
7'b0101100	15
7'b0110001	16
7'b0110010	17
7'b0110100	18
7'b0111000	19
7'b1000011	20
7'b1000101	21
7'b1000110	22
7'b1001001	23
7'b1001010	24
7'b1001100	25
7'b1010001	26
7'b1010010	27
7'b1010100	28
7'b1011000	29
7'b1100001	30
7'b1100010	31
Any other value	No error in data

46.1.4 XMEM syndrome

The table below contains the ECC syndrome information for DSPSS XMEM (data memory). For an ECC error, the index of the bit equal to 1'b1 is equal to the index of the bit with error. For example if syndrome[2] = 1'b1 and other bits are 0, then bit 2 of the ECC has error.

The same is true for other ecc bits. This is valid for single bit error scenarios only.

For multibit error position/syndrome decoding is not useful.

Syndrome	Error bit position
6'b000111	0
6'b001011	1
6'b001101	2
6'b001110	3
6'b010011	4
6'b010101	5
6'b010110	6
6'b011001	7
6'b011010	8
6'b011100	9
6'b100011	10
6'b100101	11
6'b100110	12
6'b101001	13
6'b101010	14
6'b101100	15
Any other value	No error in data

46.2 Overview

The Error Reporting Module (ERM) provides information and optional interrupt notification on memory error events associated with ECC and parity. The ERM collects error events on memory accesses for memory arrays, such as flash memory, system RAM, or peripheral RAMs. ERM supports various channels for memory sources where each ERM channel is associated with a different memory module. See the chip-specific ERM information for details about supported memory sources and specific memory channel assignments. If memory supports ECC then ERM syndrome and error address information is captured along with error event. ERM does not receive this information in case of cache or memory with parity along with error event.

46.2.1 Features

The ERM includes these features:

- Optional interrupt notification on captured error events
- Capturing of address and syndrome information on single-bit correction and non-correctable ECC events
- Support for error event capturing for memory sources, with individual reporting fields and interrupt configuration per memory channel

- Recording the count value of the number of corrected error events

46.2.2 Block diagram

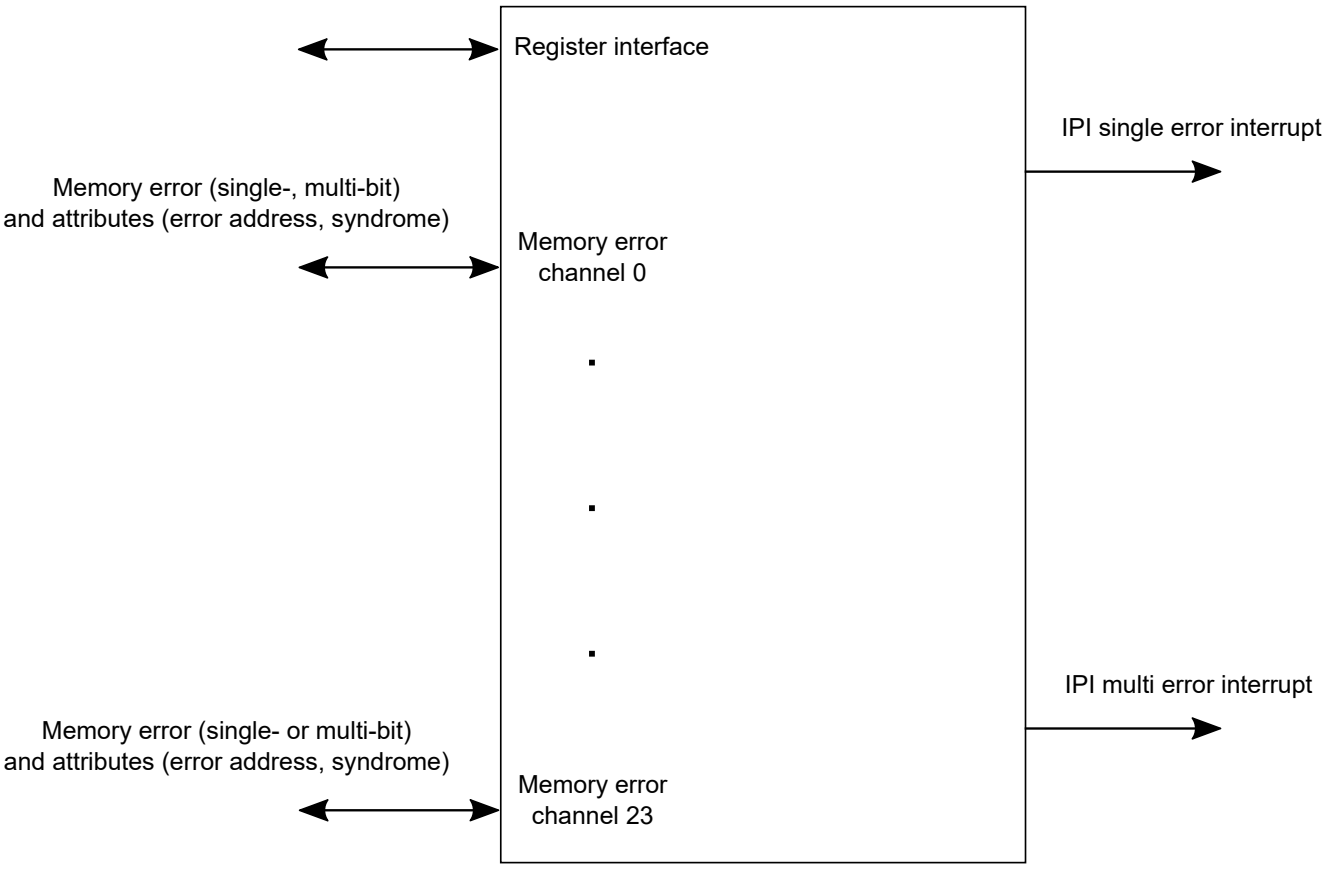


Figure 182. Block diagram

46.3 Functional description

46.3.1 Single-bit correction events

When a single-bit correction event on Memory *n* is detected, the ERM:

- Records the event by changing the value of the applicable Status Register bit SR*x*[SBC*n*] to 1.
- Increments the correctable error count value (until the counter reaches its maximum value): CORR_ERR_CNT*n*[COUNT].
- Records the corresponding access address that initiated the event in the Memory *n* Error Address Register: EAR*n* (if this register is present for the channel).
- Stores the corresponding ECC syndrome in the Memory *n* Error Syndrome Register: SYN*n* (if this register is present for the channel). This register identifies the bit position of the corrected data on single-bit data inversion.

The ERM holds event information only for the last reported event.

To clear the record of an event, write 1 to SR*x*[SBC*n*] to change its value to 0.

To reset the correctable error count value, write all zeros to CORR_ERR_CNT*n*[COUNT].

Optional interrupt notification for single-bit correction events

The ERM provides an option to generate an interrupt notification upon the report of a single-bit correction event. To enable single-bit correction interrupts for a channel:

1. To enable interrupt notification for single-bit correction events on Memory *n*, set CR*x*[ESCIE*n*] to 1.
2. Subsequently, when a single-bit correction event on Memory *n* is detected, the ERM:
   - Records the event and address, and stores the ECC syndrome as usual.
   - Additionally sends an interrupt notification corresponding to the event.
3. To clear both the record of an event and the corresponding interrupt notification, write 1 to SR*x*[SBC*n*] to change its value to 0.

46.3.2 Non-correctable error events

When a non-correctable ECC error event on Memory *n* is detected, the ERM:

- Records the event by changing the value of the applicable Status Register bit: SR*x*[NCE*n*] to 1.
- Records the corresponding access address that initiated the event in the Memory *n* Error Address Register: EAR*n* (if this register is present for the channel).
- Stores the corresponding ECC syndrome in the Memory *n* Error Syndrome Register: SYN*n* (if this register is present for the channel).
  - In the event of a non-correctable address bit inversion, SYN*n* identifies the pertinent address bit position.
  - In the event of a non-correctable, multi-bit data inversion, the syndrome value does not provide any additional diagnostic information.

The ERM holds event information only for the last reported event.

To clear the record of an event, write 1 to SR*x*[NCE*n*] to change its value to 0.

Optional interrupt notification for non-correctable error events

The ERM provides an option to generate an interrupt notification upon the report of a non-correctable ECC event. To enable non-correctable error interrupts for a channel:

1. To enable interrupt notifications for non-correctable error events on Memory *n*, set CR*x*[ENCIE*n*] to 1.
2. Subsequently, when a non-correctable error event on Memory *n* is detected, the ERM:
   - Records the event and address and stores the ECC syndrome as usual.
   - Additionally sends an interrupt notification corresponding to the event.
3. To clear both the record of an event and the corresponding interrupt notification, write 1 to SR*x*[NCE*n*] to change its value to 0.

NOTE

Parity errors can be mapped to non-correctable errors where error attributes like SYNDROME, ADDRESS are not provided.

46.4 Initialization

For each ERM channel supporting memory with ECC, prepare the corresponding memory array before enabling ERM interrupts about errors for that memory.

1. Initialize the memory to a known value so that the correct corresponding ECC codeword is stored.
2. During the memory's initialization, if the ERM captures information about any ECC error event, clear the corresponding SR*x*[SBC*n*] or SR*x*[NCE*n*] field that stores the record of the event.

3. Program the applicable CR*x*[ESCIE*n*] and CR*x*[ENCIE*n*] fields to enable ERM interrupts as desired.

46.5 ERM register descriptions

You can access the programming model:

- Only in supervisor mode
- Using only 32-bit (word) accesses

Any of the following attempted references to the programming model generates an error termination:

- In user mode
- Using non-32-bit access sizes

Based on the design implementation, the following XFR error behavior is evident at the IPS interface.

- Within the ERM memory map, an XFR error is evident at reserved addresses from location 20h to FFh.
- No XFR error is evident at reserved addresses in memory spaces allocated to each channel. For example: For channel 0, for read/write accesses to reserved address 10Ch, the XFR error is 0.
- For accesses to locations beyond the addresses allocated for the final channel, the XFR error is 1.

NOTE

- See the chip-specific ERM information at the beginning of this chapter for details on Memory channel mapping.
- To access the channel registers, corresponding memory channel clock must be enabled.

46.5.1 ERM memory map

ERM_0 base address: 4025_C000h

ERM_1 base address: 4000_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	ERM Configuration Register 0 (CR0)	32	RW	0000_0000h
4h	ERM Configuration Register 1 (CR1)	32	RW	0000_0000h
8h	ERM Configuration Register 2 (CR2)	32	RW	0000_0000h
10h	ERM Status Register 0 (SR0)	32	RW	0000_0000h
14h	ERM Status Register 1 (SR1)	32	RW	0000_0000h
18h	ERM Status Register 2 (SR2)	32	RW	0000_0000h
100h	ERM Memory 0 Error Address Register (EAR0)	32	R	0000_0000h
104h	ERM Memory 0 Syndrome Register (SYN0)	32	R	0000_0000h
108h	ERM Memory 0 Correctable Error Count Register (CORR_ERR_CNT0)	32	RW	0000_0000h
110h	ERM Memory 1 Error Address Register (EAR1)	32	R	0000_0000h
114h	ERM Memory 1 Syndrome Register (SYN1)	32	R	0000_0000h
118h	ERM Memory 1 Correctable Error Count Register (CORR_ERR_CNT1)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
128h	ERM Memory 2 Correctable Error Count Register (CORR_ERR_CNT2)	32	RW	0000_0000h
138h	ERM Memory 3 Correctable Error Count Register (CORR_ERR_CNT3)	32	RW	0000_0000h
148h	ERM Memory 4 Correctable Error Count Register (CORR_ERR_CNT4)	32	RW	0000_0000h
158h	ERM Memory 5 Correctable Error Count Register (CORR_ERR_CNT5)	32	RW	0000_0000h
168h	ERM Memory 6 Correctable Error Count Register (CORR_ERR_CNT6)	32	RW	0000_0000h
178h	ERM Memory 7 Correctable Error Count Register (CORR_ERR_CNT7)	32	RW	0000_0000h
188h	ERM Memory 8 Correctable Error Count Register (CORR_ERR_CNT8)	32	RW	0000_0000h
198h	ERM Memory 9 Correctable Error Count Register (CORR_ERR_CNT9)	32	RW	0000_0000h
1A0h	ERM Memory 10 Error Address Register (EAR10)	32	R	0000_0000h
1A4h	ERM Memory 10 Syndrome Register (SYN10)	32	R	0000_0000h
1A8h	ERM Memory 10 Correctable Error Count Register (CORR_ERR_CNT10)	32	RW	0000_0000h
1B0h	ERM Memory 11 Error Address Register (EAR11)	32	R	0000_0000h
1B4h	ERM Memory 11 Syndrome Register (SYN11)	32	R	0000_0000h
1B8h	ERM Memory 11 Correctable Error Count Register (CORR_ERR_CNT11)	32	RW	0000_0000h
1C0h	ERM Memory 12 Error Address Register (EAR12)	32	R	0000_0000h
1C4h	ERM Memory 12 Syndrome Register (SYN12)	32	R	0000_0000h
1C8h	ERM Memory 12 Correctable Error Count Register (CORR_ERR_CNT12)	32	RW	0000_0000h
1D0h	ERM Memory 13 Error Address Register (EAR13)	32	R	0000_0000h
1D4h	ERM Memory 13 Syndrome Register (SYN13)	32	R	0000_0000h
1D8h	ERM Memory 13 Correctable Error Count Register (CORR_ERR_CNT13)	32	RW	0000_0000h
1E0h	ERM Memory 14 Error Address Register (EAR14)	32	R	0000_0000h
1E4h	ERM Memory 14 Syndrome Register (SYN14)	32	R	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
1E8h	ERM Memory 14 Correctable Error Count Register (CORR_ERR_CNT14)	32	RW	0000_0000h
1F0h	ERM Memory 15 Error Address Register (EAR15)	32	R	0000_0000h
1F4h	ERM Memory 15 Syndrome Register (SYN15)	32	R	0000_0000h
1F8h	ERM Memory 15 Correctable Error Count Register (CORR_ERR_CNT15)	32	RW	0000_0000h
200h	ERM Memory 16 Error Address Register (EAR16)	32	R	0000_0000h
204h	ERM Memory 16 Syndrome Register (SYN16)	32	R	0000_0000h
208h	ERM Memory 16 Correctable Error Count Register (CORR_ERR_CNT16)	32	RW	0000_0000h
210h	ERM Memory 17 Error Address Register (EAR17)	32	R	0000_0000h
218h	ERM Memory 17 Correctable Error Count Register (CORR_ERR_CNT17)	32	RW	0000_0000h
220h	ERM Memory 18 Error Address Register (EAR18)	32	R	0000_0000h
224h	ERM Memory 18 Syndrome Register (SYN18)	32	R	0000_0000h
228h	ERM Memory 18 Correctable Error Count Register (CORR_ERR_CNT18)	32	RW	0000_0000h
230h	ERM Memory 19 Error Address Register (EAR19)	32	R	0000_0000h
234h	ERM Memory 19 Syndrome Register (SYN19)	32	R	0000_0000h
238h	ERM Memory 19 Correctable Error Count Register (CORR_ERR_CNT19)	32	RW	0000_0000h
240h	ERM Memory 20 Error Address Register (EAR20)	32	R	0000_0000h
244h	ERM Memory 20 Syndrome Register (SYN20)	32	R	0000_0000h
248h	ERM Memory 20 Correctable Error Count Register (CORR_ERR_CNT20)	32	RW	0000_0000h
250h	ERM Memory 21 Error Address Register (EAR21)	32	R	0000_0000h
254h	ERM Memory 21 Syndrome Register (SYN21)	32	R	0000_0000h
258h	ERM Memory 21 Correctable Error Count Register (CORR_ERR_CNT21)	32	RW	0000_0000h
260h	ERM Memory 22 Error Address Register (EAR22)	32	R	0000_0000h
264h	ERM Memory 22 Syndrome Register (SYN22)	32	R	0000_0000h
268h	ERM Memory 22 Correctable Error Count Register (CORR_ERR_CNT22)	32	RW	0000_0000h
270h	ERM Memory 23 Error Address Register (EAR23)	32	R	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
274h	ERM Memory 23 Syndrome Register (SYN23)	32	R	0000_0000h
278h	ERM Memory 23 Correctable Error Count Register (CORR_ERR_CNT23)	32	RW	0000_0000h

46.5.2 ERM Configuration Register 0 (CR0)

Offset

Register	Offset
CR0	0h

Function

This 32-bit control register configures the interrupt notification capability for available channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ESCIE0	ENCIE0	0		ESCIE1	ENCIE1	0		ESCIE2	ENCIE2	0		ESCIE3	ENCIE3	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ESCIE4	ENCIE4	0		ESCIE5	ENCIE5	0		ESCIE6	ENCIE6	0		ESCIE7	ENCIE7	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 ESCIE0	ESCIE0 Enable Memory 0 Single Correction Interrupt Notification **NOTE** This field is not supported in every instance. The following table includes only supported registers.

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR0</td></tr>
</table>
0b - Interrupt notification of Memory 0 single-bit correction events is disabled.
1b - Interrupt notification of Memory 0 single-bit correction events is enabled.
</td></tr>
<tr><td>30
ENCIE0</td><td>ENCIE0
Enable Memory 0 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR0</td></tr>
</table>
0b - Interrupt notification of Memory 0 non-correctable error events is disabled.
1b - Interrupt notification of Memory 0 non-correctable error events is enabled.
</td></tr>
<tr><td>29-28
—</td><td>Reserved</td></tr>
<tr><td>27
ESCIE1</td><td>ESCIE1
Enable Memory 1 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR0</td></tr>
</table>
0b - Interrupt notification of Memory 1 single-bit correction events is disabled.
</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>1b - Interrupt notification of Memory 1 single-bit correction events is enabled.</td></tr>
<tr><td>26
ENCIE1</td><td>ENCIE1
Enable Memory 1 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>CR0</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>CR0</td></tr></table>
0b - Interrupt notification of Memory 1 non-correctable error events is disabled.
1b - Interrupt notification of Memory 1 non-correctable error events is enabled.</td></tr>
<tr><td>25-24
—</td><td>Reserved</td></tr>
<tr><td>23
ESCIE2</td><td>ESCIE2
Enable Memory 2 Single Correction Interrupt Notification
0b - Interrupt notification of Memory 2 single-bit correction events is disabled.
1b - Interrupt notification of Memory 2 single-bit correction events is enabled.</td></tr>
<tr><td>22
ENCIE2</td><td>ENCIE2
Enable Memory 2 Non-Correctable Interrupt Notification
0b - Interrupt notification of Memory 2 non-correctable error events is disabled.
1b - Interrupt notification of Memory 2 non-correctable error events is enabled.</td></tr>
<tr><td>21-20
—</td><td>Reserved</td></tr>
<tr><td>19
ESCIE3</td><td>ESCIE3
Enable Memory 3 Single Correction Interrupt Notification
0b - Interrupt notification of Memory 3 single-bit correction events is disabled.
1b - Interrupt notification of Memory 3 single-bit correction events is enabled.</td></tr>
<tr><td>18
ENCIE3</td><td>ENCIE3
Enable Memory 3 Non-Correctable Interrupt Notification</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Interrupt notification of Memory 3 non-correctable error events is disabled. 1b - Interrupt notification of Memory 3 non-correctable error events is enabled.
17-16 —	Reserved
15 ESCIE4	ESCIE4 Enable Memory 4 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 4 single-bit correction events is disabled. 1b - Interrupt notification of Memory 4 single-bit correction events is enabled.
14 ENCIE4	ENCIE4 Enable Memory 4 Non-Correctable Interrupt Notification 0b - Interrupt notification of Memory 4 non-correctable error events is disabled. 1b - Interrupt notification of Memory 4 non-correctable error events is enabled.
13-12 —	Reserved
11 ESCIE5	ESCIE5 Enable Memory 5 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 5 single-bit correction events is disabled. 1b - Interrupt notification of Memory 5 single-bit correction events is enabled.
10 ENCIE5	ENCIE5 Enable Memory 5 Non-Correctable Interrupt Notification 0b - Interrupt notification of Memory 5 non-correctable error events is disabled. 1b - Interrupt notification of Memory 5 non-correctable error events is enabled.
9-8 —	Reserved
7 ESCIE6	ESCIE6 Enable Memory 6 Single Correction Interrupt Notification **NOTE** This field is not supported in every instance. The following table includes only supported registers.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR0</td></tr>
</table>
0b - Interrupt notification of Memory 6 single-bit correction events is disabled.
1b - Interrupt notification of Memory 6 single-bit correction events is enabled.
</td></tr>
<tr><td>6
ENCIE6</td><td>ENCIE6
Enable Memory 6 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR0</td></tr>
</table>
0b - Interrupt notification of Memory 6 non-correctable error events is disabled.
1b - Interrupt notification of Memory 6 non-correctable error events is enabled.
</td></tr>
<tr><td>5-4
—</td><td>Reserved</td></tr>
<tr><td>3
ESCIE7</td><td>ESCIE7
Enable Memory 7 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR0</td></tr>
</table>
0b - Interrupt notification of Memory 7 single-bit correction events is disabled.
</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Interrupt notification of Memory 7 single-bit correction events is enabled.
2 ENCIE7	ENCIE7 Enable Memory 7 Non-Correctable Interrupt Notification **NOTE** This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
ERM_0	CR0	—
ERM_1	—	CR0

Field	Function
	0b - Interrupt notification of Memory 7 non-correctable error events is disabled. 1b - Interrupt notification of Memory 7 non-correctable error events is enabled.
1-0 —	Reserved

46.5.3 ERM Configuration Register 1 (CR1)

Offset

Register	Offset
CR1	4h

Function

This 32-bit control register configures the interrupt notification capability for available channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ESCIE8	ENCIE8	0		ESCIE9	ENCIE9	0		ESCIE10	ENCIE10	0		ESCIE11	ENCIE11	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ESCIE12	ENCIE12	0		ESCIE13	ENCIE13	0		ESCIE14	ENCIE14	0		ESCIE15	ENCIE15	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>31
ESCIE8</td><td>ESCIE8
Enable Memory 8 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>CR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>CR1</td></tr></table>
0b - Interrupt notification of Memory 8 single-bit correction events is disabled.
1b - Interrupt notification of Memory 8 single-bit correction events is enabled.</td></tr>
<tr><td>30
ENCIE8</td><td>ENCIE8
Enable Memory 8 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>CR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>CR1</td></tr></table>
0b - Interrupt notification of Memory 8 non-correctable error events is disabled.
1b - Interrupt notification of Memory 8 non-correctable error events is enabled.</td></tr>
<tr><td>29-28
—</td><td>Reserved</td></tr>
<tr><td>27
ESCIE9</td><td>ESCIE9
Enable Memory 9 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR1</td></tr>
</table>
0b - Interrupt notification of Memory 9 single-bit correction events is disabled.
1b - Interrupt notification of Memory 9 single-bit correction events is enabled.
</td></tr>
<tr><td>26
ENCIE9</td><td>ENCIE9
Enable Memory 9 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR1</td></tr>
</table>
0b - Interrupt notification of Memory 9 non-correctable error events is disabled.
1b - Interrupt notification of Memory 9 non-correctable error events is enabled.</td></tr>
<tr><td>25-24
—</td><td>Reserved</td></tr>
<tr><td>23
ESCIE10</td><td>ESCIE10
Enable Memory 10 Single Correction Interrupt Notification
0b - Interrupt notification of Memory 10 single-bit correction events is disabled.
1b - Interrupt notification of Memory 10 single-bit correction events is enabled.</td></tr>
<tr><td>22
ENCIE10</td><td>ENCIE10
Enable Memory 10 Non-Correctable Interrupt Notification
0b - Interrupt notification of Memory 10 non-correctable error events is disabled.
1b - Interrupt notification of Memory 10 non-correctable error events is enabled.</td></tr>
<tr><td>21-20
—</td><td>Reserved</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
19 ESCIE11	ESCIE11 Enable Memory 11 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 11 single-bit correction events is disabled. 1b - Interrupt notification of Memory 11 single-bit correction events is enabled.
18 ENCIE11	ENCIE11 Enable Memory 11 Non-Correctable Interrupt Notification 0b - Interrupt notification of Memory 11 non-correctable error events is disabled. 1b - Interrupt notification of Memory 11 non-correctable error events is enabled.
17-16 —	Reserved
15 ESCIE12	ESCIE12 Enable Memory 12 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 12 single-bit correction events is disabled. 1b - Interrupt notification of Memory 12 single-bit correction events is enabled.
14 ENCIE12	ENCIE12 Enable Memory 12 Non-Correctable Interrupt Notification 0b - Interrupt notification of Memory 12 non-correctable error events is disabled. 1b - Interrupt notification of Memory 12 non-correctable error events is enabled.
13-12 —	Reserved
11 ESCIE13	ESCIE13 Enable Memory 13 Single Correction Interrupt Notification **NOTE** This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
ERM_0	CR1	—
ERM_1	—	CR1

0b - Interrupt notification of Memory 13 single-bit correction events is disabled.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>1b - Interrupt notification of Memory 13 single-bit correction events is enabled.</td></tr>
<tr><td>10
ENCIE13</td><td>ENCIE13
Enable Memory 13 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>CR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>CR1</td></tr></table>
0b - Interrupt notification of Memory 13 non-correctable error events is disabled.
1b - Interrupt notification of Memory 13 non-correctable error events is enabled.</td></tr>
<tr><td>9-8
—</td><td>Reserved</td></tr>
<tr><td>7
ESCIE14</td><td>ESCIE14
Enable Memory 14 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>CR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>CR1</td></tr></table>
0b - Interrupt notification of Memory 14 single-bit correction events is disabled.
1b - Interrupt notification of Memory 14 single-bit correction events is enabled.</td></tr>
<tr><td>6
ENCIE14</td><td>ENCIE14
Enable Memory 14 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR1</td></tr>
</table>
0b - Interrupt notification of Memory 14 non-correctable error events is disabled.
1b - Interrupt notification of Memory 14 non-correctable error events is enabled.
</td></tr>
<tr><td>5-4
—</td><td>Reserved</td></tr>
<tr><td>3
ESCIE15</td><td>ESCIE15
Enable Memory 15 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR1</td></tr>
</table>
0b - Interrupt notification of Memory 15 single-bit correction events is disabled.
1b - Interrupt notification of Memory 15 single-bit correction events is enabled.
</td></tr>
<tr><td>2
ENCIE15</td><td>ENCIE15
Enable Memory 15 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>CR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>CR1</td></tr>
</table>
0b - Interrupt notification of Memory 15 non-correctable error events is disabled.
</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Interrupt notification of Memory 15 non-correctable error events is enabled.
1-0 —	Reserved

46.5.4 ERM Configuration Register 2 (CR2)

Offset

Register	Offset
CR2	8h

Function

This 32-bit control register configures the interrupt notification capability for available channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ESCIE16	ENCIE16	0		ESCIE17	ENCIE17	0		ESCIE18	ENCIE18	0		ESCIE19	ENCIE19	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ESCIE20	ENCIE20	0		ESCIE21	ENCIE21	0		ESCIE22	ENCIE22	0		ESCIE23	ENCIE23	0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 ESCIE16	ESCIE16 Enable Memory 16 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 16 single-bit correction events is disabled. 1b - Interrupt notification of Memory 16 single-bit correction events is enabled.
30 ENCIE16	ENCIE16 Enable Memory 16 Non-Correctable Interrupt Notification

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Interrupt notification of Memory 16 non-correctable error events is disabled. 1b - Interrupt notification of Memory 16 non-correctable error events is enabled.
29-28 —	Reserved
27 ESCIE17	ESCIE17 Enable Memory 17 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 17 single-bit correction events is disabled. 1b - Interrupt notification of Memory 17 single-bit correction events is enabled.
26 ENCIE17	ENCIE17 Enable Memory 17 Non-Correctable Interrupt Notification 0b - Interrupt notification of Memory 17 non-correctable error events is disabled. 1b - Interrupt notification of Memory 17 non-correctable error events is enabled.
25-24 —	Reserved
23 ESCIE18	ESCIE18 Enable Memory 18 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 18 single-bit correction events is disabled. 1b - Interrupt notification of Memory 18 single-bit correction events is enabled.
22 ENCIE18	ENCIE18 Enable Memory 18 Non-Correctable Interrupt Notification 0b - Interrupt notification of Memory 18 non-correctable error events is disabled. 1b - Interrupt notification of Memory 18 non-correctable error events is enabled.
21-20 —	Reserved
19 ESCIE19	ESCIE19 Enable Memory 19 Single Correction Interrupt Notification 0b - Interrupt notification of Memory 19 single-bit correction events is disabled. 1b - Interrupt notification of Memory 19 single-bit correction events is enabled.
18 ENCIE19	ENCIE19 Enable Memory 19 Non-Correctable Interrupt Notification

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Interrupt notification of Memory 19 non-correctable error events is disabled.
1b - Interrupt notification of Memory 19 non-correctable error events is enabled.</td></tr>
<tr><td>17-16
—</td><td>Reserved</td></tr>
<tr><td>15
ESCIE20</td><td>ESCIE20
Enable Memory 20 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>—</td><td>CR2</td></tr><tr><td>ERM_1</td><td>CR2</td><td>—</td></tr></table>0b - Interrupt notification of Memory 20 single-bit correction events is disabled.
1b - Interrupt notification of Memory 20 single-bit correction events is enabled.</td></tr>
<tr><td>14
ENCIE20</td><td>ENCIE20
Enable Memory 20 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>—</td><td>CR2</td></tr><tr><td>ERM_1</td><td>CR2</td><td>—</td></tr></table>0b - Interrupt notification of Memory 20 non-correctable error events is disabled.
1b - Interrupt notification of Memory 20 non-correctable error events is enabled.</td></tr>
<tr><td>13-12
—</td><td>Reserved</td></tr>
<tr><td>11
ESCIE21</td><td>ESCIE21
Enable Memory 21 Single Correction Interrupt Notification</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>CR2</td></tr>
<tr><td>ERM_1</td><td>CR2</td><td>—</td></tr>
</table>
0b - Interrupt notification of Memory 21 single-bit correction events is disabled.
1b - Interrupt notification of Memory 21 single-bit correction events is enabled.
</td></tr>
<tr><td>10
ENCIE21</td><td>
ENCIE21
Enable Memory 21 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>CR2</td></tr>
<tr><td>ERM_1</td><td>CR2</td><td>—</td></tr>
</table>
0b - Interrupt notification of Memory 21 non-correctable error events is disabled.
1b - Interrupt notification of Memory 21 non-correctable error events is enabled.
</td></tr>
<tr><td>9-8
—</td><td>Reserved</td></tr>
<tr><td>7
ESCIE22</td><td>
ESCIE22
Enable Memory 22 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>CR2</td></tr>
</table>
</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_1</td><td>CR2</td><td>—</td></tr>
</table>
0b - Interrupt notification of Memory 22 single-bit correction events is disabled.
1b - Interrupt notification of Memory 22 single-bit correction events is enabled.
</td></tr>
<tr><td>6
ENCIE22</td><td>ENCIE22
Enable Memory 22 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>CR2</td></tr>
<tr><td>ERM_1</td><td>CR2</td><td>—</td></tr>
</table>
0b - Interrupt notification of Memory 22 non-correctable error events is disabled.
1b - Interrupt notification of Memory 22 non-correctable error events is enabled.
</td></tr>
<tr><td>5-4
—</td><td>Reserved</td></tr>
<tr><td>3
ESCIE23</td><td>ESCIE23
Enable Memory 23 Single Correction Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>CR2</td></tr>
<tr><td>ERM_1</td><td>CR2</td><td>—</td></tr>
</table>
0b - Interrupt notification of Memory 23 single-bit correction events is disabled.
1b - Interrupt notification of Memory 23 single-bit correction events is enabled.
</td></tr>
<tr><td>2</td><td>ENCIE23</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>ENCIE23</td><td>Enable Memory 23 Non-Correctable Interrupt Notification
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>CR2</td></tr>
<tr><td>ERM_1</td><td>CR2</td><td>—</td></tr>
</table>
0b - Interrupt notification of Memory 23 non-correctable error events is disabled.
1b - Interrupt notification of Memory 23 non-correctable error events is enabled.</td></tr>
<tr><td>1-0
—</td><td>Reserved</td></tr>
</table>

46.5.5 ERM Status Register 0 (SR0)

Offset

Register	Offset
SR0	10h

Function

This 32-bit status register reports error events for available channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SBC0	NCE0	0		SBC1	NCE1	0		SBC2	NCE2	0		SBC3	NCE3	0	
W	W1C	W1C			W1C	W1C			W1C	W1C			W1C	W1C		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SBC4	NCE4	0		SBC5	NCE5	0		SBC6	NCE6	0		SBC7	NCE7	0	
W	W1C	W1C			W1C	W1C			W1C	W1C			W1C	W1C		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>31
SBC0</td><td>SBC0
Memory 0 Single-Bit Correction Event
Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE0] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR0</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR0</td></tr></table>
0b - No single-bit correction event on Memory 0 detected.
1b - Single-bit correction event on Memory 0 detected.</td></tr>
<tr><td>30
NCE0</td><td>NCE0
Memory 0 Non-Correctable Error Event
Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE0] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR0</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR0</td></tr></table>
0b - No non-correctable error event on Memory 0 detected.
1b - Non-correctable error event on Memory 0 detected.</td></tr>
<tr><td>29-28
—</td><td>Reserved</td></tr>
<tr><td>27
SBC1</td><td>SBC1
Memory 1 Single-Bit Correction Event
Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE1] is enabled.</td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>SR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>SR0</td></tr>
</table>
0b - No single-bit correction event on Memory 1 detected.
1b - Single-bit correction event on Memory 1 detected.
</td></tr>
<tr><td>26
NCE1</td><td>NCE1
Memory 1 Non-Correctable Error Event
Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE1] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>SR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>SR0</td></tr>
</table>
0b - No non-correctable error event on Memory 1 detected.
1b - Non-correctable error event on Memory 1 detected.
</td></tr>
<tr><td>25-24
—</td><td>Reserved</td></tr>
<tr><td>23
SBC2</td><td>SBC2
Memory 2 Single-Bit Correction Event
Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE2] is enabled.
0b - No single-bit correction event on Memory 2 detected.
1b - Single-bit correction event on Memory 2 detected.</td></tr>
<tr><td>22</td><td>NCE2</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
NCE2	Memory 2 Non-Correctable Error Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE2] is enabled. 0b - No non-correctable error event on Memory 2 detected. 1b - Non-correctable error event on Memory 2 detected.
21-20 —	Reserved
19 SBC3	SBC3 Memory 3 Single-Bit Correction Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE3] is enabled. 0b - No single-bit correction event on Memory 3 detected. 1b - Single-bit correction event on Memory 3 detected.
18 NCE3	NCE3 Memory 3 Non-Correctable Error Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE3] is enabled. 0b - No non-correctable error event on Memory 3 detected. 1b - Non-correctable error event on Memory 3 detected.
17-16 —	Reserved
15 SBC4	SBC4 Memory 4 Single-Bit Correction Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE4] is enabled. 0b - No single-bit correction event on Memory 4 detected. 1b - Single-bit correction event on Memory 4 detected.
14 NCE4	NCE4 Memory 4 Non-Correctable Error Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE4] is enabled. 0b - No non-correctable error event on Memory 4 detected. 1b - Non-correctable error event on Memory 4 detected.

Table continues on the next page...

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Field	Function
13-12 —	Reserved
11 SBC5	SBC5 Memory 5 Single-Bit Correction Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE5] is enabled. 0b - No single-bit correction event on Memory 5 detected. 1b - Single-bit correction event on Memory 5 detected.
10 NCE5	NCE5 Memory 5 Non-Correctable Error Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE5] is enabled. 0b - No non-correctable error event on Memory 5 detected. 1b - Non-correctable error event on Memory 5 detected.
9-8 —	Reserved
7 SBC6	SBC6 Memory 6 Single-Bit Correction Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE6] is enabled. **NOTE** This field is not supported in every instance. The following table includes only supported registers. 0b - No single-bit correction event on Memory 6 detected. 1b - Single-bit correction event on Memory 6 detected.
6 NCE6	NCE6 Memory 6 Non-Correctable Error Event

Instance	Field supported in	Field not supported in
ERM_0	SR0	—
ERM_1	—	SR0

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE6] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR0</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR0</td></tr></table>
0b - No non-correctable error event on Memory 6 detected.
1b - Non-correctable error event on Memory 6 detected.</td></tr>
<tr><td>5-4
—</td><td>Reserved</td></tr>
<tr><td>3
SBC7</td><td>SBC7
Memory 7 Single-Bit Correction Event
Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ESCIE7] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR0</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR0</td></tr></table>
0b - No single-bit correction event on Memory 7 detected.
1b - Single-bit correction event on Memory 7 detected.</td></tr>
<tr><td>2
NCE7</td><td>NCE7
Memory 7 Non-Correctable Error Event
Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR0[ENCIE7] is enabled.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>SR0</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>SR0</td></tr>
</table>
0b - No non-correctable error event on Memory 7 detected.
1b - Non-correctable error event on Memory 7 detected.
</td></tr>
<tr><td>1-0
—</td><td>Reserved</td></tr>
</table>

46.5.6 ERM Status Register 1 (SR1)

Offset

Register	Offset
SR1	14h

Function

This 32-bit status register reports error events for available channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SBC8	NCE8	0		SBC9	NCE9	0		SBC10	NCE10	0		SBC11	NCE11	0	
W	W1C	W1C			W1C	W1C			W1C	W1C			W1C	W1C		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SBC12	NCE12	0		SBC13	NCE13	0		SBC14	NCE14	0		SBC15	NCE15	0	
W	W1C	W1C			W1C	W1C			W1C	W1C			W1C	W1C		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>31
SBC8</td><td>SBC8
Memory 8 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE8] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR1</td></tr></table>
0b - No single-bit correction event on Memory 8 detected.
1b - Single-bit correction event on Memory 8 detected.</td></tr>
<tr><td>30
NCE8</td><td>NCE8
Memory 8 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE8] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR1</td></tr></table>
0b - No non-correctable error event on Memory 8 detected.
1b - Non-correctable error event on Memory 8 detected.</td></tr>
<tr><td>29-28
—</td><td>Reserved</td></tr>
<tr><td>27
SBC9</td><td>SBC9
Memory 9 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE9] is enabled.</td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>SR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>SR1</td></tr>
</table>
0b - No single-bit correction event on Memory 9 detected.
1b - Single-bit correction event on Memory 9 detected.
</td></tr>
<tr><td>26
NCE9</td><td>
NCE9
Memory 9 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE9] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>SR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>SR1</td></tr>
</table>
0b - No non-correctable error event on Memory 9 detected.
1b - Non-correctable error event on Memory 9 detected.
</td></tr>
<tr><td>25-24
—</td><td>Reserved</td></tr>
<tr><td>23
SBC10</td><td>
SBC10
Memory 10 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE10] is enabled.
0b - No single-bit correction event on Memory 10 detected.
1b - Single-bit correction event on Memory 10 detected.
</td></tr>
<tr><td>22</td><td>NCE10</td></tr>
</table>

Table continues on the next page...

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Field	Function
NCE10	Memory 10 Non-Correctable Error Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE10] is enabled. 0b - No non-correctable error event on Memory 10 detected. 1b - Non-correctable error event on Memory 10 detected.
21-20 —	Reserved
19 SBC11	SBC11 Memory 11 Single-Bit Correction Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE11] is enabled. 0b - No single-bit correction event on Memory 11 detected. 1b - Single-bit correction event on Memory 11 detected.
18 NCE11	NCE11 Memory 11 Non-Correctable Error Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE11] is enabled. 0b - No non-correctable error event on Memory 11 detected. 1b - Non-correctable error event on Memory 11 detected.
17-16 —	Reserved
15 SBC12	SBC12 Memory 12 Single-Bit Correction Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE12] is enabled. 0b - No single-bit correction event on Memory 12 detected. 1b - Single-bit correction event on Memory 12 detected.
14 NCE12	NCE12 Memory 12 Non-Correctable Error Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE12] is enabled. 0b - No non-correctable error event on Memory 12 detected. 1b - Non-correctable error event on Memory 12 detected.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>13-12
—</td><td>Reserved</td></tr>
<tr><td>11
SBC13</td><td>SBC13
Memory 13 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE13] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR1</td></tr></table>
0b - No single-bit correction event on Memory 13 detected.
1b - Single-bit correction event on Memory 13 detected.</td></tr>
<tr><td>10
NCE13</td><td>NCE13
Memory 13 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE13] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR1</td></tr></table>
0b - No non-correctable error event on Memory 13 detected.
1b - Non-correctable error event on Memory 13 detected.</td></tr>
<tr><td>9-8
—</td><td>Reserved</td></tr>
<tr><td>7</td><td>SBC14</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>SBC14</td><td>Memory 14 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE14] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR1</td></tr></table>
0b - No single-bit correction event on Memory 14 detected.
1b - Single-bit correction event on Memory 14 detected.</td></tr>
<tr><td>6
NCE14</td><td>NCE14
Memory 14 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE14] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>SR1</td><td>—</td></tr><tr><td>ERM_1</td><td>—</td><td>SR1</td></tr></table>
0b - No non-correctable error event on Memory 14 detected.
1b - Non-correctable error event on Memory 14 detected.</td></tr>
<tr><td>5-4
—</td><td>Reserved</td></tr>
<tr><td>3
SBC15</td><td>SBC15
Memory 15 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ESCIE15] is enabled.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>SR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>SR1</td></tr>
</table>
0b - No single-bit correction event on Memory 15 detected.
1b - Single-bit correction event on Memory 15 detected.
</td></tr>
<tr><td>2
NCE15</td><td>
NCE15
Memory 15 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR1[ENCIE15] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>SR1</td><td>—</td></tr>
<tr><td>ERM_1</td><td>—</td><td>SR1</td></tr>
</table>
0b - No non-correctable error event on Memory 15 detected.
1b - Non-correctable error event on Memory 15 detected.
</td></tr>
<tr><td>1-0
—</td><td>Reserved</td></tr>
</table>

46.5.7 ERM Status Register 2 (SR2)

Offset

Register	Offset
SR2	18h

Function

This 32-bit status register reports error events for available channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SBC16	NCE16	0		SBC17	NCE17	0		SBC18	NCE18	0		SBC19	NCE19	0	
W	W1C	W1C			W1C	W1C			W1C	W1C			W1C	W1C		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SBC20	NCE20	0		SBC21	NCE21	0		SBC22	NCE22	0		SBC23	NCE23	0	
W	W1C	W1C			W1C	W1C			W1C	W1C			W1C	W1C		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 SBC16	SBC16 Memory 16 Single-Bit Correction Event Write 1 to clear this field.This write also clears the corresponding interrupt notification, if CR2[ESCIE16] is enabled. 0b - No single-bit correction event on Memory 16 detected. 1b - Single-bit correction event on Memory 16 detected.
30 NCE16	NCE16 Memory 16 Non-Correctable Error Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE16] is enabled. 0b - No non-correctable error event on Memory 16 detected. 1b - Non-correctable error event on Memory 16 detected.
29-28 —	Reserved
27 SBC17	SBC17 Memory 17 Single-Bit Correction Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ESCIE17] is enabled. 0b - No single-bit correction event on Memory 17 detected. 1b - Single-bit correction event on Memory 17 detected.

Table continues on the next page...

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Field	Function
26 NCE17	NCE17 Memory 17 Non-Correctable Error Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE17] is enabled. 0b - No non-correctable error event on Memory 17 detected. 1b - Non-correctable error event on Memory 17 detected.
25-24 —	Reserved
23 SBC18	SBC18 Memory 18 Single-Bit Correction Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ESCIE18] is enabled. 0b - No single-bit correction event on Memory 18 detected. 1b - Single-bit correction event on Memory 18 detected.
22 NCE18	NCE18 Memory 18 Non-Correctable Error Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE18] is enabled. 0b - No non-correctable error event on Memory 18 detected. 1b - Non-correctable error event on Memory 18 detected.
21-20 —	Reserved
19 SBC19	SBC19 Memory 19 Single-Bit Correction Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ESCIE19] is enabled. 0b - No single-bit correction event on Memory 19 detected. 1b - Single-bit correction event on Memory 19 detected.
18 NCE19	NCE19 Memory 19 Non-Correctable Error Event Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE19] is enabled. 0b - No non-correctable error event on Memory 19 detected.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>1b - Non-correctable error event on Memory 19 detected.</td></tr>
<tr><td>17-16
—</td><td>Reserved</td></tr>
<tr><td>15
SBC20</td><td>SBC20
Memory 20 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ESCIE20] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>—</td><td>SR2</td></tr><tr><td>ERM_1</td><td>SR2</td><td>—</td></tr></table>
0b - No single-bit correction event on Memory 20 detected.
1b - Single-bit correction event on Memory 20 detected.</td></tr>
<tr><td>14
NCE20</td><td>NCE20
Memory 20 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE20] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>—</td><td>SR2</td></tr><tr><td>ERM_1</td><td>SR2</td><td>—</td></tr></table>
0b - No non-correctable error event on Memory 20 detected.
1b - Non-correctable error event on Memory 20 detected.</td></tr>
<tr><td>13-12
—</td><td>Reserved</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>11
SBC21</td><td>SBC21
Memory 21 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ESCIE21] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>—</td><td>SR2</td></tr><tr><td>ERM_1</td><td>SR2</td><td>—</td></tr></table>
0b - No single-bit correction event on Memory 21 detected.
1b - Single-bit correction event on Memory 21 detected.</td></tr>
<tr><td>10
NCE21</td><td>NCE21
Memory 21 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE21] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>ERM_0</td><td>—</td><td>SR2</td></tr><tr><td>ERM_1</td><td>SR2</td><td>—</td></tr></table>
0b - No non-correctable error event on Memory 21 detected.
1b - Non-correctable error event on Memory 21 detected.</td></tr>
<tr><td>9-8
—</td><td>Reserved</td></tr>
<tr><td>7
SBC22</td><td>SBC22
Memory 22 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ESCIE22] is enabled.</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>SR2</td></tr>
<tr><td>ERM_1</td><td>SR2</td><td>—</td></tr>
</table>
0b - No single-bit correction event on Memory 22 detected.
1b - Single-bit correction event on Memory 22 detected.
</td></tr>
<tr><td>6
NCE22</td><td>
NCE22
Memory 22 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE22] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>SR2</td></tr>
<tr><td>ERM_1</td><td>SR2</td><td>—</td></tr>
</table>
0b - No non-correctable error event on Memory 22 detected.
1b - Non-correctable error event on Memory 22 detected.
</td></tr>
<tr><td>5-4
—</td><td>Reserved</td></tr>
<tr><td>3
SBC23</td><td>
SBC23
Memory 23 Single-Bit Correction Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ESCIE23] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>SR2</td></tr>
<tr><td>ERM_1</td><td>SR2</td><td>—</td></tr>
</table>
0b - No single-bit correction event on Memory 23 detected.
1b - Single-bit correction event on Memory 23 detected.
</td></tr>
<tr><td>2
NCE23</td><td>NCE23
Memory 23 Non-Correctable Error Event
Write 1 to clear this field. This write also clears the corresponding interrupt notification, if CR2[ENCIE23] is enabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>ERM_0</td><td>—</td><td>SR2</td></tr>
<tr><td>ERM_1</td><td>SR2</td><td>—</td></tr>
</table>
0b - No non-correctable error event on Memory 23 has been not been detected.
1b - Non-correctable error event on Memory 23 detected.
</td></tr>
<tr><td>1-0
—</td><td>Reserved</td></tr>
</table>

46.5.8 ERM Memory a Error Address Register (EAR0 - EAR23)

Offset

Register	Offset
EAR0	100h
EAR1	110h
EAR10	1A0h
EAR11	1B0h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
EAR12	1C0h
EAR13	1D0h
EAR14	1E0h
EAR15	1F0h
EAR16	200h
EAR17	210h
EAR18	220h
EAR19	230h
EAR20	240h
EAR21	250h
EAR22	260h
EAR23	270h

Function

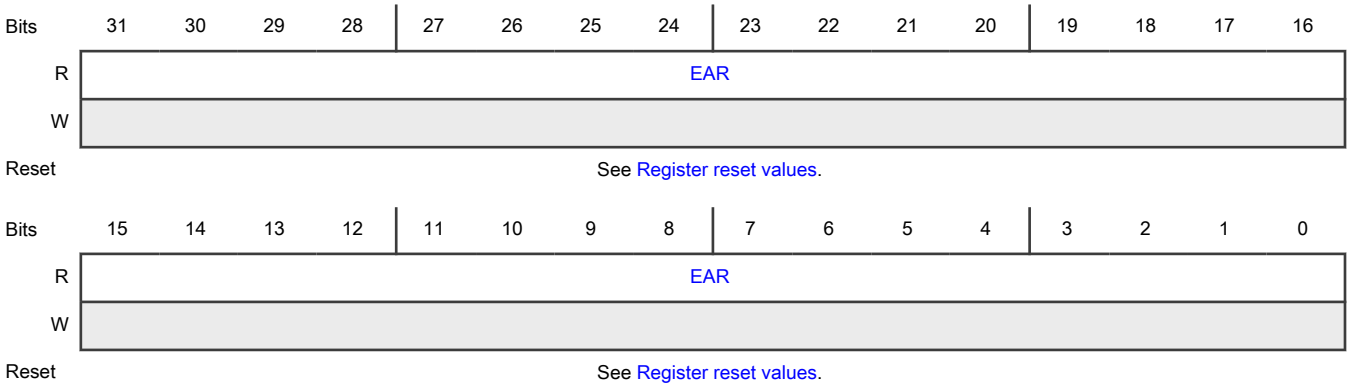
Each ERM Memory n Error Address Register is a 32-bit register for capturing the address of the last ECC event in Memory*n*, where*n* denotes the memory channel. Any attempted write to EAR*n* is ignored.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ERM_0	EAR0–EAR1 EAR10–EAR19	EAR20–EAR23
ERM_1	EAR10–EAR12 EAR16–EAR23	EAR0–EAR1 EAR13–EAR15

Diagram



Register reset values

Register	Reset value
EAR0–EAR1	0000_0000h
EAR2–EAR9	Register not supported
EAR10–EAR12	ERM_0,ERM_1: 0000_0000h
EAR13–EAR15	0000_0000h
EAR16–EAR19	ERM_0,ERM_1: 0000_0000h
EAR20–EAR23	0000_0000h

Fields

Field	Function
31-0 EAR	EAR Memory*n* Error Address — This field contains the faulting system address of the last recorded ECC event on Memory*n*.

46.5.9 ERM Memory a Syndrome Register (SYN0 - SYN23)

Offset

Register	Offset
SYN0	104h
SYN1	114h
SYN10	1A4h
SYN11	1B4h
SYN12	1C4h
SYN13	1D4h
SYN14	1E4h
SYN15	1F4h
SYN16	204h
SYN18	224h
SYN19	234h
SYN20	244h
SYN21	254h
SYN22	264h
SYN23	274h

Function

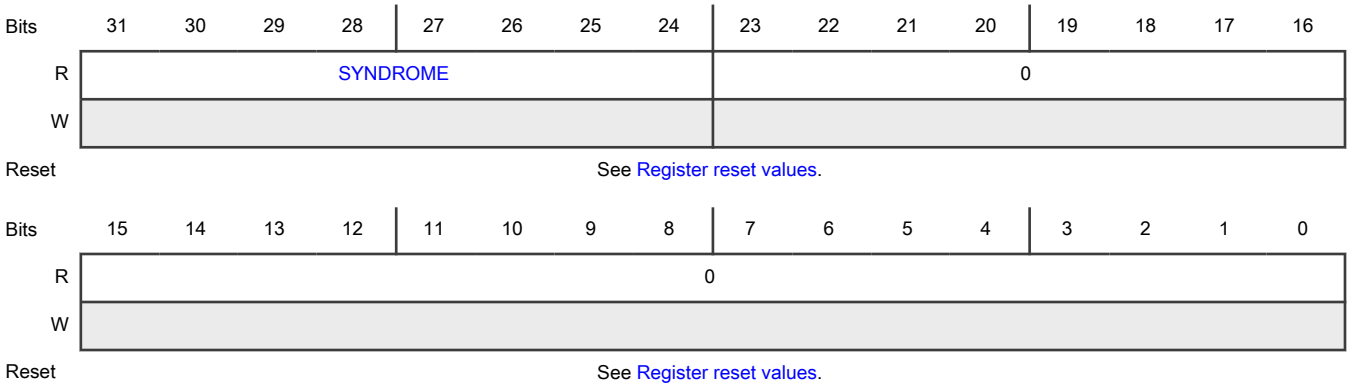
The ERM Memory *n* Syndrome Register is a 32-bit register for capturing the calculated syndrome of the last ECC event on Memory*n*, where*n* denotes the memory channel. Any attempted write to SYN*n* is ignored. The syndrome value identifies the pertinent bit position on a correctable, single-bit data inversion or a non-correctable, single-bit address inversion. The syndrome value does not provide any additional diagnostic information on non-correctable, multi-bit inversions.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ERM_0	SYN0–SYN1 SYN10–SYN16	SYN18–SYN23
ERM_1	SYN10–SYN12 SYN16 SYN18–SYN23	SYN0–SYN1 SYN13–SYN15

Diagram



Register reset values

Register	Reset value
SYN0–SYN1	0000_0000h
SYN2–SYN9	Register not supported
SYN10–SYN12	ERM_0,ERM_1: 0000_0000h
SYN13–SYN15	0000_0000h
SYN16	ERM_0,ERM_1: 0000_0000h
SYN17	Register not supported
SYN18–SYN23	0000_0000h

Fields

Field	Function
31-24 SYNDROME	SYNDROME Memory*n* Syndrome — This field contains the ECC syndrome associated with the last recorded ECC event on Memory*n*.
23-0 —	Reserved

46.5.10 ERM Memory a Correctable Error Count Register (CORR_ERR_CNT0 - CORR_ERR_CNT23)

Offset

Register	Offset
CORR_ERR_CNT0	108h
CORR_ERR_CNT1	118h
CORR_ERR_CNT2	128h
CORR_ERR_CNT3	138h
CORR_ERR_CNT4	148h
CORR_ERR_CNT5	158h
CORR_ERR_CNT6	168h
CORR_ERR_CNT7	178h
CORR_ERR_CNT8	188h
CORR_ERR_CNT9	198h
CORR_ERR_CNT10	1A8h
CORR_ERR_CNT11	1B8h
CORR_ERR_CNT12	1C8h
CORR_ERR_CNT13	1D8h
CORR_ERR_CNT14	1E8h
CORR_ERR_CNT15	1F8h
CORR_ERR_CNT16	208h
CORR_ERR_CNT17	218h
CORR_ERR_CNT18	228h
CORR_ERR_CNT19	238h
CORR_ERR_CNT20	248h
CORR_ERR_CNT21	258h

Table continues on the next page...

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Register	Offset
CORR_ERR_CNT22	268h
CORR_ERR_CNT23	278h

Function

Each 32-bit ERM Memory *n* Correctable Error Count Register records the count value of the number of correctable ECC error events for Memory*n*, where*n* denotes the memory channel.

NOTE

Non-correctable errors are considered a serious fault, so the ERM does not provide any mechanism to count non-correctable errors. Only correctable errors are counted.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ERM_0	CORR_ERR_CNT0–CORR_ERR_CNT5 CORR_ERR_CNT6–CORR_ERR_CNT9 CORR_ERR_CNT10–CORR_ERR_CNT12 CORR_ERR_CNT13–CORR_ERR_CNT15 CORR_ERR_CNT16–CORR_ERR_CNT19	CORR_ERR_CNT20–CORR_ERR_CNT23
ERM_1	CORR_ERR_CNT2–CORR_ERR_CNT23	CORR_ERR_CNT0–CORR_ERR_CNT1 CORR_ERR_CNT6–CORR_ERR_CNT9 CORR_ERR_CNT13–CORR_ERR_CNT15

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved															
W	0															
Reset	See Register reset values.															

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved								COUNT							
W	0								0							
Reset	See Register reset values.															

Register reset values

Register	Reset value
CORR_ERR_CNT0–CORR_ERR_CNT1	0000_0000h
CORR_ERR_CNT2–CORR_ERR_CNT5	ERM_0,ERM_1: 0000_0000h
CORR_ERR_CNT2–CORR_ERR_CNT19	Register not supported
CORR_ERR_CNT6–CORR_ERR_CNT9	0000_0000h
CORR_ERR_CNT10–CORR_ERR_CNT12	ERM_0,ERM_1: 0000_0000h
CORR_ERR_CNT13–CORR_ERR_CNT15	0000_0000h
CORR_ERR_CNT16–CORR_ERR_CNT19	ERM_0,ERM_1: 0000_0000h
CORR_ERR_CNT20–CORR_ERR_CNT23	0000_0000h

Fields

Field	Function
31-8 —	Reserved
7-0 COUNT	Memory n Correctable Error Count For each correctable error event, the ERM increments this field's error count value until the counter reaches its maximum value FFh. COUNT value will stop when it reaches maximum value FFh and will not wrap even if additional errors occur. Read this field to determine the correctable error count value so far. Write all zeros to this field to reset the counter. Writing a non-zero value has no effect.

46.6 Glossary

ECC Error correction code

Chapter 47
Fault Collection and Control Unit (FCCU)

47.1 Chip-specific FCCU information

47.1.1 NCF description

There are total 16 NCF slots on FCCU.

Table 221. NCF description

Channel number	Source module (error type)
NCF[0]	M7 LS and Core LOCKUP
NCF[1]	Interconnect: all EDC bus gaskets;XBIC monitors and platform gaskets
NCF[2]	ECC errors: PRAMC; TCMs; Caches; eDMA; EDC after ECC (PRAMC); QSPI FLASHA ECC errors
NCF[3]	All Flash Errors: FMU;PFALSH;DCM Flash
NCF[4]	Voltage related errors: PMC 1.1V and 2.5V GnG;PAD overvoltage;sdadc and swg gng
NCF[5][1]	Debug and Test Monitoring; STCU faults
NCF[6]	Interrupt Monitor Error
NCF[7]	SW Notification
NCF[8]	DSPSS Error
NCF[9]	SAR_ADC Faults
NCF[10]	OMU Error
NCF[11]	M7 Permanent Lockstep Error
NCF[12]	eDMA Lockstep Error
NCF[13]	LFAST LVDS pad fault
NCF[14]	eTPU global exception
NCF[15]	Reserved

1. The fault would be raised if DBGPWRUP_REQ toggles while any core is in halted state. If this operation is expected, the application can ignore/disable such an NCF event.

47.1.2 Chip-boundary FCCU signals

Fault state is indicated to off-chip logic by FCCU via EOUT pins.

Table 222. FCCU EOUT error pins

FCCU signal	Chip signal
EOUT0	FCCU_ERR0
EOUT1	FCCU_ERR1

47.1.3 Clock frequency

Table 223. FCCU clocking

FCCU clock signal	Chip clock signal
CLKSAFE	FIRC_CLK
CLKPRIM	AIPS_PLAT_CLK

47.1.4 FOSU timer interval

The FCCU Output Supervision Unit (FOSU) module timer interval is determined by the value of FOSU_COUNT. On this chip, FOSU_COUNT is 0x69780.

47.1.5 Supported internal chip reactions

- The short functional reset discussed in this chapter is equivalent to the device functional reset.

The interrupts from FCCU to NVIC can be found in the interrupt map file attached to this document.

NOTE

After the completion of self-testing procedure via Self-Test Control Unit (STCU2), device reboots and FCCU also gets reset.

47.1.6 Supported FCCU EOUT fault output modes (protocols)

Only Bistable protocol of FCCU EOUT is supported on this device. Other protocols—Dual-Rail and Time-Switching mentioned in this chapter does not apply to this device.

47.1.7 Recommended reaction programming for faults

It is possible to upgrade or downgrade the reaction of the faults with respect to the recommended reaction as per the attached fault map file attached to this document.

1. In case the reaction is upgraded no issue is expected in the behavior.
2. In case the reaction is downgraded the reaction / functionality is not guaranteed.

NOTE

Whenever there is fault due to lockstep error, you must follow the below recommendation:

1. FCCU must generate Functional Reset as a part of the Lockstep Error Fault Reaction
2. The core upon re-booting must do following things (This needs to be taken care by SW itself):
    a. Initialize the TCM (as there may be a possibility that the TCM's might have got corrupted)
    b. Invalidate the cache (as there may be a possibility that the caches might have got corrupted)
3. Clear the FCCU Fault Status register
4. If the FCCU fault gets cleared, nothing to do further related to Fault handling (This means the LOCKSTEP error has been recovered).
5. If the FCCU lockstep error still persist, this means that the internal registers of the two cores are having different values. So to bring the two cores internal registers to the same value, one of the below two steps can be followed:
    a. Give Destructive Reset through SW to recover from lockstep. In this approach the FCCU will also get initialized and there will not be any further pending faults.
    b. Initialize those CM7 registers which are sitting on destructive/POR reset. After initializing those registers, clear the FCCU faults. If it gets cleared, then perfectly fine else provide a Destructive reset to recover.

47.1.8 Fault NCF latching scheme and DCM control bit to disable NCF

In S32K396, NCF list contains sixteen NCFs. Therefore, multiple NCFs of similar nature are ored and then connected as a single NCF to FCCU. Hence a new feature has been implemented to enable/disable each NCF which is in cone of single NCF reported to FCCU, using configuration registers in DCM (DCMRWD3, DCMRWD4, DCMRWD5, DCMRWD14, and DCMRWD15). Also, there are capturing status registers (DCMROD3. DCMROD4, DCMROD5, DCMROD6, and DCMROD7) which captures each NCF being ored. These status bits numbered and NCF disable option DCM R/W register bits are same but on different bank. Capture status bits are on Read only register while control NCF disable option bits on R/W register of DCM.

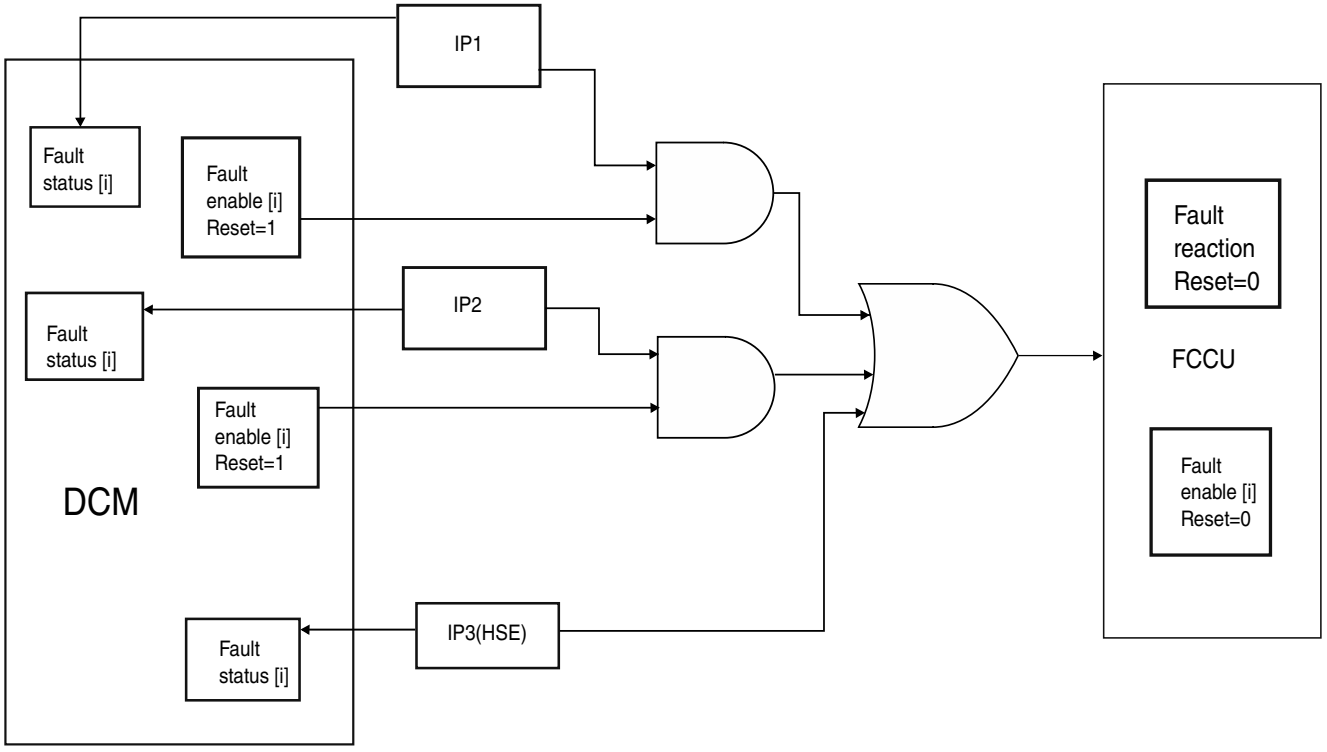


Figure 183. FCCU NCF handling architecture

DCM status registers will latch faults if triggered fakely from inside IP.

47.2 Overview

The FCCU provides a hardware interface to collect faults and to place the device into a safe state when a failure is detected in the device. No CPU intervention is requested for collection and control operations. FCCU offers a systematic approach to fault collection and control.

47.2.1 Block diagram

The following figure represents a top-level diagram of the FCCU module.

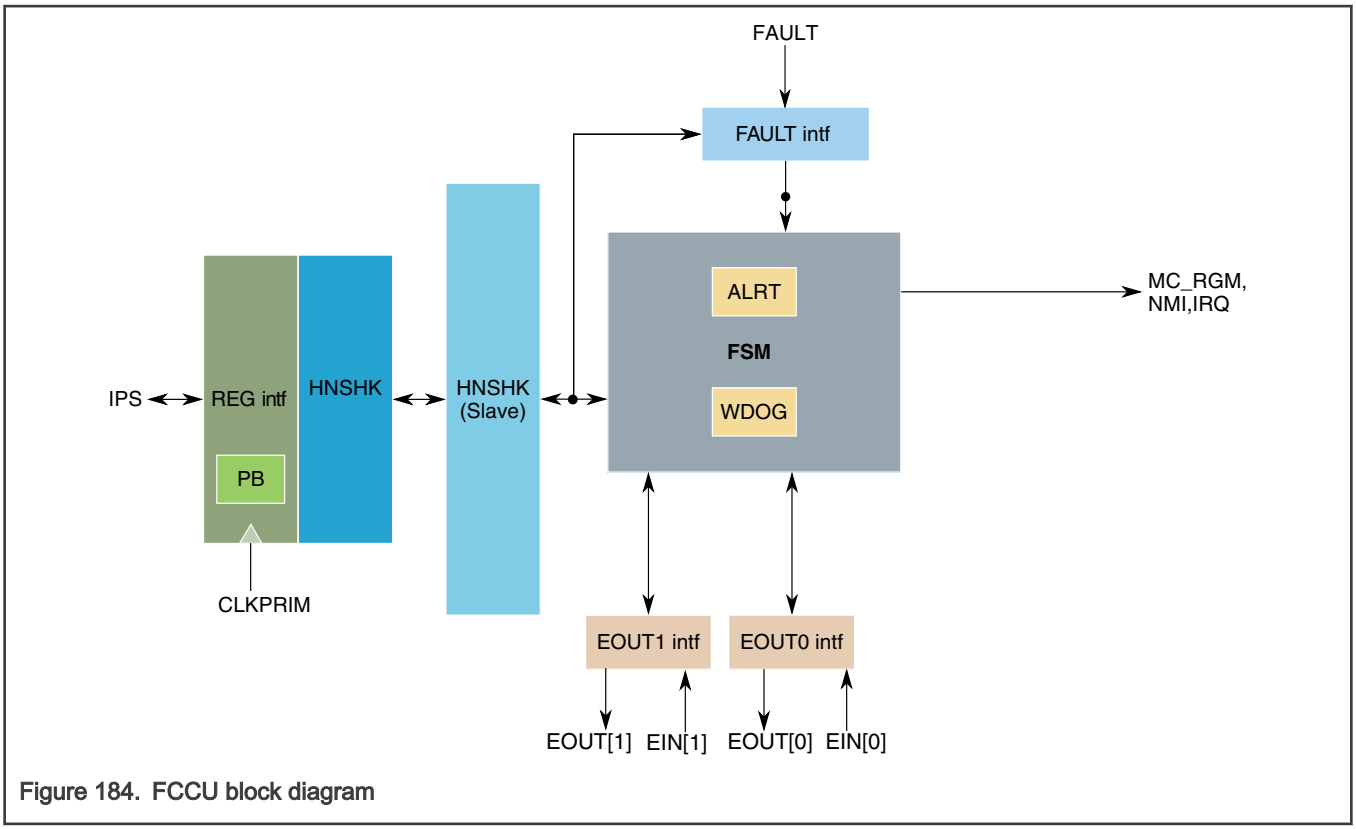


Figure 184. FCCU block diagram

This table describes the FCCU submodules.

Table 224. FCCU submodules

Submodule	Description
REG intf	Includes the register file, the IPS bus interface, the IRQ interface and the parity block (PB) for the configuration registers
HNSHK blocks (master and slave blocks)	Includes the FSM ability to support the handshake between the REG interface and the FSM unit because of the usage of two asynchronous clocks [CLKPRIM(module clock) and CLKSAFE(RC oscillator clock)]
FSM unit	Implements the main functions of FCCU. The FSM also includes the: • Watchdog timer (WDG) • Alarm timer (ALRT)
FAULT intf	Implements the interface for fault conditioning and management
EOUTx units	Implement the output stage to manage the EOUT interfaces

47.2.2 Features

The key features of the FCCU module are these:

- Management of non-critical faults
- HW or SW fault recovery management
- Fault collection from safety relevant modules on the device

- Fault injection (fake faults)
- Collection of test results
- Lockable configuration
  - Changes are only possible after entering the CONFIG state
  - Supports a transient and a permanent lock
  - Configuration changes observed by a watchdog timer
- Configurable fault control
- External reaction (FAULT state): EOUT signaling. Error indication via the pin(s) is controlled by FCCU.
- Internal chip reactions (ALARM state): interrupt request
- Configurable internal chip reactions for each NCF (FAULT state):
  - Short functional reset request pulse
  - NMI
  - No reaction
  - IRQ
- In Bi-Stable operational mode, one of the EOUT signals is high to indicate an OK operational state of FCCU.This is not true in case the error out protocol is configured to be a toggling protocol (for example, in Dual-Rail and Time-Switching operation modes).
- After power on, the EOUT signals have high impedance.[4] They indicate an operational state only after the software configures them.
- In case of a failure event or on software request for error pin indication, the pin(s) are set to faulty state for a minimum time T_{min} (see DELTA_T[DELTA_T]), even if the software tries to release it before (for the case of error pin configured in Bi-Stable mode only).

The self-checking procedure checks the FCCU circuitry at the start up. The FCCU is operational with the default configuration immediately after the completion of the self-checking procedure. Internal (short functional reset request pulse, interrupt request) and external (EOUT signaling) reactions are statically defined or programmable. The default configuration can be modified only in the Configuration (CONFIG) state. FCCU is designed to function when CLKPRIM is faster than the CLKSAFE clocks.

47.3 Functional description

47.3.1 Definitions

In general, the following definitions are applicable for fault management:

- HW recoverable fault: The fault indication is a level-sensitive signal that remains asserted until the fault cause is deasserted. That is, if logical 0 on the fault signal indicates fault, then the status flags are valid as long as the fault line stays at 0. The status is automatically cleared when the fault signal goes to 1. Typically the fault signal is latched external to the FCCU in the module where the fault occurred. The FCCU state transitions are consequently executed on the state changes of the input fault signal. No SW intervention in the FCCU is required to recover the fault condition.
- SW recoverable fault: The fault indication is a signal asserted without a defined time duration. The fault signal is latched in the FCCU. The fault recovery is executed following a SW recovery procedure (status/flag register clearing).

HW recoverable is an option to exclude the handling of error sources by FCCU management SW, in case it is known that the fault is recoverable by itself when the fault condition is corrected.

For details related to reset interface, see the reset interface section in the chip reference manual.

[4] Actual value depends on device-specific setting at pad level.

47.3.2 FSM description

The functionality of FCCU is depicted by the FSM state diagram (see Figure 185).

FCCU has four states that are identified with the following meaning:

- CONFIG: Used only to modify the configuration of FCCU from its default. A subset of the FCCU registers, dedicated to define the FCCU configuration (global configuration, reactions to fault, timeout, non-critical fault masking) can be accessed in write mode only in the CONFIG state.

  The CONFIG state is accessible only in the NORMAL state and if the configuration is not locked. A permanent configuration lock can be disabled by a reset that also resets the FCCU. The transient lock register is unlocked by writing BCh into it. FCCU gets transiently locked again if an invalid key is written into TRANS_LOCK[TRANSKEY] (that is, other than BCh). To lock FCCU for configuration, write FFh to PERMNT_LOCK[PERMNTKEY].

  After the release of reset, the state of the transient lock is locked, and the state of the permanent lock is unlocked.

  The locking feature only restricts the FSM movement into CONFIG state. After the user enters the CONFIG state and then tries to lock the configuration, the locking of configuration is effective only after FCCU moves to the NORMAL state; it will not be effective in the current CONFIG state.

  The CONFIG to NORMAL state transition can be executed by SW or automatically following a timeout condition of the watchdog. In case the timeout information and the SW request for state change to NORMAL appears at the same time, watchdog timeout has the priority and hence the configuration registers (those that are writable only in the CONFIG state) are reset to their default values. The movement to the NORMAL state is made.

  The incoming faults, occurring during the configuration phase (CONFIG state) are latched in order to process them when FCCU is moved to the NORMAL state, according to the new configuration.

  All pending faults that occur during the CONFIG state result in both of the following:

  — Highest-priority state transition

  — Interrupt generation (NMI or alarm IRQ)

  If the state transition occurs, it gives the reset reaction corresponding to the worst case based on all the faults (pending or non-pending faults) that occurred during the CONFIG state.

- NORMAL: This is FCCU's operating state when no faults are occurring. It is also the default state on the reset exit. Following state transitions occur on one of the following events:

  — Unmasked non-critical faults with the timeout disabled: FCCU moves to the FAULT state.

  — Unmasked non-critical faults with the timeout enabled: FCCU moves to the ALARM state.

  — Masked non-critical faults: FCCU stays in the NORMAL state.

- ALARM: FCCU moves into the ALARM state when an unmasked non-critical fault occurs and the timeout is enabled. Transition to the ALARM state goes along with an interrupt alarm, if enabled. By definition, this fault may be recovered within a programmable timeout period, before it generates a transition to the FAULT state. The timeout is reinitialized if FCCU enters the NORMAL state. The timeout restarts following the recovery from the FAULT state.

- FAULT: FCCU moves into the FAULT state when one of the following condition occurs:

  — Timeout related to a non-critical fault when FCCU is in the ALARM state

  — Unmasked non-critical faults with the timeout disabled

The transition from the NORMAL or ALARM to the FAULT state goes along with the generation of:

- Internal chip reaction—NMI interrupt (optional)
- External reaction—EOUT signaling (optional)
- Internal chip reaction—SW option: Soft reaction (Short functional reset request pulse if configured)
- Non Maskable Interrupt (NMI) is routed to all cores.

After moving to the FAULT state, if there is either a previous pending fault or a new fault for which NMI is enabled, NMI generation takes place.

Multiple faults can occur at the same time.

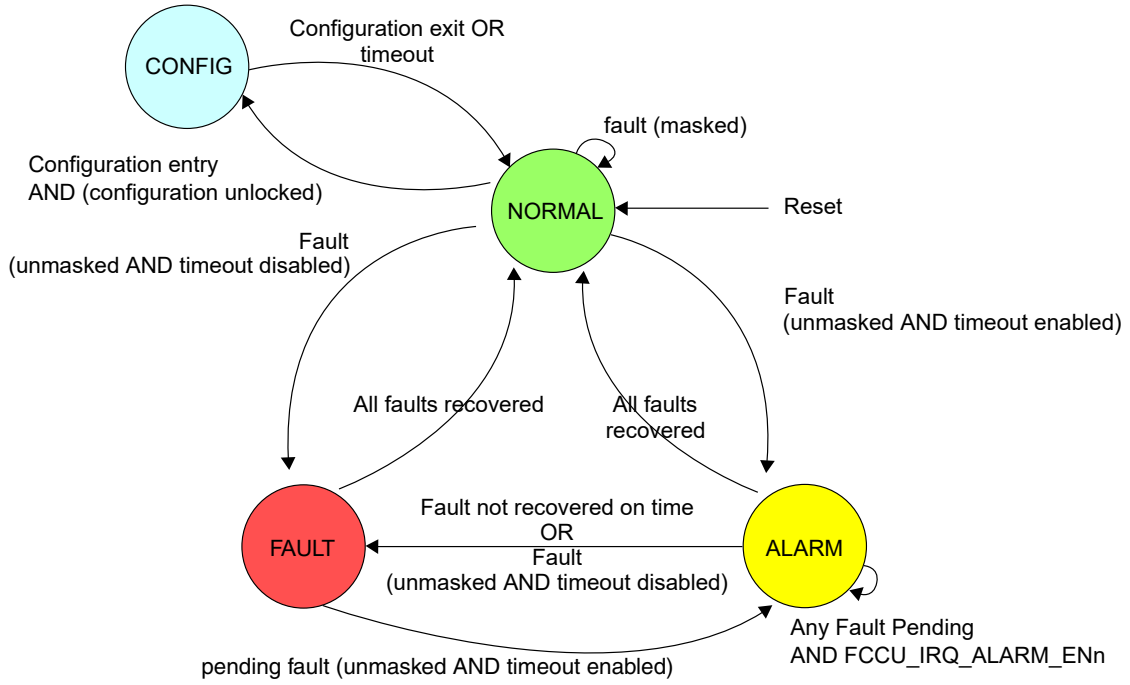


Figure 185. FCCU state diagram

47.3.3 Fault priority scheme and nesting

The FAULT state has a higher priority than the ALARM state in case of concurrent fault events (non-critical) that occur in the NORMAL state.

The ALARM to FAULT state transition occurs if a non-critical fault (unmasked and with timeout disabled) is asserted in the ALARM state.

The ALARM to NORMAL state transition occurs only if all the non-critical faults (including the faults that have been collected after the entry in the ALARM state) have been cleared (SW or HW recovery); otherwise the FCCU remains in the ALARM state.

The FAULT to NORMAL state transition occurs only if all the non-critical faults (including the faults that have been collected after the entry in the FAULT/ALARM state) have been cleared (SW or HW recovery); otherwise the FCCU moves to the ALARM state (if any non-critical fault is still pending and the timeout is not elapsed).

In general, no fault nesting is supported except for the non-critical faults that cause an ALARM to FAULT state transition. In this case, the NCF timer is stopped until the FAULT state is recovered. If FCCU is in the ALARM state and another fault occurs, which has its alarm timeout enabled, then the alarm timer shall not reload and shall not start again.

47.3.4 Fault recovery

The following timing diagrams describe the main use cases of FCCU in terms of fault events and related recovery.

A typical sequence related to non-critical fault management (ALARM state), see Figure 186 and Figure 187, is as follows:

1. Non-critical fault assertion
2. FCCU state transition (automatic): NORMAL to ALARM
   - Alarm interrupt request (if enabled)

- Timeout running

3. System state: RUN
4. Alarm interrupt management: fault recovery
   - FCCU state transition: ALARM to NORMAL

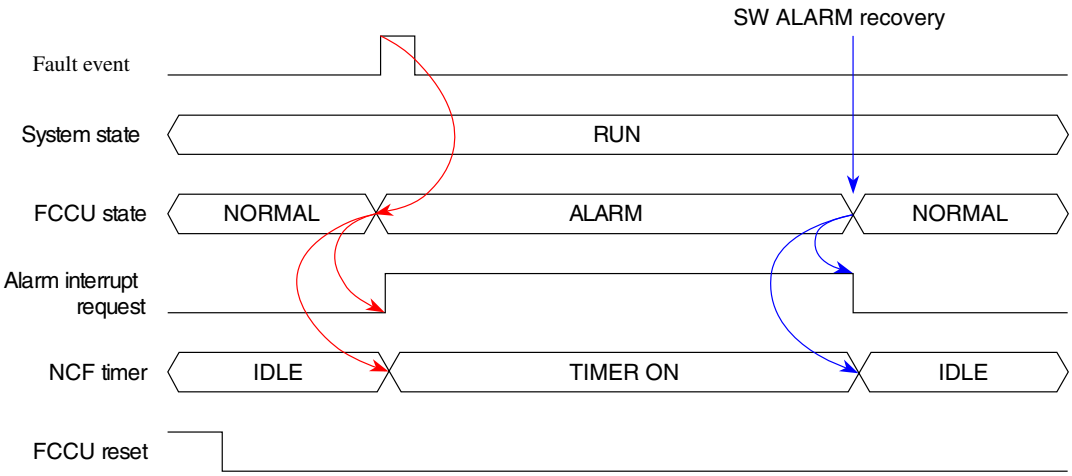


Figure 186. Non-critical fault (ALARM state) SW recovery

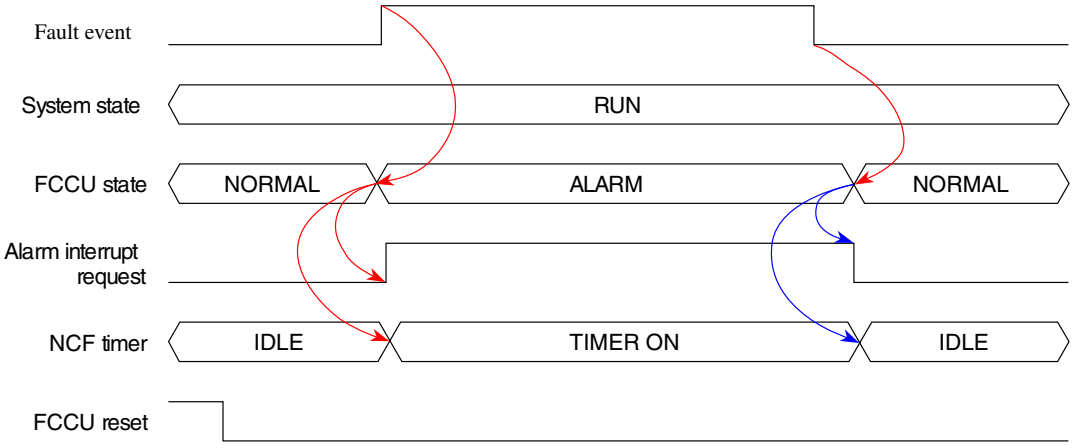


Figure 187. Non-critical fault (ALARM state) HW recovery

A typical sequence related to non-critical fault management (ALARM to FAULT state), see Figure 188, is as follows:

1. Non-critical fault assertion
2. FCCU state transition (automatic): NORMAL to ALARM
   - Alarm interrupt request (if enabled)
   - Timeout running
3. FCCU state transition (following the timeout trigger): ALARM to FAULT
   - NMI assertion (if enabled)
4. NMI interrupt management (if enabled)
   - Fault recovery (by software): FCCU state transition: FAULT to NORMAL

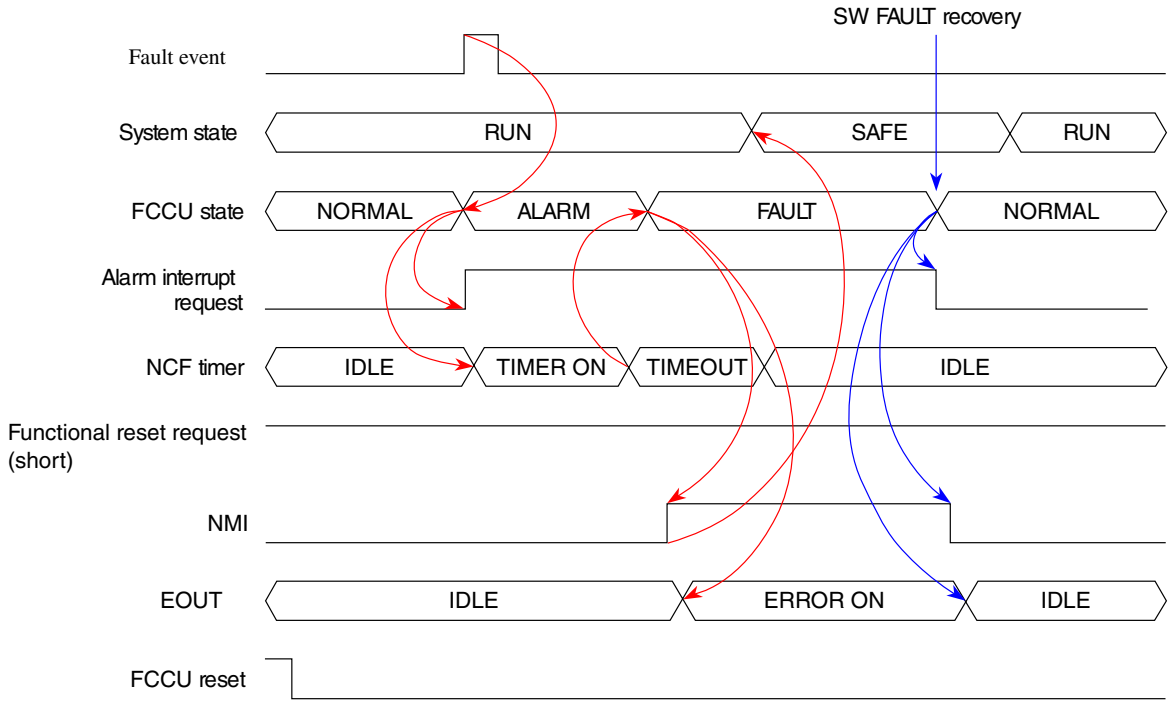


Figure 188. Non-critical fault (ALARM to FAULT state) recovery

47.3.5 EOUT interface

Introduction

You use the EOUT[1:0] signals to indicate FCCU's condition (or, for Fault-Toggle fault-output mode, faults only) to off-chip logic.

NOTE

For information on the availability and names of these FCCU signals on the boundary of this chip, see the chip-specific FCCU information.

The FCCU conditions

There are three FCCU conditions:

Condition	Description
Faulty	All of the following are true: • The fault-output (EOUT) timer is running (see How the fault-output (EOUT) timer works in Dual-Rail, Time-Switching, and Bi-Stable fault-output modes). • FCCU is in FAULT state.
Non-faulty	All of the following are true: • The fault-output (EOUT) timer is not running. • FCCU is in ALARM or NORMAL state.

Table continues on the next page...

Table continued from the previous page...

Condition	Description
Configuration	All of the following are true: • The fault-output (EOUT) timer is not running. • FCCU is in CONFIG state.

How the fault-output (EOUT) timer works in Dual-Rail, Time-Switching, and Bi-Stable fault-output modes

In Dual-Rail, Time-Switching, and Bi-Stable fault-output modes (FOM), FCCU starts the fault-output (EOUT) timer when all of the following are true:

- If the EOUT signals are in Bi-Stable FOM, and the EOUT signals are not programmed to be always low (CFG[FCCU_SET_CLEAR]).
- The EOUT timer is not already running.
- FCCU enters the FAULT state as the result of a fault.

When the fault-output (EOUT) timer is already running and a new fault occurs:

- If FCCU is in the CONFIG state: FCCU does not restart the EOUT timer.
- If FCCU is in the NORMAL or ALARM state:
  - And ALARM state is enabled for the fault (non-critical): FCCU enters (or remains in) the ALARM state but does not restart the EOUT timer.
  - And ALARM state is disabled for the fault (non-critical): FCCU enters the FAULT state and restarts the EOUT timer.
- If FCCU is in the FAULT state: FCCU restarts the fault-output (EOUT) timer.

FCCU stops and reinitializes the fault-output (EOUT) timer when all of the following are true:

- If the EOUT signals are in Bi-Stable fault-output mode (CFG[FOM]), and T_{min} (see DELTA_T[DELTA_T]) has expired.
- All faults that caused FCCU to enter or remain in the FAULT state since FCCU started the fault-output (EOUT) timer have been cleared, causing FCCU to return to the NORMAL state.

How the fault-output (EOUT) timer works in Fault-Toggle fault-output mode

In Fault-Toggle fault-output mode, FCCU initializes the fault-output (EOUT) timer with the value of T_{min} (see DELTA_T[DELTA_T]) and begins decrementing the timer when any of the following are true:

- FCCU enters the FAULT state as the result of a fault.
- In FAULT state, a fault occurs while the EOUT timer is 0 (idle).
- In FAULT state, a fault occurs while the EOUT timer is running because of a previous fault (also called a pending fault), and then in any state the EOUT timer reaches 0 (idle).

FCCU stops the EOUT timer when it reaches 0 (idle).

Prepare the EOUT signals to indicate FCCU's condition

- If the EOUT signals are in Bi-Stable or Fault-Toggle fault-output mode (CFG[FOM]), ensure that the EOUT signals are controlled by FCCU's FSM (CFG[FCCU_SET_CLEAR]).
- Ensure that the EOUT signals are active (CFG[FCCU_SET_AFTER_RESET]).

NOTE

If the EOUT signals are in Bi-Stable or Fault-Toggle fault-output mode, you must deactivate and then reactivate the EOUT signals (CFG[FCCU_SET_AFTER_RESET]) to correctly initialize them so they have opposite states.

More about the EOUT interface

Different fault-output modes (protocols) for the fault-output (EOUT) interface are supported (CFG[FOM]):

- Dual-Rail
- Time-Switching
- Bi-Stable
- Fault-Toggle

You can further configure the fault-output modes using the following attributes:

Attribute	Field	Setting used in the example diagrams and tables that follow
Configuration mode	CFG[CM]	Different
Switching mode	CFG[SM]	Slow
Polarity selection	CFG[PS]	For the faulty indication, EOUT1 is high, and EOUT0 is low.

EOUT frequency: This frequency is generated by dividing the CLKSAFE frequency by a fixed factor of 2^{18}.

$$EOUT_{freq} = \frac{CLKSAFE_{freq}}{2^{18}}$$

For example, with a CLKSAFE frequency of 16 MHz, this drives a signal of 61 Hz on EOUT.

The external monitor of the EOUT protocol should oversample the EOUT signals to synchronize periodically the external clock (used by the monitor) and CLKSAFE (which detects the edge transition of the EOUT protocol) in Dual-Rail or Time-Switching fault-output mode.

In case of a failure event or on software request for EOUT indication, the signal(s) are set to the faulty state for a minimum time (T_{min}), even if software tries to release it before. If software configures the error pins to OK(1), and if a fault comes trying to drive the pin to NOK(0), then priority is given to the fault indication and the error signals indicate NOK, such as an incoming fault is not masked even when software has set the error signal to high. Also, if the error signals are forced to low by software by writing to CFG[FCCU_SET_CLEAR], then the signals shall remain low (or high) for the entire duration of T_{min}. During the T_{min} by a non-software fault, the FCCU FSM moves independently of this signal state (low), and as soon as the timer expires, the pin behavior is dictated by the state in which the FSM finds itself in, and it is not possible to set the signals to OK by software moving FCCU to the CONFIG state, as long as this timer is running. No software intervention is needed to bring the signal from the low state.

Software can bring the pin back to OK state by clearing the faults and waiting for the T_{min} interval to expire, after which the FCCU automatically enters the NORMAL state and the error signal indicates OK.

In case another failure event happens within T_{min} after a first one, the T_{min} counter is restarted.

47.3.5.1 Dual-Rail protocol

Dual-Rail encoding is an alternate method for encoding bits. In contrast with classical encoding, where each signal carries a single-bit value, Dual-Rail encoded circuits use two wires to carry each bit. The encoding scheme is provided in Table 225 and the related timing diagram is shown in Figure 189 and Figure 190.

Table 225. Dual-Rail encoding

Condition	Reset phase3 indicator	EOUT[1:0]
Nonfaulty	0	Toggling between 01 and 10
	1	Retain same value on EOUT pins as present just before assertion of reset phase3 indicator (either 01 or 10) and no toggling
Faulty	0	Toggling between 00 and 11
	1	Retain same value on EOUT pins as present just before assertion of reset phase3 indicator (either 00 or 11) and no toggling
Reset	0	High-impedance (no toggling)[1]
	1	
Configuration (CFG[CM] is 1 and CFG[FCCU_SET_AFTER_RESET] is 0)		High-impedance (no toggling)[2]
Configuration (CFG[CM] is 1 and CFG[FCCU_SET_AFTER_RESET] is 1)		Toggling between 10 and 01

1. Final value depends on the chip setting at pad level.
2. Ensure that the EOUT signals are active (CFG[FCCU_SET_AFTER_RESET]); otherwise, the EOUT signals stay in a high-impedance state after reset lifts.

As long as FCCU is in the Normal or Alarm (non-faulty) state, output will show "nonfaulty" signal. Output pins EOUT[0:1] will toggle between 01 and 10 with EOUT frequency (See EOUT frequency).

NOTE

Figure 189 and Figure 190 are formatted to display the behavior in all four conditions (reset, nonfaulty, faulty, and configuration), not to imply transitions between one condition and another. In particular, a transition from the faulty condition to the configuration condition is not possible.

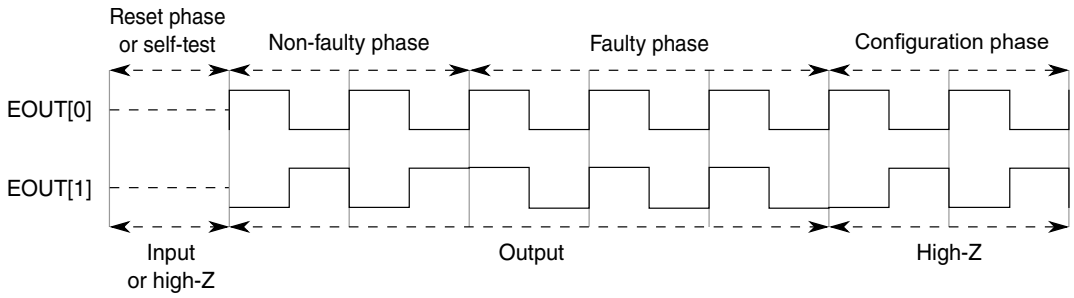


Figure 189. Dual-Rail protocol (slow-switching mode)

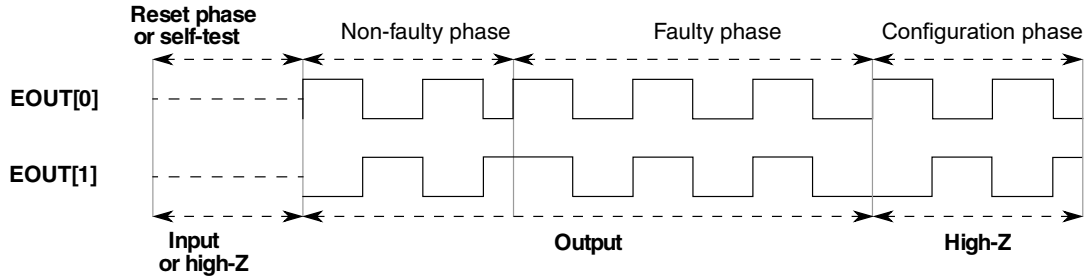


Figure 190. Dual-Rail protocol (fast-switching mode)

47.3.5.2 Time-Switching protocol

The encoding scheme is provided in Table 226 and the related timing diagram is shown in Figure 191.

Table 226. Time-Switching encoding

Condition	Reset phase3 indicator	EOUT[1:0] (CFG[PS] is 0)	EOUT[1:0] (CFG[PS] is 1)
Non-faulty	0	Toggling between 01 and 10	Toggling between 10 and 01
	1	Keep the current state of EOUT same as just before assertion of reset phase3 indicator (either 01 and 10) and no toggling	Keep the current state of EOUT same as just before assertion of Reset phase3 indicator (either 01 and 10) and no toggling
Faulty	0	Static 10	Static 01
	1	Static to 10 or 01 as per CFG[PS]	Static to 10 or 01 as per CFG[PS]
Reset	0	High-impedance (no toggling)[1]	High-impedance (no toggling)
	1		
Configuration (CFG[CM] is 1 and CFG[FCCU_SET_AFTER_RESET] is 0)		High-impedance (no toggling)[2]	High-impedance (no toggling)
Configuration (CFG[CM] is 1 and CFG[FCCU_SET_AFTER_RESET] is 1)		Toggling between 10 and 01	Toggling between 10 and 01

1. Final value depends on device specific settings at pad level.
2. Ensure that the EOUT signals are active (CFG[FCCU_SET_AFTER_RESET]); otherwise, the EOUT signals stay in a high-impedance state after reset lifts.

As long as FCCU is in the NORMAL or ALARM (non-faulty) state, outputs will show "non-faulty" signal. Output pins #0, #1 will toggle between 01 and 10 with EOUT frequency (See EOUT frequency).

Figure 191 is formatted to display the behavior in all four conditions (reset, non-faulty, faulty, and configuration), not to imply transitions between one condition and another. In particular, a transition from the faulty condition to the configuration condition is not possible.

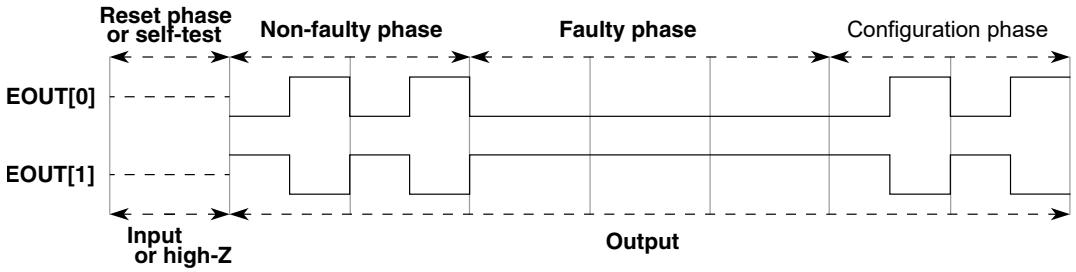


Figure 191. Time-Switching protocol

47.3.5.3 Bi-Stable protocol

The encoding scheme is provided in Table 227 and the related timing diagram is shown in Figure 192.

Table 227. Bi-Stable encoding

Condition	EOUT[1:0] (CFG[PS] is 0)	EOUT[1:0] (CFG[PS] is 1)
Non-faulty	Static 01	Static 10
Faulty	Static 10	Static 01
Reset	High-impedance (no toggling)[1]	High-impedance (no toggling)
Configuration (CFG[CM] is 1 and CFG[FCCU_SET_AFTER_RESET] is 0)	High-impedance (no toggling)[2]	High-impedance (no toggling)
Configuration (When CFG[CM] is 1 and CFG[FCCU_SET_AFTER_RESET] is 1)	Static 01	Static 10

1. Final value depends on device specific settings at pad level.
2. Ensure that the EOUT signals are active (CFG[FCCU_SET_AFTER_RESET]); otherwise, the EOUT signals stay in a high-impedance state after reset lifts.

NOTE

Figure 192 is formatted to display the behavior in all four conditions (reset, non-faulty, faulty, and configuration), not to imply transitions between one condition and another. In particular, a transition from the faulty condition to the configuration condition is not possible.

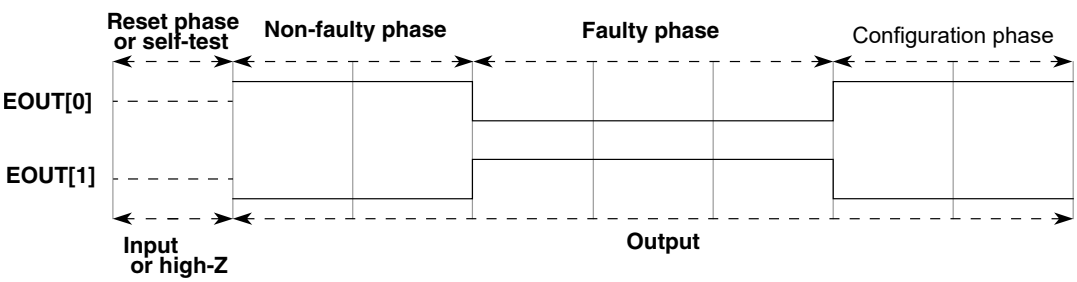


Figure 192. Bi-Stable protocol

47.3.5.4 Fault-Toggle protocol

The Fault-Toggle protocol uses the EOUT signals to indicate only the occurrences of faults, not FCCU's condition like the other protocols. In Fault-Toggle fault-output mode, when controlled by the FSM (CFG[FCCU_SET_CLEAR]), the EOUT signals:

- Have opposite states
- Toggle their states to indicate a fault and then maintain those new states for at least T_{min} (see DELTA_T[DELTA_T]), after which they are free to toggle to indicate another fault

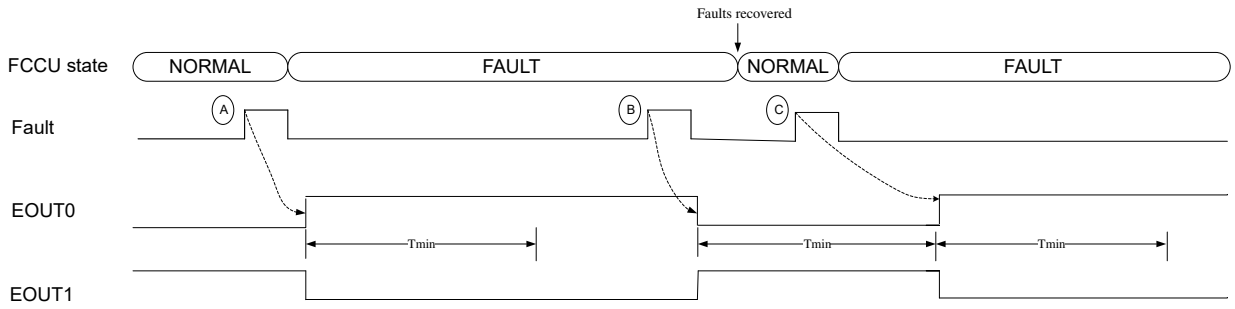
FCCU uses the fault-output (EOUT) timer to measure T_{min}. For more information, see How the fault-output (EOUT) timer works in Fault-Toggle fault-output mode.

The EOUT polarity selection (CFG[PS]) determines the initial states of the EOUT signals, which FCCU applies after you deactivate and then reactivate the EOUT signals (CFG[FCCU_SET_AFTER_RESET]).

If two or more faults occur while the EOUT timer is running, then the EOUT signals toggle only once after the EOUT timer reaches zero (idle). In other words, FCCU can pipeline only one fault.

Note that FCCU does not toggle the EOUT signals in CONFIG state. FCCU toggles the EOUT signals only when FCCU enters the FAULT state or when a fault occurs in the FAULT state.

Example 1



Stage	Description
1	A fault source indicates fault A to FCCU.
2	FCCU enters the FAULT state.
3	FCCU toggles the EOUT signals in response to fault A, initializes the fault-output (EOUT) timer with the value of T_{min} (see DELTA_T[DELTA_T]), and begins decrementing the timer.
4	A fault source indicates fault B to FCCU while FCCU is still in the FAULT state.
5	The EOUT timer has already reached 0 (idle), so FCCU toggles the EOUT signals in response to fault B, initializes the EOUT timer with the value of T_{min}, and begins decrementing the timer.
6	The source (for hardware-recoverable faults) and software (for software-recoverable faults) recovers the faults.
7	FCCU enters the NORMAL state.

Table continues on the next page...

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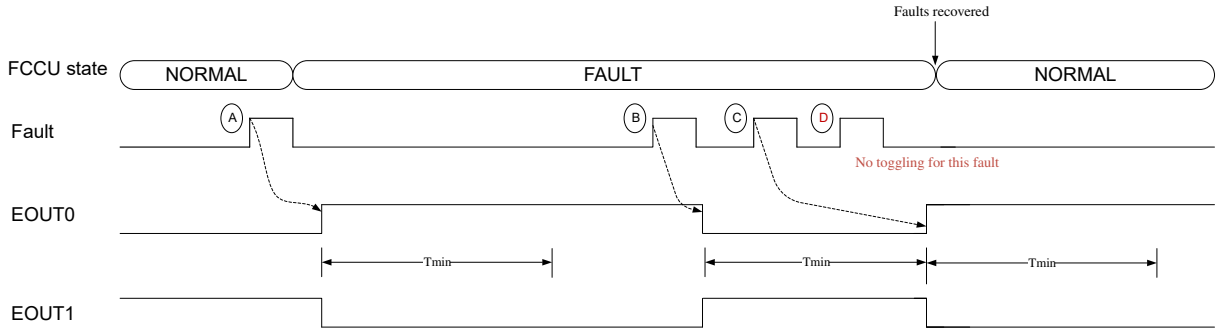
Stage	Description
8	A fault source indicates fault C to FCCU.
9	The EOUT timer has not yet reached 0 (idle), so FCCU leaves the EOUT signals as they are.
10	When the EOUT timer reaches 0 (idle), FCCU toggles the EOUT signals in response to fault C, initializes the EOUT timer with the value of T_{min}, and begins decrementing the timer.

Example 2



Stage	Description
1	A fault source indicates fault A to FCCU.
2	FCCU enters the FAULT state.
3	FCCU toggles the EOUT signals in response to fault A, initializes the fault-output (EOUT) timer with the value of T_{min} (see DELTA_T[DELTA_T]), and begins decrementing the timer.
4	A fault source indicates fault B to FCCU while FCCU is still in the FAULT state.
5	The EOUT timer has already reached 0 (idle), so FCCU toggles the EOUT signals in response to fault B, initializes the EOUT timer with the value of T_{min}, and begins decrementing the timer.
6	A fault source indicates fault C to FCCU while FCCU is still in the FAULT state.
7	The EOUT timer has not yet reached 0 (idle), so FCCU leaves the EOUT signals as they are. Fault C is now *pending*.

Table continues on the next page...

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Stage	Description
8	A fault source indicates fault D to FCCU while FCCU is still in the FAULT state. (FCCU can pipeline only one fault, so FCCU ignores fault D.)
9	The EOUT timer has not yet reached 0 (idle), so FCCU leaves the EOUT signals as they are.
10	When the EOUT timer reaches 0 (idle), FCCU toggles the EOUT signals in response to fault C, initializes the EOUT timer with the value of T_{min}, and begins decrementing the timer. FCCU never toggles the EOUT signals in response to fault D because FCCU can pipeline only one fault.

47.3.6 Modes of operation

47.3.6.1 Put FCCU in the NORMAL state

47.3.6.1.1 Introduction

You put FCCU in the NORMAL state to save changes to the configuration, and to allow FCCU to enter the ALARM or FAULT state when a fault occurs on an enabled fault channel.

47.3.6.1.2 About putting FCCU in NORMAL state

When putting FCCU in the NORMAL state:

- If you attempt to lock the configuration while FCCU is in CONFIG state, FCCU does not actually lock the configuration until FCCU leaves CONFIG state—that is, either you put FCCU in the NORMAL state, or FCCU puts itself in the NORMAL state because the Configuration-state timeout interval (CFG_TO[TO]) expires.
- After you permanently lock the configuration, you must reset FCCU before you can put FCCU in the CONFIG state.

47.3.6.1.3 Put FCCU in the NORMAL state

1. Check the FCCU status (STAT[STATUS]).
   - If the FCCU status is NORMAL, go to step 6.
   - If the FCCU status is CONFIG, go to step 2.
   - If the FCCU status is ALARM or FAULT, go to step 4.
2. Run the OP2 operation (see Run an operation).
3. Check the operation status (CTRL[OPS]).
   - If the operation status is Successful, FCCU is in the NORMAL state. Go to step 6.
   - If the operation status is Aborted, go to step 2.
4. Recover all faults (see Fault recovery).
5. Go to step 1.
6. Lock the configuration if you want to prevent any changes to it:

- To require a key to unlock the configuration, from Supervisor mode, temporarily lock the configuration (TRANS_LOCK[TRANSKEY]).
- To require a reset of FCCU to unlock the configuration, from Supervisor mode, permanently lock the configuration (PERMNT_LOCK[PERMNTKEY]).

  The configuration is permanently locked until FCCU is reset.

47.3.6.2 Manage faults

47.3.6.2.1 Introduction

After saving changes to the configuration, you are ready to use FCCU to manage faults.

47.3.6.2.2 Determine if there are any unrecovered non-critical faults

Check the unrecovered-fault indicators for the non-critical faults (NCF_Sa[NCFSn]).

47.3.6.2.3 Recover a software-recoverable non-critical fault

1. Resolve the source of the software-recoverable non-critical fault.
2. Unlock the NCF_Sa registers (NCFK[NCFK]) using a 32-bit write.
3. Initiate clearing of the unrecovered-fault indicator for the software-recoverable non-critical fault (NCF_Sa[NCFSn]) using a 32-bit write.

   FCCU initiates the OP12 operation.

   NOTE

   If you want to clear multiple unrecovered-fault indicators and those indicators reside in different NCF_Sa registers, you must perform steps 2 and 3 for each individual register.
4. Check the operation status (CTRL[OPS]).
   - If the operation status is In Progress, go to step 4.
   - If the operation status is Successful, go to step 5.
   - If the operation status is Aborted, go to step 2.
5. Check the unrecovered-fault indicator for the software-recoverable non-critical fault (NCF_Sa[NCFSn]).
   - If the indicator indicates no unrecovered fault, the fault has been recovered. Stop.
   - If the indicator still indicates an unrecovered fault, go to step 2.

47.3.6.2.4 Clear the freeze-status indicators

1. Run the OP13 operation (see Run an operation).
2. Check the operation status (CTRL[OPS]).
   - If the operation status is Successful, stop .
   - If the operation status is Aborted, go to step 1.

47.3.6.3 Run operations

47.3.6.3.1 Introduction

You run operations to perform actions such as putting FCCU in the CONFIG state or setting the operation status to Idle. For a complete list of operations you can run, see CTRL[OPR].

47.3.6.3.2 About running operations

When running operations:

- FCCU ignores any operations initiated while the operation status is In Progress.
- Certain operations must be unlocked before you can initiate them. After you initiate them, they are locked again.

47.3.6.3.3 Run an operation

1. Check the operation status (CTRL[OPS]).
2. Go to step 1 if the operation status is In Progress.
3. Unlock the operation (CTRLK[CTRLK]) using a 32-bit write, if the operation must be unlocked before you can initiate it.

   NOTE

   The Control Key (CTRLK) register used in this step and the Control (CTRL) register used in the next step must be written with consecutive instructions. Do not use read-modify-write instructions, such as bit-field instructions, to modify these registers.

4. Initiate the operation (CTRL[OPR]) using a 32-bit write.
5. Check the operation status (CTRL[OPS]).
6. Go to step 5 if the operation status is In Progress.

The operation status is now Idle (OP15 only), Aborted, or Successful.

47.3.7 FOSU

The FOSU provides a supervision of the primary fault notification path by analyzing FCCU's behavior for correctness. It waits for any reaction of the FCCU in a fixed time window after a fault is signaled.

The intention of the FOSU is to provide a secondary fault reaction path in most cases when the FCCU fails but not to needlessly propagate a fault which is already handled by the FCCU in a full chip reset. Only a failed primary fault reaction (that is, FCCU's failure) is a reason for the secondary reaction to take over (and generate a destructive reset request).

There is a 'do nothing' input coming from FCCU which indicates that the FCCU is programmed for no reaction for ALL FAULTS. It is a "static" input in the sense that it does not change after FCCU configuration. The FOSU masks the incoming faults with the 'do nothing' control from the FCCU, meaning that a fault is not captured by the FOSU if the 'do nothing' signal is asserted (that is, a disabled fault). There is no minimum pulse width requirement on the fault indication other than what is required by the technology, which is the same as that of the FCCU. FOSU does not monitor FCCU for the case of faults occurring during the CONFIG state.

The FOSU contains a timer with a duration of FOSU_COUNT, driven by CLKSAFE. The timer is initialized and started on any captured, enabled fault. While the timer is running, any subsequent captured fault will neither restart nor reinitialize the timer. The timer is stopped when the FCCU shows any of the following reactions (the FOSU does not check whether the reaction is the configured one for the faults which occurred):

- Reset: short functional reset
- IRQ (triggered by ALARM state)
- NMI
- Error out triggered (by FCCU or by SW)

When the timer is stopped, the fault capture logic is cleared to ensure that the timer is not restarted because of faults still 'stuck' in the capture logic. The timer is then restarted by the next new failure indication. When the timer expires, the FOSU's failure indicator output is asserted after it ensures that the fault is enabled and the static "fccu program to do nothing" signal is deasserted. This is because FCCU uses settings after it exits CONFIG state, even if fault captured before the exit.

The FOSU's failure indicator output is connected to one of the MC_RGM's 'destructive' reset inputs, so its assertion will cause a reset sequence to be initiated starting at DEST0. The FOSU module is reset with the same reset as is used by the FCCU. When

this reset is asserted, the FOSU's capture logic is cleared, its timer is kept stopped and in a non-expired state, and its failure indicator output is deasserted.

NOTE

FOSU is triggered on assertion of enabled fault. In case the triggering fault is disabled, FOSU times out without reaction.

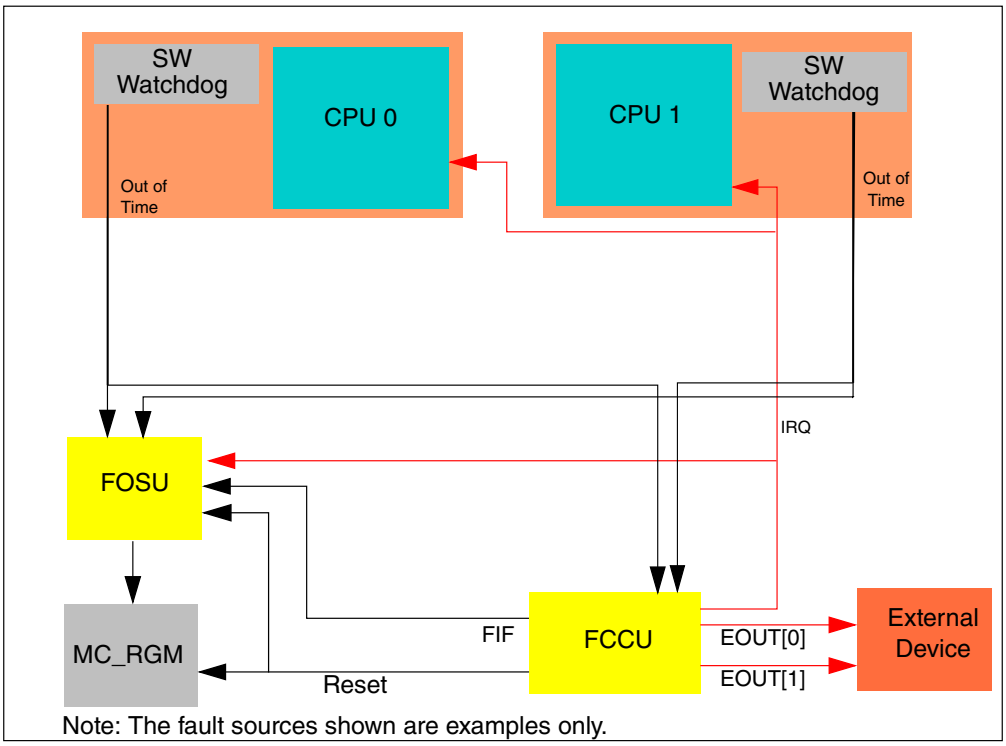


Figure 193. FOSU connections to the FCCU and MC_RGM

47.3.8 Clocking

This module has no clocking considerations.

47.3.9 Interrupts

This module has no interrupts.

47.4 External signals

FCCU interfaces with the EOUT pin. Signaling on the EOUT pin depends on whether the module is processing an error or is idle.

47.5 Initialization

47.5.1 Prepare FCCU for configuration

47.5.1.1 Introduction

You prepare FCCU for configuration by first configuring the CONFIG state and then putting FCCU in that state.

47.5.1.2 About preparing FCCU for configuration

When preparing FCCU for configuration, keep the following in mind:

- To put FCCU in CONFIG state, FCCU must be in NORMAL state.
- After FCCU is reset, the configuration is temporarily locked. You must temporarily unlock the configuration before you can put FCCU in the CONFIG state.
- When FCCU is in the CONFIG state, FCCU does not actually save the changes you make to the configuration. To save changes to the configuration, you must manually put FCCU in the NORMAL state. If FCCU automatically leaves the CONFIG state and enters the NORMAL state because the Configuration-state timeout interval (CFG_TO[TO]) expires (called a Configuration-state timeout), FCCU changes the value of the Configuration (CFG) register to its Configuration-state-timeout value and the value of each of the other configuration registers to its reset value. FCCU also changes the value of the Configuration-State Timeout Interval (CFG_TO) register to its reset value. For information on the Configuration-state timeout value, see CFG register bit value at different events. For a list of configuration registers, see Configuration registers.

47.5.1.3 Configure the CONFIG state

1. Set the Configuration-state timeout interval (CFG_TO[TO]).
2. Enable the Configuration-state-timeout interrupt signal (IRQ_EN[CFG_TO_IEN]), if you want FCCU to request an interrupt when a Configuration-state timeout occurs.

47.5.1.4 Put FCCU in the CONFIG state

1. Unlock the configuration temporarily (TRANS_LOCK[TRANSKEY]) in Supervisor mode.
2. Check the FCCU status (STAT[STATUS]).
   - If the FCCU status is CONFIG, FCCU is in the CONFIG state. Stop.
   - If the FCCU status is NORMAL, go to step 3.
   - If the FCCU status is ALARM or FAULT, go to step 5.
3. Run the OP1 operation (see Run an operation).
4. Check the operation status (CTRL[OPS]).
   - If the operation status is Successful, FCCU is in the CONFIG state. Stop.
   - If the operation status is Aborted, the configuration is probably permanently locked. Go to step 7.
5. Recover all faults (see Fault recovery).
6. Go to step 2.
7. Reset FCCU.

47.5.2 Configure FCCU

47.5.2.1 Introduction

You configure FCCU so it functions according to the needs of your particular application.

47.5.2.2 About configuring FCCU

When configuring FCCU:

- If you enable a non-critical fault channel but disable all reactions for that channel, FCCU changes state when necessary but does not perform any reaction because reactions are disabled. If you enable reactions for a non-critical fault channel but disable that channel, and FCCU is in the NORMAL state when a fault occurs on the channel, FCCU does not enter the ALARM or FAULT state and therefore does not perform any reaction.

47.5.2.3 Configure the non-critical fault channels

For each non-critical fault channel that you want FCCU to monitor:

1. Set the recovery type (NCF_CFGa[NCFCn]).
2. Enable at least one type of Fault-state reaction:
   - Chip functional reset (NCFS_CFGa[NCFSCn])
   - Non-maskable interrupt (NMI_ENa[NMIENn])
   - EOUT signaling (EOUT_SIG_ENa[EOUTENn])

   NOTE

   If you enable the chip functional reset as the type of Fault-state reaction for a channel, enable at least one other type of Fault-state reaction for the channel or enable the ALARM state (step 4) for the channel.
3. Set the Alarm-state timeout interval (NCF_TO[TO]), if you plan to enable the ALARM state for any non-critical fault channel.

   NOTE

   Ensure that the Alarm-state timeout interval is less than the FOSU module's timeout interval; otherwise, FOSU generates a chip reset every time a fault occurs on the channel. The FOSU timeout interval (FOSU_COUNT) is a chip-specific value. See the chip-specific FCCU information.
4. Enable the ALARM state (NCF_TOEa[NCFTOEn]) for any non-critical fault channel for which you want FCCU to enter the ALARM state before entering the FAULT state.
5. Enable the Alarm-state reaction (IRQ_ALARM_ENa[IRQENn]) for each non-critical fault channel for which you enabled the ALARM state.
6. Enable the corresponding NCF_Ea[NCFEn] field for each non-critical fault channel that you want FCCU to monitor.

47.6 Application information

47.6.1 Use cases and limitations

Configuration guidelines

Follow these guidelines to configure FCCU:

- If you want FCCU to react to a fault on a non-critical fault channel:
  - Enable the channel (Non-critical Fault Enable (NCF_E0)).
  - Enable at least one type of Fault-state reaction for the channel: chip reset (Non-critical Fault-State Configuration (NCFS_CFG0)), fault-output (EOUT) signaling (Non-critical Fault-State EOUT Signaling Enable (EOUT_SIG_EN0)), or non-maskable interrupt (Non-critical Fault-State Non-maskable-Interrupt-Request Enable (NMI_EN0)).
  - If you enable chip reset as the type of Fault-state reaction for the channel (Non-critical Fault-State Configuration (NCFS_CFG0)), enable either ALARM state (Non-critical-Fault Alarm-State Timeout Enable (NCF_TOE0)) or at least one other type of Fault-state reaction for the channel: fault-output (EOUT) signaling (Non-critical Fault-State EOUT Signaling Enable (EOUT_SIG_EN0)) or non-maskable interrupt (Non-critical Fault-State Non-maskable-Interrupt-Request Enable (NMI_EN0)).
  - If you enable ALARM state for the channel (Non-critical-Fault Alarm-State Timeout Enable (NCF_TOE0)), enable the Alarm-state reaction (Non-critical Alarm-State Interrupt-Request Enable (IRQ_ALARM_EN0)).
  - If you enable ALARM state for the channel (Non-critical-Fault Alarm-State Timeout Enable (NCF_TOE0)), make sure the Alarm-state timer interval (Non-critical-Fault Alarm-State Timeout Interval (NCF_TO)) is less than the FOSU module's timer interval; otherwise, FOSU generates a chip reset every time a fault occurs on the channel. The FOSU timer interval (FOSU_COUNT) is chip-specific. See the chip-specific FCCU information.

Recommendations to configure FCCU

1. After a power on, or 'destructive' reset (when initiated by the assertion of the chip reset pin, RESET_B), where both system and FCCU are reset, the following steps could be followed to configure FCCU:
    a. Check and clear any pending fault status
    b. Verify FCCU is in NORMAL state, else repeat step(a) above
    c. Configure FCCU
2. After any 'functional' reset of the system, arising out of a reset request from FCCU or other sources, the following steps could be followed to reconfigure FCCU:
    a. If active, wait for the Error out T_{min} to expire
    b. Check and clear fault status
    c. Error pin moves to "non faulty" state, once fault status is cleared and T_{min} expires
    d. Verify FCCU is in NORMAL state, else repeat step(a) above
    e. Read and verify value in NCF_En
    f. Reconfigure FCCU, if necessary

47.7 Register descriptions

47.7.1 FCCU register descriptions

The FCCU registers are listed in the table below. Any address offset not explicitly mentioned in this table is reserved.

The FCCU supports word (32-bit), half-word (16-bit), and byte (8-bit) read and write accesses.

Follow these register-access guidelines:

- Do not read from or write to any addresses that are not shown in the following table. Doing so may or may not result in a transfer error.
- Do not write to any of the configuration registers unless FCCU is in the CONFIG state. Doing so results in a transfer error.
- Do not write to the Transient Configuration Lock (TRANS_LOCK) or Permanent Configuration Lock (PERMNT_LOCK) registers unless your code runs in the Supervisor mode. Doing so results in a transfer error.

For each possible NCF failure source, a different reaction—including no reaction—is configurable through the use of NMI, IRQ, and short reset selection registers. It is not possible for a single event upset to switch off all reactions on failures as implementation is per fault source (but it will be possible to switch them all off by SW if intended). Failures themselves are not able to disable all reactions and indications.

47.7.1.1 FCCU memory map

FCCU base address: 4038_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Control (CTRL)	32	RW	0000_00C0h
4h	Control Key (CTRLK)	32	W	0000_0000h
8h	Configuration (CFG)	32	RW	0000_0000h
1Ch	Non-critical Fault Configuration (NCF_CFG0)	32	RW	0000_FFFFh

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
4Ch	Non-critical Fault-State Configuration (NCFS_CFG0)	32	RW	0000_0000h
80h	Non-critical Fault Status (NCF_S0)	32	RW	0000_0000h
90h	Non-critical Fault Key (NCFK)	32	W	0000_0000h
94h	Non-critical Fault Enable (NCF_E0)	32	RW	0000_0000h
A4h	Non-critical-Fault Alarm-State Timeout Enable (NCF_TOE0)	32	RW	0000_FFFFh
B4h	Non-critical-Fault Alarm-State Timeout Interval (NCF_TO)	32	RW	0003_A980h
B8h	Configuration-State Timeout Interval (CFG_TO)	32	RW	0000_0005h
BCh	IO Control (EINOUT)	32	RW	See section
C0h	Status (STAT)	32	R	0000_0010h
C4h	Normal-to-Alarm Freeze Status (N2AF_STATUS)	32	R	0000_0000h
C8h	Alarm-to-Fault Freeze Status (A2FF_STATUS)	32	R	0000_0000h
CCh	Normal-to-Fault Freeze Status (N2FF_STATUS)	32	R	0000_0000h
D0h	Fault-to-Alarm Freeze Status (F2AF_STATUS)	32	R	0000_0000h
DCh	Non-critical Fault Fake (NCFF)	32	RW	0000_0000h
E0h	IRQ Status (IRQ_STAT)	32	RW	0000_0000h
E4h	IRQ Enable (IRQ_EN)	32	RW	0000_0000h
F0h	Transient Configuration Lock (TRANS_LOCK)	32	RW	0000_0000h
F4h	Permanent Configuration Lock (PERMNT_LOCK)	32	RW	0000_0000h
F8h	Delta T (DELTA_T)	32	RW	0000_0000h
FCh	Non-critical Alarm-State Interrupt-Request Enable (IRQ_ALARM_EN0)	32	RW	0000_0000h
10Ch	Non-critical Fault-State Non-maskable-Interrupt-Request Enable (NMI_EN0)	32	RW	0000_0000h
11Ch	Non-critical Fault-State EOUT Signaling Enable (EOUT_SIG_EN0)	32	RW	0000_0000h
12Ch	Alarm-State Timer (TMR_ALARM)	32	R	0003_A980h
134h	Configuration-State Timer (TMR_CFG)	32	R	000F_FFFFh
138h	Fault-Output Timer (TMR_ETMR)	32	R	0000_0000h

47.7.1.2 Control (CTRL)

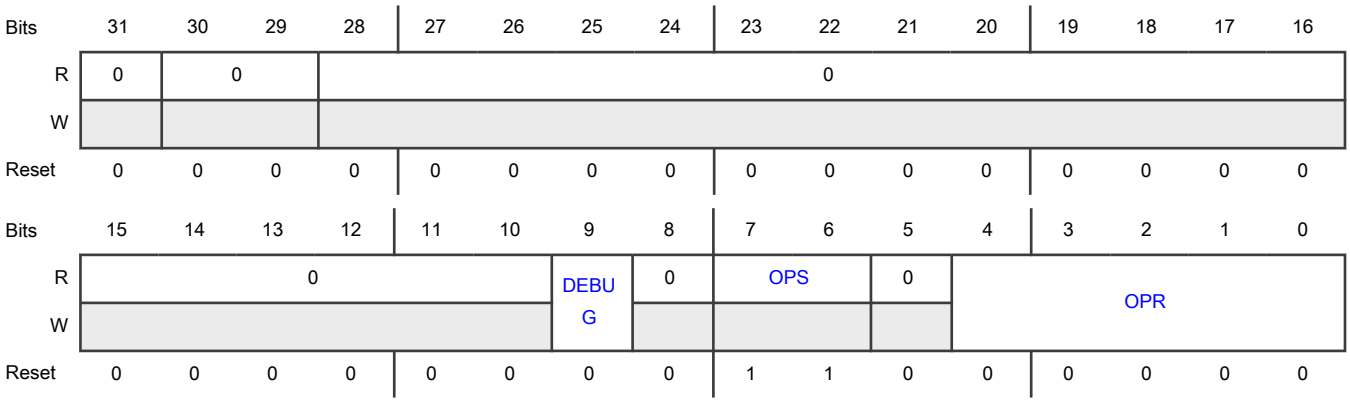
Offset

Register	Offset
CTRL	0h

Function

Initiates and indicates the status of operations—and enables the Debug mode.

Diagram



Fields

Field	Function
31 —	Reserved
30-29 —	Reserved
28-10 —	Reserved
9 DEBUG	Debug Mode Enable Specifies whether the Debug mode is enabled. If so, FCCU enters the Debug mode when the Debug signal is asserted. When FCCU enters the Debug mode, it halts operation and remains in the state it was in before it entered this mode. **NOTE** FOSU does not halt when FCCU enters the Debug mode. Therefore, FOSU can still cause a reset if a fault occurs while FCCU is in the Debug mode. 0b - Disabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Enabled
8 —	Reserved
7-6 OPS	Operation Status This field can be read and cleared (via OP15 operation) by the software. 00b - Idle 01b - In progress 10b - Aborted 11b - Successful
5 —	Reserved
4-0 OPR	Operation Run Initiates operations that perform actions such as putting FCCU in the CONFIG state or setting the operation status to Idle. For information on how to run operations, see Run operations. FCCU ignores any write to this field while the operation status (CTRL[OPS]) is "In progress". After completion of an operation, FCCU sets this field to OP0. The following events result in an operation status (CTRL[OPS]) of "Aborted": • Writing to a NCF_Sa register (which automatically initiates the OP12 operation) without first successfully unlocking the register (NCFK[NCFK]) • Initiating an OP1 operation when FCCU is not in the NORMAL state or the configuration is locked • Initiating an OP1, or OP2, operation without first unlocking the operation (CTRLK[CTRLK]) 00000 OP0—No operation 00001 OP1—Applies only when the configuration is unlocked, when FCCU is in the NORMAL state, and immediately after you unlock the operation (CTRLK[CTRLK]). Put FCCU in the CONFIG state. 00010 OP2—Applies only immediately after you unlock the operation (CTRLK[CTRLK]). Put FCCU in the NORMAL state. 00011 Reserved 00100 Reserved 00101 Reserved 00110 Reserved 00111 Reserved 01000 Reserved 01001 Reserved 01010 Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
	01011 Reserved 01100 OP12—Do not initiate this operation; it is automatically initiated by the FCCU. A NCF_Sa register status clear operation is in progress. 01101 OP13—Clear the freeze status registers. 01110 OP14—Do not initiate this operation; it is automatically initiated by the FCCU. A Configuration-state timeout is in progress. For more information, see Configuration registers. 01111 OP15—Set the operation status (CTRL[OPS]) to Idle. 10000 Reserved 10001 Reserved 10010 Reserved 10011 Reserved 10100 Reserved 10101—11110 Forbidden. Writing any of these values returns an operation status (CTRL[OPS]) of "Aborted" with no side effect. 11111 Reserved

47.7.1.3 Control Key (CTRLK)

Offset

Register	Offset
CTRLK	4h

Function

See CTRLK[CTRLK].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	CTRLK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	CTRLK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CTRLK	Locked-Operation Control Key Writable only with a 32-bit write. Unlocks locked operations (CTRL[OPR]) so you can initiate them. For information on how to unlock locked operations before you initiate them, see Run an operation. **NOTE** • You must initiate an operation in the FCCU register access that immediately follows the one that unlocks it; otherwise, the operation is again locked. • Reading from this register always returns the value 0000_0000h. Operations not listed here are not locked and do not need to be unlocked. 9137_56AFh: Unlock OP1. 825A_132Bh: Unlock OP2. Any other value: Do nothing.

47.7.1.4 Configuration (CFG)

Offset

Register	Offset
CFG	8h

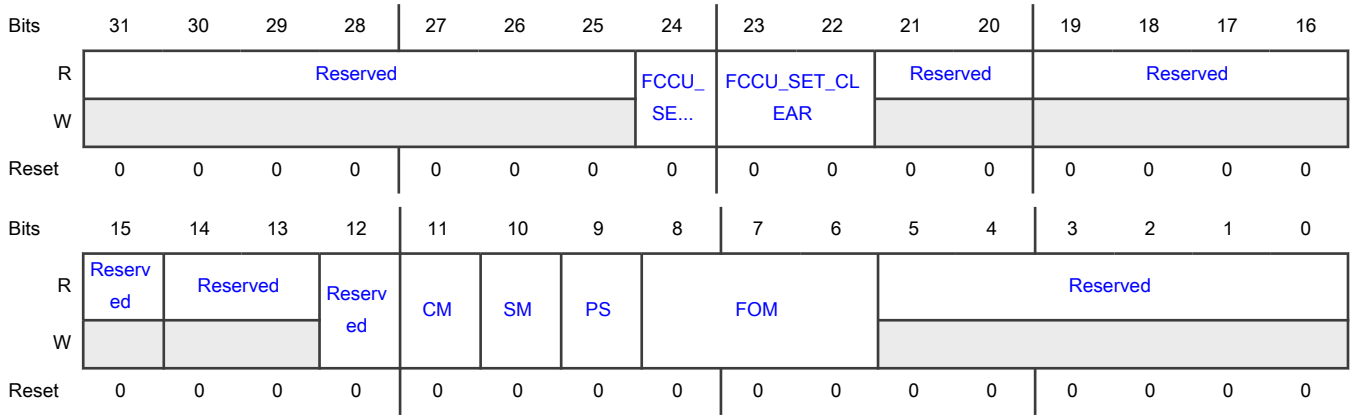
Function

Writable only when FCCU is in the CONFIG state. Changed by FCCU to another value when the chip resets FCCU, a Configuration-state timeout occurs, or you run an OP31 operation. See CFG register bit value at different events for more information. Specifies the global configuration for FCCU.

NOTE

If you specify a new value for any of the fields in this register that affect the EOUT signals while the fault-output (EOUT) timer is running (FCCU is indicating a fault on the EOUT signals), FCCU does not use the new settings you specified until after the fault-output (EOUT) timer expires (FCCU stops indicating a fault on the EOUT signals).

Diagram



Fields

Field	Function
31-25 —	Reserved
24 FCCU_SET_AFTER_RESET	Fault-Output (EOUT) Activate For fault-output (EOUT) signaling, controls whether the EOUT signals are active. 0b - Inactive (the EOUT signals are in a high-impedance state) 1b - Active (the EOUT signals indicate FCCU's condition)
23-22 FCCU_SET_CLEAR	Fault-Output (EOUT) Control Applies only to Bi-Stable and Fault-Toggle fault-output modes (CFG[FOM]) and when the EOUT signals are active (CFG[FCCU_SET_AFTER_RESET]). Controls whether the fault-output (EOUT) signals are managed by FCCU's FSM. **NOTE** When the EOUT signals are in the Fault-Toggle fault-output mode, if you change the value of this field, you must also deactivate and then reactivate the EOUT signals (CFG[FCCU_SET_AFTER_RESET]) to correctly initialize them so they have opposite states. 00b - Controlled by the FSM 01b - Always low 10b - Controlled by the FSM 11b - High until a fault occurs on a channel, regardless of whether that fault is disabled; thereafter, controlled by the FSM. Note: FCCU ignores an attempt to write this value if the fault-output (EOUT) timer is already running.
21-20 —	Reserved
19-16	Reserved

Table continues on the next page...

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Field	Function
—	
15 —	Reserved
14-13 —	Reserved
12 —	Reserved Always write the reset value to this field.
11 CM	Fault-Output (EOUT) Configuration-Indication Mode For fault-output (EOUT) signaling, this field controls whether the configuration indication is the same as the non-faulty indication. 0b - Different 1b - Same
10 SM	Fault-Output (EOUT) Switching Mode Applies only to Dual-Rail and Time-Switching fault-output modes (CFG[FOM]). For fault-output (EOUT) signaling, controls how quickly the signals switch between indicating the faulty and non-faulty conditions. 0b - Slow: No EOUT frequency violation during the FCCU state transition (NORMAL to FAULT or vice versa, and CONFIG to NORMAL). The indication transition occurs after a maximum delay equal to the duration of the semi period of the EOUT frequency. 1b - Fast: The indication transition (NORMAL to FAULT or vice versa, and CONFIG to NORMAL) occurs immediately. A pulse with the minimum duration corresponding to the CLKSAFE period can occur in this mode. It implies a frequency violation of the EOUT protocol.
9 PS	Fault-Output (EOUT) Polarity Selection Applies to fault-output (EOUT) signaling and controls the polarity of the signals for fault-output mode indications that hold the signals low or high (versus toggling them or placing them in a high-impedance state). Applies only to Time-Switching fault-output mode (for faulty and configuration indications) and Bi-Stable fault-output mode (for all indications). 0b - For the faulty indication, EOUT1 is high, and EOUT0 is low. 1b - For the faulty indication, EOUT1 is low, and EOUT0 is high.
8-6 FOM	Fault-Output (EOUT) Mode For fault-output (EOUT) signaling, controls the protocol of the signaling. **NOTE** See the chip-specific FCCU information for the fault-output modes supported by this chip. 000b - Dual-Rail

Table continues on the next page...

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Field	Function
	001b - Time-Switching 010b - Bi-Stable 011b - Fault-Toggle 100b - Reserved 101b - Test 0 (controlled by the EINOUT register; EOUT1 is an output; EOUT0 is an input) 110b - Test 1 (controlled by the EINOUT register; EOUT1 and EOUT0 are both outputs) 111b - Test 2 (controlled by the EINOUT register; EOUT1 is an input; EOUT0 is an output)
5-0 —	Reserved

47.7.1.5 Non-critical Fault Configuration (NCF_CFG0)

Offset

Register	Offset
NCF_CFG0	1Ch

Function

See NCF_CFGa[NCFCn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NCFC 15	NCFC 14	NCFC 13	NCFC 12	NCFC 11	NCFC 10	NCFC 9	NCFC 8	NCFC 7	NCFC 6	NCFC 5	NCFC 4	NCFC 3	NCFC 2	NCFC 1	NCFC 0
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-16	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
15-0 NCFCn	Non-critical Fault Configuration n Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Controls the recovery type (HW or SW) of the associated non-critical fault channel (n). For information on how to configure the non-critical fault channels, see Configure the non-critical fault channels. **NOTE** Configure a non-critical fault channel as hardware-recoverable only if the source continues to indicate a fault on the fault channel's input (NCFn) until the condition that caused the fault is no longer true; otherwise, configure the non-critical fault channel as software-recoverable. 0b - Hardware-recoverable 1b - Software-recoverable

47.7.1.6 Non-critical Fault-State Configuration (NCFS_CFG0)

Offset

Register	Offset
NCFS_CFG0	4Ch

Function

See NCFS_CFGa[NCFSCn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	NCFSC15		NCFSC14		NCFSC13		NCFSC12		NCFSC11		NCFSC10		NCFSC9		NCFSC8	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	NCFSC7		NCFSC6		NCFSC5		NCFSC4		NCFSC3		NCFSC2		NCFSC1		NCFSC0	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30: NCFSC15 29-28: NCFSC14 27-26: NCFSC13 25-24: NCFSC12 23-22: NCFSC11 21-20: NCFSC10 19-18: NCFSC9 17-16: NCFSC8 15-14: NCFSC7 13-12: NCFSC6 11-10: NCFSC5 9-8: NCFSC4 7-6: NCFSC3 5-4: NCFSC2 3-2: NCFSC1 1-0: NCFSC0	Non-critical Fault-State Configuration n Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Controls whether the chip functional reset is enabled as a Fault-state reaction for the associated non-critical fault channel (n). When the chip functional reset is enabled for an enabled non-critical fault channel, a fault on that channel causes FCCU to assert the rst_sfunc_b signal when FCCU enters the FAULT state. For information on how to configure the non-critical fault channels, see Configure the non-critical fault channels. 00b - Disabled 01b - Enabled (rst_sfunc_b) (short) 10b - Reserved 11b - Disabled

47.7.1.7 Non-critical Fault Status (NCF_S0)

Offset

Register	Offset
NCF_S0	80h

Function

See NCF_Sa[NCFSn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NCFS 15	NCFS 14	NCFS 13	NCFS 12	NCFS 11	NCFS 10	NCFS 9	NCFS 8	NCFS 7	NCFS 6	NCFS 5	NCFS 4	NCFS 3	NCFS 2	NCFS 1	NCFS 0
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-0 NCFSn	Non-critical Fault Status n Indicates whether there is an unrecovered fault on the associated non-critical fault channel (n). **NOTE** To recover a software-recoverable non-critical fault, which includes clearing its unrecovered-fault indicator, see Recover a software-recoverable non-critical fault. FCCU clears the unrecovered-fault indicator for a hardware-recoverable non-critical fault automatically when the source no longer indicates a fault on the fault channel's input signal; if you attempt to clear the unrecovered-fault indicator for a hardware-recoverable non-critical fault, FCCU does not clear the indicator and does not indicate an error. 0b - No unrecovered fault 1b - Unrecovered fault

47.7.1.8 Non-critical Fault Key (NCFK)

Offset

Register	Offset
NCFK	90h

Function

See NCFK[NCFK].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W	NCFK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W	NCFK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 NCFK	Non-critical Fault Key Writable only with a 32-bit write. Unlocks the NCF_Sa registers so you can write to them while recovering a software-recoverable non-critical fault. For information on how to unlock the NCF_Sa registers before writing to them, see Recover a software-recoverable non-critical fault. **NOTE** • You must write to one of the NCF_Sa registers immediately after unlocking it (that is, in the FCCU register access that immediately follows the one that unlocks them); otherwise the registers are again locked. If you want to write to multiple NCF_Sa registers, you must unlock each register immediately before you write to it. • Reading from this register always returns the value 0000_0000h. AB34_98FEh: Unlock. Any other value: Do nothing.

47.7.1.9 Non-critical Fault Enable (NCF_E0)

Offset

Register	Offset
NCF_E0	94h

Function

See NCF_Ea[NCFEn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NCFE 15	NCFE 14	NCFE 13	NCFE 12	NCFE 11	NCFE 10	NCFE 9	NCFE 8	NCFE 7	NCFE 6	NCFE 5	NCFE 4	NCFE 3	NCFE 2	NCFE 1	NCFE 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-0 NCFEn	Non-critical Fault Enable n Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Controls whether the associated non-critical fault channel (n) is enabled. When a non-critical fault channel is enabled, a fault on that channel causes FCCU to leave the NORMAL state and enter the FAULT state (or ALARM state if enabled for the channel). For information on how to configure the non-critical fault channels, see Configure the non-critical fault channels. 0b - Disabled 1b - Enabled

47.7.1.10 Non-critical-Fault Alarm-State Timeout Enable (NCF_TOE0)

Offset

Register	Offset
NCF_TOE0	A4h

Function

See NCF_TOEa[NCFTOEn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NCFTOE15	NCFTOE14	NCFTOE13	NCFTOE12	NCFTOE11	NCFTOE10	NCFTOE9	NCFTOE8	NCFTOE7	NCFTOE6	NCFTOE5	NCFTOE4	NCFTOE3	NCFTOE2	NCFTOE1	NCFTOE0
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-16 —	Reserved
15-0 NCFTOEn	Non-critical-Fault Alarm-State Timeout Enable n Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Controls whether the ALARM state is enabled for the associated non-critical fault channel (n). When the ALARM state is enabled for an enabled non-critical fault channel, a fault on that channel causes FCCU to leave the NORMAL state and enter the ALARM state instead of FAULT state. If the fault is not recovered within the Alarm-state timeout interval, then FCCU leaves the ALARM state and enters the FAULT state. For information on how to configure the non-critical fault channels, see Configure the non-critical fault channels. 0b - Disabled 1b - Enabled

47.7.1.11 Non-critical-Fault Alarm-State Timeout Interval (NCF_TO)

Offset

Register	Offset
NCF_TO	B4h

Function

See NCF_TO[TO]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TO															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TO															
Reset	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TO	Non-critical-Fault Alarm-State Timeout Interval Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Controls the maximum amount of time that FCCU can be in the ALARM state ($T_{Max\ Alarm}$) according to this equation: $T_{Max\ Alarm} = TO \times T_{CLKSAFE}$ where $T_{CLKSAFE}$ is the safe-clock period. If FCCU enters the ALARM state (because a fault occurs on an enabled non-critical fault channel for which the ALARM state is enabled) and this timeout interval expires (called an Alarm-state timeout), then FCCU leaves the ALARM state and enters the FAULT state. **NOTE** Make sure the Alarm-state timeout interval is less than the FOSU module's timeout interval; otherwise, a fault that occurs while FCCU is in the ALARM state can cause FOSU to generate a chip reset. The FOSU timeout interval (FOSU_COUNT) is chip-specific. See the chip-specific FCCU information.

47.7.1.12 Configuration-State Timeout Interval (CFG_TO)

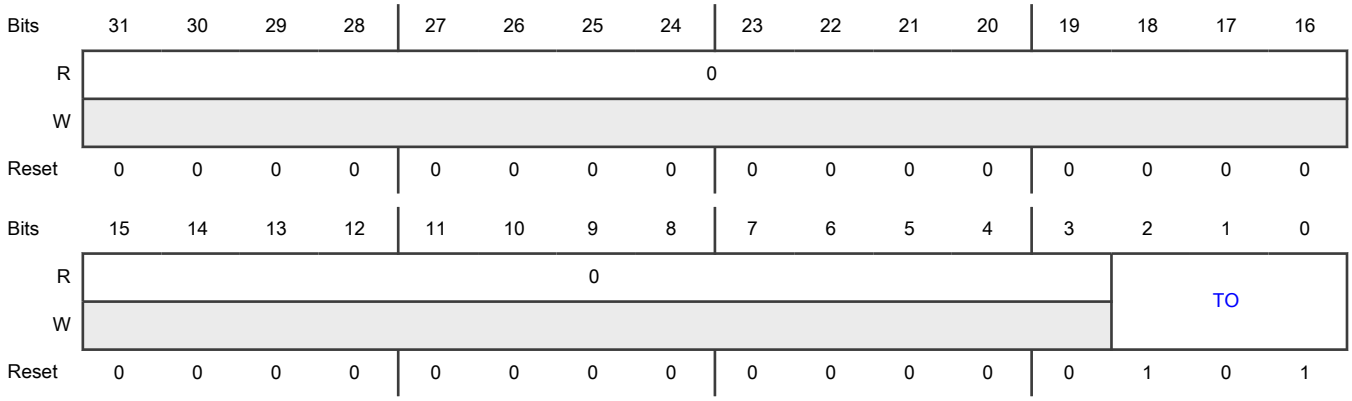
Offset

Register	Offset
CFG_TO	B8h

Function

See CFG_TO[TO]

Diagram



Fields

Field	Function
31-3 —	Reserved
2-0 TO	Configuration-State Timeout Interval Writable only when FCCU is in the NORMAL, ALARM, or FAULT state (not in the CONFIG state). Changed by FCCU to its reset value when a Configuration-state timeout occurs. Not accessible while a Configuration-state timeout (OP14 operation) is in progress. Controls the maximum amount of time that FCCU can be in the CONFIG state ($T_{\text{Max configuration}}$) according to this equation: $T_{\text{Max configuration}} = T_{\text{CLKSAFE}} \times 2^{(\text{TO} + 13)}$ where T_{CLKSAFE} is the safe-clock period. If you put FCCU in the CONFIG state and this timeout interval expires (called a Configuration-state timeout), then FCCU: • Automatically leaves the CONFIG state and enters the NORMAL state • Changes the value of the Configuration (CFG) register to its Configuration-state-timeout value and the value of each of the other configuration registers to its reset value. For information on the Configuration (CFG) register's Configuration-state-timeout value, see CFG register bit value at different events. For a list of configuration registers, see Configuration registers.

47.7.1.13 IO Control (EINOUT)

Offset

Register	Offset
EINOUT	BCh

Function

The EINOUT register allows the following operations typically in the NORMAL state:

- To control the EOUT[1] output level when the FCCU is configured in "Test1" or "Test0" fault output mode (CFG[FOM])

- To control the EOUT[0] output level when the FCCU is configured in "Test1" or "Test2" fault output mode (CFG[FOM])
- to observe the state of signals at EIN[1:0] pins

The following table shows Bi-Stable encoding.

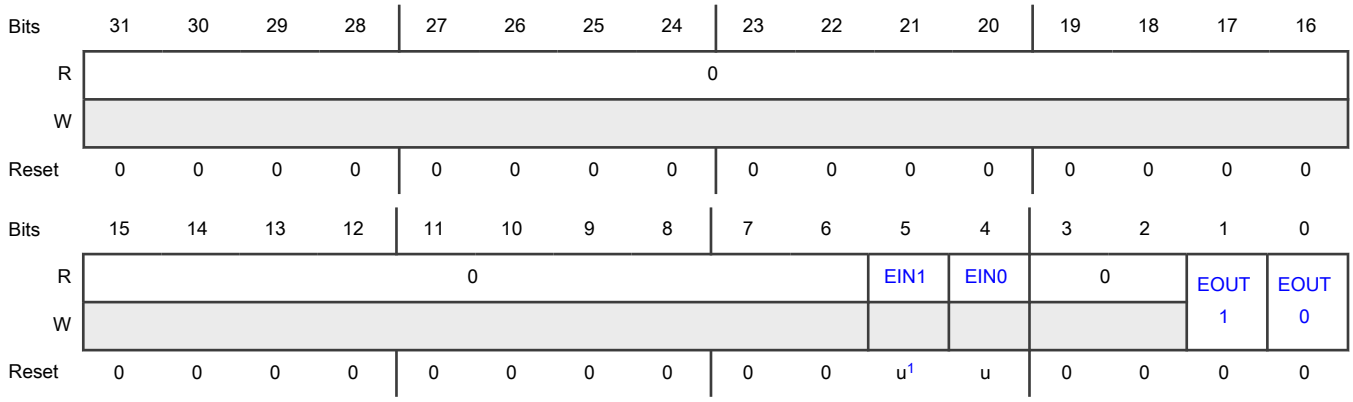
Table 228. Bi-Stable encoding

Mode = CFG[FOM]	EOUT[0]	EOUT[1]
Test1	output	output
Test2	output	input
Test0	input	output

NOTE

Because of the resynchronization stage of the EOUT interface, there is a latency of a few CLKSAFE cycles following a write/read operation of the EINOUT register.

Diagram



1. Reset value varies as per the corresponding EIN signal.

Fields

Field	Function
31-6 —	Reserved
5 EIN1	Error Input 1 Indicates the state of the EIN1 signal. **NOTE** When IP's SET_AFTER_RESET bit is 0, then corresponding pad is in High-Z state, in this case values sampled on EIN1 will depend on board/pad pull up/down values. 0b - Low 1b - High

Table continues on the next page...

Table continued from the previous page...

Field	Function
4 EIN0	Error Input 0 Indicates the state of the EIN0 signal. **NOTE** When IP's SET_AFTER_RESET bit is 0, then corresponding pad is in High-Z state, in this case values sampled on EIN0 will depend on board/pad pull up/down values. 0b - Low 1b - High
3-2 —	Reserved
1 EOUT1	EOUT1 Error out 1 (significant only if the CFG.FOM = Test1 or Test0 => EOUT[1] configured in output mode). The EOUT1 set/clear the respective EOUT[1] output signal if CFG.FOM = 110 or 101, otherwise it is a "don't-care" value. **NOTE** When the configuration watchdog timer expires, FCCU changes the value of this field to its reset value. 0b - force EOUT[1] = 0 1b - force EOUT[1] = 1
0 EOUT0	EOUT0 Error out 0 (significant only if the CFG.FOM = Test1 or Test2 => EOUT[0] configured in output mode). The EOUT0 set/clear the respective EOUT[0] output signal if CFG.FOM = 110 or 111, otherwise it is a "don't care" value. **NOTE** When the configuration watchdog timer expires, FCCU changes the value of this field to its reset value. 0b - force EOUT[0] = 0 1b - force EOUT[0] = 1

47.7.1.14 Status (STAT)

Offset

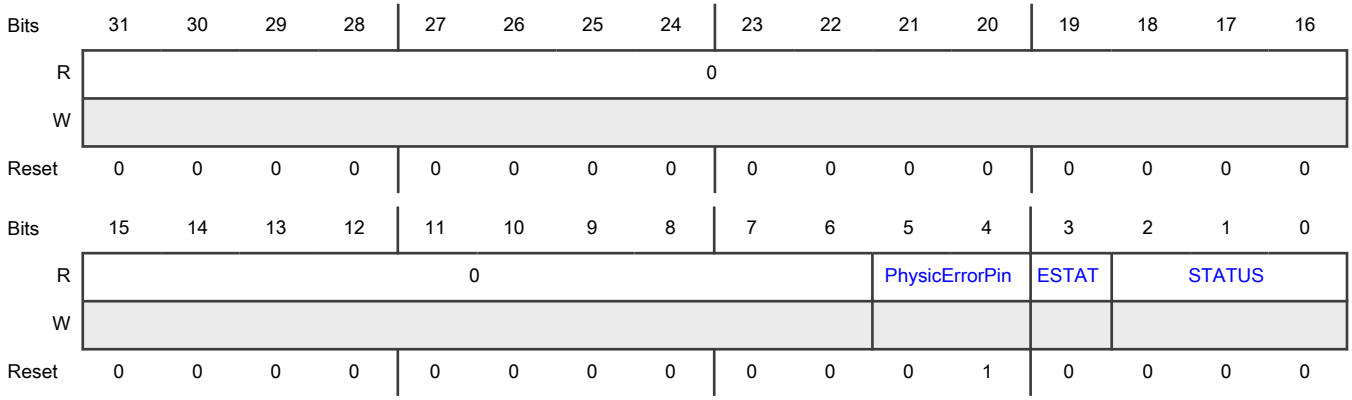
Register	Offset
STAT	C0h

Function

This register indicates the following:

- States that FCCU is driving on the EOUT signals
- Whether FCCU is in a faulty condition
- Current state of FCCU

Diagram



Fields

Field	Function
31-6 —	Reserved
5-4 PhysicErrorPin	EOUT Signal States Applies only when the EOUT signals are active (CFG[FCCU_SET_AFTER_RESET]). Indicates the states that FCCU is driving on the EOUT signals. 00b - EOUT1 is low; EOUT0 is low. 01b - EOUT1 is low; EOUT0 is high. 10b - EOUT1 is high; EOUT0 is low. 11b - EOUT1 is high; EOUT0 is high.
3 ESTAT	FCCU Faulty Condition Indicates whether FCCU is in faulty condition (as indicated by the EOUT signals). For more information, see The FCCU conditions. 0b - Not in faulty condition (in non-faulty or configuration condition) 1b - In faulty condition
2-0 STATUS	FCCU State Indicates the current state of FCCU 000b - NORMAL

Table continues on the next page...

Table continued from the previous page...

Field	Function
	001b - CONFIG 010b - ALARM 011b - FAULT 100b - Reserved 101b - Reserved 110b - Reserved 111b - Reserved

47.7.1.15 Normal-to-Alarm Freeze Status (N2AF_STATUS)

Offset

Register	Offset
N2AF_STATUS	C4h

Function

See N2AF_STATUS[NAFS].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								NAFS							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0	Normal-to-Alarm Freeze Status

Table continues on the next page...

Table continued from the previous page...

Field	Function
NAFS	Used only for testing and debugging. Indicates whether FCCU left the NORMAL state and entered the ALARM state since the last time this register was cleared and, if so, which non-critical fault caused FCCU to do so. **NOTE** To clear this register and the other freeze status registers, see Clear the freeze-status indicators. 00h: No Normal-to-Alarm-state transition (cleared) 01h: NCF0 10h: NCF1 ... 7Fh: NCF126 80h: NCF127 ... FFh: Multiple Normal-to-Alarm-state transitions

47.7.1.16 Alarm-to-Fault Freeze Status (A2FF_STATUS)

Offset

Register	Offset
A2FF_STATUS	C8h

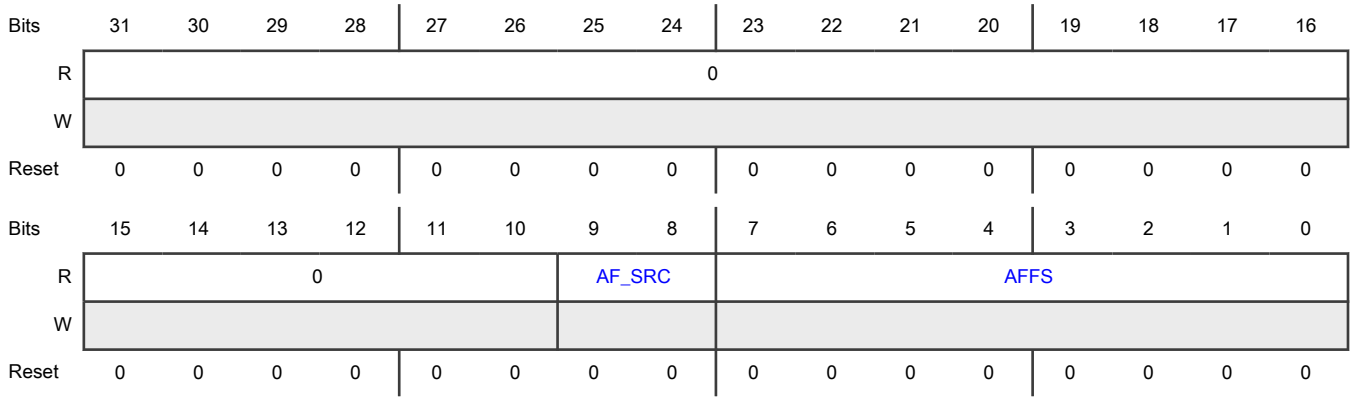
Function

Used only for testing and debugging. Indicates whether FCCU left the ALARM state and entered the FAULT state since the last time this register was cleared and, if so, which type of fault caused FCCU to do so.

NOTE

To clear this register and the other freeze status registers, see Clear the freeze-status indicators.

Diagram



Fields

Field	Function
31-10 —	Reserved
9-8 AF_SRC	Alarm-to-Fault Source Used only for testing and debugging. Indicates the type of fault that caused FCCU to leave the ALARM state and enter the FAULT state since the last time this register was cleared. **NOTE** To clear this register and the other freeze status registers, see Clear the freeze-status indicators. 00b - No Alarm-to-Fault-state fault 01b - Reserved 10b - Non-critical fault 11b - Multiple Alarm-to-Fault-state faults
7-0 AFFS	Alarm-to-Fault Freeze Status Used only for testing and debugging. Indicates whether FCCU left the ALARM state and entered the FAULT state since the last time this register was cleared and, if so, which fault caused FCCU to do so. **NOTE** To clear this register and the other freeze status registers, see Clear the freeze-status indicators. 00h: No Alarm-to-Fault-state transition (cleared) 01h: NCF0 (due to an Alarm-state timeout) 10h: NCF1 (due to an Alarm-state timeout) ... 7Fh: NCF126 (due to an Alarm-state timeout)

Table continues on the next page...

Table continued from the previous page...

Field	Function
	80h: NCF127 (due to an Alarm-state timeout) ... FFh: Multiple Alarm-to-Fault-state transitions

47.7.1.17 Normal-to-Fault Freeze Status (N2FF_STATUS)

Offset

Register	Offset
N2FF_STATUS	CCh

Function

Used only for testing and debugging. Indicates whether FCCU left the NORMAL state and entered the FAULT state since the last time this register was cleared and, if so, which type of fault caused FCCU to do so.

NOTE

To clear this register and the other freeze status registers, see Clear the freeze-status indicators.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0						NF_SRC		NFFS							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-10 —	Reserved
9-8 NF_SRC	Normal-to-Fault Source Used only for testing and debugging. Indicates the type of fault that caused FCCU to leave the NORMAL state and enter the FAULT state since the last time this register was cleared.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE To clear this register and the other freeze status registers, see Clear the freeze-status indicators. 00b - No Normal-to-Fault-state fault 01b - Reserved 10b - Non-critical fault 11b - Multiple Normal-to-Fault-state faults
7-0 NFFS	Normal-to-Fault Freeze Status Used only for testing and debugging. Indicates whether FCCU left the NORMAL state and entered the FAULT state since the last time this register was cleared and, if so, which fault caused FCCU to do so. **NOTE** To clear this register and the other freeze status registers, see Clear the freeze-status indicators. 00h: No Normal-to-Fault-state transition (cleared) 01h: NCF0 10h: NCF1 ... 7Fh: NCF126 80h: NCF127 ... FFh: Multiple Normal-to-Fault-state transitions

47.7.1.18 Fault-to-Alarm Freeze Status (F2AF_STATUS)

Offset

Register	Offset
F2AF_STATUS	D0h

Function

See F2AF_STATUS[FAFS].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0							FAFS								
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-9 —	Reserved
8-0 FAFS	Fault-to-Alarm Freeze Status Used only for testing and debugging. Indicates whether FCCU left the FAULT state and entered the ALARM state since the last time this register was cleared and, if so, which non-critical fault caused FCCU to do so. **NOTE** To clear this register and the other freeze status registers, see Clear the freeze-status indicators. 00h: No Fault-to-Alarm-state transition (cleared) 01h: NCF0 10h: NCF1 ... 7Fh: NCF126 80h: NCF127 ... FFh: Multiple Fault-to-Alarm-state transitions

47.7.1.19 Non-critical Fault Fake (NCFF)

Offset

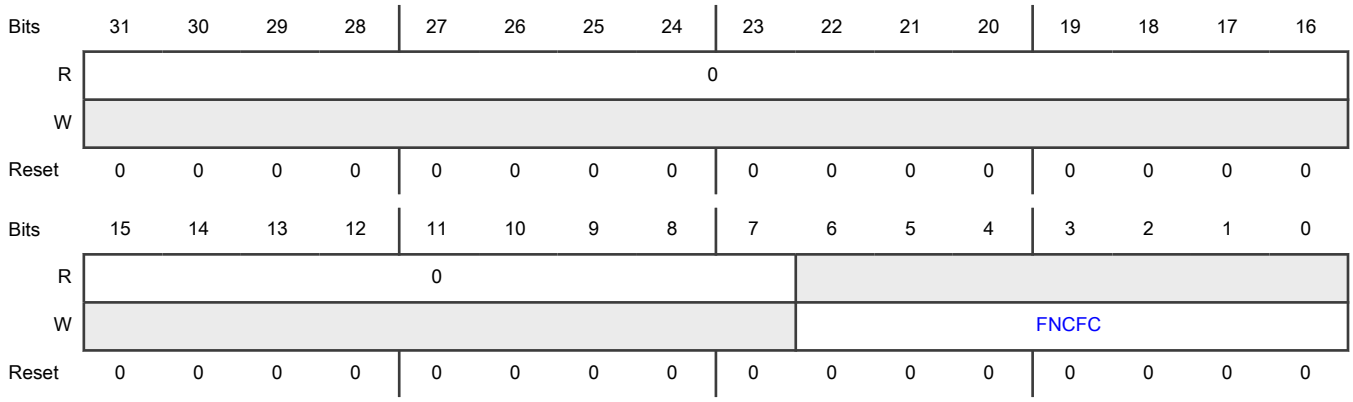
Register	Offset
NCFF	DCh

Function

This register contains a unique code to set a non-critical fault in mutually exclusive mode by the external FAULT interface (signal setting). It allows the SW emulation of the non-critical faults, by injecting the fault directly in the FAULT root, to verify the entire path and reaction. The reaction following a fake non-critical fault cannot be masked.

This is a write-only register with a set of codes corresponding to each non-critical fault injection.

Diagram



Fields

Field	Function
31-7 —	Reserved
6-0 FNCFC	FNCFC Fake non-critical fault code **NOTE** Writing to this field injects fake faults; writing 00 and the default value being 0 renders different results. 00h: Fake non-critical fault injection at non-critical fault source 0 01h: Fake non-critical fault injection at non-critical fault source 1 02h: Fake non-critical fault injection at non-critical fault source 2 ... 7Fh: Fake non-critical fault injection at non-critical fault source 127

47.7.1.20 IRQ Status (IRQ_STAT)

Offset

Register	Offset
IRQ_STAT	E0h

Function

This register provides the FCCU interrupt status related to the following events:

- Configuration-state timeout error
- Alarm interrupt
- NMI interrupt

The configuration-state timeout interrupt is asserted if both IRQ_STAT[CFG_TO_STAT] and IRQ_EN[CFG_TO_IEN] bits are asserted. It is cleared when a 1 is written to the IRQ_STAT[CFG_TO_STAT] bit.

The NMI and ALARM interrupts are asserted and cleared according to the FCCU state. The status bits of the IRQ_STAT trace the status of the related interrupt lines.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0											Reserved	Reserved	NMI_STAT	ALRM_ST...	CFG_TO_...
W																W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-5 —	Reserved
4 —	Reserved
3 —	Reserved
2 NMI_STAT	NMI Interrupt Status 0b - NMI interrupt is OFF 1b - NMI interrupt is ON
1 ALRM_STAT	Alarm Interrupt Status 0b - Alarm interrupt is OFF 1b - Alarm interrupt is ON
0	Configuration-State Timeout Status

Table continues on the next page...

Table continued from the previous page...

Field	Function
CFG_TO_STAT	0b - No configuration-stat timeout error 1b - Configuration-state timeout error

47.7.1.21 IRQ Enable (IRQ_EN)

Offset

Register	Offset
IRQ_EN	E4h

Function

This register is used to configure enabling of interrupt related to the "Configuration-state timeout error".

The configuration-state timeout interrupt is asserted if both the IRQ_STAT[CFG_TO_STAT] and IRQ_EN[CFG_TO_IEN] fields are set to 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												0	0		CFG_TO_...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved
3 —	Reserved
2-1 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 CFG_TO_IEN	Configuration-State Timeout Interrupt Enable 0b - Configuration-state timeout interrupt disabled 1b - Configuration-state timeout interrupt enabled

47.7.1.22 Transient Configuration Lock (TRANS_LOCK)

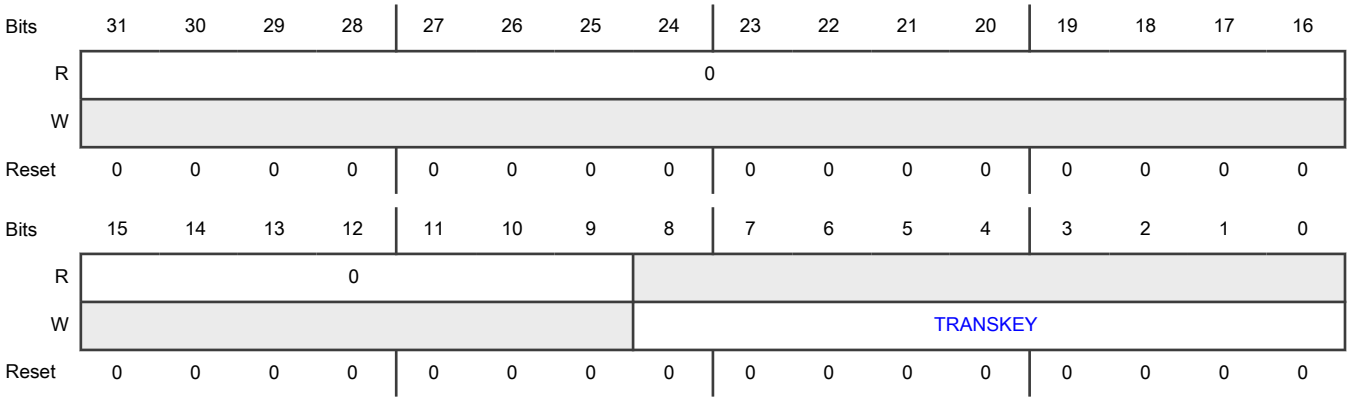
Offset

Register	Offset
TRANS_LOCK	F0h

Function

See TRANS_LOCK[TRANSKEY]

Diagram



Fields

Field	Function
31-9 —	Reserved
8-0 TRANSKEY	Transient Configuration Lock Writable only by code running in Supervisor mode. Temporarily locks and unlocks the configuration. Locking the configuration prevents FCCU from entering the CONFIG state. For information about putting FCCU in configuration, see Prepare FCCU for configuration and Configure FCCU.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE You can write to this field when FCCU is in any state, but the lock will not get into effect until FCCU is in the NORMAL state. BCh: Unlock. Any other value: Lock.

47.7.1.23 Permanent Configuration Lock (PERMNT_LOCK)

Offset

Register	Offset
PERMNT_LOCK	F4h

Function

See PERMNT_LOCK[PERMNTKEY]

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W								PERMNTKEY								
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-9 —	Reserved
8-0 PERMNTKEY	Permanent Configuration Lock Writable only by code running in the Supervisor mode. Permanently locks the configuration, which prevents FCCU from entering the CONFIG state until FCCU is reset. For information about putting FCCU in configuration, see Prepare FCCU for configuration and Configure FCCU.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE You can write to this field when FCCU is in any state, but the lock will not get into effect until FCCU is in NORMAL state. FFh: Lock. Any other value: Do nothing.

47.7.1.24 Delta T (DELTA_T)

Offset

Register	Offset
DELTA_T	F8h

Function

The DELTA_T register is used for programming the value of delta_T constant (see DELTA_T), in microseconds.

NOTE
This register can be written only when the FCCU is in the CONFIG state.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved		Reserved													
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved		DELTA_T													
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-16	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
15-14 —	Reserved
13-0 DELTA_T	Minimum Fault-Output (EOUT) Timer Interval Applies only to Bi-Stable and Fault-Toggle fault-output modes (CFG[FOM]). Controls the minimum amount of time (T_{min}) that the fault-output (EOUT) timer runs according to this equation: T_{min} = (250+ DELTA_T) µs * (48000/CLKSAFE freq KHz) **NOTE** The durations shown for the DELTA_T values depend on CLKSAFE signals. For frequency of CLKSAFE signals see the chip-specific FCCU information). Also see chip's data sheet for the trimmed frequency variation (for example, δF_{var}).

47.7.1.25 Non-critical Alarm-State Interrupt-Request Enable (IRQ_ALARM_EN0)

Offset

Register	Offset
IRQ_ALARM_EN0	FCh

Function

See IRQ_ALARM_ENa[IRQENn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	IRQEN 15	IRQEN 14	IRQEN 13	IRQEN 12	IRQEN 11	IRQEN 10	IRQEN 9	IRQEN 8	IRQEN 7	IRQEN 6	IRQEN 5	IRQEN 4	IRQEN 3	IRQEN 2	IRQEN 1	IRQEN 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-0 IRQENn	Non-critical Alarm-State Interrupt-Request Enable n Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Controls whether the interrupt request is enabled as the Alarm-state reaction for the associated non-critical fault channel (n). When the ALARM state and the Alarm-state interrupt request are enabled for an enabled non-critical fault channel, a fault on that channel causes FCCU to assert the irq_alarm signal when FCCU enters the ALARM state; irq_alarm remains asserted until FCCU is in the NORMAL state. For information on how to configure the non-critical fault channels, see Configure the non-critical fault channels. 0b - Disabled 1b - Enabled

47.7.1.26 Non-critical Fault-State Non-maskable-Interrupt-Request Enable (NMI_EN0)

Offset

Register	Offset
NMI_EN0	10Ch

Function

See NMI_ENa[NMIENn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	NMIEN15	NMIEN14	NMIEN13	NMIEN12	NMIEN11	NMIEN10	NMIEN9	NMIEN8	NMIEN7	NMIEN6	NMIEN5	NMIEN4	NMIEN3	NMIEN2	NMIEN1	NMIEN0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-0 NMIENn	Non-critical Fault-State Non-maskable-Interrupt-Request Enable n Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Controls whether the non-maskable interrupt request is enabled as a Fault-state reaction for the associated non-critical fault channel (n). When the non-maskable interrupt request is enabled for an enabled non-critical fault channel, a fault on that channel causes FCCU to assert the NMIOUT signal when FCCU enters the FAULT state; NMIOUT remains asserted until FCCU exits FAULT state. For information on how to configure the non-critical fault channels, see Configure the non-critical fault channels. 0b - Disabled 1b - Enabled

47.7.1.27 Non-critical Fault-State EOUT Signaling Enable (EOUT_SIG_EN0)

Offset

Register	Offset
EOUT_SIG_EN0	11Ch

Function

See EOUT_SIG_ENa[EOUTENn].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	EOUTEN15	EOUTEN14	EOUTEN13	EOUTEN12	EOUTEN11	EOUTEN10	EOUTEN9	EOUTEN8	EOUTEN7	EOUTEN6	EOUTEN5	EOUTEN4	EOUTEN3	EOUTEN2	EOUTEN1	EOUTEN0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-0 EOUTENn	Non-critical Fault-State EOUT Signaling Enable n Writable only when FCCU is in the CONFIG state. Changed by FCCU to its reset value when a Configuration-state timeout occurs. Applies only when the EOUT signals are active (CFG[FCCU_SET_AFTER_RESET]). When FCCU is configured for Bi-Stable fault-output mode (CFG[FOM]), controls whether EOUT signaling is enabled as a Fault-state reaction for the associated non-critical fault channel (n). (For other fault-output modes, EOUT signaling is always enabled, regardless of the value of this field.) When EOUT signaling is enabled for an enabled non-critical fault channel, a fault on that channel causes FCCU to indicate the faulty condition on the EOUT[1:0] signals when FCCU enters the FAULT state. For information on how to configure the non-critical fault channels, see Configure the non-critical fault channels. For all fault-output modes, also controls whether FCCU asserts the FIF signal when a fault on the associated non-critical fault channel (n) causes FCCU to enter the FAULT state. **NOTE** For all fault-output modes, you must set this field to enabled to ensure that FCCU asserts the FIF signal when FCCU enters FAULT state as the result of a fault on the associated non-critical fault channel (n) so the FOSU module does not mistakenly generate a destructive chip reset. 0b - In Bi-Stable fault-output mode, both EOUT signaling and FIF assertion are disabled; in other fault-output modes, EOUT signaling is enabled and FIF assertion is disabled. 1b - Both EOUT signaling and FIF assertion are enabled in all fault-output modes.

47.7.1.28 Alarm-State Timer (TMR_ALARM)

Offset

Register	Offset
TMR_ALARM	12Ch

Function

See TMR_ALARM[COUNT].

This table shows how the Alarm-state timer's state and value vary by FCCU state:

Table 229. TMR_ALARM reset value

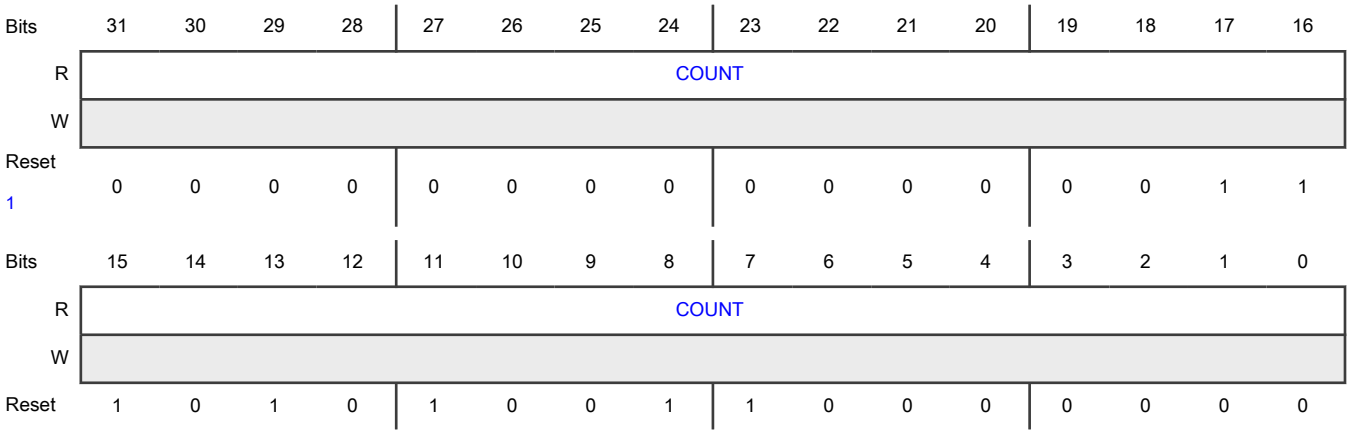
FCCU state	Timer state	Timer value
CONFIG	Idle	0000_0000h
NORMAL	Idle	Initial value: NCF_TO[TO]

Table continues on the next page...

Table 229. TMR_ALARM reset value (continued)

FCCU state	Timer state	Timer value
ALARM	Running	Value when read
FAULT	Idle	End of count

Diagram



1. The default reset value is provided by NCF_TO[TO]. See Table 229 for the reset value at different FCCU states.

Fields

Field	Function
31-0 COUNT	Alarm-State Timer Count Specifies the value of the Alarm-state timer in CLKSAFE periods.

47.7.1.29 Configuration-State Timer (TMR_CFG)

Offset

Register	Offset
TMR_CFG	134h

Function

See TMR_CFG[COUNT].

This table shows how the Configuration-state timer's state and value vary by FCCU state:

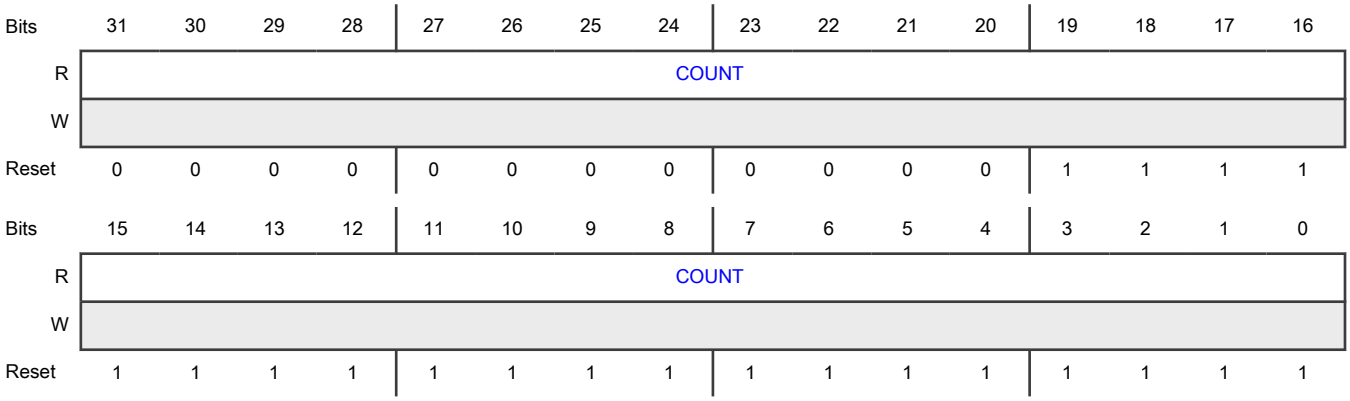
FCCU state	Timer state	Timer value
CONFIG	Running	Value when read

Table continues on the next page...

Table continued from the previous page...

FCCU state	Timer state	Timer value
NORMAL	Idle	000F_FFFFh
ALARM	Idle	000F_FFFFh
FAULT	Idle	000F_FFFFh

Diagram



Fields

Field	Function
31-0 COUNT	Configuration-State Timer Count Specifies the value of the Configuration-state timer in CLKSAFE periods.

47.7.1.30 Fault-Output Timer (TMR_ETMR)

Offset

Register	Offset
TMR_ETMR	138h

Function

See TMR_ETMR[COUNT].

This table shows how the fault-output timer's state and value vary by FCCU state and fault-output mode:

FCCU state	Timer state (value)
CONFIG	Not Fault-Toggle: Idle (0000_0000h)

Table continues on the next page...

Table continued from the previous page...

FCCU state	Timer state (value)
	Fault-Toggle: Running (value when read) or idle (0000_0000h)
NORMAL	Not Fault-Toggle: Idle (0000_0000h) Fault-Toggle: Running (value when read) or idle (0000_0000h)
ALARM	Not Fault-Toggle: Idle (0000_0000h) Fault-Toggle: Running (value when read) or idle (0000_0000h)
FAULT	Not Fault-Toggle: Running (value when read. It is an up-counter which rollbacks to zero after reaching maximum value and then it begins counting again.) Fault-Toggle: Running (value when read) or idle (0000_0000h)

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	COUNT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	COUNT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 COUNT	Fault-Output Timer Count Specifies the value of the fault-output timer in CLKSAFE periods.

47.7.2 Configuration registers

47.7.2.1 Definition

Configuration registers are registers that:

- Let you configure FCCU's Alarm-state timer interval, fault channels, and fault-output (EOUT) signals.
- You can write to only when the configuration is not locked and FCCU is in CONFIG state (see Put FCCU in the CONFIG state).
- Save the values you write to them while FCCU is in CONFIG state only after you manually put FCCU in NORMAL state. If FCCU automatically leaves CONFIG state and enters NORMAL state because the configuration-timer interval (CFG_TO[TO]) expires (called a Configuration-state timeout), FCCU changes the value of the Configuration (CFG) register to its Configuration-state-timeout value and the value of each of the other configuration registers to its reset value; FCCU also

changes the value of the Configuration-State Timeout Interval (CFG_TO) register to its reset value. For information on the Configuration-state timeout value, see CFG register bit value at different events.

47.7.2.2 Configuration registers

Following is the list of configuration registers in this module. They are listed in an offset order from lowest to highest.

- Configuration (CFG)
- Non-critical Fault Configuration (NCF_CFGa)
- Non-critical Fault-State Configuration (NCFS_CFG0)
- Non-critical Fault Enable (NCF_E0)
- Non-critical-Fault Alarm-State Timeout Enable (NCF_TOE0)
- Non-critical-Fault Alarm-State Timeout Interval (NCF_TO)
- Delta T (DELTA_T)
- Non-critical Alarm-State Interrupt-Request Enable (IRQ_ALARM_EN0)
- Non-critical Fault-State Non-maskable-Interrupt-Request Enable (NMI_EN0)
- Non-critical Fault-State EOUT Signaling Enable (EOUT_SIG_EN0)

47.7.3 CFG register bit value at different events

In this chip, there are no events that affect the bits in the configuration register.

47.8 Glossary

CF	Critical fault
EOUT	Error out
FOSU	FCCU output supervision unit
FSM	Finite state machine
intf	Interface
IRQ	Interrupt request
NCF	Non-critical fault
NMI	Non-maskable interrupt

Chapter 48
Self-test General-Purpose Registers (SELFTEST_GPR)

48.1 Introduction

SELFTEST_GPR configures the STCU2 LBIST shift cycles. Programming self-test GPRs is a part of the self-test programming sequence. See the "Self-test programming sequence" section in the STCU2 chapter.

NXP supports only STCU2 Built-In Self-Test (BIST) sequences that have been validated by NXP for in-field testing usage.

The detailed programming sequences for supported configurations are available in a separate application note (contact your NXP sales representative).

The values for SELFTEST_GPR registers must be aligned with the NXP supported configurations only.

NOTE

While accessing SELFTEST_GPR space, software must ensure that the STCU2 block has its clock enabled, i.e., MC_ME.PRTN1_COFB3_CLKEN[REQ104] configured as 1'b1. Not ensuring this might result in unpredictable device behaviour.

48.2 Progressive shift clock switching (PCS)

The PCS feature is used to enable progressive switching of the operating frequency at the start and/or end of LBIST. Kindly configure the PCS as per the recommended self-test configurations.

With each PCS enabled, there are additional (SELFTEST_GPR.CONFIG_REG[PCS_STEP_SIZE] + 1)*16 patterns beyond the configured count. If enabled at the start of LBIST (using SELFTEST_GPR.CONFIG_REG[PCS_ENABLE_START]), it would cause the shift clock to scale up in this duration from divide by 16 to the original frequency (by changing divider by one in each step).

Similarly, if configured at the end of LBIST (using SELFTEST_GPR.CONFIG_REG[PCS_ENABLE_END]), the shift clock frequency will be scaled down from original frequency to divide by 16 (by changing divider by one in each step).

48.3 SELFTEST_GPR register descriptions

48.3.1 SELFTEST_GPR memory map

SELFTEST_GPR base address: 403B_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Configuration register (CONFIG_REG)	32	RW	0000_ADD5h
14h	LBIST Program (LBIST_PROG_REG)	32	RW	0003_0050h

48.3.2 Configuration register (CONFIG_REG)

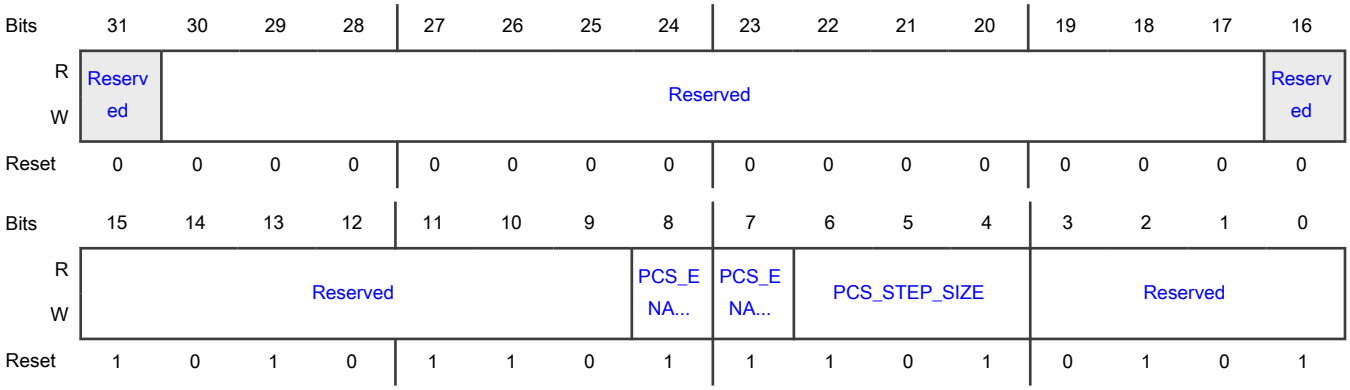
Offset

Register	Offset
CONFIG_REG	0h

Function

Configuration register

Diagram



Fields

Field	Function
31 —	Reserved
30-17 —	Reserved
16 —	Reserved
15-9 —	Reserved
8 PCS_ENABLE_END	PCS Enable End Enables Progressive Shift Clock Switching for LBIST at end. The feature gets enabled when this bit is set to 1. It is recommended to run LBIST patterns by enabling this feature.
7 PCS_ENABLE_START	PCS Enable Start Enables Progressive Shift Clock Switching for LBIST at start. The feature gets enabled when this bit is set to 1. It is recommended to run LBIST patterns by enabling this feature.
6-4 PCS_STEP_SIZE	PCS Step Size Controls the step size for progressive increase of shift frequency: 000 - step size of 1 pattern 001 - step size of 2 patterns ... 111 - step size of 8 patterns

Table continues on the next page...

Table continued from the previous page...

Field	Function
3-0 —	Reserved

48.3.3 LBIST Program (LBIST_PROG_REG)

Offset

Register	Offset
LBIST_PROG_REG	14h

Function

Configures the LBIST shift count.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved								LBIST_SHIFT_COUNT							
Reset	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0 LBIST_SHIFT_COUNT	LBIST Shift Count Specifies the number of shift cycles in a scan chain in one pattern count for the LBIST partition.

48.4 Glossary

LBIST Logic built-in self-test

Pattern count The pattern count refers to an empirically determined value of shift patterns run in LBIST on a scan chain to result in predetermined fault coverage, based on device safety integrity level. Since the LBIST scheme is

	Pseudo Random Testing, a sufficiently good value of pattern count is used which provides the required fault coverage.
Scan chain	A sequential chain of flops in scan mode over which one scan pattern (generated by PRPG, that is, Pseudo Random Pattern Generator) in LBIST will be shifted and the output MISR (Multi Input Signature Register) will be matched with earlier known value to determine pass or fail criterion of that particular chain.

Chapter 49
Self-Test Control Unit (STCU2)

49.1 Chip-specific STCU2 information

49.1.1 Supported BIST sequence

NXP supports only STCU2 Built-In Self-Test (BIST) sequences that have been validated by NXP for in-field testing usage. After the chip has been validated, this section is extended with information on the supported BIST sequences. The detailed programming sequences for supported configurations are available in a separate application note (contact your NXP sales representative).

49.1.2 Self-Test overview

STCU2 provides the overall control of both Logic Built-in Self Test (LBIST) and Memory Built-in Self-Test (MBIST) in serial or parallel depending on the power, timing, or coverage constraints.

STCU2 is a hardware module that manages the execution of BIST and indicates whether each BIST passed.

The Self-Test is initiated by the software. The application software has the provisions to bypass the Self-Test and directly move to normal RUN mode by bypassing the Self-Test configurations.

NOTE

Offline Self-Test (Hardware Initiated Self-Ttest) is not supported by the chip.

There is a programmable BIST-sequence-execution watchdog timer that specifies the maximum time allowed for the execution of a BIST sequence. In case the selected LBISTs or MBISTs are not yet completed during the assigned time, the current LBISTs or MBISTs execution is interrupted and following are not executed. A failure is flagged into ERR_STAT[WDTOSW], MBESW0, LBESW0, MBSSW0, and LBSSW0.

The STCU2 execution has three phases:

- SW configuration (load/program test configuration parameters to be executed, depending on ASIL target and performance requirements). The "Self-Test configuration" parameters allow Self-Test to run with different times (depends on pattern numbers and type) and therefore different levels of coverage are achieved.
- Start BIST execution by SW register configuration in STCU2. The BIST completion is followed by a reset (functional reset).
- After BIST execution is finished and the functional reset is completed, the BIST results are made available to the SW and a decision how to continue (trigger a new reset or start safety application) is taken by SW. The BIST execution completion is signalized in an internal STCU2 register (LBESWn) bit which is not affected by the functional reset. The BIST test results are also not affected by the functional reset.

The following figure shows a pictorial representation of two LBIST partitions having two and one MBIST groups, respectively. The STCU2 interacts with LBIST_CTRL (Logic built-in-self-test control) for the respective partitions to configure and control the LBIST sequence and result comparison of LBIST. It also interacts with MBIST Master Controller (MCT) for MBIST. Each LBIST partition has its corresponding controller whereas a single MCT controller can cater to multiple MBIST groups.

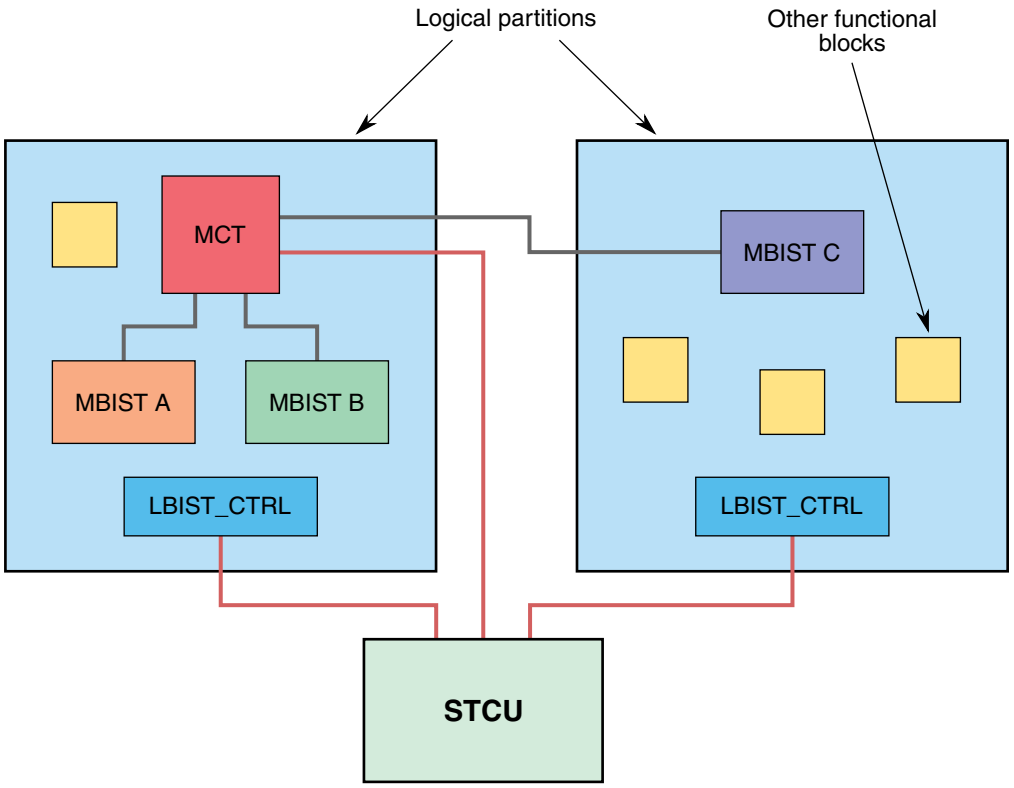


Figure 194. Self-Test overview

Each LBIST partition also includes a block called Self-Test GPR, a set of registers that provide miscellaneous configurations or parameters for LBIST operation.

If a Self-Test is triggered, the device becomes unavailable for software application during the Self-Test run.

49.1.3 STCU2 LBIST/MBIST mapping

This topic covers STCU2 LBIST/MBIST mapping.

LBIST mapping

The below table lists the LBIST mapping of the chip. The NLBIST value is 1.

Table 230. LBIST mapping

LBIST Number	Modules
LBIST0	DMA: • DMA controller
	eMIOS0
	EIM2
	ERM0, ERM1
	XRDC

Table continues on the next page...

Table 230. LBIST mapping (continued)

LBIST Number	Modules
	• MDAC0 • MDAC1 • MDAC2 • MDAC3 • MDAC4 • MDAC5 • MDAC6 • MDAC7 • MDAC8 • MRC0 • MRC1 • MRC2 • MRC3 • PDAC1 • PDAC2
	CRC
	FCCU
	FOSU
	PFLASH_CTL
	PRAMC_0
	PRAMC_1
	SWT_1 and SWT2
	CMU: • CMU1 • CMU2 • CMU4 • CMU5 • CMU6
	iAHB Gaskets: • DMA_GSKT • DMA1_GSKT • HSE_GSKT • QSPI_GSKT

Table continues on the next page...

Table 230. LBIST mapping (continued)

LBIST Number	Modules
	• ZIPWIRE_GSKT • CM7_0_AHBP_GSKT • CM7_0_AHBM_GSKT • CM7_1_AHBP_GSKT • CM7_1_AHBM_GSKT • CM7_2_AHBP_GSKT • CM7_2_AHBM_GSKT • TCM_GSKT • EMAC_GSKT • EDC master checker gaskets (See block diagram in Introduction chapter for details) • EDC slave checker gasket (See block diagram in Introduction chapter for details)
	Crossbars • AXBS • DMA_AXBS • DMA1_AXBS • HSE_AXBS • PERIPHERAL_AXBS • TCM_AXBS • ZIPWIRE_AXBS

MBIST mapping

The below tables lists the MBIST mapping of different variants of this chip. The NMCUT value is 12.

Table 231. S32K396 MBIST mapping

MBIST Number	MBIST Name	Memory Index	Instance Name
0	HSE_ROMS	0	BOOTROMS block 1 bootrom_160KB_cut1
			BOOTROMS block 2 bootrom_160KB_cut1
			BOOTROMS block 3 bootrom_160KB_cut1
			BOOTROMS block 4 bootrom_160KB_cut1
			BOOTROMS block 5 bootrom_160KB_cut1

Table continues on the next page...

Table 231. S32K396 MBIST mapping (continued)

MBIST Number	MBIST Name	Memory Index	Instance Name
1	HSE_RAMS	0	HSE secure RAM hse_secure_ram_64KB
		1	HSE PCK memory block 1 hse_pkc_8KB_cut1
		2	HSE PCK memory block 2 hse_pkc_8KB_cut2
		3	HSE MTB memory hse_MTB_1KB
2	SYS0_RAMS	0	PRAM0 block 1 sys_ram0_64KB_cut1_pd0
		1	PRAM0 block 2 sys_ram0_64KB_cut2_pd1
		2	PRAM0 block 3 sys_ram0_128KB_cut3_pd1
3	SYS1_DMA_RAMS	0	PRAM1 block 1 sys_ram1_128KB_cut1_pd1
		1	PRAM1 block 2 sys_ram1_128KB_cut2_pd1
		2	DMA TCD RAM block 0 dma_tcd_ram
		3	DMA TCD RAM block 1 dma_tcd_ram_1
4	FLEX_CAN_RAMS	0	FLEXCAN0 MB memory d_ip_flexcan3_syn_0_mb_memory
		1	FLEXCAN1 MB memory d_ip_flexcan3_syn_1_mb_memory
		2	FLEXCAN2 MB memory d_ip_flexcan3_syn_2_mb_memory
		3	FLEXCAN3 MB memory d_ip_flexcan3_syn_3_mb_memory
		4	FLEXCAN4 MB memory d_ip_flexcan3_syn_4_mb_memory
		5	FLEXCAN5 MB memory d_ip_flexcan3_syn_5_mb_memory

Table continues on the next page...

Table 231. S32K396 MBIST mapping (continued)

MBIST Number	MBIST Name	Memory Index	Instance Name
5	COOLFLUX_RAMS	0	COOLFLUX PMEM coolflux_PMEM_32KB
		1	COOLFLUX even XMEM coolflux_XMEM_24KB_even
		2	COOLFLUX odd XMEM coolflux_XMEM_24KB_odd
6	eTPU_RAMS	0	eTPU SCM eTPU_SCM_32KB
		1	eTPU SDM eTPU_SDM_8KB
7	CM7_0_TOP	0	CM7_0 instruction cache data block 1 cm7_0_cache_instruction_data_16KB_cut1
		1	CM7_0 instruction cache data block 2 cm7_0_cache_instruction_data_16KB_cut2
		2	CM7_0 instruction cache tag block 1 cm7_0_cache_instruction_tag_cut1
		3	CM7_0 instruction cache tag block 2 cm7_0_cache_instruction_tag_cut2
		4	CM7_0 data cache data block 1 cm7_0_cache_data_data_16KB_cut1
			CM7_0 data cache data block 5 cm7_0_cache_data_data_16KB_cut5
		5	CM7_0 data cache data block 2 cm7_0_cache_data_data_16KB_cut2
			CM7_0 data cache data block 6 cm7_0_cache_data_data_16KB_cut6
		6	CM7_0 data cache data block 3

Table continues on the next page...

Table 231. S32K396 MBIST mapping (continued)

MBIST Number	MBIST Name	Memory Index	Instance Name
			cm7_0_cache_data_data_16KB_cut3
			CM7_0 data cache data block 7 cm7_0_cache_data_data_16KB_cut7
		7	CM7_0 data cache data block 4 cm7_0_cache_data_data_16KB_cut4
			CM7_0 data cache data block 8 cm7_0_cache_data_data_16KB_cut8
		8	CM7_0 data cache tag block 1 cm7_0_cache_data_tag_cut1
		9	CM7_0 data cache tag block 2 cm7_0_cache_data_tag_cut2
		10	CM7_0 data cache tag block 3 cm7_0_cache_data_tag_cut3
		11	CM7_0 data cache tag block 4 cm7_0_cache_data_tag_cut4
		12	CM7_0 instruction TCM(Tightly Coupled Memory) cm7_0_itcm_32KB
		13	CM7_0 data TCM block 1 cm7_0_d0tcm_32KB
			CM7_0 data TCM block 2 cm7_0_d1tcm_32KB
8	CM7_1_TOP	0	CM7_1 instruction cache data block 1 cm7_1_cache_instruction_data_16KB_cut1
		1	CM7_1 instruction cache data block 2 cm7_1_cache_instruction_data_16KB_cut2
		2	CM7_1 instruction cache tag block 1 cm7_1_cache_instruction_tag_cut1

Table continues on the next page...

Table 231. S32K396 MBIST mapping (continued)

MBIST Number	MBIST Name	Memory Index	Instance Name
		3	CM7_1 instruction cache tag block 2 cm7_1_cache_instruction_tag_cut2
		4	CM7_1 data cache data block 1 cm7_1_cache_data_data_16KB_cut1
			CM7_1 data cache data block 5 cm7_1_cache_data_data_16KB_cut5
		5	CM7_1 data cache data block 2 cm7_1_cache_data_data_16KB_cut2
			CM7_1 data cache data block 6 cm7_1_cache_data_data_16KB_cut6
		6	CM7_1 data cache data block 3 cm7_1_cache_data_data_16KB_cut3
			CM7_1 data cache data block 7 cm7_1_cache_data_data_16KB_cut7
		7	CM7_1 data cache data block 4 cm7_1_cache_data_data_16KB_cut4
			CM7_1 data cache data block 8 cm7_1_cache_data_data_16KB_cut8
		8	CM7_1 data cache tag block 1 cm7_1_cache_data_tag_cut1
		9	CM7_1 data cache tag block 2 cm7_1_cache_data_tag_cut2
		10	CM7_1 data cache tag block 3 cm7_1_cache_data_tag_cut3

Table continues on the next page...

Table 231. S32K396 MBIST mapping (continued)

MBIST Number	MBIST Name	Memory Index	Instance Name
		11	CM7_1 data cache tag block 4 cm7_1_cache_data_tag_cut4
		12	CM7_1 instruction TCM cm7_1_itcm_32KB
		13	CM7_1 data TCM block 1 cm7_1_d0tcm_32KB.mem
			CM7_1 data TCM block 2 cm7_1_d1tcm_32KB
9	CM7_2_TOP	0	CM7_2 instruction cache data block 1 cm7_2_cache_instruction_data_16KB_cut1
		1	CM7_2 instruction cache data block 2 cm7_2_cache_instruction_data_16KB_cut2
		2	CM7_2 instruction cache tag block 1 cm7_2_cache_instruction_tag_cut1
		3	CM7_2 instruction cache tag block 2 cm7_2_cache_instruction_tag_cut2
		4	CM7_2 data cache data block 1 cm7_2_cache_data_data_16KB_cut1
			CM7_2 data cache data block 5 cm7_2_cache_data_data_16KB_cut5
		5	CM7_2 data cache data block 2 cm7_2_cache_data_data_16KB_cut2
			CM7_2 data cache data block 6 cm7_2_cache_data_data_16KB_cut6
		6	CM7_2 data cache data block 3

Table continues on the next page...

Table 231. S32K396 MBIST mapping (continued)

MBIST Number	MBIST Name	Memory Index	Instance Name
			cm7_2_cache_data_data_16 KB_cut3
			CM7_2 data cache data block 7 cm7_2_cache_data_data_16 KB_cut7
		7	CM7_2 data cache data block 4 cm7_2_cache_data_data_16 KB_cut4
			CM7_2 data cache data block 8 cm7_2_cache_data_data_16 KB_cut8
		8	CM7_2 data cache tag block 1 cm7_2_cache_data_tag_cut1
		9	CM7_2 data cache tag block 2 cm7_2_cache_data_tag_cut2
		10	CM7_2 data cache tag block 3 cm7_2_cache_data_tag_cut3
		11	CM7_2 data cache tag block 4 cm7_2_cache_data_tag_cut4
		12	CM7_2 instruction TCM cm7_2_itcm_32KB
		13	CM7_2 data TCM block 1 cm7_2_d0tcm_32KB
			CM7_2 data TCM block 2 cm7_2_d1tcm_32KB
10	QSPI_PERI_RAMS	0	QSPI RAM qspi_ram
		1	QSPI TX memory qspi_tx
11	ENET_TSN_RAM	0	ENET Timestamp memory enet_tsn

NOTE

The MBIST index 5 corresponds to CoolFlux memories. MBIST on MBIST index 5 should be executed with ADCBIST.BISTCFG[ADCBISTEN] configured as 1'b0 since the ADCBIST interacts with CoolFlux memories and will cause MBIST5 failures if MBIST is executed on Coolflux memories with ADCBIST enabled.

49.1.4 STCU2 clocking

STCU2 works on system clock domain. The LBIST scan operations are done on JTAG_TCK clock.

Table 232. STCU2 clock connectivity

STCU2 clock	SoC connected clock	Remarks
CORE_CLK	AIPS_SLOW_CLK	System clock divider output clock node for STCU2 operations and register interface accesses.
REG_INTF_CLK		
SHIFT_CLK	JTAG_TCK	JTAG_TCK used for shift operations while Self-Test is under progress.

49.1.5 Memory map for Self-Test GPRs

See the memory map file attached to this document and 'SELFTEST_GPR' chapter for details.

49.1.6 Handling unrecoverable faults

The STCU2 provides faults in case if BIST fails to execute. These faults can be either recoverable or unrecoverable based on STCU2 programmable fault mapping. The unrecoverable faults are routed to MC_RGM and the recoverable faults are routed to FCCU. Therefore, any references to mapping of unrecoverable/critical faults with FCCU in the chapter Self-Test Control Unit (STCU2) should be ignored.

49.1.7 Indicating fault state during the main reset domain Self-Test

FCCU EOUT indicates the fault state during the Self-Test as soon as the UTEST_MISC[FCCU_EOUT_ DEDICATED] is set and DCMRWD2[EOUT_STAT_DUR_STEST] is set at the time of Self-Test setup steps.

The fault state remains asserted until the bit DCMRWD2[EOUT_STAT_DUR_STEST] is cleared by application post Self-Test reset sequence.

In case it is not required to indicate the fault state during the Self-Test, then the bit DCMRWD2[EOUT_STAT_DUR_STEST] has to be cleared.

49.1.8 Error events management in main reset domain Self-Test

Error events must be mapped to unrecoverable faults in STCU2_ERR_FM register for main reset domain Self-Test.

49.1.9 AUTOLOCK_VALUE for register write access via STCU2_SKC

Register write-access watchdog timer explains that access to STCU2 registers via the STCU2_SKC security-key mechanism times out after a number of AIPS_SLOW_CLK equal to AUTOLOCK_VALUE. On this chip, AUTOLOCK_VALUE is 32'hFFFF_FFFF.

49.1.10 PLL loss of lock during Self-Test

Detection of PLL loss of lock during LBIST or MBIST causes a destructive reset in the system.

CMU0 programming is required before the Self-Test programming begins for checking the proper working of FXOSC clock which is used by the PLL for running the Self-Test.

All the registers present in LBIST domains do not retain their content after Self-Test reset.

49.1.11 STCU2 BIST start (BSTART) register description

Attempted accesses with the undefined reserved values in the BSTART register can result in undefined behavior. The following table defines the BSTART field on this chip.

Table 233. STCU2 BIST start (BSTART) field description

Field	Description
31 CLKEN	IPS clock enable, enables the IPS clock for BISTs. 0b - If cleared, disables the clock 1b - Enables the IPS clock for BISTs
30 - 3	Reserved
2 - 0 BSTART	BSTART 000b - Reserved 001b - Reserved 010b - Reserved 011b - Reserved 100b - Reserved 101b - Program BISTs and start them 110b - Reserved 111b - Reserved

49.1.12 STCU2 algorithm select (ALGOSEL) register description

This register selects any one of the predefined algorithms. The value used in this register is mapped to a predefined algorithm register in BIST. After MCT has programmed information on this register and starts some BIST operation, this value is transferred to the predefined algorithm register in every BIST that is selected.

If multiple predefined algorithms are selected, the order of execution is from LSB to MSB.

Any field that does not have a predefined algorithm associated with it is a reserved bit. No data is written to reserved bits and when you read these bits, they always return 0.

Table 234. ALGOSEL register description

Field	Name	Description
0-2, 4-12, 14-31	Reserved	—
3	March C+ single	March C+ with column fast and solid background
13	BasicChk	Basic self-contained checkerboard, using column fast

49.1.13 Self-Test programming sequence

This section describes a high level programming sequence for executing Self-Test. The detailed programming sequences for supported configurations are available in a separate application note (contact your NXP sales representative).

1. Program clock sources and MC_CGMs as per the clock configuration.

   NOTE

   When MBIST is running on EMAC timestamp memory, the EMAC_CLK_TS (MC_CGM.MUX_9_DC_0[DIV]) must be atleast 1.5 times the AIPS_SLOW_CLK frequency.

2. Program SELFTEST_GPR CONFIG_REG and LBIST_PROG_REG registers as per the LBIST configurations.

3. Program STCU2 as per NXP recommended.
4. Program dcf_client_utest_misc[FCCU_EOUT_DEDICATED] and DCMRWD2[EOUT_STAT_DUR_STEST] to configure EOUT pins as dedicated and to indicate FCCU error states on EOUT pins during Self-Test respectively.
5. Configure ERCTRL[ERASSERT] register bit in MC_RGM to achieve desired behaviour of Reset Pin as documented in Reset Section and Pad States Section.
6. Disable functional reset sources to avoid false Self-Test abort scenarios. For example, software watchdog timers cannot be serviced while Self-Test because the software is not accessible and can cause invalid timeout reset. See Reset events and configurations while Self-Test.
7. Program the PCS_ENABLE_END and PCS_ENABLE_START fields of the CONFIG_REG register (SELFTEST_GPR) to 1 to enable PCS.
8. Trigger Self-Test execution by programming RUNSW register in STCU2.
9. At the end of the Self-Test run, a functional reset is generated. Out of reset, the software can check the status registers inside STCU2 and take actions accordingly.

NOTE

EIM should be disabled when running STCU based Self-Test.

49.1.14 Modules operation during/post Self-Test

The clock, reset, power generation modules, such as MC_CGM, FIRC, PLLDIG, SIRC, MC_RGM, and PMC are available during and post Self-Test. However, because the chip undergoes the reset sequence at the end of Self-Test, the PLLDIG gets reset and the MC_CGM is re-initialized to the default configuration.

CMU0 and CMU3 will be available during Self-Test if enabled prior to Self-Test, but will be Reset post Self-Test.

STCU2 will also be available during Self-Test and the results can be read post Self-Test.

49.1.15 Reset events and configurations while Self-Test

As Self-Test is a software initiated Self-Test, it is expected by software to ensure all the peripherals are disabled as documented in Software considerations before Self-Test.

The functional reset sources must be appropriately configured to avoid any functional reset while Self-Test is running (disable SWTx_RST and HSE_SWT_RST, JTAG should not be in EXTEST, HIGHZ or CLAMP instructions). This ensures no selftest abort while running selftest due to functional reset source. The below table specifies the state of functional reset sources for Self-Test.

Table 235. Reset events and configurations while self-test

Reset source	Reset description	Configurations/remarks for selftest
FCCU_RST	FCCU reset reaction	The FCCU is a part of logic which is under Self-Test and thus it is disabled during the Self-Test
ST_DONE	Self-Test done reset	The selftest done indication resets the device post selftest. While Self-Test is running, the Self-Test done indication will be in disabled state
SWTx_RST	SWTx reset request	SWT must be disabled in Self-Test configuration sequence.
JTAG_RST	JTAG Reset	JTAG communication must be inactive while Self-Test and JTAGC state machine should not be in EXTEST, HIGHZ or CLAMP instructions
HSE_SWT_RST	HSE SWT timeout	HSE_SWT must be disabled in Self-Test configuration sequence.
HSE_SNVS_RST	HSE SNVS tamper detected	These are security subsystem controlled resets. No software configuration is allowed by application.

Table continues on the next page...

Table 235. Reset events and configurations while self-test (continued)

Reset source	Reset description	Configurations/remarks for selftest
HSE_BOOT_RST	HSE boot reset	These are security subsystem controlled resets. No software configuration is allowed by application.
SW_FUNC	software 'functional' reset	The software is inactive during Self-Test and hence software functional reset will not arrive while the chip is under Self-Test.
DEBUG_FUNC	debug 'functional' reset	MDM DAP must not be configured for debug functional reset generation while Self-Test is running.

The destructive reset sources are available while in Self-Test. In case of any destructive reset event, the device undergoes a destructive reset sequence, thereby resetting the STCU2 and Self-Test logic itself.

After completion of Self-Test (LBIST and MBIST), a functional reset sequence is executed by MC_RGM.

49.1.16 Software considerations before Self-Test

1. As all the communication peripherals are not in LBIST partitions; hence, it is required by SW to stop all communications and disable all the PCTLs of the communication peripherals before initiating Self-Test as the device will be unusable in Self-Test. This is needed so that there is graceful safe stating of inputs of non-lbisted peripheral modules.
2. Configure RGM functional reset sources before Self-Test as per the considerations mentioned in Reset events and configurations while Self-Test, that is, the SWTs should be disabled, the JTAGC should not be in states which can cause a JTAG reset event (EXTEST, HIGHZ or CLAMP instructions) and the software should not trigger a functional reset event via MC_ME or MDM_AP while Self-Test is ongoing. This is to avoid any abort scenario due to any functional reset source as Self-Test is initiated by SW.

There is no issue with Reset pin as Reset pin is a source of destructive Reset and will reset STCU2 and Self-Test related logic etc.

Table 236. Reset sources and software considerations before Self-Test

Reset Source	Reset description	SW considerations
FCCU_RST	FCCU reset reaction	Should be configured as Interrupt in RGM as SW will be un-available and device is un-usable during self test. [FCCU is part of LBIST. But to avoid any abort window between run and safe state].
SWTx_RST	SWTx reset request	SWTx should be disabled by SW before running Self-Test.
JTAG_RST	JTAG Reset	Should be configured as Interrupt in RGM as SW will be un-available and device is un-usable during Self-Test.
HSE_SWT_RST	HSE SWT timeout	HSE SWT should be disabled by SW before running Self-Test .
HSE_SNVS_RST	HSE SNVS tamper detected	These are security subsystem controlled resets. No software configuration is allowed by application.
HSE_BOOT_RST	HSE boot reset	These are security subsystem controlled resets. No software configuration is allowed by application.

Table continues on the next page...

Table 236. Reset sources and software considerations before Self-Test (continued)

Reset Source	Reset description	SW considerations
SW_FUNC	software 'functional' reset	Should be configured as Interrupt in RGM as SW will be un-available and device is un-usable during Self-Test.
DEBUG_FUNC	debug 'functional' reset	Should be configured as Interrupt in RGM as SW will be un-available and device is un-usable during Self-Test.

49.1.17 End of Self-Test

The Self-Test completion is a source of functional reset to the device, by which the device executes a functional reset sequence. The logic which is LBISTed additionally undergoes a complete POR sequence to ensure that the random content shifted during BIST sequence get cleared.

After the online self-test is done, the software should execute below steps:

1. Software reads the MBIST end flag to identify that the MBIST sequence had ended properly without any interruption or abort, by reading STCU2.MBESWn.
2. Software reads the MBIST status to identify whether the MBIST was successful or not, by reading STCU2.MBSSWn.

NOTE

The MBIST status must always be read in accordance with MBIST end flag. The STCU2.MBSSWn status is irrelevant if STCU2.MBESWn indicates that MBIST execution is incomplete.

3. Software reads the LBIST end flag to identify that the LBIST sequence had ended properly without any interruption or abort, by reading STCU2.LBESWn.
4. Software reads the LBIST status to identify whether the LBIST was successful or not, by reading STCU2.LBSSWn.

NOTE

The LBIST status must always be read in accordance with LBIST end flag. The STCU2.LBSSWn status is irrelevant if STCU2.LBESWn indicates that LBIST execution is incomplete.

49.2 Introduction

STCU2 is a comprehensive programmable hardware module that:

- Manages the execution of BISTs
- Indicates whether each BIST passed
- Manages the chip's LBIST and the MBIST blocks

49.3 Main features

STCU2 includes:

- System interface for reading from and writing to the STCU2 registers (online) via the CPU
- Programmable scheduler for BIST execution
- Control over LBIST concurrent or sequential execution
- Control over MBIST concurrent or sequential execution
- Programmable LBIST delayed concurrent start
- Programmable internal clock prescaler to reduce internal and BIST clocks

- PLL lock signal monitoring during BIST sequences
- Programmable BIST-sequence-execution watchdog timer that specifies the maximum time allowed for the execution of a BIST sequence
- Fixed register-write-access watchdog timer that specifies the maximum amount of time that STCU2 allows you to write to its registers after you unlock them
- Fields that indicate the pass/fail indication of each BIST, see Types of BIST sequences and Types of BIST partitions
- Fields that indicate the status of each type of online STCU2 internal error condition
- Programmable fault mapping of each BIST for controlling the type of fault that STCU2 reports (recoverable or unrecoverable) when the BIST fails to execute
- Programmable fault mapping of each STCU2 internal error condition for controlling the type of fault that STCU2 reports (recoverable or unrecoverable) when the condition occurs
- Signals to report recoverable and unrecoverable faults to the FCCU module
- Redundant recoverable and unrecoverable fault-generation logic to improve reliability
- FCCU recoverable and unrecoverable fault-injection mechanism
- Global register write-protection mechanism that requires two security key codes
- Global automatic power saving after a BIST sequence is completed when watchdog timer time-out is detected
- Watchdog automatic clock wake-up mechanism when software unlocks the STCU2 registers for write access
- Watchdog automatic power saving when the fixed register-write-access watchdog timer times out

49.4 Block diagram

This diagram shows the parts of STCU2:

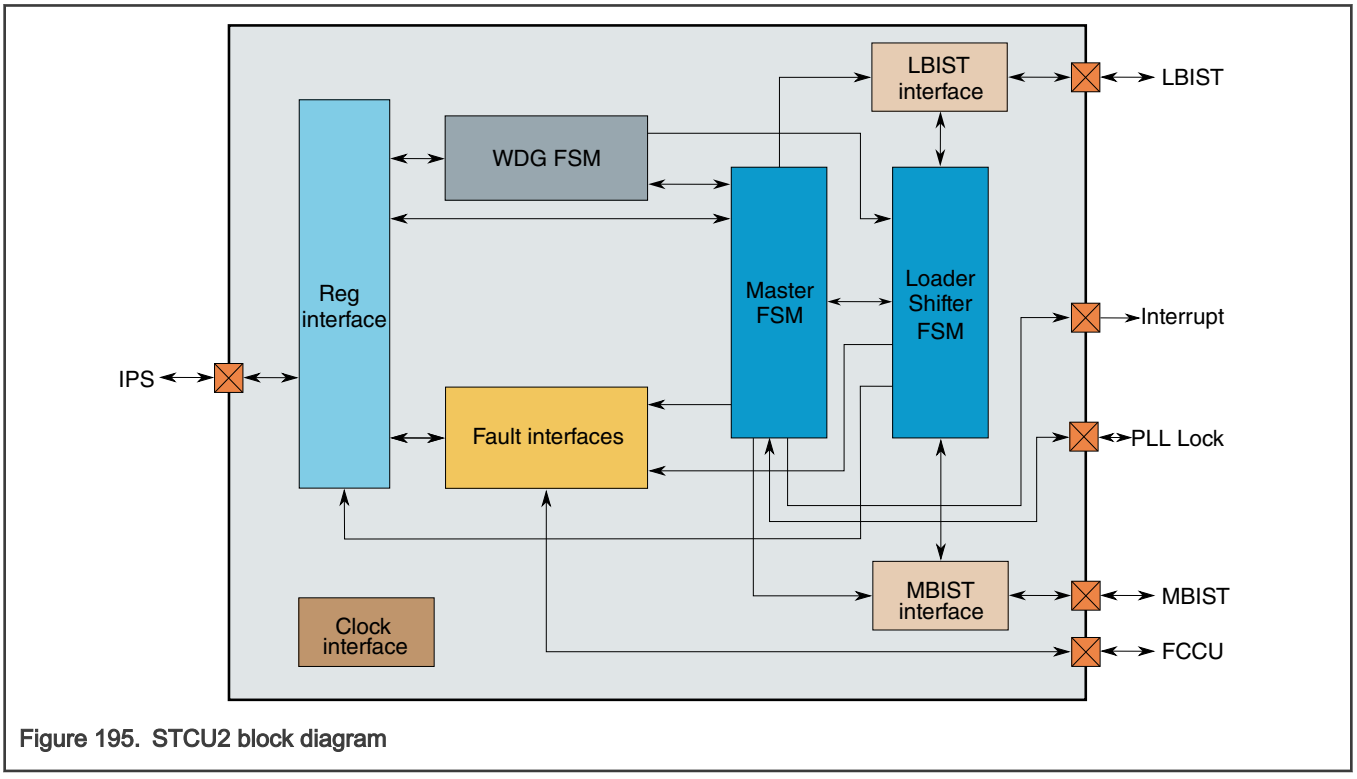


Figure 195. STCU2 block diagram

This table describes the parts of STCU2:

Table 237. STCU2 parts

Part	Function
Reg interface	Provides access to: • Registers • The security key logic • The IPS interface
Fault interfaces	Performs the following tasks: • Collects the fault conditions caused by STCU2 internal error conditions and each BIST executed in a sequence • Sets the global recoverable or unrecoverable status flag, depending on the fault mapping for a given BIST • Manages the recoverable and unrecoverable fault lines to and from the FCCU module • Manages the set/clear injection mechanism provided by the FCCU module To improve the intrinsic reliability of this critical logic, the generation logic is duplicated.
Clock interface	Manages the internal and the BIST clock prescaler, the internal clock-gating power saving, and the wake-up clock feature
WDG FSM	Provides the following: • A programmable BIST-sequence-execution watchdog timer that specifies the maximum time allowed for the execution of a BIST sequence • A fixed register-write-access watchdog timer that specifies the maximum amount of time that STCU2 allows you to write to its registers after you unlock them
Master FSM	Coordinates and schedules all of the operations performed during a BIST sequence
Loader Shifter FSM	Programs the BIST registers and reads back the data to be checked at the end of each test operation
LBIST interface	Provides the interface between the chip's LBIST engines and the STCU2 controllers
MBIST interface	Provides the interface between the MBIST controller and the STCU2 controller

49.5 Peripheral bus interface

The peripheral bus interface is a slave bus used for configuration purposes via CPU. The module supports the following bus read operations:

- Word (32 bits) data read operations to any registers
- Any other operation is not supported.

Word, low and high half-words, byte operations are supported in write mode only:

- Write access is allowed by software only when CFG[WRP] is cleared. The default value of CFG[WRP] is cleared, exceptions are the following read/write fields: CFG[WRP], ERR_STAT[UFSF] and ERR_STAT[RFSF].

- STCU2 Configuration (CFG) should only be accessed in 32 bit (partial access not allowed).

The STCU2 module generates a transfer error in the following cases:

- Any read access to the registers after writing Key1 and before writing Key2 (in online) and before register write-access watchdog timer expires.
- Any write/read access to the register addresses not mapped on the peripheral but included in the address space of the peripheral
- Any write/read operation different from byte/halfword/word (free byte enables or other operations) on each register
- Any write operation on Double Security Key register applying a wrong sequence of keys (the two write operations cannot be interleaved with other access to STCU2 registers)
- Any write operation performed on a register when the Double Security keys have not been applied
- Any write operation performed on registers when CFG[WRP] is set and the access is performed through software (internal peripheral interface). The exceptions are SKC register (for valid keys value and sequence) in which STCU2 does not assert transfer error.
- Any write operation performed on Read Only registers

The registers of the STCU2 module are accessible (read/write) in each access mode: user, supervisor, or test.

In case there are write operations on bits marked as reserved, the transfer error is not generated.

NOTE

See the chip-specific STCU2 information for the wait time necessary to write to the online registers.

49.6 BISTs and BIST partitions

49.6.1 Definition: BIST

A BIST is a test that the chip can execute to verify the functional integrity of a part of itself. The chip uses STCU2 and other on-chip hardware to execute a BIST.

49.6.2 Definition: BIST partition

A BIST partition is a part of a chip for which a BIST has been defined. The hardware that is included in a given BIST partition is chip-specific. For a list of the hardware included in each of the BIST partitions on this chip, see the chip-specific STCU2 information.

49.6.3 Example: BIST partitions on a chip

This is an example of a chip with six BIST partitions:

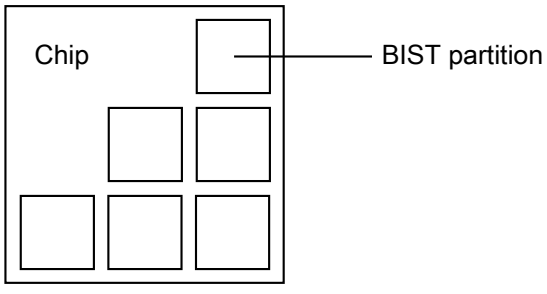


Figure 196. BIST partitions on a chip

49.6.4 Types of BIST partitions

The STCU2 module on this chip supports the following types of BIST partitions:

Table 238. Types of BIST partitions

BIST partition type	Description
MBIST partition	An SRAM or ROM block
LBIST partition	One or more digital modules

49.7 BIST sequences

49.7.1 Definition: BIST sequence

A BIST sequence is a programmable series of one or more phases, each of which executes one or more individual BISTs.

49.7.2 STCU2 executes MBISTs before LBISTs

If a BIST sequence includes both MBISTs and LBISTs; STCU2 executes the MBISTs first.

49.7.3 Example: Single-phase BIST sequence

This is an example of a single-phase BIST sequence in which STCU2 executes only one BIST:

Table 239. Example: Single-phase BIST sequence

Phase	BIST executed
0	MBIST 16

49.7.4 Example: Multi-phase BIST sequence

This is an example of a multiphase BIST sequence in which STCU2 executes more than one BIST in parallel in some phases:

Table 240. Example: Multi-phase BIST sequence

Phase	BISTs executed
0	MBISTs 7, 30
1	MBIST 23
2	MBISTs 6, 16, 29, 23
3	LBIST 12
4	LBISTs 13, 8, 11
5	LBISTs 19, 6

49.7.5 Types of BIST sequences

The STCU2 module on this chip supports these types of BIST sequences:

Table 241. Example: Types of BIST sequences

BIST sequence type	Description
Online BIST sequence	A BIST sequence that STCU2 executes during runtime at the request of software. Application software configures and initiates execution of the BIST sequence by loading values into STCU2 registers.

49.7.6 Supported BIST sequences

NXP supports only a specific set of BIST sequences for this chip. For the list of supported BIST sequences, see the chip-specific STCU2 information.

49.8 Functional description

49.8.1 FSM description

The module has three FSM that work together: Master FSM, Loader/Shifter FSM, and the Watchdog FSM. Basically the Master FSM is the core unit of the STCU2 module. It coordinates all the self-test operations and the other FSM. The Loader/Shifter FSM is used to program the MBIST and the LBIST parameters and to retrieve the related results depending on the parameters stored into the STCU2 registers and under the control of the Master FSM. The Watchdog FSM evaluates all the schedule time for MBIST and LBIST and the time-out in case of wrong STCU2 programming.

49.8.2 Reset management

STCU2 generates reset signals at the end of the self-test execution phase depending upon on the self-test conditions and configurations.

49.8.2.1 Online reset generation

See the chip-specific STCU2 information for details about online reset generation.

49.8.3 BIST scheduling

STCU2 is designed to program the parallel/serial execution of the MBIST or LBIST depending on the power, timing, and coverage constraints.

The mechanism used to provide this flexibility is a linked list of BIST descriptors where the starting pointer is defined in CFG[PTR]. The first LBIST is mapped on 0, the second on 1, and so on. A BIST descriptor identifies a LBIST or MBIST via an index that is associated with its control register (STCU2 LBIST Control (LB_CTRL0) or STCU2 MBIST Control (MB_CTRL0 - MB_CTRL11)). The first MBIST is mapped on (00000080h + 0), the second on (00000080h + 1), and so on. The additional pointers of the linked list are in LB_CTRL*n*[PTR] for LBIST *n* (where *n* is the selected LBIST) and MB_CTRL*m*[PTR] for MBIST *m* (where *m* is the selected MBIST) and must be populated depending on the selected run sequence. The additional fields LB_CTRL[CSM] and MB_CTRL[CSM] provide the flexibility to run concurrently or sequentially the chosen set of the LBIST or MBIST or to close the linked list by setting the NIL pointer.

49.8.4 FCCU interface

The FCCU interface is the hardware flag mechanism towards the system, to indicate the occurrence of an Unrecoverable fault and/or a Recoverable fault failure during the Self Test sequence. Two independent signals have been used to mitigate the common cause faults.

To diagnose physical defects on the two fault signals, a fault injection mechanism is also provided. In this case, the FCCU interface allows the user application to check the integrity of the UF and RF connection lines between the STCU2 and the FCCU. Refer to the description of FCCU fault injection mechanism to understand how the UF/RF set/clear mechanism works.

49.8.5 Watchdogs

The STCU2 implements different watchdogs to ensure that operations are finished in time.

49.8.5.1 BIST watchdog timer

The LBIST and MBIST execution time has to be configured as described in STCU2 Watchdog Granularity (WDG), to account for the overall execution time of the self test sequence. In case the selected LBISTs or MBISTs are not yet completed during assigned time, the current LBISTs or MBISTs execution is interrupted and a failure is flagged into ERR_STAT[WDTOSW] and MBESWx or LBESW.

In case of multiple sequential run in the same online session and the time-out happens in the middle of a sequential run, the next sequential run will be skipped and the execution ends with the current updated status of the registers reported above.

In all the cases, the STCU2 reset generation is managed in one of the modes described in Reset management.

49.8.5.2 Register write-access watchdog timer

As explained in the STCU2 SK Code (SKC):

- A key mechanism protects STCU2 registers during the self-test configuration phase by preventing any unwanted access.
- A hardware watchdog timer locks register-write access after a number of STCU2 clock cycles. To refresh the hardware watchdog timer before it times out, write Key1 and Key2 sequences.

AUTOLOCK_VALUE is the number of STCU2 clock cycles after which the hardware watchdog timer locks register-write access. See the chip-specific STCU2 information for the value of AUTOLOCK_VALUE.

The hardware watchdog timer is particularly useful in case CFG[WRP] is 0 during the software self-test configuration. In this case, the software application might enable write access to the STCU2 registers.

49.9 STCU2 register descriptions

The STCU2 registers are listed in this section.

NOTE

Always write the reset value for the Reserved fields.

During online self-test, after the STCU2 registers are configured, they must not be overridden via internal peripheral system until the self-test is complete.

49.9.1 STCU2 memory map

STCU base address: 403A_0000h

Offset	Register	Width (In bits)	Access	Reset value
4h	STCU2 Run Software (RUNSW)	32	RW	0000_0000h
8h	STCU2 SK Code (SKC)	32	W	0000_0000h
Ch	STCU2 Configuration (CFG)	32	RW	0000_0000h
14h	STCU2 Watchdog Granularity (WDG)	32	RW	0000_FFFFh
24h	STCU2 Error (ERR_STAT)	32	RW	0000_0000h
28h	STCU2 Error FM (ERR_FM)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
4Ch	STCU2 Online LBIST Status (LBSSW0)	32	R	0000_0000h
5Ch	STCU2 Online LBIST End Flag (LBESW0)	32	R	0000_0000h
6Ch	STCU2 Online LBIST Reset Management (LBRMSW0)	32	RW	0000_0000h
7Ch	STCU2 Online LBIST Unrecoverable FM (LBUFM0)	32	RW	0000_0000h
10Ch	STCU2 Online MBIST Status (MBSSW0)	32	R	0000_0000h
14Ch	STCU2 Online MBIST End Flag (MBESW0)	32	R	0000_0000h
18Ch	STCU2 MBIST Unrecoverable FM (MBUFM0)	32	RW	0000_0000h
200h	STCU2 LBIST Control (LB_CTRL0)	32	RW	0000_0000h
204h	STCU2 LBIST PC Stop (LB_PCS0)	32	RW	0000_0000h
220h	STCU2 Online LBIST MISR Expected Low (LB_MISRELSW0)	32	RW	FFFF_FFFFh
224h	STCU2 Online LBIST MISR Expected High (LB_MISREHSW0)	32	RW	FFFF_FFFFh
228h	STCU2 Online LBIST MISR Read Low (LB_MISRRLSW0)	32	R	0000_0000h
22Ch	STCU2 Online LBIST MISR Read High (LB_MISRRHSW0)	32	R	0000_0000h
2200h	STCU2 Algorithm Select (ALGOSEL)	32	RW	0000_0000h
220Ch	STCU2 MBIST Stagger (STGGR)	32	RW	0000_0000h
2210h	STCU2 BIST Start (BSTART)	32	RW	0000_0000h
2214h - 2240h	STCU2 MBIST Control (MB_CTRL0 - MB_CTRL11)	32	RW	0000_0000h

49.9.2 STCU2 Run Software (RUNSW)

Offset

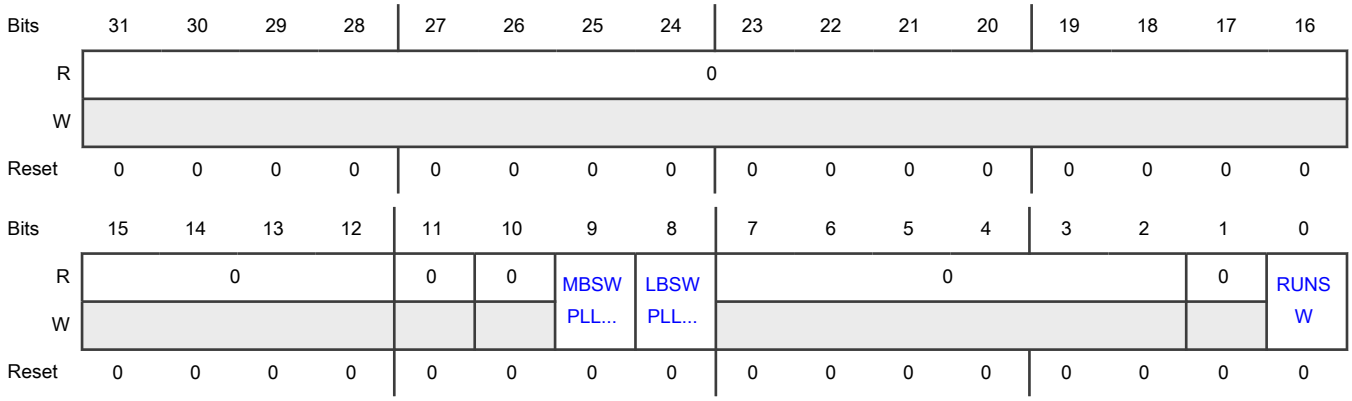
Register	Offset
RUNSW	4h

Function

The RUNSW register defines the RUNSW bit to start the online self-testing procedure.

The R/W fields in this register are readable at any time. However, you can write to these fields only when CFG[WRP] = 0.

Diagram



Fields

Field	Function
31-12 —	Reserved
11 —	Reserved
10 —	Reserved
9 MBSWPLLEN	Online MBIST with PLL Enabled 0b - Online MBIST is executed without using the on-chip PLL. 1b - Online MBIST is executed using the PLL configuration provided by software. STCU2 does not take the PLL control but monitors the PLL lock signal to check if PLL is working correctly.
8 LBSWPLLEN	Online LBIST with PLL Enabled 0b - Online LBIST is executed without using the on-chip PLL. 1b - Online LBIST is executed using the PLL configuration provided by the software. STCU2 does not take the PLL control but monitors the PLL lock signal to check if PLL is working correctly.
7-2 —	Reserved
1 —	Reserved
0 RUNSW	The RUNSW bit is automatically cleared by STCU2 when the online self-testing procedure is complete. 0b - Idle 1b - Online self-testing procedure is running

49.9.3 STCU2 SK Code (SKC)

Offset

Register	Offset
SKC	8h

Function

The SKC register implements the security key code mechanism needed to access in write mode to the other STCU2 registers.

To unlock STCU2 access after the STCU2 asynchronous reset and at the end of the STCU2 run, the software (IPS bus) need to apply the following sequence:

- write the key1 into the SKC register
- write the key2 into the SKC register

Depending on the online test step, the two keys are different. Byte write operation is not allowed because the full key has to be recognized as one unit.

A hard-coded WDG counter (Register write-access watchdog timer) starts decrementing its value right after POR is deasserted. Therefore, user must ensure to complete unlocking and programming sequence before its expiry. In case the STCU2 register access lasts more cycles than the one defined in the hard-coded WDG timeout, the STCU2 write access is locked and the WDG and register interface clocks are switched off. Also, in this case, to enable the write access to the STCU2 again and the WDG and register interface clocks, it is required to apply the sequence again. In case of invalid access or sequence (Key1/2 have to be applied consecutively), a transfer error on the IPS is asserted. The STCU2 write access is locked and to unlock the access, the sequence has to be applied again. This can also happen if watchdog expires between key1 and key2. In this case, user needs to apply the key1-key2 sequence again. In case it is required to extend the STCU2 register access cycles before the hard-coded WDG timeout expires, Key1 and Key2 sequences need to be applied. The effect of this write operation is to re-initialize the WDG timeout counter. The STCU2 write access is locked and to unlock the access, the sequence has to be applied again.

The SKC register is not readable. The value 00000000h is always returned in case of read operation.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	SKC															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	SKC															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0	STCU2 SK Code

Table continues on the next page...

Field	Function
SKC	STCU2 security key code for online test = 753F924Eh: Key1 to unlock the write access the STCU2 = 8AC06DB1h: Key2 to unlock the write access the STCU2

49.9.4 STCU2 Configuration (CFG)

Offset

Register	Offset
CFG	Ch

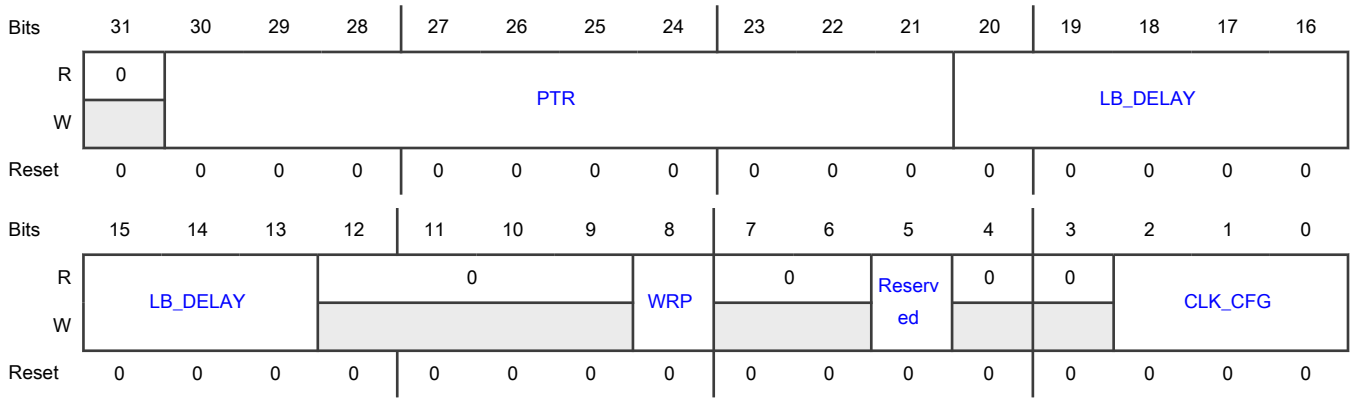
Function

The CFG register includes the global configuration of the STCU2 and can be updated in the online test steps.

The access to this register is described in the following figure. It further depends on the state of the WRP bit as follows:

- When WRP = 0: The register can be written during the online self-test case without restrictions.
- When WRP = 1:
  - The only bit that can be written without any restriction is WRP.
  - In case there are software operations that write all the register's bits, a transfer error is raised only if the value of the selected byte written differs from the current status of the register. This functionality has been implemented to prevent potential compilation behavior that might invalidate this single bit clean capability.

Diagram



Fields

Field	Function
31 —	Reserved

Table continues on the next page...

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Field	Function
30-21 PTR	First LBIST or MBIST pointer PTR defines the logical pointer to the first LBIST or MBIST to be scheduled when the self-testing procedure is enabled. PTR is the entry pointer to a linked list of BIST descriptors. If PTR = 0 then the LBIST0 is initially scheduled. See BIST scheduling for details. 0h to (01h - 1): pointer to LBIST 00000080h to (00000080h + 00Ch - 1): pointer to MBIST 3FFh: pointer to NIL. No BIST execution. others: invalid pointer => an error is set into the ERR_STAT[INVPSW].
20-13 LB_DELAY	Delay LBIST run LB_DELAY defines the delay between the LBIST starts when more than a single LBIST is selected to be executed concurrently with the purpose of smoothing the power consumption transient. The allowed delay time are these: 00h: No delay 01h: 1 x 16 STCU2 CORE_CLK cycles 02h: 2 x 16 STCU2 CORE_CLK cycles 03h: 3 x 16 STCU2 CORE_CLK cycles ... FDh: 253 x 16 STCU2 CORE_CLK cycles FEh: 254 x 16 STCU2 CORE_CLK cycles FFh: 255 x 16 STCU2 CORE_CLK cycles
12-9 —	Reserved
8 WRP	Write Protection 0: Specific STCU2 registers can be written through IPS bus interface 1: STCU2 registers cannot be written through IPS, preventing any user application write operation
7-6 —	Reserved
5 —	Reserved
4 —	Reserved
3	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
2-0 CLK_CFG	Logic, Memory BIST, and STCU2 CORE_CLK configuration CLK_CFG defines the ratio between the sys_clk and the internal clock used to program both the LBIST and the MBIST and the STCU2 CORE_CLK. The punch-out mechanism is used to generate the derived clocks. The following configurations are allowed: 000b - sys_clk/1 001b - sys_clk/2 010b - sys_clk/3 011b - sys_clk/4 100b - sys_clk/5 101b - sys_clk/6 110b - sys_clk/7 111b - sys_clk/8

49.9.5 STCU2 Watchdog Granularity (WDG)

Offset

Register	Offset
WDG	14h

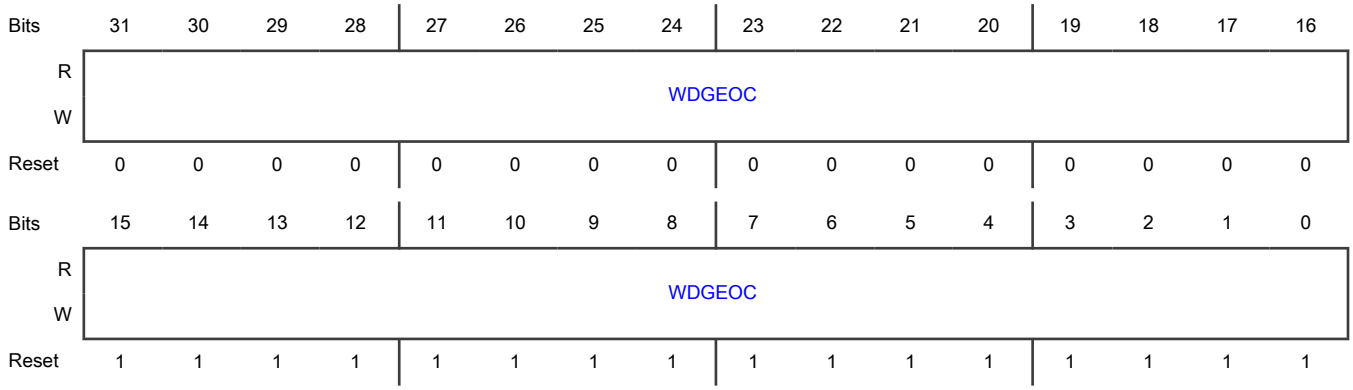
Function

The WDG register defines the time budget of LBIST and MBIST execution providing a protection mechanism in case of dead-lock or endless conditions during the self-test procedure.

In case online self-test sequence is run, it defines the timeout of the execution run.

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram



Fields

Field	Function
31-0 WDGEOC	Watchdog End of Count Timer This value has to be set to define the time budget related to the online self-test execution and check that everything is correctly working within this slot of time. The delay time slots that are allowed are as follows: 0000 0000h: 1 x 16 STCU2 CORE_CLK cycles 0000 0001h: 2 x 16 STCU2 CORE_CLK cycles 0000 0002h: 3 x 16 STCU2 CORE_CLK cycles ... FFFF FFFDh: 4294967294 x 16 STCU2 CORE_CLK cycles FFFF FFFEh: 4294967295 x 16 STCU2 CORE_CLK cycles FFFF FFFFh: 4294967296 x 16 STCU2 CORE_CLK cycles

49.9.6 STCU2 Error (ERR_STAT)

Offset

Register	Offset
ERR_STAT	24h

Function

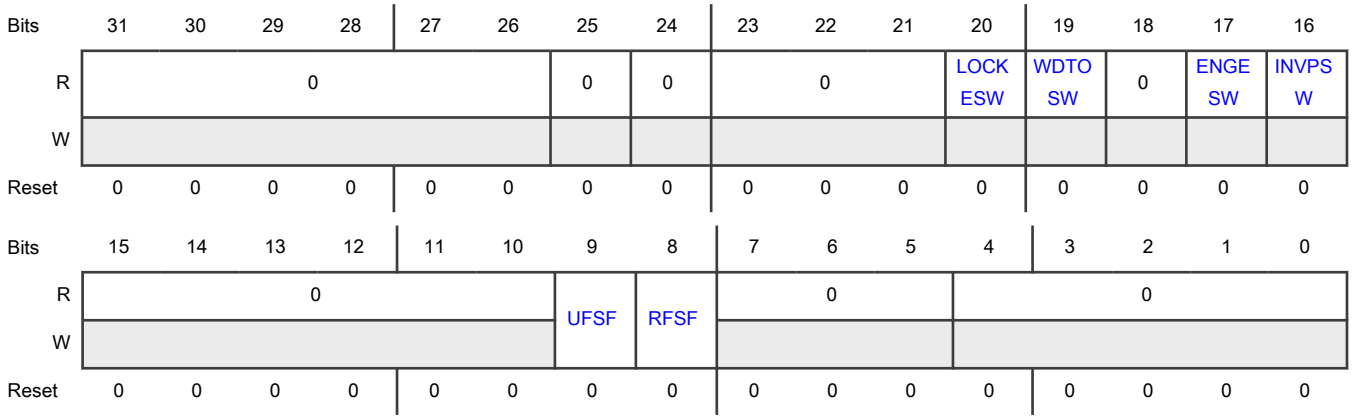
The ERR_STAT register includes the status flags related to the STCU2 internal error conditions occurred during the configuration or the online self-testing execution.

The UFSF and RFSF can be set/cleared using the FCCU dedicated channels.

The access to this register is described in the following figure and as follows:

- If you select the byte write capability to write only UFSF and RFSF, then there is no restriction in writing these bits.
- If your software performs the write operations on other bits besides UFSF/RFSF, then a transfer error is generated only if the value you are writing to the other bits differs from their value currently stored in the register. This functionality has been implemented to prevent potential compilation behavior that might invalidate the UFSF/RFSF single bit set/clean capability.

Diagram



Fields

Field	Function
31-26 —	Reserved
25 —	Reserved
24 —	Reserved
23-21 —	Reserved
20 LOCKESW	Online LOCK error You can always read this field. The content of this field is initialized to its reset value when RUNSW[RUNSW] is set to 1. 0b - In case PLL is enabled, it is correctly locked during the self-test sequence 1b - When the PLL is enabled, this flag highlights that there has been an unexpected PLL unlock(loss-of-lock) event during the online self-test sequence execution. The online self-test run is stopped and the status of the currently running LBISTs or MBISTs is saved in the related registers. The LOCK signal is monitored during the LBIST run when RUNSW[LBSWPLLEN] is set and/or during the MBIST run when RUNSW[MBSWPLLEN] = 1.
19 WDTOSW	Online watchdog timeout You can always read this field. The content of this field is initialized to its reset value when RUNSW[RUNSW] is set to 1. 0b - LBIST and MBIST time slots completed within the assigned watchdog time. 1b - LBIST and MBIST time slots not completed within the assigned watchdog time or there are internal mismatches among End of Execution signals.

Table continues on the next page...

Table continued from the previous page...

Field	Function
18 —	Reserved
17 ENGESW	Online engine error You can always read this field. The content of this field is initialized to its reset value when RUNSW[RUNSW] is set to 1. 0b - Valid engine execution 1b - Invalid engine execution. The error conditions that set this bit are FSM, protocol error, and so on.
16 INVPSW	Online invalid pointer You can always read this field. The content of this field is initialized to its reset value when RUNSW[RUNSW] is set to 1. 0b - Valid linked pointer list 1b - Invalid linked pointer list. The following conditions set this bit: Initial LBIST or MBIST pointer is out of range; LBIST is selected when MBIST is concurrently running or vice versa; Error in the LBIST/MBIST linking (execution generates an infinite loop).
15-10 —	Reserved
9 UFSF	Unrecoverable Faults Status Flag This flag reports the global status of the Unrecoverable Faults(UF). This field can be set or cleared using the FCCU dedicated channel, and can also be set or cleared by software. 0b - No errors that trigger the UF condition. 1b - There are errors that trigger the UF condition.
8 RFSF	Recoverable Faults Status Flag This flag reports the global status of the Recoverable Fault (RF). This field can be set or cleared using the FCCU dedicated channel, and can also be set or cleared by software. 0b - No errors that trigger the Recoverable Faults condition 1b - There are errors that trigger the Recoverable Faults condition
7-5 —	Reserved
4-0 —	Reserved Write may occur on these fields but writes have no effect.

49.9.7 STCU2 Error FM (ERR_FM)

Offset

Register	Offset
ERR_FM	28h

Function

The ERR_FM register defines the fault mapping of the STCU2 faults described in the register ERR_STAT in terms of UF or RF. All sources of internal faults can be routed to UF and RF.

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0											LOCKEUFM	WDTOUFM	Reserved	ENGEUFM	INVPUFM
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-5 —	Reserved
4 LOCKEUFM	PLL LOCK Unrecoverable Fault Mapping 0b - Recoverable Fault Mapping 1b - Unrecoverable Fault Mapping
3 WDTOUFM	Watchdog Timeout Unrecoverable Fault Mapping 0b - Recoverable Fault Mapping 1b - Unrecoverable Fault Mapping
2 —	Reserved
1	Engine Error Unrecoverable Fault Mapping

Table continues on the next page...

Table continued from the previous page...

Field	Function
ENGEUFM	0b - Recoverable Fault Mapping 1b - Unrecoverable Fault Mapping
0 INVPUFM	Invalid Pointer Unrecoverable Fault Mapping 0b - Recoverable Fault Mapping 1b - Unrecoverable Mapping

49.9.8 STCU2 Online LBIST Status (LBSSW0)

Offset

Register	Offset
LBSSW0	4Ch

Function

This register includes the results corresponding to the execution of the selected online LBIST.

The size of the register depends on the number of LBIST .

The content of this register is initialized to its reset value when RUNSW[RUNSW] is set to 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															LBSSW0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
0-0 LBSSWn	LBSSWn online status of the selected LBIST 0b - Failed LBIST execution 1b - Successful LBIST execution

49.9.9 STCU2 Online LBIST End Flag (LBESW0)

Offset

Register	Offset
LBESW0	5Ch

Function

This register includes the results corresponding to the execution of the selected online LBIST.

The size of the register depends on the number of LBIST .

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															LBESW0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved
0-0 LBESWn	LBESW LBESWx: online LBIST end status 0b - LBIST execution not yet completed 1b - LBIST execution finished

49.9.10 STCU2 Online LBIST Reset Management (LBRMSW0)

Offset

Register	Offset
LBRMSW0	6Ch

Function

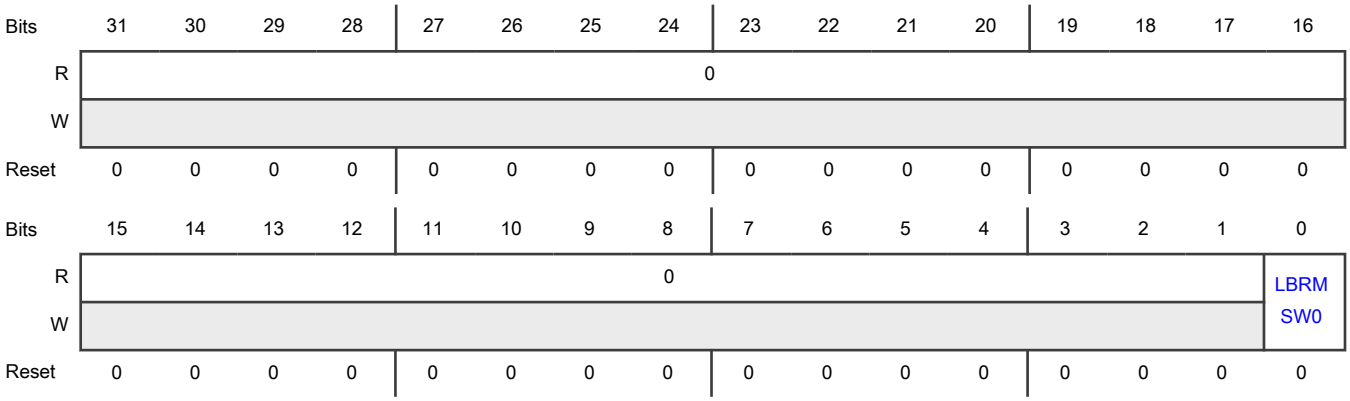
The LBRMSW register defines the online reset mapping for each LBIST. Global or specific functional reset can be programmed depending on the online self-test requirements and top-level integration architecture .

The size of the register depends on the number of LBIST .

The R/W fields in this register are readable at any time. You can write to these fields when either of the following conditions is true:

- Online self-test phase is active and CFG[WRP] = 0

Diagram



Fields

Field	Function
31-1 —	Reserved
0-0 LBRMSWn	LBRMSW Online LBIST Reset Management **NOTE** In case one of the selected LBIST has this bit set to '1', then only the Global functional reset is pulsed. 0b - Dedicated functional reset is pulsed at the end of LBIST run 1b - Global functional reset is pulsed at the end of LBIST run

49.9.11 STCU2 Online LBIST Unrecoverable FM (LBUFM0)

Offset

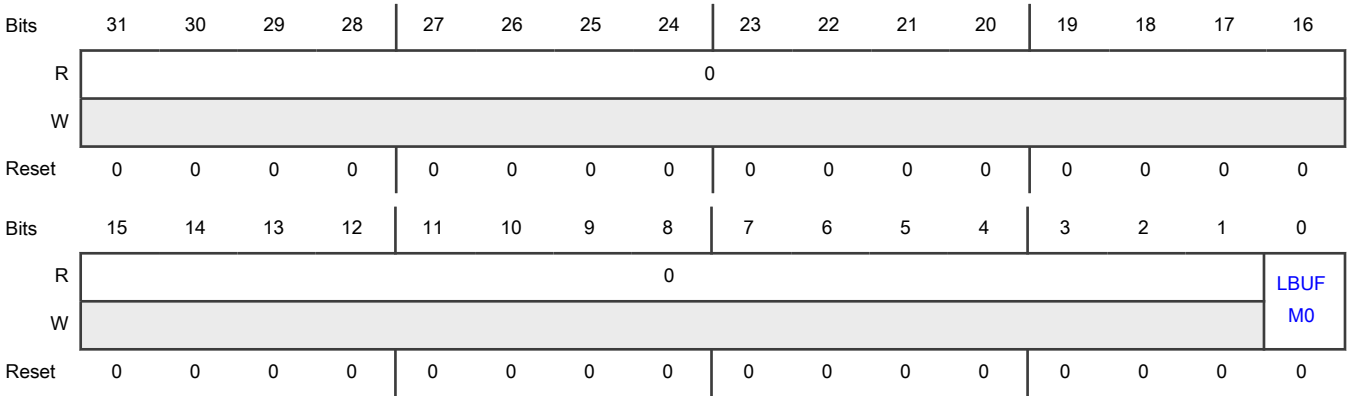
Register	Offset
LBUFM0	7Ch

Function

This register defines the fault mapping of each LBIST in terms of UF or RF.

The size of the register 0 depends on the number of LBIST .

Diagram



Fields

Field	Function
31-1 —	Reserved
0-0 LBUFMn	LBIST Unrecoverable Fault Mapping 0b - Recoverable Fault mapping 1b - Unrecoverable Fault mapping

49.9.12 STCU2 Online MBIST Status (MBSSW0)

Offset

Register	Offset
MBSSW0	10Ch

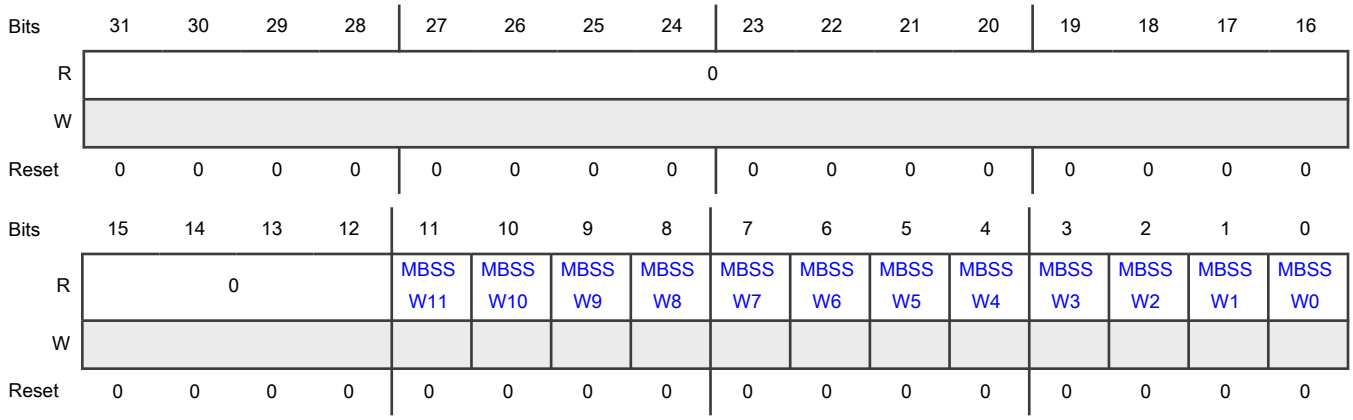
Function

This register includes the results corresponding to the execution of the selected online MBIST in the range 0:11.

The size of the register depends on the number of BISTed RAMs/ROMs.

The content of this register is initialized to its reset value when RUNSW[RUNSW] is set to 1.

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 MBSSWn	MBSSW Online status of the selected MBISTn (where n = 11:0). 0b - Failed MBIST execution 1b - Successful MBIST execution

49.9.13 STCU2 Online MBIST End Flag (MBESW0)

Offset

Register	Offset
MBESW0	14Ch

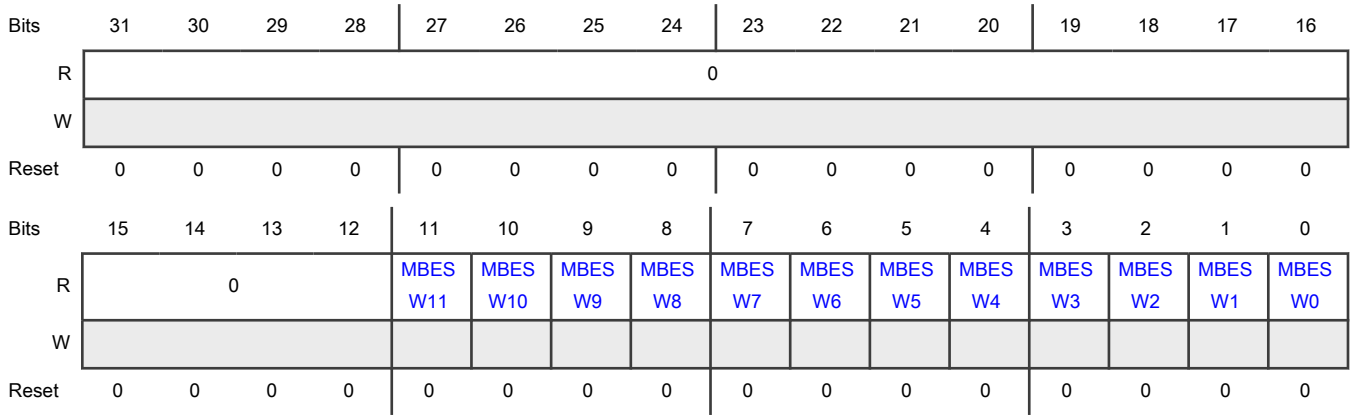
Function

This register includes the End Flag related to the execution of the selected online MBIST in the range 0:11.

The size of the register depends on the number of BISTed RAMs/ROMs.

The content of this register is initialized to its reset value when RUNSW[RUNSW] is set to 1.

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 MBESWn	Online MBISTn (where n = 11:0) end status. 0b - MBIST execution not yet completed 1b - MBIST execution finished

49.9.14 STCU2 MBIST Unrecoverable FM (MBUFM0)

Offset

Register	Offset
MBUFM0	18Ch

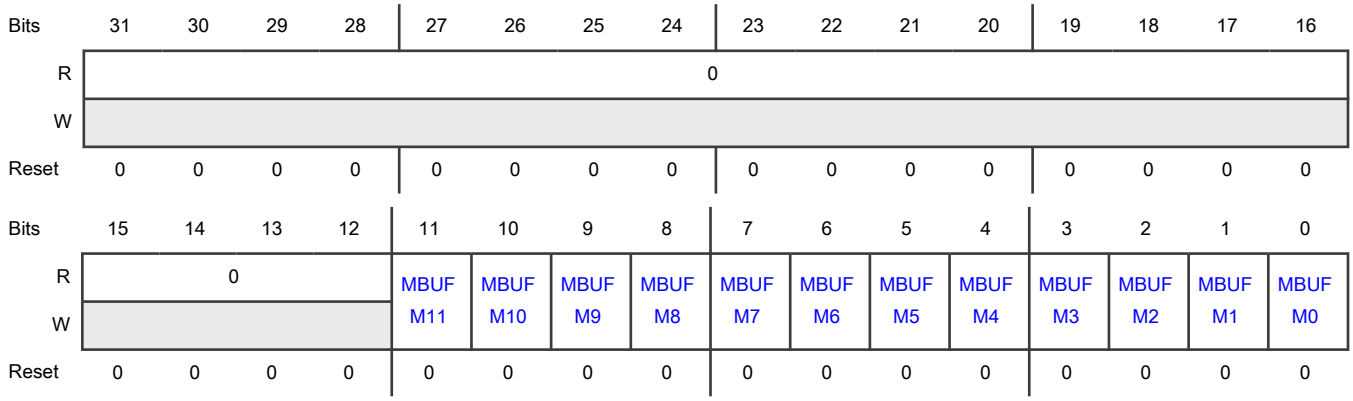
Function

This register defines the fault mapping, in terms of UF or RF, of the MBIST in the range 0:11

The size of the register depends on the number of BISTed RAMs/ROMs.

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 MBUFMn	MBESW Online end status of MBISTn (where n = 11:0). 0b - Recoverable fault mapping 1b - Unrecoverable fault mapping

49.9.15 STCU2 LBIST Control (LB_CTRL0)

Offset

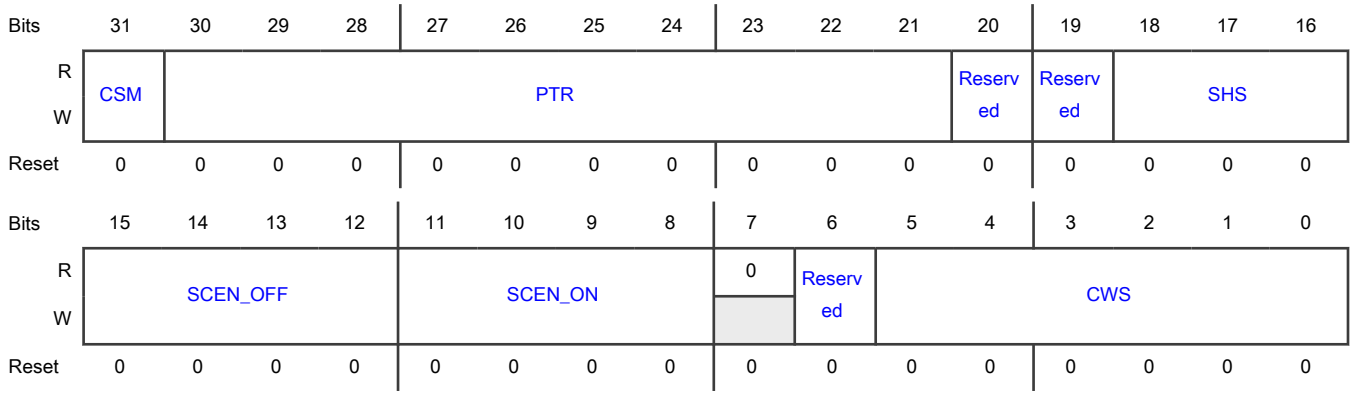
Register	Offset
LB_CTRL0	200h

Function

This register defines the control setting of each LBIST controller.

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram



Fields

Field	Function
31 CSM	Concurrent/sequential mode The next LBIST is scheduled concurrently to the current one if the CSM bit is set to 1; otherwise, it is scheduled sequentially to the completion of the current LBIST execution. 0b - Sequential mode 1b - Concurrent mode
30-21 PTR	Next LBIST or MBIST pointer PTR defines the logical pointer to the next LBIST or MBIST to be scheduled. The next LBIST or MBIST is scheduled concurrently to the current one if the CSM bit is set to 1, otherwise it is scheduled sequentially to the completion of the current LBIST execution. In case of NIL pointer, the CSM bit has to be set Sequential (0) to define this is the end of the list. The self-testing procedure stops after the last BIST in the configuration chain is complete. See BIST scheduling for details. 0h to (01h - 1): pointer to NLBIST-1 00000080h to (00000080h + 00Ch - 1): pointer to MBIST 3FFh: pointer to NIL. No BIST execution. others: invalid pointer => an error is set into the ERR_STAT[INVPSW].
20 —	Reserved **NOTE** This reserved field is writable but do not write any value to it other than its reset value
19 —	Reserved **NOTE** This reserved field is writable but do not write any value to it other than its reset value
18-16 SHS	Shift speed SHS defines the shift speed

Table continues on the next page...

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Field	Function
	000b - Shift at full rate (BIST clock). 001b - Shift at 1/2 rate (BIST clock). 010b - Shift at 1/3 rate (BIST clock). 011b - Shift at 1/4 rate (BIST clock). 100b - Shift at 1/5 rate (BIST clock). 101b - Shift at 1/6 rate (BIST clock). 110b - Shift at 1/7 rate (BIST clock). 111b - Shift at 1/8 rate (BIST clock).
15-12 SCEN_OFF	Scan enable OFF SCEN_OFF information is used to configure the lbist controller hardware to generate off_cycles, delay cycles during the scan enable off transition. **NOTE** SCEN_OFF must be programmed to a value >=1. 0000b - 0 delay cycles 0001b - 1 delay cycle 0010b - 2 delay cycles 0011b - 3 delay cycles 0100b - 4 delay cycles 0101b - 5 delay cycles 0110b - 6 delay cycles 0111b - 7 delay cycles 1000b - 8 delay cycles 1001b - 9 delay cycles 1010b - 10 delay cycles 1011b - 11 delay cycles 1100b - 12 delay cycles 1101b - 13 delay cycles 1110b - 14 delay cycles 1111b - 15 delay cycles
11-8 SCEN_ON	Scan enable ON SCEN_ON information is used to configure the lbist controller hardware to generate on_cycles, delay cycles during the scan enable on transition,

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE SCEN_ON delay register value must be programmed to a value >=1 0000b - 0 delay cycles 0001b - 1 delay cycle 0010b - 2 delay cycles 0011b - 3 delay cycles 0100b - 4 delay cycles 0101b - 5 delay cycles 0110b - 6 delay cycles 0111b - 7 delay cycles 1000b - 8 delay cycles 1001b - 9 delay cycles 1010b - 10 delay cycles 1011b - 11 delay cycles 1100b - 12 delay cycles 1101b - 13 delay cycles 1110b - 14 delay cycles 1111b - 15 delay cycles
7 —	Reserved
6 —	Reserved
5-0 CWS	Capture window size CWS defines the capture window size. 00_0000b - Illegal 00_0001b - Controller waits 1 shift cycle for capture to finish. 00_0010b - Controller waits 2 shift cycles for capture to finish. 00_0011b - Controller waits 3 shift cycles for capture to finish. 00_0100b - Controller waits 4 shift cycles for capture to finish. 00_0101b - Controller waits 5 shift cycles for capture to finish. 00_0110b - Controller waits 6 shift cycles for capture to finish. 00_0111b - Controller waits 7 shift cycles for capture to finish.

49.9.16 STCU2 LBIST PC Stop (LB_PCS0)

Offset

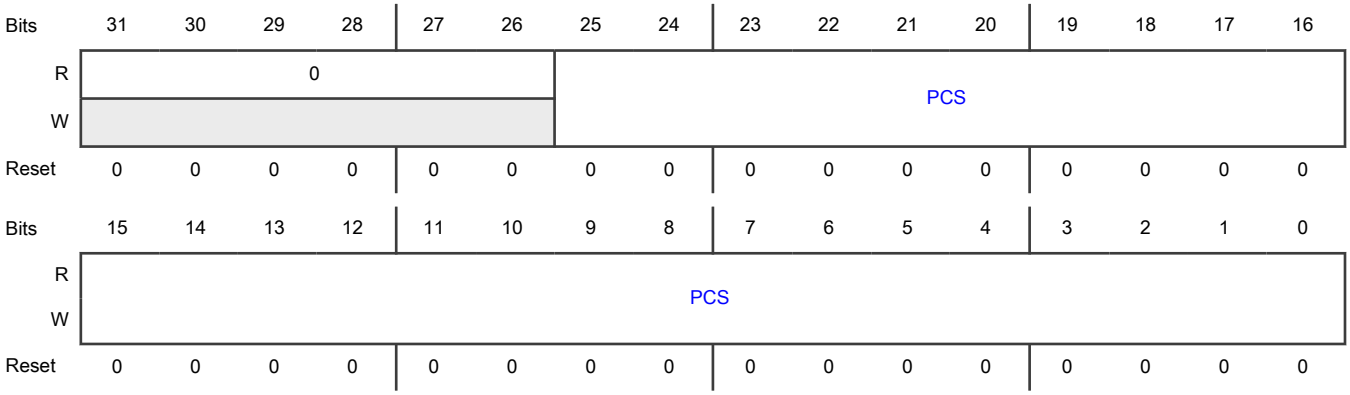
Register	Offset
LB_PCS0	204h

Function

This register defines the pattern counter stop of each LBIST controller.

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-0 PCS	PCS Pattern counter stop PCS defines the pattern counter stop value.

49.9.17 STCU2 Online LBIST MISR Expected Low (LB_MISRELSW0)

Offset

Register	Offset
LB_MISRELSW0	220h

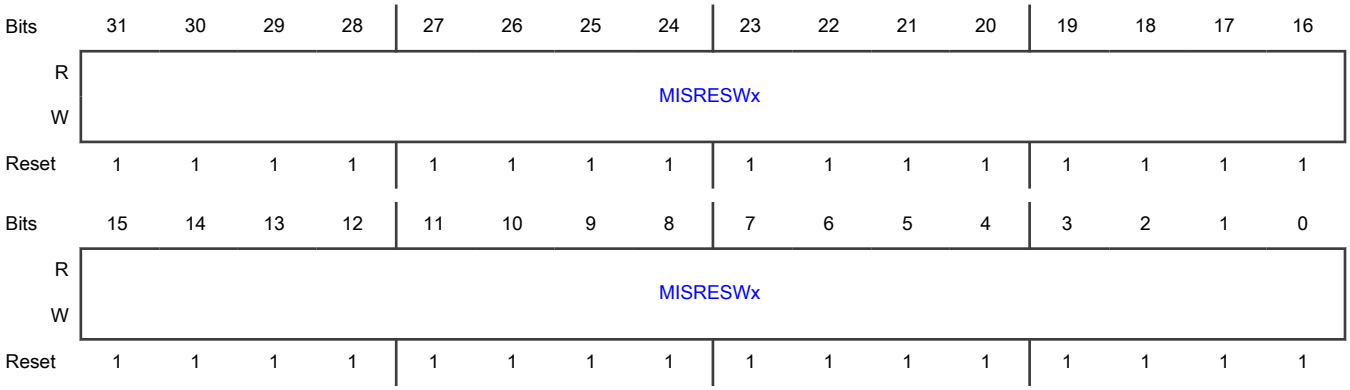
Function

This register defines bits 32 of the expected MISR of the online LBIST controller.

The size of the register depends on the number of MISR bits of the related LBIST. .

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram



Fields

Field	Function
31-0 MISRESWx	Online MISR expected low bits This field defines 32 bits of the expected MISR.

49.9.18 STCU2 Online LBIST MISR Expected High (LB_MISREHSW0)

Offset

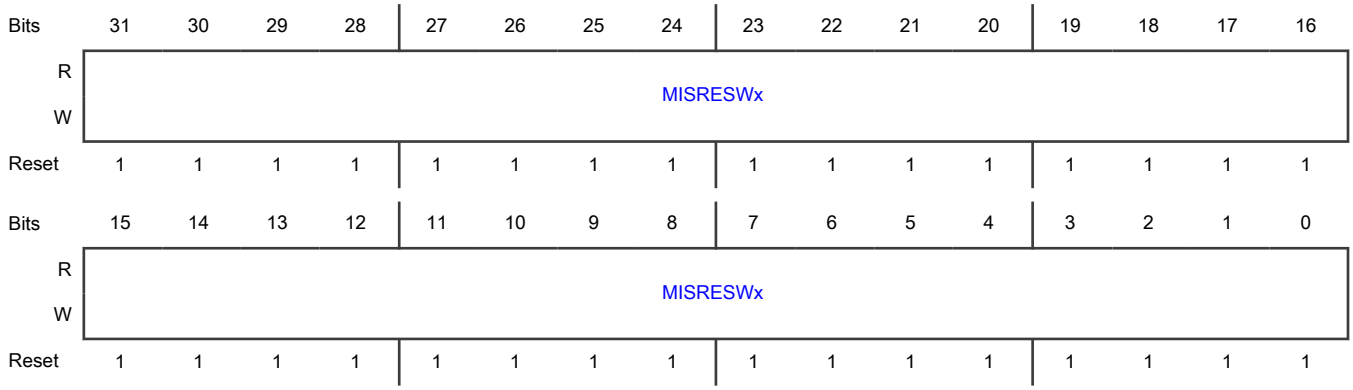
Register	Offset
LB_MISREHSW0	224h

Function

The size of the register depends on the number of MISR bits of the related LBIST. .

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram



Fields

Field	Function
31-0 MISRESWx	Online MISR Expected High Bits This field defines the 32 bits of the expected MISR.

49.9.19 STCU2 Online LBIST MISR Read Low (LB_MISRRLSW0)

Offset

Register	Offset
LB_MISRRLSW0	228h

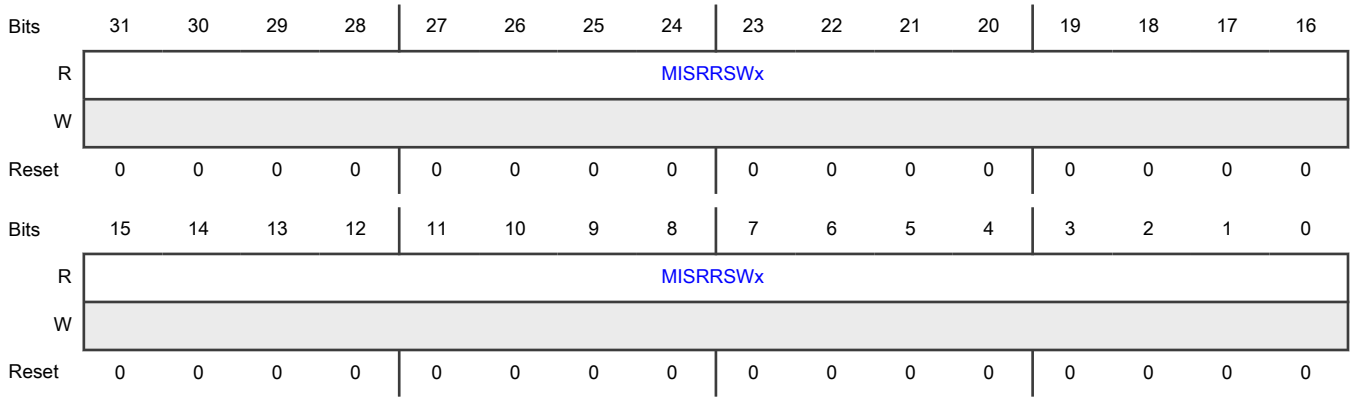
Function

This register reports 32 bits of the MISR obtained at the end of the online LBIST controller execution.

The size of the register depends on the number of MISR bits of the related LBIST. .

The content of this register is initialized to its reset value when RUNSW[RUNSW] is set to 1.

Diagram



Fields

Field	Function
31-0 MISRRSWx	MISRRSWx Online MISR Read Low Bin This field is equivalent to 32 bits of the MISR obtained at the end of the online LBIST execution.

49.9.20 STCU2 Online LBIST MISR Read High (LB_MISRRHSW0)

Offset

Register	Offset
LB_MISRRHSW0	22Ch

Function

The size of the register depends on the number of MISR bits of the related LBIST. .

The content of this register is initialized to its reset value when RUNSW[RUNSW] is set to 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MISRRSWx															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MISRRSWx															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 MISRRSWx	MISRRSWx Online MISR Read High Bits This field is equivalent to 32 bits of the MISR obtained at the end of the online LBIST execution.

49.9.21 STCU2 Algorithm Select (ALGOSEL)

Offset

Register	Offset
ALGOSEL	2200h

Function

This is a 32-bit register intended to be programmed by the user to select algorithms to be run on BIST. See the chip-specific STCU2 information for details of this register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL...	ALGO SEL9	ALGO SEL8	ALGO SEL7	ALGO SEL6	ALGO SEL5	ALGO SEL4	ALGO SEL3	ALGO SEL2	ALGO SEL1	ALGO SEL0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 ALGOSELn	Algorithm Select

49.9.22 STCU2 MBIST Stagger (STGGR)

Offset

Register	Offset
STGGR	220Ch

Function

This register allows one to program number of clock cycles between execution of one BIST and the next one.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	STAG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	STAG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 STAG	STAG Number of STCU2 CORE_CLK cycles between execution of one BIST and the next one.

49.9.23 STCU2 BIST Start (BSTART)

Offset

Register	Offset
BSTART	2210h

Function

This is a 32-bit register intended to be programmed by the user to run BISTs with different configuration. See the chip-specific STCU2 information for details of this register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BSTART31	BSTART30	BSTART29	BSTART28	BSTART27	BSTART26	BSTART25	BSTART24	BSTART23	BSTART22	BSTART21	BSTART20	BSTART19	BSTART18	BSTART17	BSTART16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BSTART15	BSTART14	BSTART13	BSTART12	BSTART11	BSTART10	BSTART9	BSTART8	BSTART7	BSTART6	BSTART5	BSTART4	BSTART3	BSTART2	BSTART1	BSTART0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 BSTARTn	BIST Start

49.9.24 STCU2 MBIST Control (MB_CTRL0 - MB_CTRL11)

Offset

For a = 0 to 11:

Register	Offset
MB_CTRLa	2214h + (a × 4h)

Function

The MB_CTRL register defines the control setting of MBIST controller.

The R/W fields in this register are readable at any time. You can write to these fields when online self-test phase is active and CFG[WRP] = 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CSM	PTR											0			
W												BSEL				
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 CSM	CSM Concurrent/sequential mode 0b - Sequential mode 1b - Concurrent mode
30-21	PTR

Table continues on the next page...

Table continued from the previous page...

Field	Function
PTR	Next LBIST or MBIST pointer PTR defines the logical pointer to the next LBIST or MBIST to be scheduled. The next LBIST or MBIST is scheduled concurrently to the current one if the CSM bit is set to 1; otherwise it is scheduled sequentially to the completion of the current MBIST execution. In case of NIL pointer the CSM bit must be set Sequential (0) to define this is the end of the list. The self-testing procedure stops after the last BIST in the configuration chain is complete. See BIST scheduling for details. **NOTE** If the pointer is invalid and MBIST is scheduled to run concurrently than this invalid scenario is handled by watchdog timeout feature and corresponding watchdog timeout status bit will be updated in ERR_STAT[WDTOSW]. In this particular case ERR_STAT[INVPSW] will not be set. 0h to (01h - 1): pointer to LBIST 00000080h to (00000080h + 00Ch - 1): pointer to MBIST 3FFh: pointer to NIL. No next BIST execution. others: invalid pointer => an error is set into the ERR_STAT[INVPSW].
20 BSEL	BSEL BIST Select 0b - Selected BIST is not selected for execution. 1b - Selected BIST is selected for execution.
19-0 —	Reserved

49.10 Glossary

BIST	Built-in self-test
BIST Clock	BIST controller clock corresponding to the specific BIST
CORE_CLK	Clock specified by the CFG register
FSM	Finite state machine
IPS	Internal peripheral system
LBIST	Logic BIST
MBIST	Memory BIST
NLBIST	Number of logic built-in self-test controller
NMCUT	Number of memory checked using memory built-in self-test controller
Online self-test phase	In this condition, system is alive and the SW can program STCU2
RF	Recoverable faults
UF	Unrecoverable faults

WDG FSM	Watchdog finite state machine

Chapter 50
Register Protection (REG_PROT)

50.1 Chip-specific REG_PROT information

50.1.1 REG_PROT configuration

The MCU safety relevant configuration registers are protected against unauthorized HW/S changes during read/write/clear access by implementing them with register protection module. See the REG_PROT details file attached to this document.

50.1.1.1 CMU_BRIDGE register protection

The CMUs in the device reside on a common peripheral slot as CMU_BRIDGE in the system memory map. Figure 197 indicates the locations of the CMUs along with the memory map.

Based on the CMU location in system peripheral memory map, the below locations in the CMU 16KB space are reserved and any access on these locations results in a bus transfer error.

402B_C018 – 402B_C01F

402B_C030 – 402B_C03F

402B_C050 – 402B_C05F

402B_C078 – 402B_C07F

402B_C098 – 402B_C09F

402B_C0B8 – 402B_C0BF

402B_C0D8 – 402B_CFFF

Since the register protection is available in the device for CMU_BRIDGE, the 4KB offset locations (refers as the Area 2 in register protection) are also reserved and accesses over these regions also result in bus transfer error.

402B_D018 – 402B_D01F

402B_D030 – 402B_D03F

402B_D050 – 402B_D05F

402B_D078 – 402B_D07F

402B_D098 – 402B_D09F

402B_D0B8 – 402B_D0BF

402B_D0D8 – 402B_DFFF

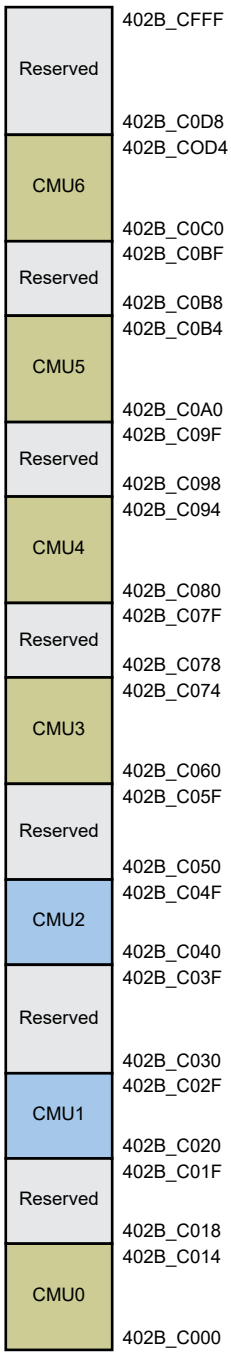


Figure 197. Location of CMUs

50.2 Overview

REG_PROT offers a mechanism to protect defined memory-mapped address locations, in a module under protection, from being written.

REG_PROT is a protection module that is located between the module under protection and the peripheral interface. The address locations to be protected exist in the module under protection and the address locations that can be protected are module specific. Writes to these protected address locations are locked using a Soft Lock Bit Register (SLBR*n*). Any access to address locations in the module under protection is restricted if their corresponding Soft lock fields in a Soft Lock Bit Register (SLBR*n*) are 1.

The configured soft-lock fields can also be write-restricted by using GCR[HLB]. When GCR[HLB]=1, you cannot write to the soft-lock fields. The address locations in the module under protection can be restricted to Supervisor mode access using GCR[UAA].

50.2.1 Block Diagram

The following figure shows the block diagram of this module.

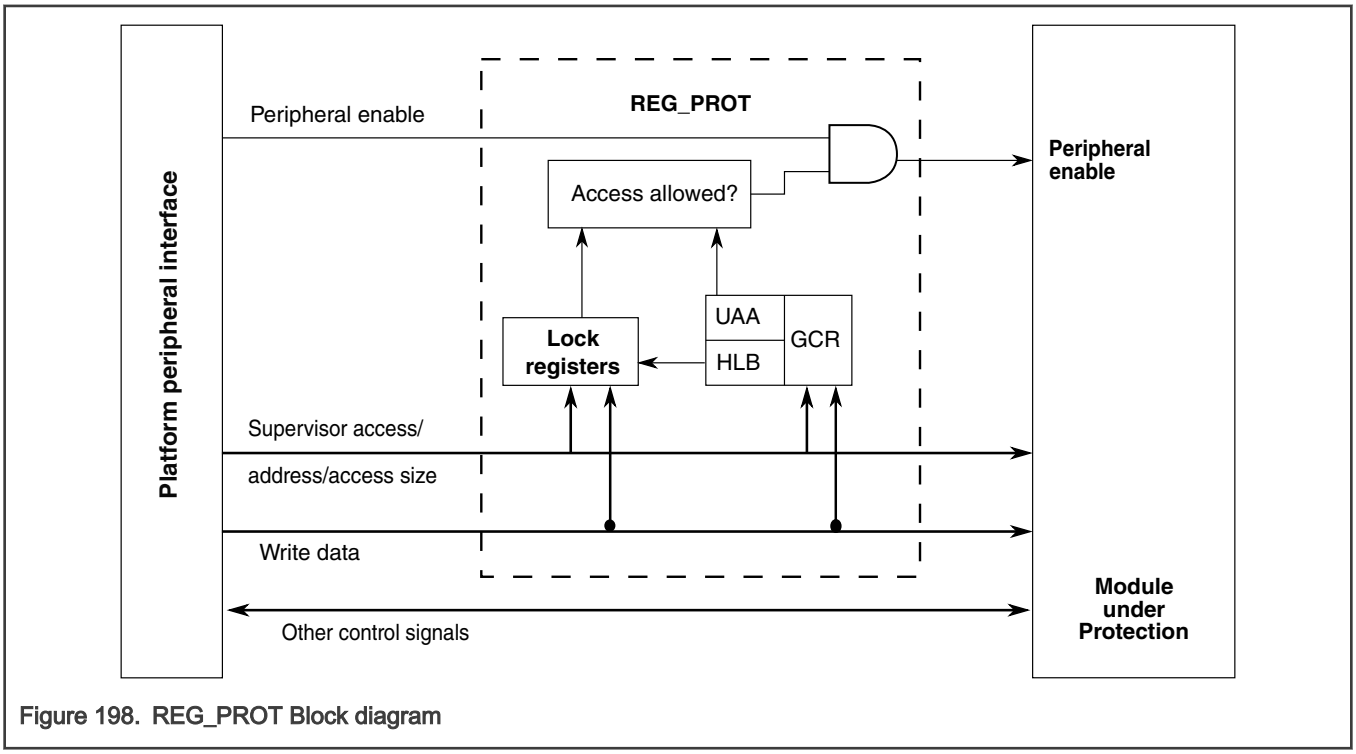


Figure 198. REG_PROT Block diagram

50.2.2 Features

REG_PROT includes these distinctive features:

- Write accesses for the module under protection can be restricted to the supervisor mode only.
- Registers of modules with their register slot size occupying 1 KB to 32 KB of memory-mapped address space, depending on the PROT_MEM parameter, can be dynamically locked. See Memory space and Protection size.
- Multiple ways are present to set the lock bits.
- After the lock bits are configured, they can be protected from changes.

50.3 Functional description

The following sections describe the functional characteristics of the REG_PROT module.

50.3.1 Modes of operation

The mode of REG_PROT depends on the Module Under Protection (MUP). The REG_PROT is operable when the MUP is operable.

The below table shows the write operations in user mode.

Table 242. User mode access table

GCR[UAA]	SLBRn[SLBm]	Write Operation on MUP	Write Operation on REG_PROT
0	0	Transfer error generated, write operation unsuccessful.	Transfer error generated, write operation unsuccessful.
0	1	Transfer error generated, write operation unsuccessful.	Transfer error generated, write operation unsuccessful.
1	0	• If register is implemented and write operation allowed on accessed address location then write operation is successful. • If register is not implemented or write operation is not allowed on accessed address location then transfer error is generated, write operation is unsuccessful.	• If register is implemented and write operation allowed on accessed address location then write operation is successful. • If register is not implemented or write operation is not allowed on accessed address location then transfer error is generated, write operation is unsuccessful.
1	1	Transfer error generated, write operation unsuccessful.	• If register is implemented and write operation allowed on accessed address location then write operation is successful. • If register is not implemented or write operation is not allowed on accessed address location then transfer error is generated.

Note:

- Read operation is always allowed
- n >= 0, m = [0,3]

50.3.2 Memory space and Protection size

This section provides a detailed description of the memory space and protection size of a module using REG_PROT.

The PROT_MEM size varies per chips. It can be:

- 1 KB
- 2 KB
- 4 KB
- 8 KB
- 16 KB
- 32 KB

The resulting memory space is divided into four areas. Memory locations within area #1 and area #2 are a part of the module under protection. Area #3 and area #4 are a part of REG_PROT.

The proper register slot size for each protected module is mentioned in the REG_PROT details file attached to this document.

Following is the memory space for a module that is protected by the REG_PROT module. Reserved registers in area #1 are handled as specified in the protected module's documentation. There is a single register in configuration space that corresponds

to area #4 while the size mentioned in Area size column is to turn the whole area multiple of 4 KB. See the Offset column to know the exact location of the GCR register.

Table 243. Area offset based on protection size

PROT_MEM	Area	Area size	Use	Offset
1 KB	Area 1	1 KB	Module Register(MR0—MR1023)	0000h—03FFh
	Area 2	1 KB	Module Register and Set Soft Lock Bit (LMR0—LMR1023)	0400h—07FFh
	Area 3	256 B	Soft Lock Bit Register (SLBR0—255)	0800h—08FFh
	Area 4	256 B	Global Configuration Register (GCR)	0900h—09FFh
		1.5 KB	Reserved	0A00h— 0FFFh
2 KB	Area 1	2 KB	Module Register (MR0—MR2047)	0000h—07FFh
	Area 2	2KB	Module Register and Set Soft Lock Bit (LMR0—LMR2047)	0800h—0FFFh
	Area 3	512 B	Soft Lock Bit Register (SLBR0—511)	1000h—11FFh
	Area 4	256 B	Global Configuration Register (GCR)	1200h—12FFh
		3.25 KB	Reserved	1300h—1FFFh
4 KB	Area 1	4 KB	Module Register (MR0—MR4095)	0000h—0FFFh
	Area 2	4 KB	Module Register and Set Soft Lock Bit (LMR0—LMR4095)	1000h—1FFFh
	Area 3	1 KB	Soft Lock Bit Register (SLBR0—1023)	2000h—23FFh
	Area 4	256 B	Global Configuration Register (GCR)	2400h—24FFh
		6.75 KB	Reserved	2500h—3FFFh
8 KB	Area 1	8 KB	Module Register (MR0—MR8191)	0000h—1FFFh
	Area 2	8 KB	Module Register and Set Soft Lock Bit (LMR0—LMR8191)	2000h—3FFFh
	Area 3	2 KB	Soft Lock Bit Register (SLBR0—2047)	4000h—47FFh
	Area 4	256 B	Global Configuration Register (GCR)	4800h—48FFh
		1.75 KB	Reserved	4900h—4FFFh
16 KB	Area 1	16 KB	Module Register (MR0—MR16383)	0000h—3FFFh
	Area 2	16 KB	Module Register and Set Soft Lock Bit (LMR0—LMR16383)	4000h—7FFFh
	Area 3	4 KB	Soft Lock Bit Register (SLBR0—4095)	8000h—8FFFh
	Area 4	4 KB	Global Configuration Register (GCR)	9000h—9FFFh
32 KB	Area 1	32 KB	Module Register (MR0—MR32767)	0000h—7FFFh
	Area 2	32 KB	Module Register and Set Soft Lock Bit (LMR0—LMR32767)	8000h—FFFFh
	Area 3	8 KB	Soft Lock Bit Register (SLBR0—8191)	10000h—11FFFh
	Area 4	4 KB	Global Configuration Register (GCR)	12000h—12FFFh

- Area #1 can take the memory space of 1 KB/2 KB/4 KB/8 KB/16 KB/32 KB, which holds the normal functional module registers and is transparent for all read/write operations.
- Area #2 can take the memory space of 1 KB/2 KB/4 KB/8 KB/16 KB/32 KB and is a mirror of area #1. For an example, if area #1 takes 8 KB of memory space, then read/write access to an offset 2000+X reads/writes the register at offset X. However, a write access to offset 2000+X additionally sets the optional soft lock bits for this offset X in the same cycle

as the register at offset X is written. This provides for an automatic write and lock operation. Not all registers in area #1 need to have protection defined by the associated soft lock bits. For unprotected registers at offset Y, accesses to offset 2000+Y are identical to accesses at offset Y.

- Area #3 can take the memory space of 256 B/512 B/1 KB/2 KB/4 KB/8 KB and hold soft lock bits, one bit per byte in area #1. The four soft lock bits associated with one module register word are arranged at byte boundaries in the memory map. The Soft Lock Bit registers can be directly written using a bit mask.
- Area #4 can take the memory space of 1.75 KB/3.5 KB/7 KB/2 KB/4 KB/4 KB and holds the configuration bits of the protection mode. There is one configuration Hard lock bit per module that prevents all further modifications to the soft lock bits and can only be cleared by a system reset after it is set. When user access allowed bit is set, it allows user access to the protected module.

If you access a locked byte with a write transaction, a bus error is issued to the system and the write transaction is not executed. This is true even if not all accessed bytes are locked.

Accessing unimplemented 32—bit registers in area #3 results in a bus transfer error. In area #4, there will not be any transfer error for the address range mentioned in the table above because these address spaces of area #4 are mapped to the GCR register. Accesses in area #4, beyond the address range mentioned in the Module memory map table, are prohibited and might or might not result into a bus abort.

50.3.2.1 Module register (MR)

Each functional module has its own unique set of registers. This chapter refers to these registers generically as module registers (MR), which exist in the lower module memory space (memory area 1), and receive protection from the REG_PROT module.

50.3.2.2 Module Register and Set Soft Lock Bit (LMR)

This is memory area #2 that provides mirrored access to module registers with the side-effect of setting soft lock bits in case of a write access to a register that is defined as protectable by the locking mechanism. Each MR byte is protectable by one associated bit in SLBR*n* [SLB*m*], according to the mapping described in Soft Lock Bit Register (SLBR*n*).

50.3.3 General

This module provides a generic register (address) write-protection mechanism. The register protection size can be:

- 32 bits (address == multiples of 4)
- 16 bits (address == multiples of 2)
- 8 bits (address == multiples of 1)

The addresses that are protected and the register protection size depends on the chip and/or module.

For all addresses that are protected, there are SLBR*n*[SLB*m*] bits that specify whether the address is locked. When an address is locked, it can only be read but not written in any mode (supervisor/normal). If an address is unprotected, the corresponding SLBR*n*[SLB*m*] bit is always 0, regardless of what the software writes to that field.

NOTE

For more information on register protection specification, see the REG_PROT details file attached to this document.

50.3.4 Change lock settings

To change the setting whether an address is locked or unlocked, the corresponding SLBR*n*[SLB*m*] bit needs to be changed. This can be done using the following methods:

- Set the SLBR*n*[SLB*m*] bit(s) by writing to area #2
- Modify the SLBR*n*[SLB*m*] directly by writing to area #3

Both methods are explained in the following sections.

50.3.4.1 Change lock settings via area #2

You can lock a register after writing to it. Note that reading area #2 does not affect soft lock bits. To do so, you must use area # 2.

The following shows an example with PROT_MEM = 8 KB where SLBs are modified using area #2.

When writing 16-bit to address 0008h, MR9 and MR8 in the protected module are updated. The corresponding lock fields remain unchanged (see the left part of Figure 199).

When writing 16-bit to address 2008h, MR9 and MR8 in the protected module are updated. The corresponding lock fields SLBR2[SLB0:1] become 1, and the lock fields SLBR2[SLB2:3] remain unchanged (see the right part of Figure 199).

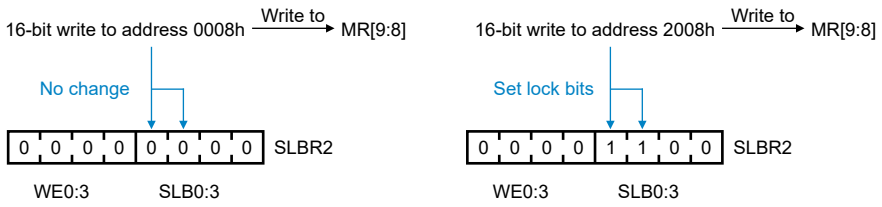


Figure 199. Enable locking via area #2

The following figure shows an example where some addresses are protected and some are not.

In Figure 200, addresses 000Ch and 000Dh are unprotected. Therefore, their corresponding lock fields SLBR3[SLB0:1] are always 0 (shown in bold). During a 32-bit write access to address 200Ch, the lock fields in SLBR3 change as follows:

- SLBR3[SLB2:3] become 1.
- SLBR3[SLB0:1] remain 0.

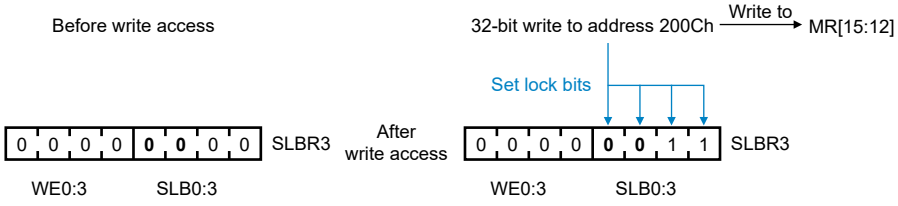


Figure 200. Enable locking for protected and unprotected addresses

50.3.4.2 Change lock settings via area #3

The lock bits are located in area #3 (see Table 243). You can modify them by writing to them. Each SLB*m* field in Soft Lock Bit Register (SLBR*n*) has a mask field, WE*m*, that protects SLB*m* from modification. This masking makes read-modify-write operations unnecessary.

Figure 201 shows two modification examples for registers with 8-bit protection. In part A, a write access to SLBR*n* specifies a mask value that allows modification of all SLBR*n*[SLB0:3] fields. Part B specifies a mask that allows modification only to SLBR*n*[SLB1:3].

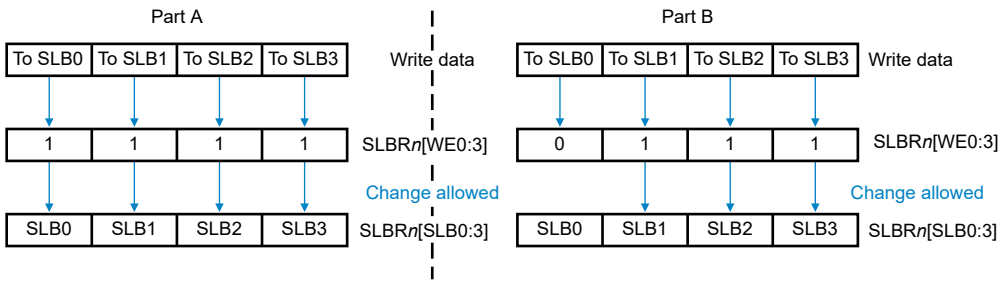


Figure 201. Change lock settings directly via area #3

Figure 202 shows examples for registers with 16-bit protection.

Part A of Figure 202 shows that for SLBR*n*:

- The data written to SLBR*n*[SLB0] is automatically written to SLBR*n*[SLB1].
- The data written to SLBR*n*[SLB2] is automatically written to SLBR*n*[SLB3].

This is because the address reflected by SLBR*n*[SLB0] and SLBR*n*[SLB2] are protected 16-bit wise. Note that in this case, the write enable SLBR*n*[WE0] and SLBR*n*[WE2] must be set while SLBR*n*[WE1] and SLBR*n*[WE3] don't matter.

Part B of Figure 202 shows that the data written to SLBR*n*[SLB0] is automatically written to SLBR*n*[SLB1]. This is done because the address reflected by SLBR*n*[SLB0] has 16-bit protection. In this case, SLBR*n*[WE0] must be 1 and SLBR*n*[WE1] does not matter. SLBR*n*[SLB2] and SLBR*n*[SLB3] remain unchanged because SLBR*n*[WE2] and SLBR*n*[WE3] are 0.

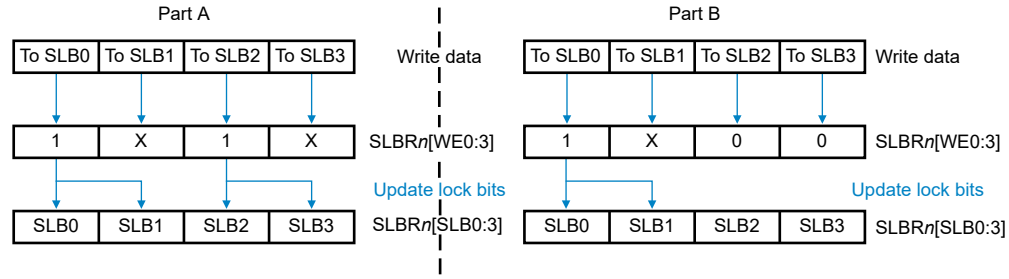


Figure 202. Change lock settings for addresses with 16-bit protection

Figure 203 shows a register with 32-bit protection. In SLBR*n*:

- When SLBR*n*[WE0]=1, the data written to SLBR*n*[SLB0] is automatically written to SLBR*n*[SLB1:3] as well.
- When SLBR*n*[WE0]=0, then SLBR*n*[SLB0:3] remain unchanged. Note that in this case, the write enable SLBR*n*[WE0] must be set while SLBR*n*[WE1:3] does not matter.

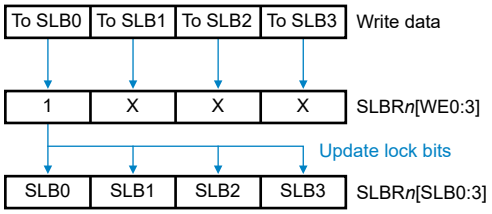


Figure 203. Change lock settings for addresses with 32-bit protection

The following figure shows a mixed protection size configuration.

In SLBR*n*:

- The data written to SLBR*n*[SLB0] is mirrored to SLBR*n*[SLB1] because the corresponding register has 16-bit protection.
- The data written to SLBR*n*[SLB2] is blocked because the corresponding register is unprotected.
- The data written to SLBR*n*[SLB3] is successfully written to SLBR*n*[SLB3] because the corresponding register has 8-bit protection.

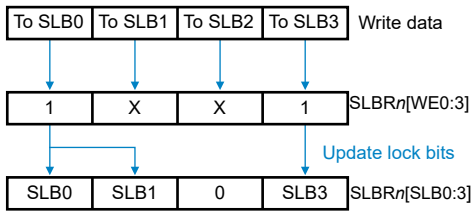


Figure 204. Change lock settings for mixed protection

50.3.4.3 Write protection for locking bits

Changing the locking bits through any of the procedures mentioned in Change lock settings via area #3 and Change lock settings via area #2 is only possible as long as the field GCR.HLB is cleared. After you write 1 to this field, the locking bits cannot be modified until there is a system reset.

50.3.5 Access errors

REG_PROT generates transfer errors under several circumstances, as described below. For the area definition, see Memory space and Protection size.

- If accessing area #1 or area #2, REG_PROT sends any access error from the underlying module under protection.
- If User mode is not allowed, the attempted User mode writes to all areas cause a transfer error, and the writes are blocked.
- If accessing the reserved area, a transfer error is asserted.
- If accessing unimplemented 32-bit registers in areas #3 and #4, a transfer error is asserted.
- If writing to a register in areas #1 and #2, and an SLB field is 1 for any of the affected bytes, then:
  - A transfer error is asserted.
  - The write is blocked.
  - The complete write operation to non-protected bytes in this word is ignored.
- If writing to an SLBR in area #3 with GCR[HLB]=1, a transfer error is asserted.
- Any write operation in any access mode to area #2, when GCR[HLB]=1, is not allowed.

NOTE

The transfer error generated by REG_PROT can only be observed on the CPU that initiates the target register write and has defined the strongly ordered memory region (through its MPU or MMU) covering the target register address.

50.4 External Signals

There are no external signals.

50.5 Initialization

The following sections contain information related to initialization of the Register Protection module.

50.5.1 Sequence

You must configure the REG_PROT first. And then, you need to write 1 to the HLB field in REG_PROT. This ensures that registers under protection are not updated in the user access mode. You need to follow these steps:

1. Enable XRDC protection for the module to enable writes in the supervisor mode only. This step is mandatory, if protected registers of the module are expected to be configured multiple times.
2. Configure REG_PROT to enable write on registers of module under protection.
3. Configure the registers of module under protection.
4. Configure the REG_PROT for the required SLB fields.
5. Set the HLB field in REG_PROT. This step is mandatory, if protected registers of module are expected to be configured only once.

50.5.2 Reset

It is a single clock IP, with single reset.

50.6 Writing C code using the register protection scheme

There is a set of macros provided as part of the device specific header file, which defines the memory map, the peripheral registers, and the fields of these registers. These macros are intended to make working with the register protection scheme easier for the developers of device driver software and/or other application code. This section describes these macros and how to use them.

A first macro is made available to perform a write to the mirrored module register space (Area 2). As described in this document, this results in concurrently setting the corresponding soft lock bit while writing to the module register. There are three types of this macro for each memory protection size `<PROT_MEM>`, to account for the different size of the related module register `<thereg>` (the value of `<size>` is either 8-bit, 16-bit, or 32-bit):

```
          WRITE_WITH_LOCK_<PROT_MEM>_<size>(<thereg>,
        <newvalue>)
```

This macro writes the value `<newvalue>` into the register `<thereg>` assuming a register size of `<size>`. The parameter `<thereg>` must be the name of a register using the notation in the device specific header file.

Example of using the macro for EMIOS_0.UCDIS.R register which is 32-bit width and the module has 4k memory protection size:

```
 WRITE_WITH_LOCK_4K_32BIT(&EMIOS_0.UCDIS.R, 0x000000FF);
```

A second set of macros is made available to work with the soft lock bits provided by the register protection scheme. The value of these bits associated with a particular module register `<thereg>` can be retrieved, set, and cleared. And, these macros are:

```
GET_SOFTLOCK_<PROT_MEM>
        (<modulebase>,<thereg>,<dest>)
```

```
SET_SOFTLOCK_<PROT_MEM>_<size>(<modulebase>,<thereg>)
```

```
CLR_SOFTLOCK_<PROT_MEM>_<size>(<modulebase>,<thereg>)
```

The macro GET_SOFTLOCK retrieves the value of the soft lock bit register associated with the given register `<thereg>` and stores it in the variable `<dest>`; which is always an 8-bit value. The other two macros (SET_SOFTLOCK, CLR_SOFTLOCK) set or clear the softlock bits associated with the given register `<thereg>`; assuming this register has a `<size>` of 8BIT, 16BIT, or 32BIT as indicated by the macro name. For all three macros, the parameter `<thereg>` must be the name of a register and the parameter `<modulebase>` base address of the module using the notation in the device specific header file.

Example of using the macros for SIUL2_0.PGPDO0.R register which is 16-bit width and the module has 8k memory protection size:

```
GET_SOFTLOCK_8K(&SIUL2_0, &SIUL2_0.PGPDO0.R, &variable);
```

```
SET_SOFTLOCK_8K_16BIT(&SIUL2_0, &SIUL2_0.PGPDO0.R);
```

```
CLR_SOFTLOCK_8K_16BIT(&SIUL2_0, &SIUL2_0.PGPDO0.R);
```

Three more macros are available to modify bits in the Global Configuration Register (GCR) of the protection gasket for the corresponding block. These macros receive the base address of the corresponding module `<modulebase>` as a parameter.

```
SET_HARDLOCK_<PROT_MEM>
      (<modulebase>)
```

Sets the Hard Lock Bit HLB in the Global Configuration Register associated with the module identified by the given module base address `<modulebase>`.

Example of using macro for DMAMUX_0 module which has 4k memory protection size:

```
SET_HARDLOCK_4K(&DMAMUX_0);
```

```
USER_ACCESS_FORBIDDEN_<PROT_MEM>
        (<modulebase>)
```

Clears the User Access Allowed Bit UAA in the Global Configuration Register associated with the module identified by the given module base address `<modulebase>`. When it is cleared, this bit denies any write access to the protected module in user mode and generates a transfer error in case of an attempt to write a protected register.

Example of using macro for DMAMUX_0 module which has 4k memory protection size:

```
USER_ACCESS_FORBIDDEN_4K(&DMAMUX_0);
```

```
USER_ACCESS_ALLOWED_<PROT_MEM>
        (<modulebase>)
```

Sets the User Access Allowed Bit UAA in the GCR register associated with the module identified by the given module base address `<modulebase>`. When it is set, this bit permits write accesses to the protected module in user mode when the corresponding register are not additionally protected by other means.

Example of using macro for DMAMUX_0 module which has 4k memory protection size:

```
USER_ACCESS_ALLOWED_4K(&DMAMUX_0);
```

The following macro is for reading the content of the GCR register.

```
GET_GCR_<PROT_MEM>
        (<modulebase>,<dest>)
```

Provides the content of the Global Configuration Register (GCR) for the block identified by its module base address `<modulebase>` and stores it in the variable `<dest>`; which is always 32-bit value.

Example of using macro for DMAMUX_0 module which has 4 k memory protection size:

```
GET_GCR_4K(&DMAMUX_0, &variable);
```

50.7 REG_PROT register descriptions

This register information documents memory area #3 and area #4.

50.7.1 REG_PROT memory map

REG_PROT base address: base address of protected module instance

Table 244. REG_PROT memory map

PROT_MEM	Offset	Register	Width (In bits)	Access	Reset value
1kB	0x800 – 0x8FF	Soft Lock Bit Register (SLBR0-255)	8	RW	00h
	0x900 – 0x9FF	Global Configuration Register (GCR)	32	RW	0000_0000h
2kB	0x1000 – 0x11FF	Soft Lock Bit Register (SLBR0-511)	8	RW	00h
	0x1200 – 0x12FF	Global Configuration Register (GCR)	32	RW	0000_0000h
4kB	0x2000 – 0x23FF	Soft Lock Bit Register (SLBR0-1023)	8	RW	00h
	0x2400 – 0x24FF	Global Configuration Register (GCR)	32	RW	0000_0000h
8kB	0x4000 – 0x47FF	Soft Lock Bit Register (SLBR0-2047)	8	RW	00h
	0x4800 – 0x48FF	Global Configuration Register (GCR)	32	RW	0000_0000h
16kB	0x8000 – 0x8FFF	Soft Lock Bit Register (SLBR0-4095)	8	RW	00h
	0x9000-0x9FFF	Global Configuration Register (GCR)	32	RW	0000_0000h
32kB	0x10000-0x11FFF	Soft Lock Bit Register (SLBR0-8191)	8	RW	00h
	0x12000 – 0x12FFF	Global Configuration Register (GCR)	32	RW	0000_0000h

50.7.2 Soft Lock Bit Register (SLBR*n*)

Offset

See REG_PROT memory map for SLBR*n* offset ranges. For SLBR*n* addresses, see the REG_PROT details file attached to this document.

Function

These registers hold the Soft Lock Bits (SLBs) for the protected registers in memory area #1, which is the normal register address space of the protected module. Multiple Soft Lock Bit Registers (SLBR*n*) can be implemented, depending on the number of protected module register bytes. Each SLBR*n* has four soft lock fields (SLB0-SLB3), each of which controls write access to a byte in memory area #1. Each soft lock field also has a corresponding write enable field in the same register that controls whether the soft lock field can be written. The following table shows the mapping between the soft lock fields to the bytes in memory area #1.

Table 245. SLBs vs. protected address

SLB	Protected address
SLBR0[SLB0]	MR0
SLBR0[SLB1]	MR1
SLBR0[SLB2]	MR2

Table continues on the next page...

Table 245. SLBs vs. protected address (continued)

SLB	Protected address
SLBR0[SLB3]	MR3
SLBR1[SLB0]	MR4
SLBR1[SLB1]	MR5
SLBR1[SLB2]	MR6
SLBR1[SLB3]	MR7
SLBR2[SLB0]	MR8
...	...

Diagram

Bits	7	6	5	4	3	2	1	0
R	0	0	0	0	SLB0	SLB1	SLB2	SLB3
W	WE0	WE1	WE2	WE3				
Reset	0	0	0	0	0	0	0	0

Fields

Field	Function
7 WE0	Write enable fields for SLB WE0 enables writing to SLB0. 0b - SLB is not modified. 1b - Value is written to SLB.
6 WE1	Write enable fields for SLB WE1 enables writing to SLB1. 0b - SLB is not modified. 1b - Value is written to SLB.
5 WE2	Write enable fields for SLB WE2 enables writing to SLB2. 0b - SLB is not modified. 1b - Value is written to SLB.
4 WE3	Write enable bits for SLB WE3 enables writing to SLB3. 0b - SLB is not modified. 1b - Value is written to SLB.

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 SLB0	Soft lock fields for one MRn register SLB0 can block accesses to MR[n *4 + 0]. 0b - Associated MRn byte is unprotected and writable. 1b - Associated MRn byte is locked against write accesses.
2 SLB1	Soft lock bits for one MRn register SLB1 can block accesses to MR[n *4 + 1]. 0b - Associated MRn byte is unprotected and writable. 1b - Associated MRn byte is locked against write accesses.
1 SLB2	Soft lock fields for one MRn register SLB2 can block accesses to MR[n *4 + 2]. 0b - Associated MRn byte is unprotected and writable. 1b - Associated MRn byte is locked against write accesses.
0 SLB3	Soft lock fields for one MRn register SLB3 can block accesses to MR[n *4 + 3]. 0b - Associated MRn byte is unprotected and writable. 1b - Associated MRn byte is locked against write accesses.

50.7.3 Global Configuration Register (GCR)

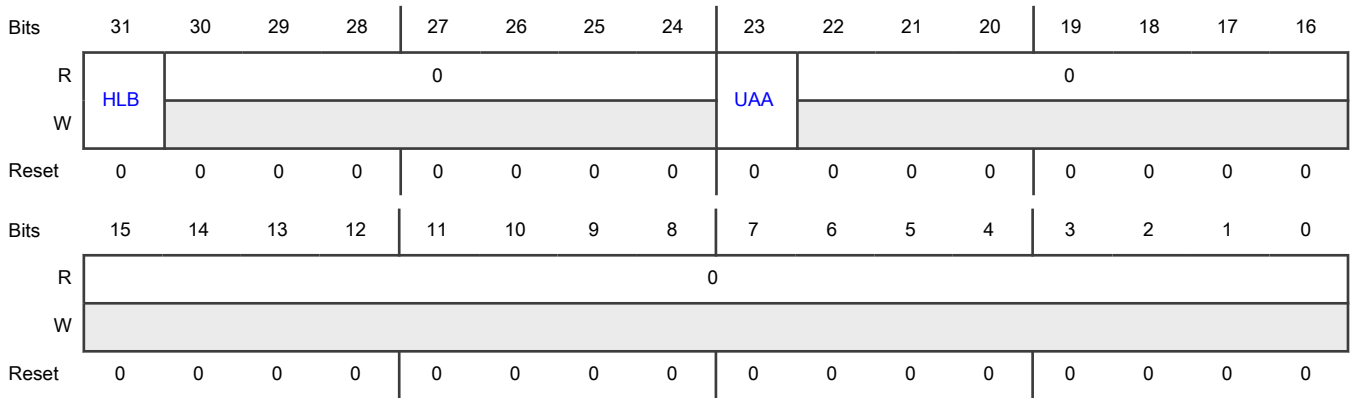
Offset

See REG_PROT memory map for GCR offset.

Function

This register controls module level configurations.

Diagram



Fields

Field	Function
31 HLB	Hard Lock Bit This field cannot be cleared after it is set by the software. It can only be cleared by a system reset. 0b - All SLB fields are accessible and can be modified. 1b - All SLB fields are write protected and cannot be modified. **NOTE** Once this bit is set, it will set all registers under the same PROT_MEM region.
30-24 —	Reserved
23 UAA	User Access Allowed Controls the user and supervisor mode access to registers of the module under protection. 0b - The registers in the module under protection can only be written in the supervisor mode (user access is not allowed). All the write accesses in user (non-supervisor) mode are not executed and a transfer error is issued. This access restriction is in addition to any access restrictions imposed by the protected IP module. 1b - The registers in the module under protection can be accessed in the mode defined for the module registers without any additional restrictions. It can be modified in both user (non-supervisor) and supervisory mode.
22-0 —	Reserved

50.8 Glossary

PROT_MEM Integration parameter that specifies the size of the module register slot protected. The PROT_MEM size depends on the chip or module.

Hard lock A lock that restricts access to any register bit. You can unlock or clear this lock through the hardware reset.

Soft lock A lock that restricts access to any register bit. You can unlock or clear this lock through the software.

Chapter 51
Clock Monitoring Unit – Frequency Check (CMU_FC)

51.1 Chip-specific CMU_FC information

51.1.1 CMU_FC configuration

The device consists of a robust clock monitoring architecture targeted to monitor various clock nodes to ensure device clock robustness. There are 7 clock monitoring units present in the device out of which 5 are of type CMU_FC. See 'Clock monitoring' section in Clocking chapter for details on device clock monitoring architecture.

NOTE

CMU_5 is accessible by Cortex-M0+ core only.

CMU_FC combined spec variation: The combined spec variation for CMU (used for configuring CMU_FCx.HTCR[HFREF] and CMU_FCx.HTCR[LFREF]) is the absolute sum of frequency variations of the clock sources. Refer device datasheet for frequency variations for the corresponding clock sources.

51.2 Overview

CMU_FC ensures the clock integrity of selected clocks and allows continuous clock integrity verification.

CMU_FC checks if the frequency of a monitored clock (*monitored_clock*) is within a programmable frequency range specified by the user. If the frequency is outside the specified limits, it could lead to performance, protocol, and timing failures. CMU_FC requires a clock used as a base reference for the frequency check operation. This reference clock (*reference_clock*) must be within documented limits for correct CMU_FC operation.

51.2.1 Block diagram

CMU_FC counts clock cycles of the monitored clock during a user programmable time duration of *n* clock cycles of the reference clock. There is a comparison between the final count of the monitored clock and the user programmable upper and lower threshold count limits. The control logic determines whether the cycle count is within the programmed limits. If not it sets the Frequency Higher than High frequency reference threshold event status (FHH) field or the Frequency Lower than Low frequency reference threshold event status (FLL) field in the Status Register (SR). If you enable interrupts, an interrupt asserts when the status flag sets.

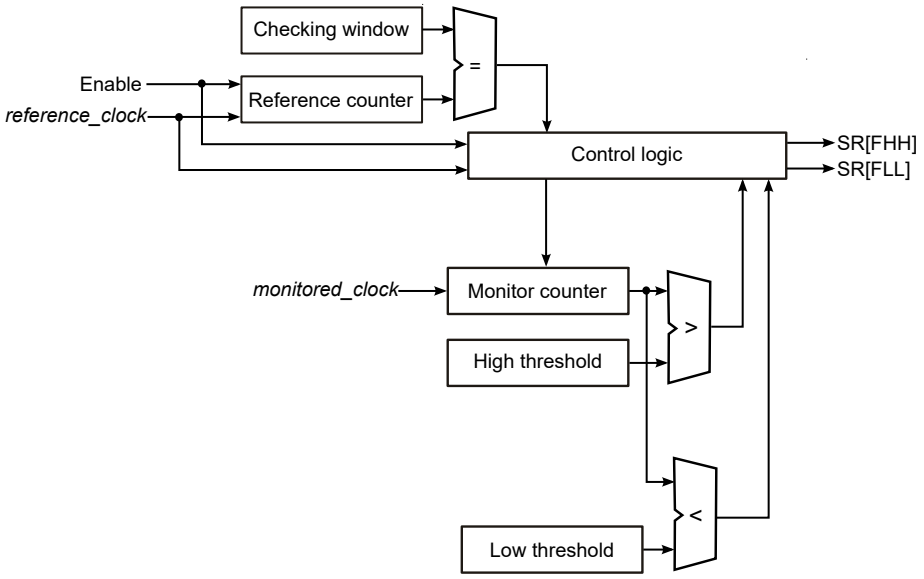


Figure 205. CMU_FC block diagram

CMU_FC cannot detect the following:

- Monitored clock duty cycle variations
- Instantaneous monitored clock frequency variations that do not cross upper or lower threshold limits

51.2.2 Features

The CMU_FC features are:

- Programmable duration of reference clock cycles
- Initiates an event if a monitored clock frequency is higher than high frequency reference (FHH)
- Initiates an event if a monitored clock frequency is lower than low frequency reference (FLL)
- FLL event (if enabled) is generated when monitored clock is very slow or stops functioning
- Masking of FHH event interrupt
- Masking of FLL event interrupt

51.3 Functional description

51.3.1 Operating modes

CMU_FC supports the following operating modes:

- Frequency checking

See the succeeding sections for detailed descriptions of the functions.

51.3.2 Frequency checking

Frequency checking starts when software writes GCR[FCE] = 1. The Run Status field SR[RS] shows 1 after frequency check operation starts.

CMU_FC performs continuous periodic clock checking of the monitored clock. Each checking window involves the following operations:

- Stage 1 – Reference clock counter runs for RCCR[REF_CNT] reference clock cycles. Monitored clock counter runs in parallel for the same time duration as reference clock counter.
- Stage 2 – After stage 1, the module compares the final monitored clock count against the programmed thresholds.

If the monitored clock count is greater than the high threshold value in HTCR[HFREF], an FHH event occurs.

If the monitored clock count is lower than the low threshold value in LTCR[LFREF], an FLL event occurs.

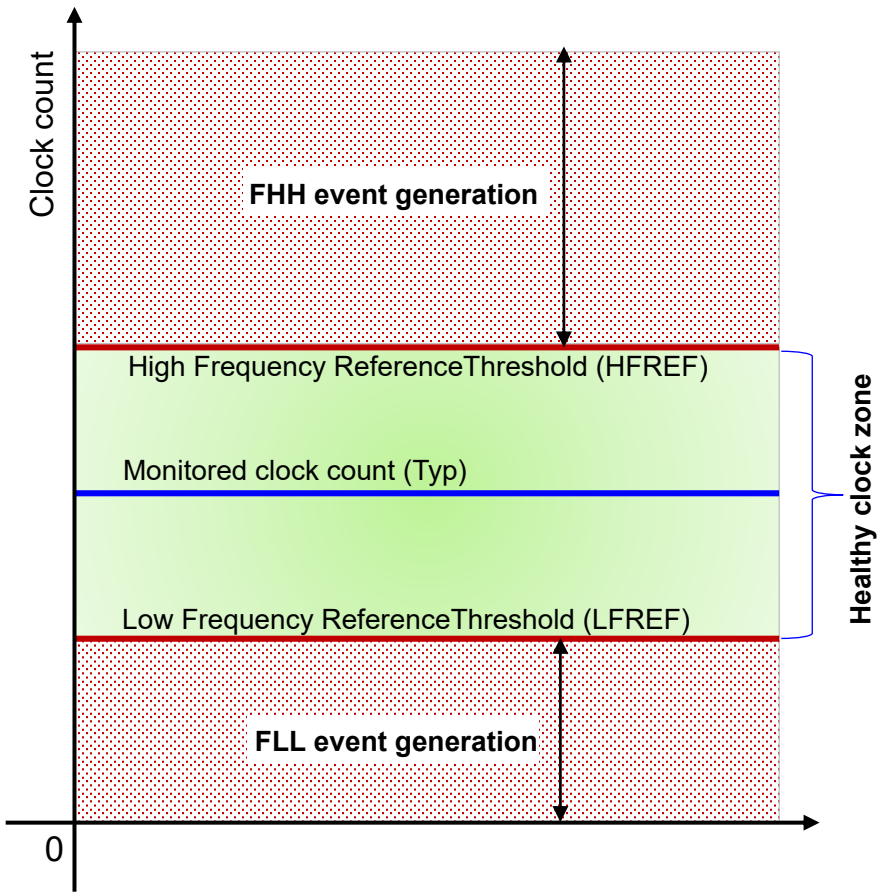


Figure 206. Frequency checking HFREF and LFREF thresholds

51.3.2.1 Monitored clock lost

If a monitored clock ceases operation before evaluation of that clock (Stage 2, see Frequency checking), CMU_FC waits for RCCR[REF_CNT] reference clock periods by extending Stage 2 before triggering an FLL event.

- If *monitored_clock* is not running when enabling CMU_FC:

Worst case FLL response time = (2 × RCCR[REF_CNT] + 12) *reference_clock* cycles + 15 *bus_clock* cycles

- If *monitored_clock* stops when the CMU_FC is running:

Worst case FLL response time = (2 × RCCR[REF_CNT] + 2) *reference_clock* cycles + 3 *bus_clock* cycles

51.3.3 Clocking

This module has the following clock sources.

Table 246. Clock description

Clock	I/O	Description
reference_clock	I	Clock signal that the module uses as a reference to evaluate *monitored_clock*
monitored_clock	I	Clock signal on which frequency check is performed
bus_clock	I	Clock signal on which register read/write operation is performed

NOTE

See the Clocking chapter for details of monitored and reference clocks used on this chip.

51.3.4 Reset

This module has the following reset sources.

- Global hard reset input
- Reset port synchronized to reference clock domain input
- Reset port synchronized to monitored clock domain input

51.4 External signals

This module has no external signals.

51.5 Programming guidelines

51.5.1 Programming RCCR[REF_CNT]

RCCR[REF_CNT] defines the duration of the checking operation in number of *reference_clock* cycles. The minimum RCCR[REF_CNT] value can be calculated using the following formula:

$$\textbf{Minimum RCCR [REF_CNT]} = \text{CEILING value of MAX}\left(3 \text{ X } \left(\frac{f_{reference_clock}}{f_{bus_clock}}\right), 8 + 5 \text{ X } \left(\frac{f_{reference_clock}}{f_{monitored_clock}}\right)\right)$$

...where:

- $f_{reference_clock}$ is the frequency of the reference clock
- f_{bus_clock} is the frequency of the bus clock
- $f_{monitored_clock}$ is the frequency of the monitored clock

Example to determine RCCR[REF_CNT]:

- f_{bus_clock} = 16 MHz
- $f_{reference_clock}$ = 8 MHz
- $f_{monitored_clock}$ = 48 MHz

Formula #1:	$3 \text{ X } \left(\frac{f_{reference_clock}}{f_{bus_clock}} \right)$
Inserting the values:	3 × (8 / 16) = 1.5
Formula #2:	$8 + 5 \text{ X } \left(\frac{f_{reference_clock}}{f_{monitored_clock}} \right)$
Inserting the values:	8 + 5 × (8 / 48) ≈ 8.83
MAX (1.5, 8.83):	8.83
CEILING value of MAX:	9
Therefore, minimum RCCR[REF_CNT]:	9

Programmed RCCR[REF_CNT] value must be greater than or equal to the calculated minimum value and should be decided after considering application requirements of frequency check completion response time and overall accuracy required from CMU_FC.

- Higher values of RCCR[REF_CNT] results in longer measurement window, leading to better accuracy in monitored clock check.
- Lower values of RCCR[REF_CNT] results in shorter measurement window, leading to faster FHH and FLL event response, but higher inaccuracy in reported result.

For measurement window calculation, see step 8 in Programming HFREF and LFREF

51.5.2 Programming HFREF and LFREF

You must consider the following when programming HFREF/LFREF:

- Tolerable monitored clock frequency variation
- Maximum reference clock frequency variation
- Inherent module inaccuracy

CMU_FC has an expected maximum deviation of ± 3 *monitored_clock* cycles (CMU_FC_{VAR+} = 3, CMU_FC_{VAR-} = –3).

The following procedure shows how to calculate optimum values for HTCR[HFREF] and LTCR[LFREF] (numbers shown are from example in table):

1. Determine the ideal *monitored_clock* frequency ($f_{monitored_clock}$ (ideal), 48 MHz).
2. Determine the specified variation of the *monitored_clock* (1.1%).
3. Calculate *monitored_clock* frequency variation: .

   $$f_{monitored_clock}\,(ideal) \text{ X} \left(1 \pm variation\ (\text{step 2})\right)$$

   - $f_{monitored_clock}$ (max) = 48 MHz × (1 + (1.1 ÷ 100)) = 48.53 MHz
   - $f_{monitored_clock}$ (min)= 48 MHz × (1 – (1.1 ÷ 100)) = 47.47 MHz
4. Determine the ideal *reference_clock* frequency ($f_{reference_clock}$ (ideal), 8 MHz).
5. Determine the specified variation of the *reference_clock* (3.3%).

6. Calculate ideal *reference_clock* frequency variation:

$$f_{reference_clock}\ (ideal) \times (1 \pm variation\ (\text{step 5}))$$

   - $f_{reference_clock}$ (max) = 8 MHz × (1 + (3.3 ÷ 100)) = 8.26 MHz
   - $f_{reference_clock}$ (min) = 8 MHz × (1 – (3.3 ÷ 100)) = 7.74 MHz
7. Select the value of RCCR[REF_CNT] needed (80). See Programming RCCR[REF_CNT].
8. Calculate ideal measurement window:

$$\frac{RCCR\,[REF_CNT]}{f_{reference_clock}\ (ideal)}$$

   - 80 ÷ 8 MHz = 10000 ns
9. Calculate ideal *monitored_clock* count:

$$\frac{RCCR[REF_CNT]}{f_{reference_clock}(ideal)} \times f_{monitored_clock}\ (ideal)$$

   - 80 ÷ 8 MHz × 48 MHz = 480.00 (round off this value, 480 in this case)
10. Calculate high threshold value (HTCR[HFREF]):

$$\text{Ceiling value of } \left(\frac{f_{monitored_clock}\ (max)}{f_{reference_clock}\ (min)} \times RCCR[REF_CNT]\right) + CMU_FC_{VAR+}$$

    - HTCR[HFREF] = Ceiling(48.53 MHz ÷ 7.74 MHz × 80 + 3) = 505
11. Calculate low threshold value (LTCR[LFREF]):

$$\text{Floor value of } \left(\frac{f_{monitored_clock}\ (min)}{f_{reference_clock}\ (max)} \times RCCR[REF_CNT]\right) - CMU_FC_{VAR-}$$

    - LTCR[LFREF] = Floor(47.47 MHz ÷ 8.26 MHz × 80 – 3) = 456

Table 247. HTCR[HFREF] and LTCR[LFREF] calculation example

Property	Value	Unit
Bus clock frequency (f_{bus_clock})	16	MHz
Monitored clock frequency ($f_{monitored_clock}$ (ideal))	48	MHz
Specified variation of monitored clock	1.1	%
Monitored clock frequency (maximum after specified variation, $f_{monitored_clock}$ (max))	48.53	MHz

Table continues on the next page...

Table 247. HTCR[HFREF] and LTCR[LFREF] calculation example (continued)

Property	Value	Unit
Monitored clock frequency (minimum after specified variation, $f_{monitored_clock}$ (min))	47.47	MHz
Reference clock frequency ($f_{reference_clock}$ (ideal))	8	MHz
Specified variation of reference clock	3.3	%
Reference clock frequency (maximum after specified variation, $f_{reference_clock}$ (max))	8.26	MHz
Reference clock frequency (minimum after specified variation, $f_{reference_clock}$ (min))	7.74	MHz
Minimum reference count (RCCR[REF_CNT])	9	—
Programmed reference count (RCCR[REF_CNT]) (must be ≥ minimum RCCR[REF_CNT])	80	—
Measurement window	10000.00	ns
Calculated monitored clock count	480.00	—
Calculated monitored clock Count (rounded)	480	—
Module positive variation (CMU_FC_{VAR+})	3	—
Module negative variation (CMU_FC_{VAR-})	-3	—
Programmed higher threshold (HTCR[HFREF])	505	—
Programmed lower threshold (LTCR[LFREF])	456	—

51.5.3 Module programming sequence

51.5.3.1 Module programming sequence

The recommended programming sequence for CMU_FC frequency checking is:

1. In any order, complete the following:
   - Program RCCR[REF_CNT] to define the frequency measuring window duration in *reference_clock* cycles.
   - Program LTCR[LFREF] and HTCR[HFREF] to set the permissible frequency range of the *monitored_clock*.
   - Program IER to enable interrupt.
2. Write GCR[FCE] = 1 to start the frequency check operation.

   NOTE

   When GCR[FCE] = 1, you must not write to RCCR, HTCR, LTCR, or IER. Attempting to do so generates a bus transfer error.

3. To reconfigure RCCR, LTCR, HTCR , and IER or to stop frequency check operation, wait for SR[RS] = 1, then write GCR[FCE] = 0.

51.6 CMU_FC register descriptions

51.6.1 CMU_FC memory map

This section describes the address order of all the CMU_FC registers. Each description includes a standard register diagram and associated field descriptions.

CMU_0 base address: 402B_C000h

CMU_3 base address: 402B_C060h

CMU_4 base address: 402B_C080h

CMU_5 base address: 402B_C0A0h

CMU_6 base address: 402B_C0C0h

Offset	Register	Width (In bits)	Access	Reset value
0h	Global Configuration Register (GCR)	32	RW	0000_0000h
4h	Reference Count Configuration Register (RCCR)	32	RW	0000_0000h
8h	High Threshold Configuration Register (HTCR)	32	RW	00FF_FFFFh
Ch	Low Threshold Configuration Register (LTCR)	32	RW	0000_0000h
10h	Status Register (SR)	32	RW	0000_0000h
14h	Interrupt Enable Register (IER)	32	RW	0000_0000h

51.6.2 Global Configuration Register (GCR)

Offset

Register	Offset
GCR	0h

Function

Controls module level configurations such as enabling frequency check.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															FCE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved
0 FCE	Frequency Check Enable Starts or stops frequency checking. FCE is disabled by default. Software can enable FCE at any time. To stop the ongoing operation, write 0 to FCE only when SR[RS] = 1. 0b - Stops frequency checking 1b - Starts frequency checking

51.6.3 Reference Count Configuration Register (RCCR)

Offset

Register	Offset
RCCR	4h

Function

Programs reference count duration of the frequency check window.

NOTE

Write to RCCR only when GCR[FCE] = 0. A bus transfer error results if software writes RCCR when GCR[FCE] = 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REF_CNT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
15-0 REF_CNT	Reference clock count Total number of counts of *reference_clock* for which frequency check runs. This field defines the duration of one frequency check window. See Programming RCCR[REF_CNT] for RCCR calculation.

51.6.4 High Threshold Configuration Register (HTCR)

Offset

Register	Offset
HTCR	8h

Function

Determines the high threshold limit of the monitored clock counter.

NOTE

Write HTCR only when GCR[FCE] = 0. A bus transfer error results if software writes HTCR when GCR[FCE] = 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								HFREF							
W																
Reset	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	HFREF															
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-24 —	Reserved
23-0 HFREF	High frequency reference threshold HFREF determines the high reference value for the monitored clock frequency. See Programming HFREF and LFREF for HFREF calculation.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE Do not program HFREF to a value greater than 0x00FFFFFC.

51.6.5 Low Threshold Configuration Register (LTCR)

Offset

Register	Offset
LTCR	Ch

Function

Determines the low threshold limit of the monitored clock counter.

NOTE

Write LTCR only when GCR[FCE] = 0. A bus transfer error results if software writes LTCR when GCR[FCE] = 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								LFREF							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LFREF															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-0 LFREF	Low Frequency Reference Threshold LFREF determines the low reference value for the monitored clock frequency. See Programming HFREF and LFREF for LFREF calculation. **NOTE** Do not program LFREF to a value less than 0x00000003.

51.6.6 Status Register (SR)

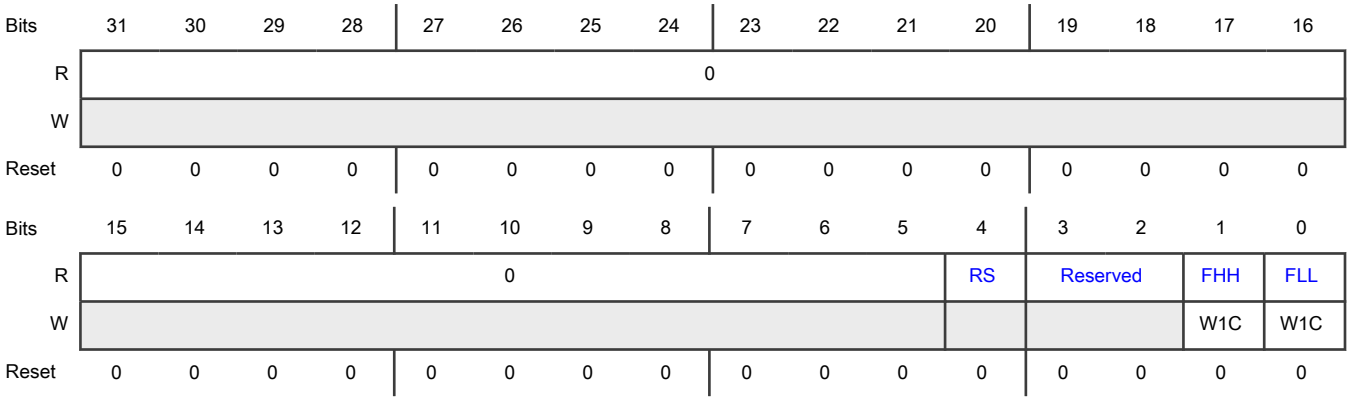
Offset

Register	Offset
SR	10h

Function

Provides the internal status of the module.

Diagram



Fields

Field	Function
31-5 —	Reserved
4 RS	Run Status Shows the running status of module internal operation. After enabling the frequency check operation (GCR[FCE] = 1), there is a fixed delay before this field shows running status. If the system wants to disable the frequency check operation, then the software should read this register and write GCR[FCE] = 0 only when this field is 1. 0b - Frequency check stopped 1b - Frequency check running
3-2 —	Reserved
1 FHH	Frequency higher than high frequency reference threshold event status Hardware writes 1 to FHH when the monitored clock frequency becomes higher than the high threshold value in HTCR[HFREF]. FHH clears when software writes 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No FHH event 1b - FHH event occurred
0 FLL	Frequency lower than low frequency reference threshold event status Hardware writes 1 to FLL when the monitored clock frequency becomes lower than the low threshold value in LTCR[LFREF]. FLL clears when software writes 1. 0b - No FLL event 1b - FLL event occurred

51.6.7 Interrupt Enable Register (IER)

Offset

Register	Offset
IER	14h

Function

Enables CMU_FC interrupts.

NOTE

Write IER only when GCR[FCE] = 0. A bus transfer error results if software writes IER when GCR[FCE] = 1.

Enable only either asynchronous FHH event interrupt or synchronous FHH event interrupt at a time.

For example:

- If IER[FHHIE] is set to 1 then set IER[FHHAIE] to 0.
- If IER[FHHAIE] is set to 1 then set IER[FHHIE] to 0.

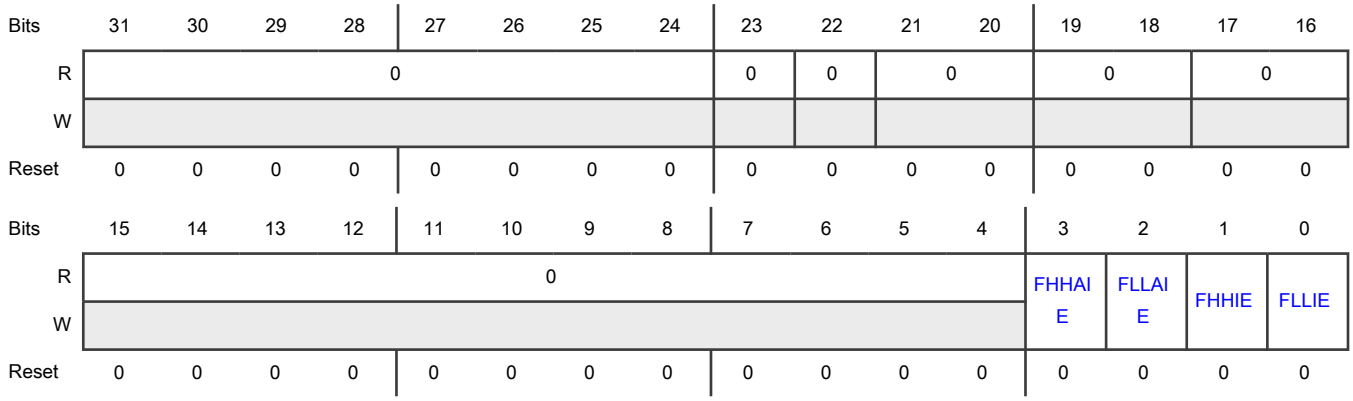
Enable only either asynchronous FLL event interrupt or synchronous FLL event interrupt at a time.

For example:

- If IER[FLLIE] is set to 1 then set IER[FLLAIE] to 0.
- If IER[FLLAIE] is set to 1 then set IER[FLLIE] to 0.

See Clocking chapter for interrupt usage information based on CMU_FC instances.

Diagram



Fields

Field	Function
31-24 —	Reserved
23 —	Reserved
22 —	Reserved
21-20 —	Reserved
19-18 —	Reserved
17-16 —	Reserved
15-4 —	Reserved
3 FHHAIE	Frequency Higher than High Frequency Reference Threshold Asynchronous Interrupt Enable FHHAIE enables FHH asynchronous interrupt at the module boundary. 0b - Asynchronous FHH event interrupt disabled 1b - Asynchronous FHH event interrupt enabled
2 FLLAIE	Frequency Lower than Low Frequency Reference Threshold Asynchronous Interrupt Enable FLLAIE enables FLL asynchronous interrupt at the module boundary.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - Asynchronous FLL event interrupt disabled
1b - Asynchronous FLL event interrupt enabled</td></tr>
<tr><td>1
FHHIE</td><td>Frequency Higher than High Frequency Reference Threshold Synchronous Interrupt Enable
FHHIE enables an FHH synchronous interrupt at the module boundary.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>CMU_0</td><td>IER</td><td>—</td></tr><tr><td>CMU_3</td><td>—</td><td>IER</td></tr><tr><td>CMU_4</td><td>—</td><td>IER</td></tr><tr><td>CMU_5</td><td>—</td><td>IER</td></tr><tr><td>CMU_6</td><td>—</td><td>IER</td></tr></table>0b - Synchronous FHH event interrupt disabled
1b - Synchronous FHH event interrupt enabled</td></tr>
<tr><td>0
FLLIE</td><td>Frequency Lower than Low Frequency Reference Threshold Synchronous Interrupt Enable
FLLIE enables an FLL synchronous interrupt at the module boundary.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>CMU_0</td><td>IER</td><td>—</td></tr><tr><td>CMU_3</td><td>—</td><td>IER</td></tr><tr><td>CMU_4</td><td>—</td><td>IER</td></tr><tr><td>CMU_5</td><td>—</td><td>IER</td></tr><tr><td>CMU_6</td><td>—</td><td>IER</td></tr></table></td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Synchronous FLL event interrupt disabled 1b - Synchronous FLL event interrupt enabled

51.7 Glossary

FHH The state that the monitored clock frequency is higher than the high frequency reference. FHH is also the name of the register field that indicates this state.

FHH event The event that the module triggers when it detects FHH.

FLL The state that the monitored clock frequency is lower than the lower frequency reference. FLL is also the name of the register field that indicates this state.

FLL event The event that the module triggers when it detects FLL.

Chapter 52
Clock Monitoring Unit – Frequency Meter (CMU_FM)

52.1 Chip-specific CMU_FM information

52.1.1 CMU_FM configuration

The device consists of a robust clock monitoring architecture targeted to monitor various clock nodes to ensure device clock robustness. There are 7 clock monitoring units present in the device out of which 2 are of type CMU_FM. See 'Clock monitoring' section in Clocking chapter for details on device clock monitoring architecture.

NOTE

CMU metering interrupt is not generated if the clock which is being metered is lost. A timeout status flag, CMU.SR[FMTO] is updated in this case.

NOTE

Software must ensure that CMU1 interrupt is serviced within POR_WDG timeout. In absence of CMU1 interrupt servicing, the POR_WDG detects this as an FIRC failure and initiates a POR recovery.

52.2 Overview

CMU_FM measures the frequency of the metered clock (*metered_clock*) using another clock as reference. This reference clock (*reference_clock*) must be within documented limits for correct CMU_FM operation. CMU_FM operation is only guaranteed if a reference clock is within normal operating parameters.

52.2.1 Block diagram

The CMU_FM counts the clock cycles of a metered clock in the user programmable time duration *n* number of clock cycles of the reference clock. After completion of a metered clock operation, a register field sets, indicating the operation has completed. The count of the metered clock also updates in the Status Register (SR) after completion of a metered clock operation.

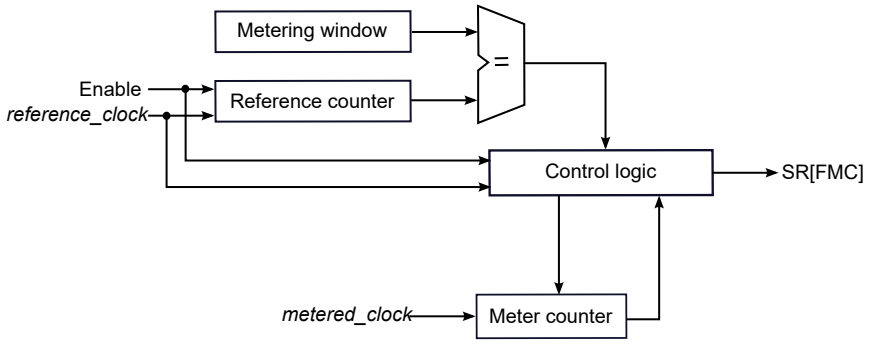


Figure 207. Block diagram

52.2.2 Features

Features of the CMU_FM are:

- Programmable duration of *reference_clock* cycles
- Maskable interrupt generation when frequency metering completes
- Timeout feature indicates loss of *metered_clock*

52.3 Functional description

The frequency meter operation initiates when software writes GCR[FME] = 1. When the operation starts, hardware writes SR[RS] = 1. Safety critical applications must poll SR[RS] to determine when metering operation starts.

Frequency metering window involves these operations:

1. Stage 1 — The reference clock counter runs for RCCR[REF_CNT] cycles of *reference_clock*. The metered clock counter runs in parallel for the same time duration as the *reference_clock* counter.
2. Stage 2 — At the end of stage 1, SR[FMC] = 1, SR[MET_CNT] updates with the *metered_clock* count, and CMU_FM writes GCR[FME] = 0.

52.3.1 Clocking

The following table lists the clock sources for this module.

Table 248. Clock description

Clock	I/O	Description
reference_clock	I	Clock signal that the module uses as a reference to evaluate *metered_clock*
metered_clock	I	Clock signal on which frequency metering is performed
bus_clock	I	Clock signal on which register read/write operation is performed

NOTE

See the Clocking chapter for details of metered and reference clocks used on this chip.

52.3.2 Reset

This module has the following reset sources.

- Global hard reset input
- Reset port synchronized to reference clock domain input
- Reset port synchronized to monitored clock domain input

52.4 Programming guidelines

52.4.1 Programming RCCR[REF_CNT]

RCCR[REF_CNT] defines the duration of the metering operation in number of *reference_clock* cycles. The minimum RCCR[REF_CNT] value can be calculated using the following formula:

$$\textbf{Minimum RCCR [REF_CNT]} = \text{CEILING value of MAX}\left(3 \text{ X } \left(\frac{f_{reference_clock}}{f_{bus_clock}}\right), 8 + 5 \text{ X } \left(\frac{f_{reference_clock}}{f_{monitored_clock}}\right)\right)$$

...where:

- $f_{reference_clock}$ is the frequency of the reference clock
- f_{bus_clock} is the frequency of the bus clock
- $f_{metering_clock}$ is the frequency of the metered clock

Example to determine RCCR[REF_CNT]:

- f_{bus_clock} = 16 MHz
- $f_{reference_clock}$ = 8 MHz
- $f_{metered_clock}$ = 48 MHz

Formula #1:

$$3 \text{ X } \left(\frac{f_{reference_clock}}{f_{bus_clock}} \right)$$

Inserting the values: 3 × (8 / 16) = 1.5

Formula #2:

$$8 + 5 \text{ X } \left(\frac{f_{reference_clock}}{f_{monitored_clock}} \right)$$

Inserting the values: 8 + 5 × (8 / 48) ≈ 8.83

MAX (1.5, 8.83): 8.83

CEILING value of MAX: 9

Therefore, minimum RCCR[REF_CNT]: 9

Programmed RCCR[REF_CNT] value must be greater than or equal to the calculated minimum value and should be decided after considering application requirements of frequency metering completion response time and overall accuracy required from CMU_FM.

- Higher values of RCCR[REF_CNT] results in longer metering window, leading to better accuracy in metered clock measurement.
- Lower values of RCCR[REF_CNT] results in shorter metering window, leading to faster FMC response, but higher inaccuracy in reported result.

52.4.2 Module programming sequence

The recommended programming sequence of CMU_FM is:

1. In any order, complete the following:
   - Program RCCR[REF_CNT] to define the frequency metering window duration in *reference_clock* cycles.
   - Program IER[FMCIE] to enable interrupt.
2. Write GCR[FME] = 1 to start frequency metering operation. Writes to RCCR and IER are disabled after GCR[FME] = 1. Attempting a write to any of them after GCR[FME] = 1 generates a bus transfer error.
3. To reconfigure RCCR and IER or to stop frequency metering operation, wait for SR[RS] = 1, then write GCR[FME] = 0.

Upon completion of metering operations:

- Hardware writes SR[FMC] = 1
- SR[MET_CNT] updates with metered count value
- Hardware writes GCR[FME] = 0

52.5 External signals

This module has no external signals.

52.6 CMU_FM register descriptions

52.6.1 CMU_FM memory map

This section describes the address order of all the CMU_FM registers. Each description includes a standard register diagram and associated field descriptions.

CMU_1 base address: 402B_C020h

CMU_2 base address: 402B_C040h

Offset	Register	Width (In bits)	Access	Reset value
0h	Global Configuration Register (GCR)	32	RW	0000_0000h
4h	Reference Count Configuration Register (RCCR)	32	RW	0000_0000h
8h	Status Register (SR)	32	RW	0000_0000h
Ch	Interrupt Enable Register (IER)	32	RW	0000_0000h

52.6.2 Global Configuration Register (GCR)

Offset

Register	Offset
GCR	0h

Function

Controls module level configurations such as enabling frequency metering.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															FME
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved
0 FME	Frequency Meter Enable Starts or stops frequency metering. FME is disabled by default. Software can enable FME at any time. To stop the ongoing operation, write 0 to FME only when SR[RS] = 1. FME automatically clears upon frequency metering completion or timeout event. 0b - Stops frequency metering 1b - Starts frequency metering

52.6.3 Reference Count Configuration Register (RCCR)

Offset

Register	Offset
RCCR	4h

Function

Programs reference count duration of the frequency meter window.

NOTE

Write to RCCR only when GCR[FME] = 0. A bus transfer error results if software writes RCCR when GCR[FME] = 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	REF_CNT															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
15-0 REF_CNT	Reference Clock Count Total number of counts of *reference_clock* for which frequency metering runs. This field defines the duration of one frequency metering window. See Programming RCCR[REF_CNT] for RCCR calculation.

52.6.4 Status Register (SR)

Offset

Register	Offset
SR	8h

Function
Provides the internal status of the module and metered clock count.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MET_CNT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MET_CNT								0			RS	Reserved		FMTO	FMC
W															W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 MET_CNT	Meter Clock Count This field stores the count value of the metered clock cycles when frequency metering operation is complete, in other words, SR[FMC] = 1. CMU_FM has a maximum deviation of ± 3 *metered_clock* cycles over the ideal *metered_clock* cycles expected by the user.
7-5 —	Reserved
4	Run Status

Table continues on the next page...

Table continued from the previous page...

Field	Function
RS	Shows the running status of module internal operation. After enabling the frequency metering operation (GCR[FME] = 1), there is a fixed delay before this field shows running status. If the system wants to disable the frequency metering operation, then the software should read this register and write GCR[FME] = 0 only when this field is 1. 0b - Frequency meter stopped 1b - Frequency meter running
3-2 —	Reserved
1 FMTO	Frequency Meter Time Out Sets if there is a loss of metered clock during the metering operation. After metering window, the module waits for a timeout duration of RCCR[REF_CNT] cycles before writing one to this field. GCR[FME] = 0 and SR[FMC] = 0 when FMTO = 1. Writing one clears this field.
0 FMC	Frequency Meter Operation Complete On completion of frequency metering operation, FMC = 1, SR[MET_CNT] field updates, and GCR[FME] clears. Writing one clears this field.

52.6.5 Interrupt Enable Register (IER)

Offset

Register	Offset
IER	Ch

Function

Enables CMU_FM interrupts.

NOTE

Write IER only when GCR[FME] = 0. A bus transfer error results if software writes IER when GCR[FME] = 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															FMCIE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved
0 FMCIE	Frequency Meter Complete Interrupt Enable This bit is used to enable/disable Frequency Meter complete interrupt at the module boundary. 0b - Frequency Meter complete interrupt is disabled 1b - Frequency Meter complete interrupt is enabled

Chapter 53
Cyclic Redundancy Check (CRC)

53.1 Chip specific CRC information

53.1.1 CRC configuration

This chip supports one instance of CRC module.

53.2 Overview

CRC generates 16-bit or 32-bit CRC codes output for error detection. You can calculate these codes for up to 32 bits input data at a time.

CRC provides a programmable polynomial and other parameters to meet 16-bit or 32-bit CRC standards.

53.2.1 Block diagram

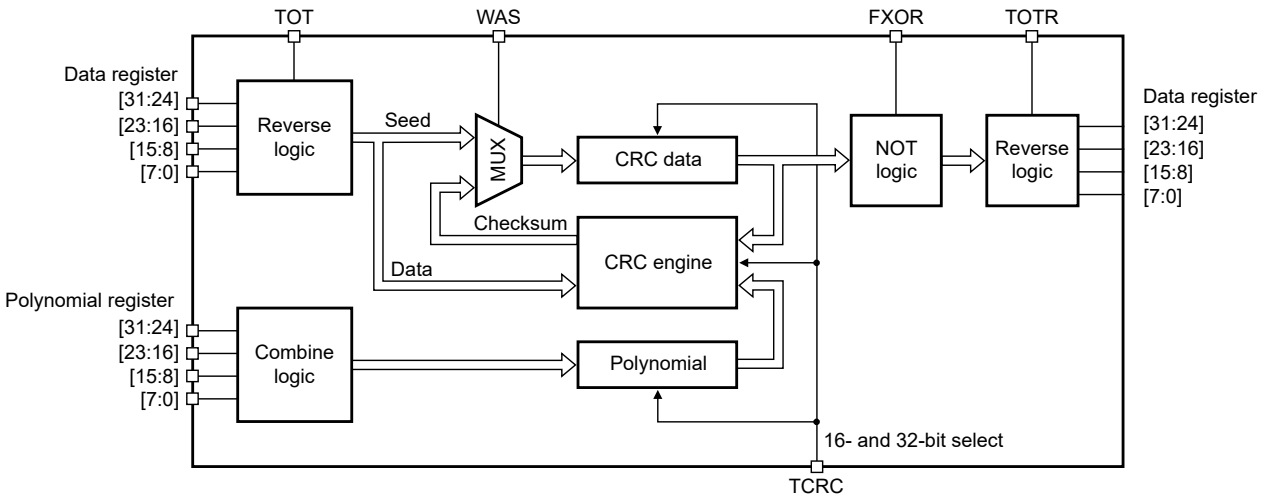


Figure 208. Block diagram

53.2.2 Features

CRC has the following features:

- Hardware CRC generator circuit using 16-bit or 32-bit programmable shift registers
- Programmable initial seed value and polynomial
- Transpose of input or output data (CRC result) in bitwise or bytewise (this option is required for certain CRC standards. You cannot perform a bytewise transpose operation when accessing DATA via 8-bit access.)
- Invert final CRC result
- 32-bit CPU register programming interface

53.3 Functional description

53.3.1 Modes of operation

The following sections describe various modes of operation that affect the functionality of CRC: Run mode and Low power mode.

53.3.1.1 Run mode

Run mode is the basic mode of operation.

53.3.1.2 Low power mode

When the chip enters the lower power mode, the CRC module clock (ipg_clk and ipg_clk_s) is disabled and the in-progress CRC calculation stops. The calculation resumes after the CRC module clock is enabled or the chip exits low power mode via system reset.

53.3.2 CRC calculations

In 16-bit and 32-bit CRC modes, you can program data values as 8 bits, 16 bits, or 32 bits at a time, provided all bytes are contiguous. Noncontiguous bytes lead to an incorrect CRC calculation.

53.3.2.1 Calculating a 16-bit CRC

Perform these steps to calculate a 16-bit CRC:

1. Write 0 to CTRL[TCRC] to enable 16-bit CRC mode.
2. Program the transpose and complement options in Control (CTRL) as required for the CRC calculation.
3. Write a 16-bit polynomial to GPOLY[LOW].

   GPOLY[HIGH] is not usable in 16-bit CRC mode.
4. Write 1 to CTRL[WAS] to program the seed value.
5. Write a 16-bit seed to DATA[LU] and DATA[LL].

   DATA[HU] and DATA[HL] are not used.
6. Write 0 to CTRL[WAS] to start writing data values.
7. Write data values into DATA[LU], and DATA[LL]

   CRC is calculated on every data value write and the intermediate CRC result is stored back into DATA[LU] and DATA[LL]
8. After writing all the data values, read the final CRC result from DATA[LU] and DATA[LL].

CRC is calculated bytewise and two clocks are required to complete one CRC calculation.

The transpose and complement operations are performed on-the-fly when reading or writing values. See Transpose feature and Result complement for details.

53.3.2.2 Calculating a 32-bit CRC

Perform these steps to calculate a 32-bit CRC:

1. Write 1 to CTRL[TCRC] to enable 32-bit CRC mode.
2. Program the transpose and complement options in Control (CTRL) as required for CRC calculation. See Transpose feature and Result complement for details.
3. Write a 32-bit polynomial to GPOLY[HIGH] and GPOLY[LOW] .
4. Write 1 to CTRL[WAS] to program the seed value.
5. Write a 32-bit seed to DATA[HU], DATA[HL], DATA[LU], and DATA[LL].

6. Write 0 to CTRL[WAS] to start writing data values.
7. Write data values into DATA[HU], DATA[HL], DATA[LU], and DATA[LL]

   CRC is computed on every data value write and the intermediate CRC result is stored back into DATA .
8. After writing all the values, read the final CRC result from DATA[HU], DATA[HL], DATA[LU], and DATA[LL].

   CRC is calculated bytewise and two clocks are required to complete one CRC calculation.

The transpose and complement operations are performed on-the-fly when reading or writing values. See Transpose feature and Result complement for details.

53.3.3 Transpose feature

Transpose is not enabled by default. However, CRC requires input data and/or final checksum to be transposed. You have an option to configure each transpose operation separately to meet CRC standards. The data is transposed on-the-fly while being read or written.

Some protocols use the little-endian format for data stream to calculateCRC. In this case, transpose flips bits.

53.3.3.1 Types of transpose

CRC provides several types of transpose to flip bits and/or bytes for both writing input data and reading result separately using the CTRL[TOT] and CTRL[TOTR] according to the CRC calculation being used.

The following types of transpose are available for writing to and reading from DATA.

1. CTRL[TOT] or CTRL[TOTR] is 0.

   No transposition occurs.
2. CTRL[TOT] or CTRL[TOTR] is 1.

   Bits in a byte are transposed when bytes are not transposed.

   reg[31:0] becomes {reg[24:31], reg[16:23], reg[8:15], reg[0:7]}.

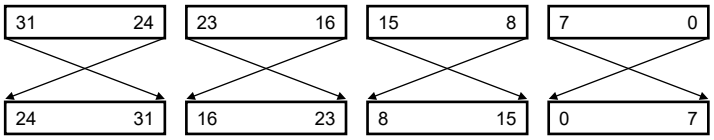


Figure 209. Transpose type 1b

3. CTRL[TOT] or CTRL[TOTR] is 10b.

   Both bits in bytes and bytes are transposed.

   reg[31:0] becomes {reg[0:7], reg[8:15], reg[16:23], reg[24:31]}.

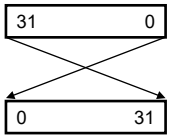


Figure 210. Transpose type 10b

4. CTRL[TOT] or CTRL[TOTR] is 11b.

   Bytes are transposed but bits are not transposed.

   reg[31:0] becomes {reg[7:0], reg[15:8], reg[23:16], reg[31:24]}.

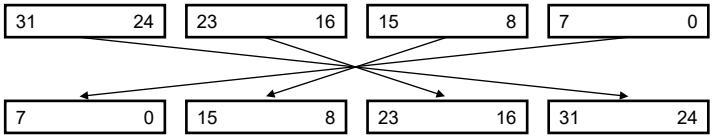


Figure 211. Transpose type 11b

NOTE

For 8-bit and 16-bit write accesses to Data (DATA), the data is transposed with 0s on the unused byte or bytes (taking 32 bits as a whole), but CRC is calculated on the valid byte(s) only. When reading the Data (DATA) for a 16-bit CRC result and using transpose options 10 and 11, the resulting value after transposition resides in DATA[HU] and DATA[HL]. You must account for this situation when reading the 16-bit CRC result, so reading 32 bits is preferred.

53.3.4 Result complement

When CTRL[FXOR] = 1, the checksum is complemented. The CRC result complement function outputs the complement of the checksum value stored in Data (DATA) every time Data (DATA) is read. When CTRL[FXOR] = 0,, reading Data (DATA) accesses the raw checksum value.

53.3.5 Clocking

Table 249. CRC clocks

Type of clock	Description
Bus clock (ipg_clk/ipg_clk_s)	ipg_clk_s controls the access to the CRC registers. ipg_clk and ipg_clk_s function the CRC module.

53.3.6 Interrupts

This module has no interrupts.

53.4 External signals

There is no CRC signal that connects off chip.

53.5 Initialization

To enable CRC calculation, you must program:

- CTRL[WAS] .
- Polynomial (GPOLY).
- Parameters for transposition and CRC result inversion in the applicable registers.

Writing 1 to CTRL[WAS] enables you to program the seed value into CRC Data registers.

After writing all the data, you must wait for at least two clock cycles to read the data from CRC Data (DATA) register.

After a CRC calculation completes, you can reinitialize the module for a new CRC computation by again writing 1 to CTRL[WAS] and programming a new, or previously used, seed value. You must set all other parameters before programming the seed value and subsequent data values.

53.6 Use cases

The following tables use the little-endian format.

53.6.1 CTRL programming

The following table shows Control (CTRL) programming for 16-bit CRC.

Table 250. CTRL programming for 16-bit CRC

Algorithm	Polynomial	Seed	Ref in	Ref out	XOR out	CTRL[TOT]	CTRL[TOTR]	CTRL[FXOR]
CRC-16_CCITT_FALSE	1021h	FFFFh	0	0	0000h	0h	0h	0h
CRC-16_ARC	8005h	0000h	1	1	0000h	1h	2h	0h
CRC-16_AUG_CCITT	1021h	1D0Fh	0	0	0000h	0h	0h	0h
CRC-16_BUYPASS	8005h	0000h	0	0	0000h	0h	0h	0h
CRC-16_CCITT_ZERO	1021h	0000h	0	0	0000h	0h	0h	0h
CRC-16_CDMA2000	C867h	FFFFh	0	0	0000h	0h	0h	0h
CRC-16_DDS_110	8005h	800Dh	0	0	0000h	0h	0h	0h
CRC-16_DECT_X	589h	0000h	0	0	0000h	0h	0h	0h
CRC-16_DNP	3D65h	0000h	1	1	FFFFh	1h	2h	1h
CRC-16_EN_13757	3D65h	0000h	0	0	FFFFh	0h	0h	1h
CRC-16_GENIBUS	1021h	FFFFh	0	0	FFFFh	0h	0h	1h
CRC-16_MAXIM	8005h	0000h	1	1	FFFFh	1h	2h	1h
CRC-16_MCRF4XX	1021h	FFFFh	1	1	0000h	1h	2h	0h
CRC-16_RIELLO	1021h	B2AAh	1	1	0000h	1h	2h	0h
CRC-16_T10_DIF	8BB7h	0000h	0	0	0000h	0h	0h	0h
CRC-16_TELEDISK	A097h	0000h	0	0	0000h	0h	0h	0h
CRC-16_TMS37157	1021h	89ECh	1	1	0000h	1h	2h	0h
CRC-16_USB	8005h	FFFFh	1	1	FFFFh	1h	2h	1h
CRC-16_A	1021h	C6C6h	1	1	0000h	1h	2h	0h
CRC-16_KERMIT	1021h	0000h	1	1	0000h	1h	2h	0h
CRC-16_MODBUS	8005h	FFFFh	1	1	0000h	1h	2h	0h
CRC-16_X_25	1021h	FFFFh	1	1	FFFFh	1h	2h	1h
CRC-16_XMODEM	1021h	0000h	0	0	0000h	0h	0h	0h

The following table shows Control (CTRL) programming for 32-bit CRC.

Table 251. CTRL programming for 32-bit CRC

Algorithm	Polynomial	Seed	Ref in	Ref out	XOR out	CTRL[TOT]	CTRL[TOTR]	CTRL[FXOR]
CRC-32	04C11DB7h	FFFFFFFFh	1	1	FFFF_FFFFh	1h	2h	1h
CRC-32_BZIP2	04C11DB7h	FFFFFFFFh	0	0	FFFF_FFFFh	0h	0h	1h
CRC-32C	1EDC6F41h	FFFFFFFFh	1	1	FFFF_FFFFh	1h	2h	1h

Table continues on the next page...

Table 251. CTRL programming for 32-bit CRC (continued)

Algorithm	Polynomial	Seed	Ref in	Ref out	XOR out	CTRL[TOT]	CTRL[TOTR]	CTRL[FXOR]
CRC-32D	A833982Bh	FFFFFFFFh	1	1	FFFF_FFFFh	1h	2h	1h
CRC-32_MPEG-2	04C11DB7h	FFFFFFFFh	0	0	0000_0000h	0h	0h	0h
CRC-32_POSIX	04C11DB7h	00000000h	0	0	FFFF_FFFFh	0h	0h	1h
CRC-32Q	814141ABh	00000000h	0	0	0000_0000h	0h	0h	0h
CRC-32_JAMCRC	04C11DB7h	FFFFFFFFh	1	1	0000_0000h	1h	2h	0h
CRC-32_XFER	000000AFh	00000000h	0	0	0000_0000h	0h	0h	0h

53.6.2 Expected read data fields

The following table shows the expected read data fields for 16-bit CRC.

Table 252. Expected read data fields for 16-bit CRC

Algorithm	Data (DATA)
CRC16_CCITT_FALSE	[31:16] = Unknown[15:0] = Valid data
CRC16_ARC	[31:16] = Valid data [15:0] = Unknown
CRC16_AUG_CCITT	[31:16] = Unknown [15:0] = Valid data
CRC16_BUYPASS	[31:16] = Unknown [15:0] = Valid data
CRC16_CCITT_ZERO	[31:16] = Unknown [15:0] = Valid data
CRC16_CDMA2000	[31:16] = Unknown [15:0] = Valid data
CRC16_DDS_110	[31:16] = Unknown [15:0] = Valid data
CRC16_DECT_X	[31:16] = Unknown [15:0] = Valid data
CRC16_DNP	[31:16] = Valid data [15:0] = Unknown
CRC-16_EN_13757	[31:16] = Unknown [15:0] = Valid data
CRC-16_GENIBUS	[31:16] = Unknown [15:0] = Valid data
CRC-16_MAXIM	[31:16] = Valid data [15:0] = Unknown
CRC-16_MCRF4XX	[31:16] = Valid data [15:0] = Unknown
CRC-16_RIELLO	[31:16] = Valid data [15:0] = Unknown
CRC-16_T10_DIF	[31:16] = Unknown [15:0] = Valid data
CRC-16_TELEDISK	[31:16] = Unknown [15:0] = Valid data
CRC-16_TMS37157	[31:16] = Valid data [15:0] = Unknown
CRC-16_USB	[31:16] = Valid data [15:0] = Unknown
CRC-16_A	[31:16] = Valid data [15:0] = Unknown
CRC-16_KERMIT	[31:16] = Valid data [15:0] = Unknown
CRC-16_MODBUS	[31:16] = Valid data [15:0] = Unknown

Table continues on the next page...

Table 252. Expected read data fields for 16-bit CRC (continued)

Algorithm	Data (DATA)
CRC-16_X_25	[31:16] = Valid data [15:0] = Unknown
CRC-16_XMODEM	[31:16] = Unknown [15:0] = Valid data

The following table shows the expected read data fields for 32-bit CRC.

Table 253. Expected read data fields for 32-bit CRC

Algorithm	Data (DATA)
CRC-32	[31:0] = Valid data
CRC-32_BZIP2	[31:0] = Valid data
CRC-32C	[31:0] = Valid data
CRC-32D	[31:0] = Valid data
CRC-32_MPEG-2	[31:0] = Valid data
CRC-32_POSIX	[31:0] = Valid data
CRC-32Q	[31:0] = Valid data
CRC-32_JAMCRC	[31:0] = Valid data
CRC-32_XFER	[31:0] = Valid data

53.7 Memory map and register descriptions

NOTE

You must reconfigure CRC engine in case an IPS transfer error occurs (ips_xfr_err).

The CRC module generates a transfer error in the following cases:

- Write accesses to the register addresses that are not mapped to the peripherals but included in the address spaces of the peripherals.

53.7.1 CRC register descriptions

53.7.1.1 CRC memory map

CRC base address: 4038_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Data (DATA)	32	RW	FFFF_FFFFh
4h	Polynomial (GPOLY)	32	RW	0000_1021h
8h	Control (CTRL)	32	RW	0000_0000h

53.7.1.2 Data (DATA)

Offset

Register	Offset
DATA	0h

Function

Configures the value of seed, data, and checksum. When CTRL[WAS] = 1, any write to this register is regarded as the seed value. When CTRL[WAS] becomes 0, any write to this register is regarded as data for general CRC calculation.

In 16-bit CRC mode, DATA[HU] and DATA[HL] are not used for programming the seed value, and reads of these fields return an indeterminate value. In 32-bit CRC mode, all fields are used for programming the seed value.

When programming data values, you can program to write 8 bits, 16 bits, or 32 bits in big endian order, provided all bytes are contiguous.

After writing all data values, you can read the CRC result from DATA register. In 16-bit CRC mode, the CRC result is available in DATA[LU] and DATA[LL]. In 32-bit CRC mode, all fields contain the result. After writing all data, you must wait for at least two clock cycles to read the data from CRC data (DATA) register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	HU								HL							
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	LU								LL							
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-24 HU	Upper Part of High Byte Generates CRC checksum in both 16-bit and 32-bit CRC modes if CTRL[WAS] = 0. • In 16-bit CRC mode (CTRL[TCRC] = 0), this field is not used for programming a seed value. • In 32-bit CRC mode (CTRL[TCRC] = 1), the values written to this field are part of the seed value when CTRL[WAS] = 1.
23-16 HL	Lower Part of High Byte Generates CRC checksum in both 16-bit and 32-bit CRC modes if CTRL[WAS] = 0. • In 16-bit CRC mode (CTRL[TCRC] = 0), this field is not used for programming a seed value.

Table continues on the next page...

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Field	Function
	• In 32-bit CRC mode (CTRL[TCRC] = 1), the values written to this field are part of the seed value when CTRL[WAS] = 1.
15-8 LU	Upper Part of Low Byte Generates CRC checksum when CTRL[WAS] = 0. When CTRL[WAS] = 1,the values written to this field are part of the seed value.
7-0 LL	Lower Part of Low Byte Generates CRC checksum when CTRL[WAS] = 0. When CTRL[WAS] = 0, the values written to this field are part of the seed value.

53.7.1.3 Polynomial (GPOLY)

Offset

Register	Offset
GPOLY	4h

Function

Configures polynomial value for CRC calculation.

- Sets the upper 16 bits of polynomial that are used only in 32-bit CRC mode. Writes to this field are ignored in 16-bit CRC mode.
- Sets the lower 16 bits of polynomial that are used in both 16-bit and 32-bit CRC modes.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	HIGH															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	LOW															
Reset	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1

Fields

Field	Function
31-16 HIGH	High Half-Word Writable and readable in 32-bit CRC mode (CTRL[TCRC] = 1). You cannot write to this field in 16-bit CRC mode (CTRL[TCRC] = 0).
15-0 LOW	Low Half-Word Writable and readable in both 16-bit and 32-bit CRC modes.

53.7.1.4 Control (CTRL)

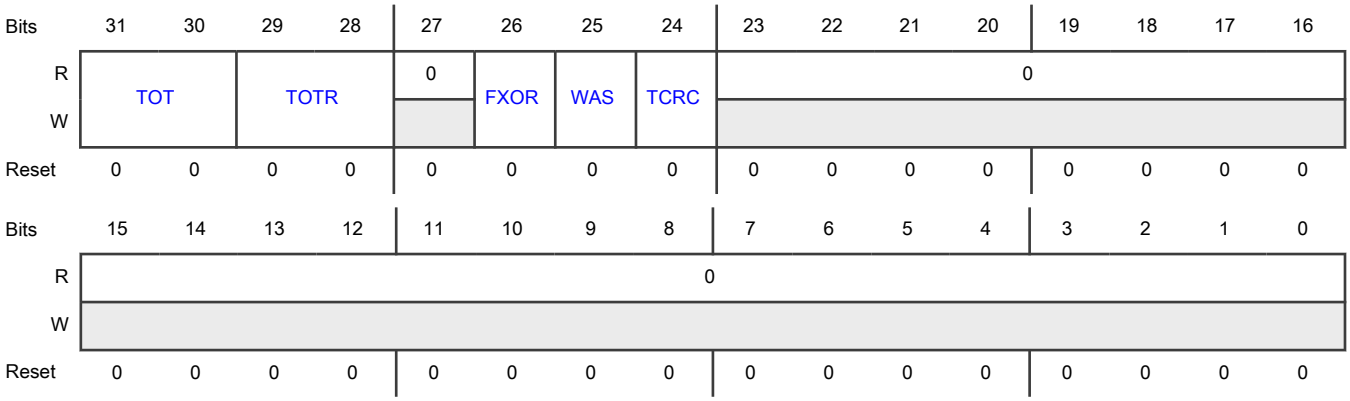
Offset

Register	Offset
CTRL	8h

Function

Sets control for CRC. You must write 1 to the appropriate fields of this register before starting a new CRC calculation, which you can initialize by writing 1 to CTRL[WAS] and then writing the seed into DATA.

Diagram



Fields

Field	Function
31-30 TOT	Transpose Type for Write Sets transpose type for the values written to DATA. See Transpose feature for the available transpose options. 00b - No transposition 01b - Bits in bytes are transposed, but bytes are not transposed.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	10b - Both bits in bytes and bytes are transposed. 11b - Only bytes are transposed, no bits in a byte are transposed.
29-28 TOTR	Transpose Type for Read Sets transpose type for the values read from DATA . See Transpose feature for the available transpose options. 00b - No transposition 01b - Bits in bytes are transposed, but bytes are not transposed. 10b - Both bits in bytes and bytes are transposed. 11b - Only bytes are transposed, no bits in a byte are transposed.
27 —	Reserved
26 FXOR	Complement Read of CRC Data Register Enables on-the-fly complementing of read data. Some CRC protocols require the final checksum to be XORed with FFFFFFFFh or FFFFh. 0b - Disables XOR on reading data. 1b - Inverts or complements the read value of the CRC Data.
25 WAS	Write as Seed Specifies whether writes to DATA are data values or seed values. When this field = 1, the value that you write to is considered as seed value. When this field = 0, the value that you write to is considered as data for CRC calculation. 0b - Data values 1b - Seed values
24 TCRC	TCRC Defines the width of CRC. 0b - 16 bits 1b - 32 bits
23-0 —	Reserved

53.8 Glossary

Transpose	Flipping input or output data bits (or bytes)
Seed value	Initial value of CRC calculation

Chapter 54
Power Conversion and Motor Control (PCMC)

54.1 Introduction

The PCMC subsystem is a group of modules that can be interconnected to perform a variety of real-time tasks, such as:

- Motor control
- Power conversion
- Advanced PWM generation

The modules that make up the PCMC subsystem are:

- SAR ADC
- BCTU
- eMIOS
- LCU
- LPCMP
- TRGMUX
- IGF
- eFlexPWM
- eTPU
- SDADC
- CoolFlux (DSPSS)

See Feature comparison for the number of instances of each module in your chip.

54.2 Block diagram and description of components

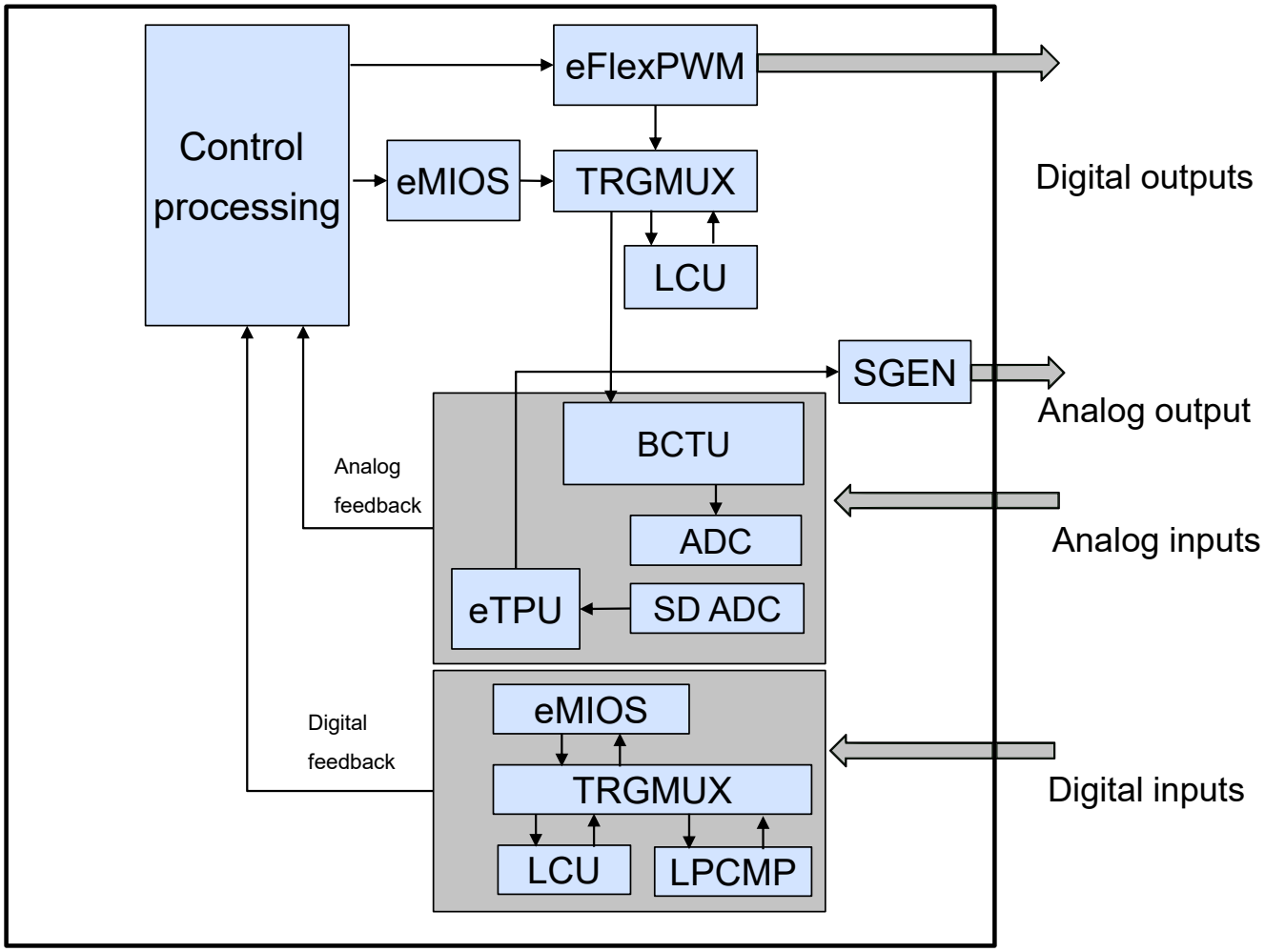


Figure 212. Block diagram

NOTE

Other blocks, such as eMIOS interacts with eTPU via TRGMUX.

Table 254. Block diagram components

Component	Description
ADC	Measures external analog signals
BCTU	Performs advanced ADC triggering
Control processing	The Arm Cortex-M7 core: • Processes digital and analog inputs to generate control outputs • Writes control outputs to peripherals
eMIOS	• Processes the digital feedback • Measures time-based digital inputs

Table continues on the next page...

Table 254. Block diagram components (continued)

Component	Description
LCU	Performs programmable logic functions and fault control
LPCMP	Compares analog values to detect faults
TRGMUX	• Routes signals between internal peripherals • Routes external signals to internal peripherals
GlitchFilter	Enables the filtering of eTPU channel inputs
eTPU	Is a coprocessor designed for timing control, capable of: • Resolver feedback processing • Generating Motor control PWM to drive 3 phs motor • Triggering and synchronization
SGEN	Generates a high-quality sinusoidal voltage signal
eFlexPWM	• Generates PWM signals in motor control applications with at least six channels enabled • Helps with digital power conversion application with at least eight channels enabled
SDADC	Decodes resolver signals and performs other tasks
CoolFlux (DSPSS)	Processes SDADC data output

54.3 Functional overview

54.3.1 Analog signal measurement

ADC measures the voltage of external analog signals and converts that voltage to a digital value. Each ADC instance operates independently of other instances. Either you or ADC can trigger conversions. Together with BCTU, eFlexPWM, and/or eMIOS, ADC can preempt normal measurements by injecting high-priority measurements when needed.

See the "Analog-to-Digital Converter" chapter for more information.

54.3.2 Advanced ADC triggering

BCTU works with ADC to initiate conversions that other modules trigger in the PCMC subsystem, such as PWM signals from eFlexPWM and eTPU or LCU sequential logic outputs.

With BCTU, you can group measurements into configuration lists containing up to 32 items. Each item contains information pertaining to the following:

- An ADC instance to use for the conversion
- The ADC channel
- The trigger event for initiating the next conversion
- The conversion list address

BCTU can store conversion results by routing them through eDMA or adding them to FIFO queues, which enable conversions to occur seamlessly by storing conversion results without your intervention.

BCTU_0 and BCTU_1 are instances of BCTU integrated in the S32K396 chip. The timer trigger configuration for both these instances is as follows:

- 0–22: eMIOS_0 (CH0–22)

- 23–30: eTPU_A (channels 0-7)
- 31–38: eTPU_B (channels 0-7)
- 39–41: TRGMUX_APP

BCTU can issue a single conversion or a list of conversions based on a single-trigger occurrence. BCTU signals the eMIOS timers when ADC receives a single command or a list of commands. Next, ADC sends conversion data back to BCTU, which loads the data in BCTU.ADC*n*DR for the CPU to read.

BCTU-to-ADC interface illustrates the connections between BCTU and an ADC. For more information, see:

- The "Body Cross-triggering Unit (BCTU)" chapter.
- The PCDR*n*, ICDR*n*, and ECDR*n* register descriptions in the "Analog-to-Digital Converter (ADC)" chapter.

54.3.3 BCTU-to-ADC interface

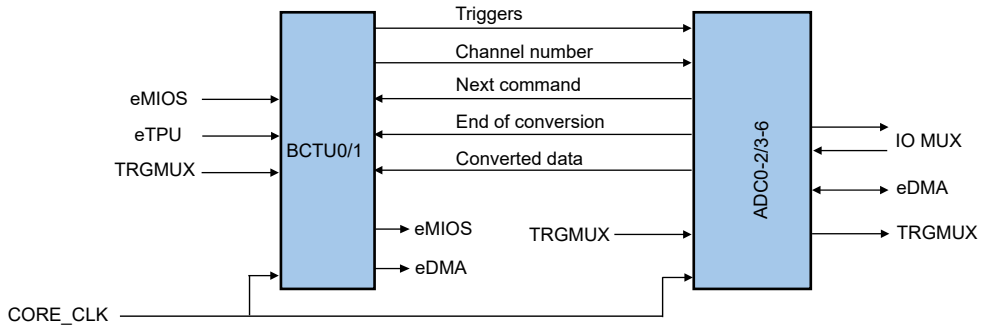


Figure 213. BCTU-to-ADC interface

54.3.4 Generate PWM outputs and measure digital inputs

The main periphery to generate PWM signals to drive motor, it is dedicated eFlexPWM. The second one to generate PWM outputs is eTPU. eMIOS is the third one.

eMIOS is the best fit for the digital inputs processing and measurement.

54.3.4.1 Generate PWM outputs

The enhance Flex Pulse Width Modulator (eFlexPWM) module can generate various switching patterns, including highly sophisticated waveforms. You can use it to control all known motor types and is ideal for controlling different Switched Mode Power Supply (SMPS) topologies as well. eFlexPWM contains PWM submodules (four per instance), each set up to control a single half-bridge, containing A and B channels primarily intended to generate complementary PWM outputs with independent hardware dead-time and one X auxiliary channel. eFlexPWM also provides fault channel support.

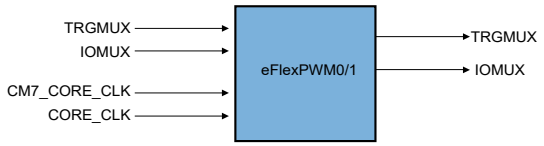


Figure 214. eFlexPWM connections

The enhanced Time Processing Unit is a programmable I/O controller with it's own core and memory system, allowing it to perform complex timing and I/O management independently on the CPU. It can generate various output patterns, process inputs and master low level timing. eTPU needs CPU to be loaded with binary and execute so called eTPU functions. Main functions to be executed for this device:

- SW Resolver

- Motor control PWM

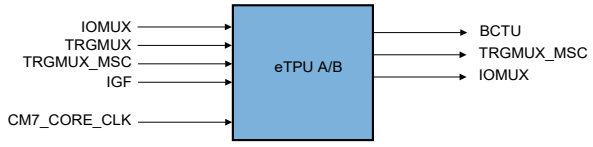


Figure 215. eTPU connections

eMIOS has 24 channels. You can configure each channel to operate in a different mode. Depending on the mode, eMIOS channels can:

- Measure the period of an input signal.
- Measure the width of an input pulse.
- Function as general-purpose I/O.
- Count pulses or edges.
- Capture input values.
- Compare outputs.

For example, eMIOS can generate periodic ADC triggers. Using TRGMUX, you can route eMIOS triggers to other on-chip peripherals, such as LCU, external chip I/O, and so on.

The image shown below illustrates the input and output connections for eMIOS. For more information, see the following chapters:

- Enhanced Modular IO Subsystem (eMIOS)
- Body Cross-triggering Unit (BCTU)
- Trigger MUX (TRGMUX)

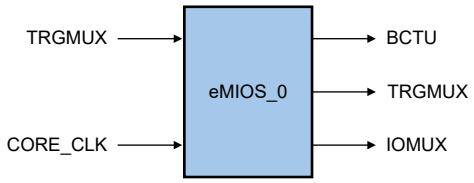


Figure 216. eMIOS connections

54.3.5 Combinatorial and sequential logic functions

You can use LCU to implement a variety of chip-based combinatorial and sequential logic functions with no CPU intervention, including a simple OR gate, flip-flops, and motor control logic. This capability reduces cost and decreases application size.

Each LCU instance includes 12 dedicated inputs and 12 outputs. As detailed in Fault detection, LCU also plays a significant role in fault management.

LCU connections shows the I/O connections for LCU. For more information, see:

- The "Logic Control Unit (LCU)" chapter
- LCU use case examples
- The "Trigger MUX (TRGMUX)" chapter

See the TRGMUX connectivity file attached to this document for more information.

54.3.6 LCU connections

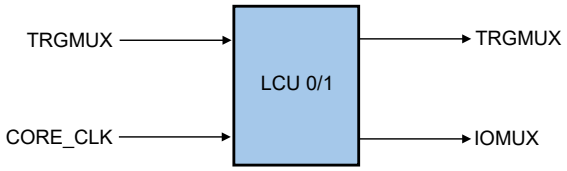


Figure 217. LCU connections

54.3.7 Fault detection

The PCMC subsystem uses LPCMP and LCU to implement fault detection.

LPCMP can detect fault conditions (such as short circuits, overvoltages, and excessive temperature) by comparing an external input voltage with a programmable reference voltage. It produces a digital output that indicates whether the input voltage is higher or lower than the reference voltage.

The chip can detect faults via external digital or analog signals. TRGMUX routes digital signals from SIUL to a peripheral to trigger the appropriate behavior.

LCU includes four force inputs that you can use to manage fault assertion via its own internal logic mechanism.

The typical reaction to the presence of fault is to put the system in a safe state by:

- De-asserting output signals such as PWM outputs controlling a power stage.
- Disconnecting an entire circuit by switching off a relay.

See the "Low Power Comparator (LPCMP)" chapter for more information.

54.3.8 Programmable module interconnections

TRGMUX enables you to interconnect on-chip peripherals to create application-specific configurations. For more information on TRGMUX and TRGMUX MSC configurations, see the S32K39_and_S32K37_TRGMUX_connectivity.xlsx attached to this document. TRGMUX enables the interconnection in hundreds of combinations using the software during runtime.

You can also route on-chip peripheral outputs to chip I/O pins to enable signal debugging. Similarly, you can route external signals to on-chip peripheral inputs.

NOTE

There is a two-cycle AIPS_SLOW_CLK delay through TRGMUX.

For more on PCMC interconnections, see PCMC connections diagram.

The following figure shows a portion of the S32K39_and_S32K37_TRGMUX_connectivity.xlsx, which specifies the possible interconnections between module instances. Column B in the spreadsheet lists TRGMUX inputs. Row 3 lists TRGMUX outputs. A connection between an input and an output is possible if the intersecting cell of the input row and the output column is blank. "NA" indicates that a connection is not possible.

	A	B	C	D	E	F
1		**Output no.**	**0**	**1**	**2**	**4**
2		**Output register no.**	**0**	**0**	**0**	**1**
3		**TRGMUX output**	ADC12_0_External trigger for normal conversion	ADC12_0_External trigger for injected conversion	ADC12_0_External trigger to sync the start pulses	ADC12_1_External trigger for normal conversion
4			yes	yes	yes	yes
6	**0**	LOGIC 0 (VSS)	NA	NA	NA	NA
7	**1**	LOGIC 1 (VDD)	NA	NA	NA	NA
8	**2**	Trigger_monitor_mux0 (disabled by default)				
9	**3**	Trigger_monitor_mux1 (disabled by default)				
10	**4**	Trigger_monitor_mux2 (disabled by default)				
11	**5**	SD_0_End of conversion (valid_data_available)				
12		SD_1_End of conversion (valid_data_available)				
13	**6**	SD_2_End of conversion (valid_data_available)				
14		SD_3_End of conversion (valid_data_available)				

Figure 218. Portion of TRGMUX connectivity

For more information, see:

- The "Trigger MUX (TRGMUX)" chapter.
- The S32K39_and_S32K37_TRGMUX_connectivity.xlsx attached to this document.

54.3.8.1 PCMC connections diagram

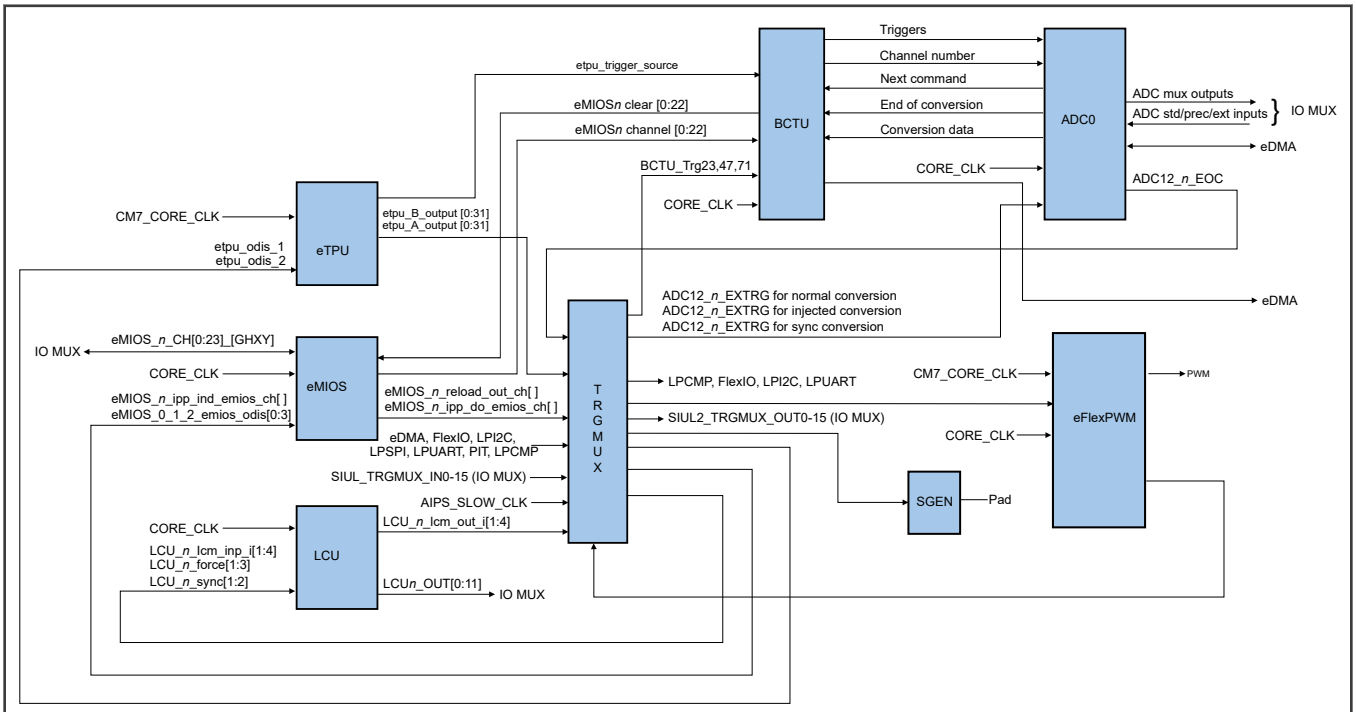


Figure 219. PCMC connections diagram

54.4 Reset, clocking, and other considerations

54.4.1 Reset

ADC, BCTU, eMIOS, LCU, TRGMUX, eFlexPWM, eTPU, SGEN, IGF, SDADC, LPCMP and DSPSS fully reset during a POR, destructive reset, or functional reset.

For more information, see:

- Module reset status
- Software reset

54.4.2 Clocking

See the following resources for detailed clocking information. To summarize:

- CORE_CLK clocks ADC, BCTU, eMIOS, and LCU.
- AIPS_SLOW_CLK clocks TRGMUX.
- In general, you must set AIPS_SLOW_CLK to one-fourth or one-half of the frequency of CORE_CLK.
- eTPU: CM7_CORE_CLOCK.
- eFlexPWM: CM7_CORE_CLK, CORE_CLOCK.
- DSPSS: CORE_CLK, CM7_CORE_CLK.
- SDADC,SGEN: AIPS_PLAT_CLK
- LPCMP: AIPS_SLOW_CLK

For more information, see:

- ADC and motor control modules
- System clocking configurations
- System clock frequency limitations
- Clock frequency

54.4.3 Power modes

All ADC, BCTU, eMIOS, LCU, TRGMUX, eTPU, eFlexPWM, SGEN, LPCMP, SDADC, IGF and DSPSS instances operate only in Run mode. None of the instances operate in Standby mode.

LPCMP operates in Standby mode.

For more information, see:

- Module reset status
- Modes of operation

54.5 Use case examples

54.5.1 Motor control use case

The following sections show:

- A PMSM control system.
- A BLDC control system.
- A EESM control system
- A ACIM control system

All listed machines, both PMSM and BLDC, EESM, and ACIM use a rotating magnetic stator field to turn the stator consisting of permanent magnets rotor flux. Rotor flux can be created by permanent magnets, excitation winding, or other constructions like a squirrel cage. Symmetrical three-phase AC voltage drives the stator. The difference between PMSM and BLDC is the way that the stator position is calculated:

- PMSM calculates the stator position by measuring feedback from motor sensors, typically resolver.

- PMSM calculates the stator position by measuring back EMF from the motor.
- BLDC calculates the stator position based on feedback from motor sensors.

EESM is a new type of machine used in the main traction drive use case. Traditionally used permanent magnets were replaced by a rotor winding with external excitation.

- EESM calculates the stator position by measuring feedback from motor sensors, typically resolver

ACIM also known as asynchronous induction machine is used in main traction drive use-case due to its robustness and manufacturing cost.

- ACIM calculates the stator position by measuring feedback from motor sensors, typically resolver.

54.5.1.1 PMSM motor control use case

54.5.1.1.1 Generic PMSM motor control

The following figure and table illustrate a generic PMSM motor control system. The feedback loops in the system create a motor control loop.

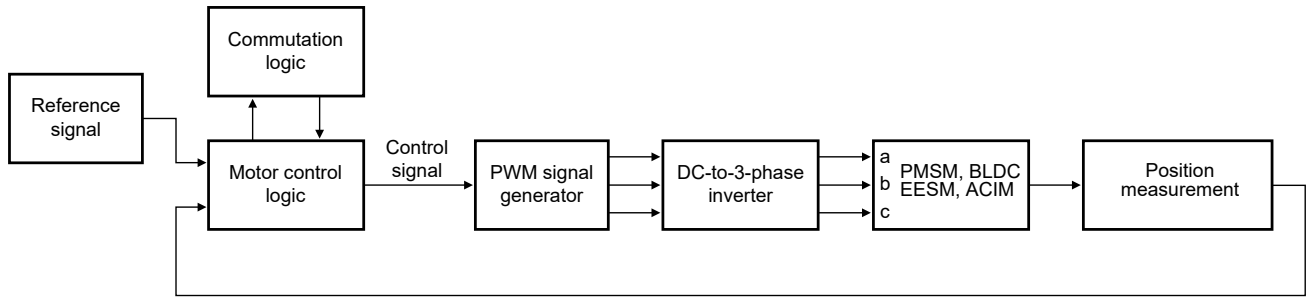


Figure 220. Generic motor control diagram

Table 255. Generic PMSM motor control: description of components

Component	Description
Angular position sensor	Generates data that enables commutation logic to calculate the rotor position.
PMSM,BLDC,EESM,ACIM	Represents an electric motor.
Commutation logic	Compares values from the rotor angular position sensors in the case of BLDC motor control to entries in a lookup table and applies voltage to the stator winding that corresponds to the same set of values in the lookup table.
DC-to-3-phase inverter	Helps in switching network that transmits power to the motor stator windings according to a control signal.
Motor control logic	• Compares speed measurement to the required speed and adjusts the PWM signal generator. • Generates assertions for the PWM signal generator according to the commutation logic input.
PWM signal generator	Generates the PWM signal voltage source.
Reference signal	Gives signal that indicates the required motor speed.
Position measurement	Gets linked as an ADC to a shunt resistor or resolver output signals to perform measurements and detect also overcurrent conditions. If one is found, the hardware generates a fault interrupt.

54.5.1.1.2 PMSM motor control

The PCMC subsystem consists of a group of modules that enables you to implement PMSM motor control loops in a variety of ways. The following figure and table illustrate a possible implementation.

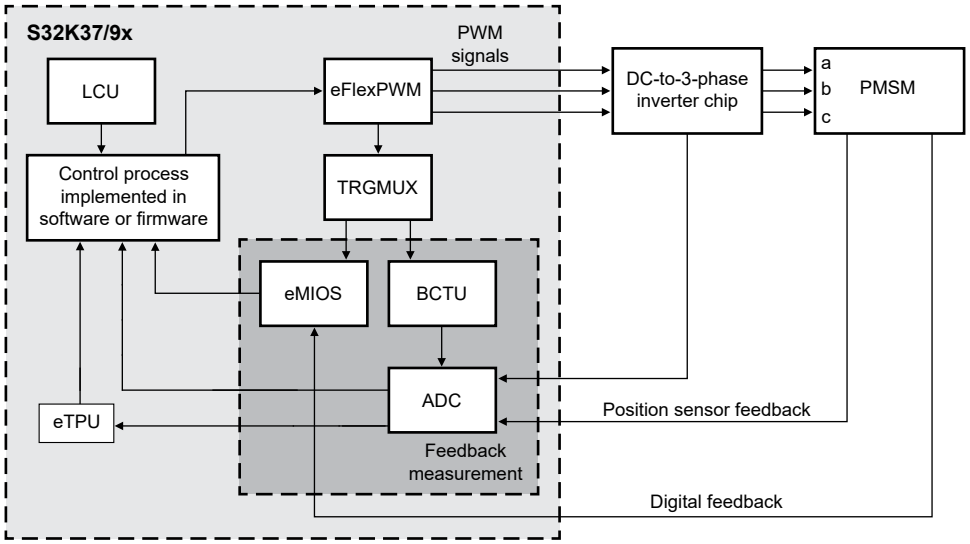


Figure 221. PMSM motor control diagram

Table 256. PMSM motor control: description of components

Component	Description
ADC	Measures analog inputs (currents and/or voltages) and converts them to digital values. Typically, ADC measures currents and can be configured to generate a fault interrupt when a measured input is outside a predefined acceptable range.
BCTU	Triggers conversions by ADC.
Control process	Provides top-level system control functions for FOC or another feasible control algorithm: • Compares speed measurement to the required speed and adjusts the PWM signal generator. • Generates assertions for the PWM signal generator according to the commutation logic input.
DC-to-3-phase inverter	Helps in switching network that transmits power to the motor stator windings according to a control signal.
eFlexPWM	Generates a PWM input for the DC-to-3-phase inverter.
eTPU	Is a coprocessor designed for timing control capable of: • Resolver feedback processing • Generating Motor control PWM to drive 3-phs motor • Triggering and synchronization
eMIOS	Measures digital feedback inputs, for example, BLDC position sensors.

Table continues on the next page...

Table 256. PMSM motor control: description of components (continued)

Component	Description
LCU	Implements the commutation lookup table. The control process compares values from the angular position sensors to entries in the lookup table. It then applies voltage to stator winding that corresponds to the same set of values in the lookup table.
TRGMUX	• Enables interconnect to the required set of on-chip peripherals. • Indirectly triggers ADC sampling via BCTU. • Triggers eMIOS to measure digital feedback signals.

54.5.1.2 Sensored BLDC motor control use case

54.5.1.2.1 Generic sensored BLDC motor control

The following figure and table illustrate a generic sensored BLDC motor control system. The feedback loops in the system create a motor control loop.

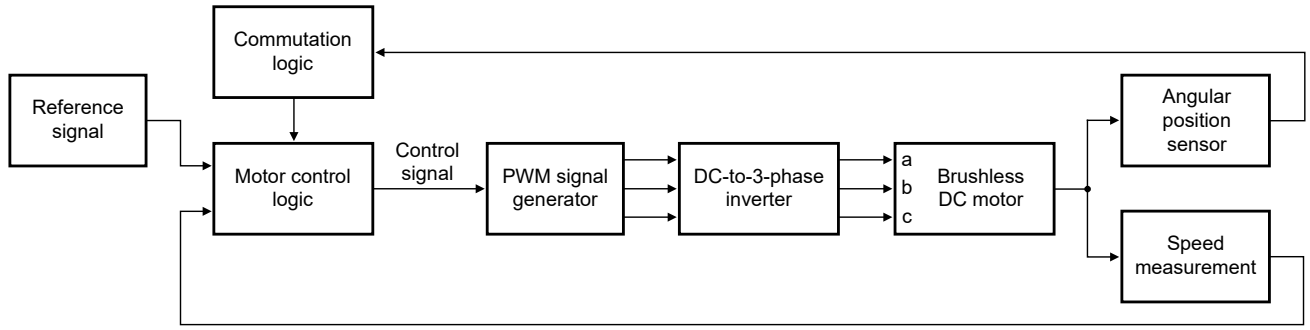


Figure 222. Generic sensored BLDC motor control: diagram

Table 257. Generic sensored BLDC motor control: description of components

Component	Description
Angular position sensor	Acts as a Hall effect sensor or an optical decoder to detect the rotor position.
Commutation logic	Compares values from the angular position sensors to entries in a lookup table and applies voltage to the stator winding that corresponds to the same set of values in the lookup table.
Reference signal	Sends a signal that indicates the required motor speed.
DC-to-3-phase inverter	Helps in switching network that transmits power to the stator windings according to a control signal.
Motor control logic	• Compares speed measurement to the required speed and adjusts the PWM signal generator. • Generates assertions for the PWM signal generator according to the commutation logic input.
Speed measurement	Uses an ADC linked to a shunt resistor to perform measurements and detect overcurrent conditions, in which case hardware generates an interrupt.

54.5.1.2.2 Three-phase FOC of the BLDC motor

FOC is a VFD control method in which the stator current of a three-phase AC electric motor (such as BLDC, PMCM, reluctance motor, or any other spinning electrical machine) is identified as a vector.

The PCMC subsystem consists of a group of modules that enables you to implement sensored FOC BLDC motor control loops in a variety of ways. The following figure and table show one of the possible implementations.

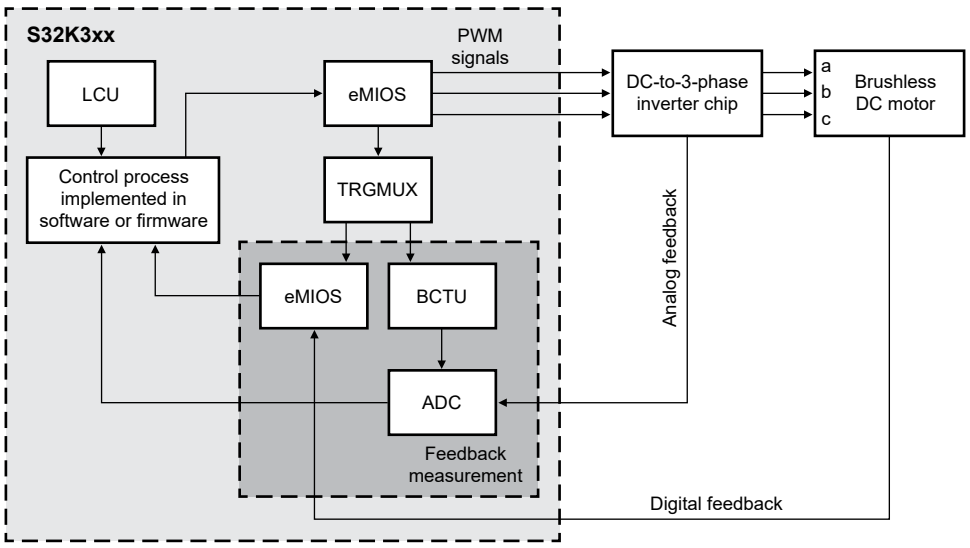


Figure 223. Three-phase FOC of the BLDC motor: diagram

Table 258. Three-phase FOC of the BLDC motor: description of components

Component	Description
ADC	Measures analog inputs (currents and/or voltages) and converts them to digital values. Typically, ADC measures currents and can be configured to generate a fault interrupt when a measured input is outside a predefined acceptable range.
BCTU	Triggers conversions by ADC.
Control process	Provides top-level system control functions for FOC control: • Compares speed measurement to the required speed and adjusts the PWM signal generator. • Generates assertions for the PWM signal generator according to the commutation logic input.
DC-to-3-phase inverter	Helps in switching network that transmits power to the motor stator windings according to a control signal.
eMIOS	• Generates PWM input for DC-to-3-phase inverter. • Measures digital feedback inputs, for example, BLDC position sensors.
LCU	Implements the commutation lookup table. The control process compares values from the angular position sensors to entries in the lookup table. It then applies voltage to the stator winding that corresponds to the same set of values in the lookup table.
TRGMUX	• Enables interconnect of the required set on on-chip peripherals.

Table continues on the next page...

Table 258. Three-phase FOC of the BLDC motor: description of components (continued)

Component	Description
	• Indirectly triggers ADC sampling via BCTU. • Triggers eMIOS to measure digital feedback signals.

54.6 ADC design considerations

The following topics discuss factors that affect the ADC function in applications.

54.6.1 Measurement accuracy

The FOC motor control algorithm requires a high degree of confidence in the reliability of conversion data. Here are some of the best practices that contribute to ADC precision:

- Use precision channels (see Precision channels).
- Minimize input noise (see Input noise).
- Use BCTU triggering (see Triggering).

54.6.1.1 Precision channels

See the chip-specific ADC configuration information for the number of precision channels in each ADC instance.

You can find the channel numbers for the precision channels in the channel mapping table.

54.6.1.2 Input noise

Regardless of the application, ADCs are inherently sensitive to input noise. The following best practices help minimize input noise:

- Avoid simultaneous conversions.
- Consider using a low-pass filter on input pins.

All variants of this chip include multiple, independent ADC instances. Therefore, it is possible to have simultaneous sampling by different ADC instances. However, you must avoid simultaneous sampling because ADC sampling can cause noise on adjacent device ADC inputs. This is an important consideration for implementation of the FOC algorithm.

Additionally, an RC low-pass filter on ADC input pins can help reduce noise and enhance accuracy.

54.6.1.3 Triggering

Some applications, including FOC motor control, must use BCTU for precise triggering of ADC measurement. This is because the FOC algorithm requires sampling at specific times to implement the observer or predictor. BCTU helps you perform precisely-timed ADC measurement.

For less exigent algorithms or nonclosed loop-controlled motors, BCTU triggering and precision ADC channels are not necessarily required.

54.6.2 Examples of ADC configurations

Following are some of the ADC configurations that you may use for FOC motor control.

Table 259. Examples of ADC configurations

Mode	Settings
Single-Shot	• ADC.MCR[OWREN] = 1

Table continues on the next page...

Table 259. Examples of ADC configurations (continued)

Mode	Settings
	• ADC.MCR[WLSIDE] = 0 • ADC.MCR[MODE] = 0 • ADC.MCR[TRGEN] = 0 • ADC.MCR[JTRGEN] = 0 • ADC.MCR[BCTUEN] = 0 • ADC.MCR[AVGEN] = 0 • ADC.MCR[ADCCLKSEL] = 01 (1/2 module clock)
Normal Conversion Scan	• ADC.MCR[OWREN] = 1 • ADC.MCR[WLSIDE] = 0 • ADC.MCR[MODE] = 1 • ADC.MCR[TRGEN] = 0 • ADC.MCR[JTRGEN] = 0 • ADC.MCR[BCTUEN] = 0 • ADC.MCR[AVGEN] = 0 • ADC.MCR[ADCCLKSEL] = 01 (1/2 module clock)
BCTU Control	• ADC.MCR[OWREN] = 1 • ADC.MCR[WLSIDE] = 0 • ADC.MCR[MODE] = 0 • ADC.MCR[TRGEN] = 0 • ADC.MCR[JTRGEN] = 0 • ADC.MCR[BCTUEN] = 1 • ADC.MCR[AVGEN] = 0 • ADC.MCR[ADCCLKSEL] = 01 (1/2 module clock)
BCTU Trigger	• ADC.MCR[OWREN] = 1 • ADC.MCR[WLSIDE] = 0 • ADC.MCR[MODE] = 0 • ADC.MCR[TRGEN] = 0 • ADC.MCR[JTRGEN] = 0 • ADC.MCR[BCTUEN] = 1 • ADC.MCR[BCTU_MODE] = 1 • ADC.MCR[AVGEN] = 0 • ADC.MCR[ADCCLKSEL] = 01 (1/2 module clock)

54.7 BCTU design considerations

For reasons discussed in Triggering, some applications require precise ADC triggering and BCTU provides that capability. The following topics discuss some of the BCTU design considerations.

54.7.1 BCTU or ADC data retrieval

The primary function of BCTU is to provide precisely timed triggers for ADC conversions. However, there is some overlap in BCTU and ADC functions and data for conversion can be retrieved from either of the modules. For applications in which frequent conversions are performed, such as real-time motor control, BCTU offers a distinct advantage over ADC. This is because BCTU trigger sources can be configured to route conversion results to a BCTU-internal FIFO. Doing so prevents subsequent conversion data from overwriting previous data, making it available for either direct access or DMA transfer to system RAM.

54.7.2 Disabling BCTU triggers

In some fault scenarios, you must disable BCTU triggers as part of placing the system into a safe state. Examples of these scenarios include:

- Overvoltage condition
- Undervoltage condition
- Calibration parameter mismatch between the embedded motor control system and motor

An application fault reaction design must include the disabling of BCTU triggers in scenarios wherein either system conditions indicate an impending failure or ADC conversion data is outside control boundaries.

54.8 Glossary

BLDC Brushless DC. An electronically-commutated DC motor.

CF Crest factor. A waveform parameter that is the ratio of peak values to its RMS value.

DF Distortion factor

DPF Displacement power factor. In power electronics, the phase relationship between voltage and current is $\cos(\theta_v - \theta_i)$, where θ_v is the phase of the voltage and θ_i is the phase of the current.

DVA Distortion volt-amperes

FF Form factor

FOC Field-oriented control

GM Gain margin

PF Power factor. In power electronics, it is the ratio of average power to RMS power.

PMSM Permanent magnet synchronous motor

THD Total harmonic distortion

VFD Variable-frequency drive

Chapter 55
Input Glitch Filter

55.1 Chip-specific Glitch Filter information

55.1.1 Glitchfilter configuration

The following table lists the Glitchfilter configuration.

Table 260. Glitchfilter configuration

Parameters	igf_0
NUM_FILTERS (number of channels supported)	32
FILTER_0_CNT_NUM_BITS	24 (Each channel has a 24-bit counter)
FILTER_0_PS_NUM_BITS	Channels 0 and 16 have prescalers and the prescalers are 10-bits

The IGF filter outputs are connected to the eTPU inputs.

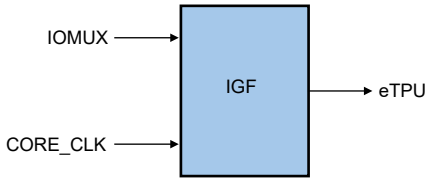


Figure 224. IGF connections

Table 261. IGF channel mapping

IGF channel	Destination
0	TCRCLK_A
1	eTPU A ch 0
2	eTPU A ch 1
3	eTPU A ch 2
4	eTPU A ch 3
5	eTPU A ch 4
6	eTPU A ch 5
7	eTPU A ch 6
8	eTPU A ch 7
9	eTPU A ch 16
10	eTPU A ch 17
11	eTPU A ch 18
12	eTPU A ch 19

Table continues on the next page...

Table 261. IGF channel mapping (continued)

13	eTPU A ch 20
14	eTPU A ch 21
15	eTPU A ch 22
16	TCRCLK_B
17	eTPU B ch 0
18	eTPU B ch 1
19	eTPU B ch 2
20	eTPU B ch 3
21	eTPU B ch 4
22	eTPU B ch 5
23	eTPU B ch 6
24	eTPU B ch 7
25	eTPU B ch 16
26	eTPU B ch 17
27	eTPU B ch 18
28	eTPU B ch 19
29	eTPU B ch 20
30	eTPU B ch 21
31	eTPU B ch 21

55.2 Overview

The Input Glitch Filter provides programmable glitch rejection filtering of digital input signals.

55.2.1 Block diagram

The figure below is the block diagram for the Input Glitch Filter module.

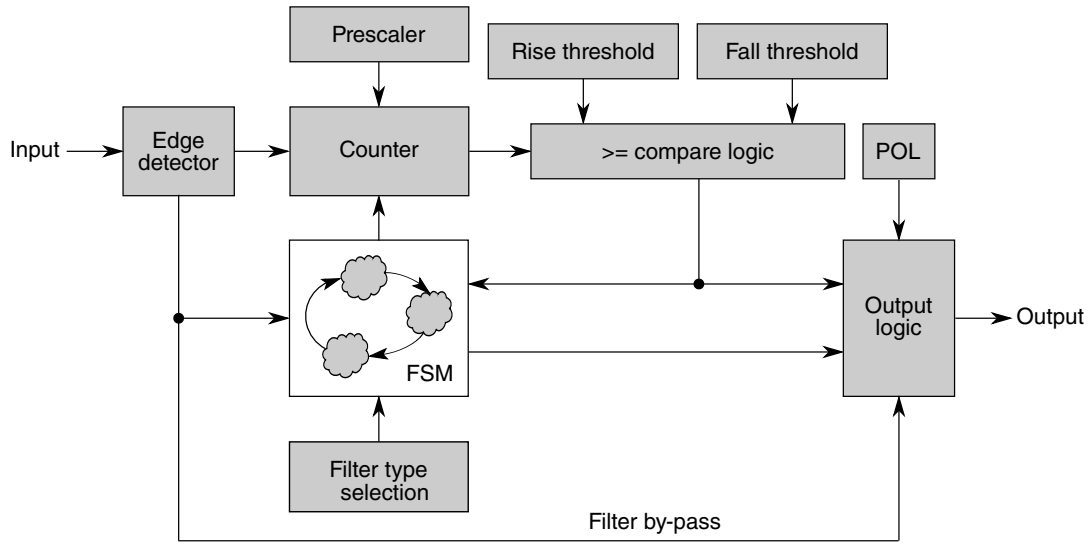


Figure 225. Input Glitch Filter block diagram

NOTE

Each filter counter needs of (rising edge threshold + 2) counts to achieve the rising threshold. Similarly, it needs (falling edge threshold + 2) counts to achieve the falling threshold. It is valid for all filters type that use the threshold values. The rate of these counts depends the prescaler settings and the system clock frequency.

55.2.2 Features

Input Glitch Filter includes the following features:

1. Supports several filtering modes on the input signal
2. Filter output polarity selection
3. Allows forcing filter outputs to defined values
4. Allows edge selection for different filtering modes
5. Supports prescaling
6. Supports debug on freeze
7. Supports low power mode of operation

55.3 Functional description

The Input Glitch Filter receives an input signal usually from a device PAD. Signals generated externally to the device are affected by environmental noise or glitches. The signal level has to be evaluated with some criteria in order to remove the noise which could affect the measurements done over this signal, such as transition time, period and level.

In a typical application, the Input Glitch Filter interfaces with one or more timer peripherals.

The strategy to remove glitches from an input signal is to monitor the level of the signal during a wide time window thus the glitches can be evaluated and removed.

55.3.1 Interaction with other peripherals

The figure below shows an example of how the Input Glitch Filter interacts with on-chip peripherals.

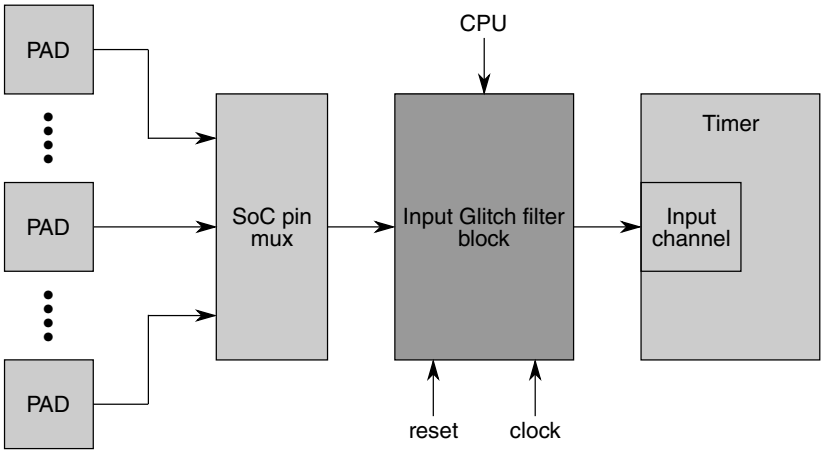


Figure 226. Input Glitch Filter application example

55.3.2 Input double sampling

The filter input is double sampled for clock domain translation thus avoiding asynchronous signals to propagate through the filter internal logic. This stage is composed by two flip-flops connected back to back. The delay caused by this logic is therefore two clock cycles.

Note that due to the synchronous nature of the Input Glitch Filter design, if a glitch smaller than one clock cycle occurs at the filter input it will not propagate to the filter internal logic and thus will not propagate to the filter output. Also, if clock is not applied to the filter (i.e. in low power mode) any transition at the filter input will not propagate to the filter output.

55.3.3 Filter types

The Input Glitch Filter implements four main filter types:

- Windowing
- Windowing with post sample
- Integrating
- Integrating hold

These filter types can be selected for the rising and falling edges independently, thus allowing different filter types to be selected for different edges (i.e. rising edge filtered with windowing filter and falling edge filtered with integrating).

55.3.3.1 Windowing filter

This filter type detects an edge (positive or negative edge) at the filter input and then mask out detection of subsequent edges over a period of time, which is defined as the blanking period, thus effectively behaving as a high pass filter. After an edge is detected the level at the filter input is propagated to the filter output within three clock cycles. The delay is caused by the synchronization stage at the input and by the filter output register stage. During the blanking period any transition at the filter input is disregarded. After the blanking period has elapsed, the filter compares the input level state with the filter output state. In case they are different a transition is inferred and re-evaluate according to the filter type assigned to that transition (positive or negative edges). Since, in this example, the windowing filter type is programed for both edges, the inferred negative edge is propagated to the filter output and another blanking period is initiated. The figure below describes the windowing filter type behavior.

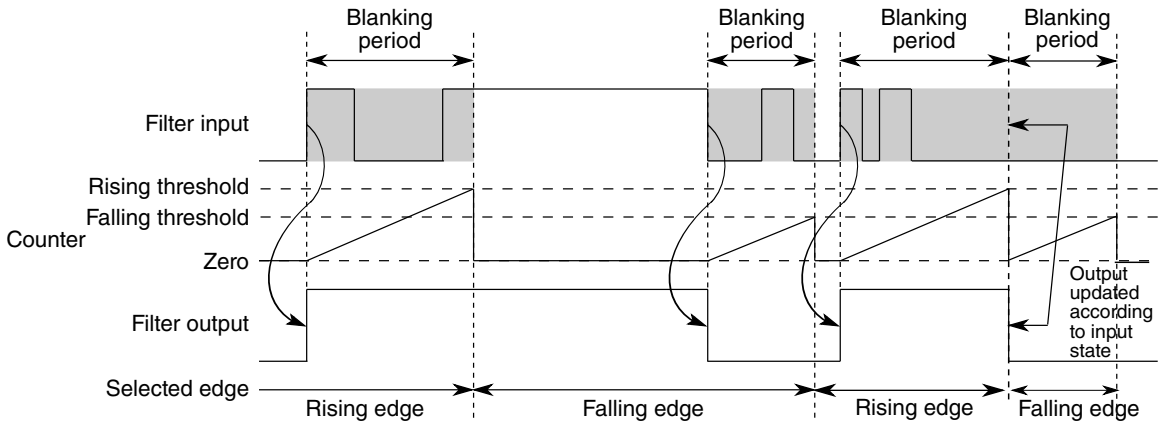


Figure 227. Windowing filter type

The windowing filter type is used when no delay is allowed in the detection of a signal transition. This filter also removes glitches that occurs after a transition is detected which could affect the correct capturing of the signal transition, i.e. by a Timer channel set to input capture.

In the figure above the blanking period starts when a rising edge is detected. The duration of this period is defined by the 'rising threshold ' value. If a falling edge is detected the ‘falling threshold’ value is used as the compare limits for the filter counter.

A transition that had occurred within a blanking period is delayed to the end of the blanking period. In this case it is not possible to determine the exact moment that transition occurred.

55.3.3.2 Windowing filter with post sample

This filter type detects an edge (positive or negative edge) at the filter input and then masks out detection of subsequent edges over a period of time, which is defined as the blanking period. During the blanking period, any transition at the filter input is disregarded.

When the blanking period finishes, the filter input level is propagated to the filter output. If the filter input is equal to the filter output when the blanking period finishes, then the filter output is not changed at the end of blanking period.

The figure below describes the windowing filter with post sample.

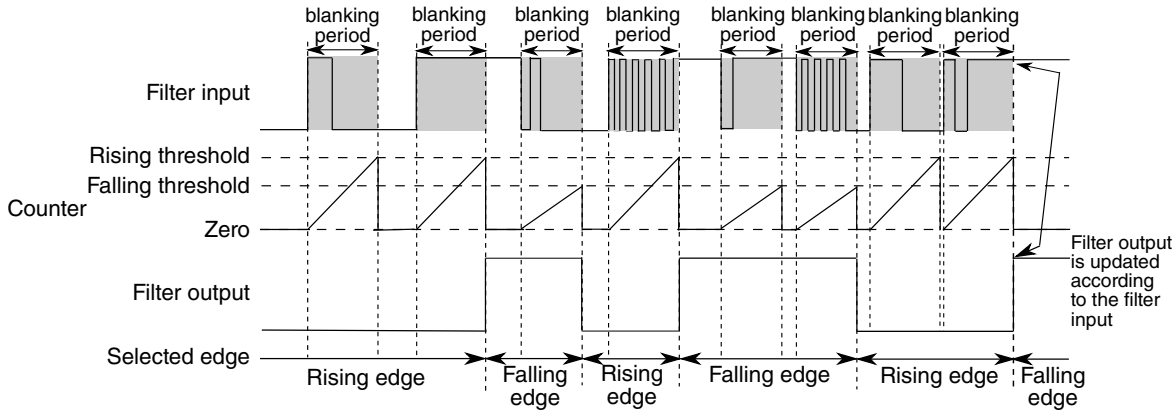


Figure 228. Windowing filter with post sample type

The windowing filter with post sample type is used to remove glitches and sparks around an edge.

55.3.3.3 Integrating filter

The integrating filter behaves like a low-pass filter, thus removing high frequency bursts from the input signal. The input and output signals are compared and if they are at different states an internal filter counter is enabled.

The direction of the counter (up or down counting) is defined by the states of the input and output filter signals as follows:

- Filter output is at the same state as the filter input: down-counting
- Filter output is at different state as the filter input: up-counting

The counter is compared with the rising or falling threshold register according to:

- Rising threshold register is selected if the rising edge is being filtered.
- Falling threshold register is selected if the falling edge is being filtered.

The filter output changes state to the same state as the filter input:

- If filter counter reaches the selected threshold for the edge being filtered.

The internal counter is disabled and cleared:

- If filter counter reaches the selected threshold for the edge being filtered.

The figure below describes an example of the Integrating filter type operation.

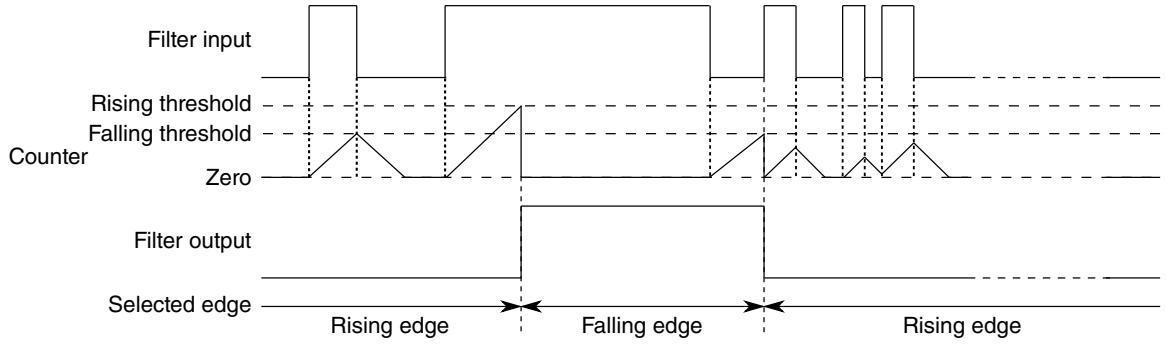


Figure 229. Integrating filter type

55.3.3.4 Integrating-hold filter

The integrating-hold filter type is similar to the integrating filter. The difference is the counter, which only counts in up direction instead of up-down in the integrating mode. In this filter configuration the input and output signals are compared and if they are at different states the filter counter is enabled. This counter is controlled by the state of the filter input and filter output signals as follows:

- Filter output is at the same state as the filter input: counter is in hold state (no-counting).
- Filter output is at different state as the filter input: counter is counting up.

The counter is compared with the rising or falling threshold register according to:

- Rising threshold register is selected if the rising edge is being filtered.
- Falling threshold register is selected if the falling edge is being filtered.

The filter output changes state to the same state as the filter input:

- If the filter counter reaches the selected threshold for the edge being filtered.

The internal counter is disabled and cleared:

- If the filter counter reaches the selected threshold for the edge being filtered.

The figure below shows an example of the Integrating-hold filter type operation.

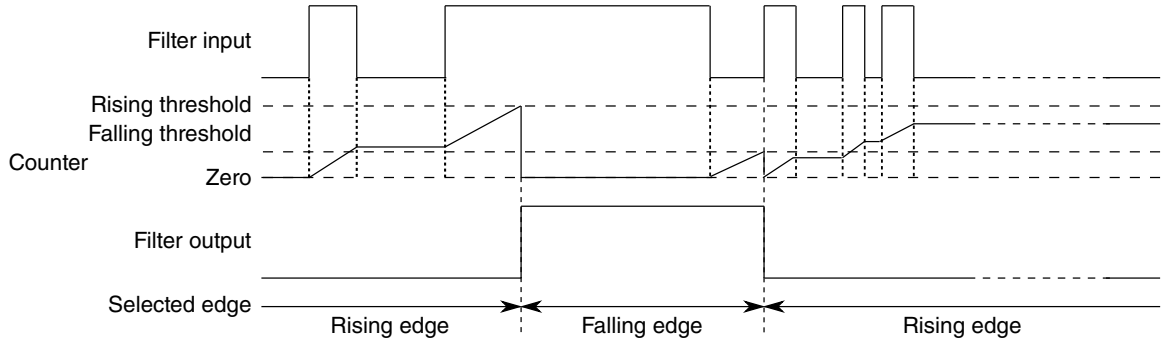


Figure 230. Integrating-hold filter type

55.3.3.5 Bypass filter

In the bypass filter type, the Input Glitch Filter immediately propagates any transition on the filter input to the filter output. This filter type does not provide any protection against glitches in the input signal. It is intended to be used in situations where the input signal is already filtered, or it is a glitch free signal, or the filter output is connected to a module that already has filtering capabilities. The bypass filter type is independently selected for rising or falling edges. Thus rising edges may be not filtered by the bypass filter type while the falling edges are filtered by any of the available filter types.

The bypass filter presents a delay in the edge propagation through the filter that is caused by the double sampling at the filter input and by the output filter register. Therefore, the total delay is three clock cycles.

55.3.3.6 Combined filter

The Input Glitch Filter allows the combination of filter types for different edges, positive and negative. As an example, the rising edges may be filtered using the windowing filter while the falling edges are filtered with an integrating filter. This configuration of the Input Glitch Filter is provided for situations where the noise present in the rising edges is different from the noise in the falling edges. Another use case is when the delay requirements of the input signal is different for rising and falling edges.

The figure below shows the combined filter operation. The windowing filter type is applied to the rising edges. The integrating filter is used for the falling edges.

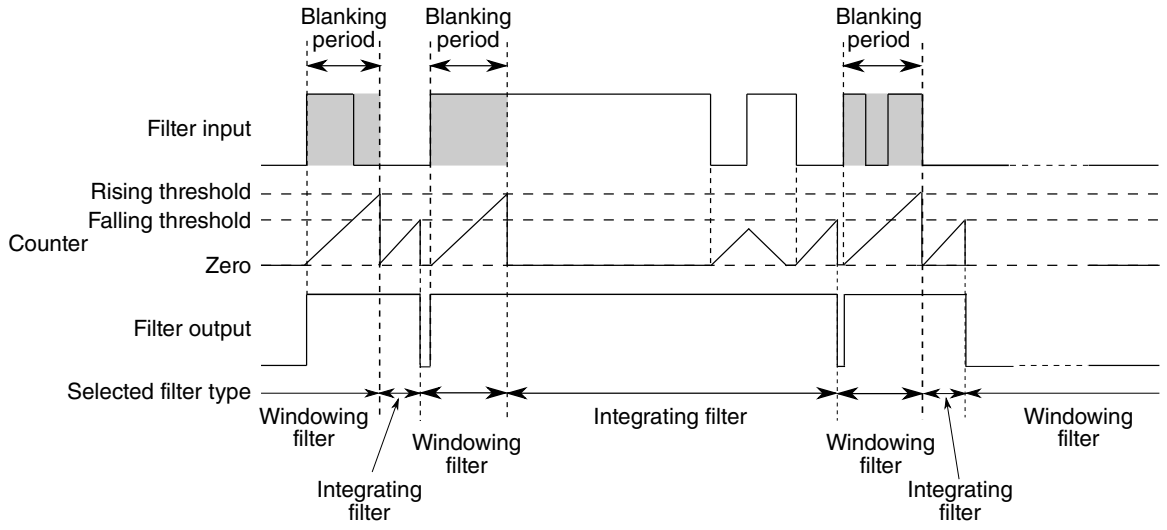


Figure 231. Combined filter type (windowing + integrating)

55.3.4 Mode of operation

The Input Glitch Filter has the following modes of operation:

- Configuration mode
- Normal mode
- Debug mode
- Low power mode

55.3.4.1 Configuration mode

The configuration mode is the initial mode of the Input Glitch filter after system reset is applied. The configuration mode is selected when FGEN = ‘0’ in the MCR register. The filter parameters such as rising and falling thresholds can be programmed when the filter is in configuration mode without disturbing the internal device logic since the filter output is kept at logic '0' state. Once FGEN is programmed with logic ‘1’ the filter enters the normal operating mode and is able to initiate the filtering process.

NOTE

The MDIS bit in the MCR register, if set to logic '1', makes the filter transition to low power mode independent of FGEN bit settings. Thus, in order to enter the configuration mode MDIS bit needs to be at logic '0'.

55.3.4.2 Normal mode

The normal mode of operation is entered when MCR register FGEN = ‘1’. In this mode the filter implements one of the filter types:

- Bypass filter
- Windowing filter
- Windowing filter with post-sample
- Integrating filter
- Integrating-hold filter

These filter types are described in the following sections. Before entering the normal mode, the filter parameters, such as rise and fall thresholds, need to be programmed in the appropriate registers, as well as the type needs to be defined in the corresponding register.

NOTE

In the normal mode it is still possible to change the filter parameters, such as rise and fall thresholds. See section On-the-fly filter reconfiguration for more details.

55.3.4.3 Debug mode

The debug mode is entered when the MCR FRZ bit is set and a system level debug request occurs. Once the debug mode is entered, the internal filter counter is halted and the debug functions controlled by the FBP, FOH, and FOL bits are enabled. The filter output is frozen and remains at the state it was immediately before the debug mode was entered. The FOH and FOL MCR bits can be used to force the filter output to logic '1' or '0', respectively. These bits are self-negating, thus they always read as zero.

By setting the MCR FBP bit, the filter input state is copied to the filter output, thus allowing to control the filter output based on the filter input state. The output is forced during one clock cycle. After that the filter output remains at the new forced state until it is changed again by using a debug control bit or if the filter returns to the normal mode of operation.

NOTE

The system level debug request occurs when a specific event, or a series of events, occurs in one of the device sub-modules and is interpreted by the device debug logic as a debug request. The Input Glitch Filter is not capable of generating an event that causes the assertion of the system level debug request.

55.3.4.4 Low power mode

The low power mode is controlled by the MDIS bit in the MCR register or by the STOP signal which is the system level low power control signal. When entering low power mode the filter output remains unchanged at the state it was just before the low power mode was entered. Since the Input Glitch Filter clocks are stopped in this mode, the internal counter remains inactive. The description of this mode is covered in the Low Power Mode section of this document.

55.3.5 Power saving mode

The Input Glitch Filter implements power saving mode thus allowing to reduce power consumption when device inputs connected to the filter are not used or the filter is not necessary to be functioning in a specific SoC mode of operation.

55.3.6 Clocking

This module has no clocking considerations.

55.3.7 Interrupts

This module has no interrupts.

55.4 External signals

This section describes the block's input/output signals.

Table 262. FlexSPI_FLR External Signals

Signal	Description	Direction
ipp_ind_gf_in	Input signal from device PAD	I

55.5 Initialization

The following generalized procedure may be used to configure the Input Glitch Filter Block:

1. Program the SoC pin mux logic to route an external signal to the input of the selected glitch filter.
2. Enable the destination module to receive the Input Glitch filter output.
3. Enable the clock source at the SoC level.
4. Program the Glitch Filter counter prescaler(s) to the desired rate.
5. Select the filter type for each edge using MCR[FFM] and MCR[RFM].
6. Clear any status bits if necessary.
7. Enable the filter using MCR[FGEN]

55.5.1 On-the-fly filter reconfiguration

The architecture of the Input Glitch Filter allows for on the fly reconfiguration of filter parameters such as rise and fall threshold values.

If a parameter is changed it influences the filter operation immediately after the new parameter value was written. The main problem when changing parameters, such as a threshold value, when the filter is enabled is that the filter counter could lose a match due to the parameter change. A great or equal comparator is used in the threshold match logic which allows correct filter operation when the threshold parameters are changed. The figure below shows an example of changing the rising edge parameter value. Note that in this case the match occurs immediately after the parameter is changed since the new parameter value is below the current counter value.

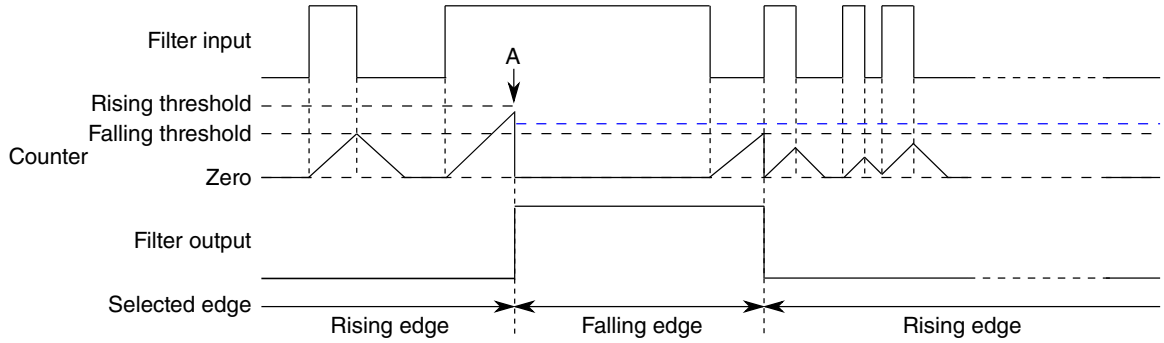


Figure 232. On-the-fly rising threshold parameter change

In the case shown in the figure above the match occurs immediately after the new rising threshold is programmed at 'A'.

NOTE

Note that when changing the threshold values the match may not occur when the counter is equal to the threshold value (the old or the new programmed value). Instead, the match may occur in between the old and new programmed thresholds when the threshold re-programming instant A is done when the counter is greater than the new value. This is a transitory effect which may occur when the threshold value is changed and should be considered by the application.

55.6 Application information

This section describes several applications for the Input Glitch filter module.

55.6.1 Application use case 1: integrating filter

The integrating filter type is particularly useful in applications where glitches occur spuriously while the signal is expected to be in a steady state (either 1 or 0). Choosing correct up and down filter clock rates can ensure that the effects of spurious glitches can be completely eliminated, whilst minimizing propagation delays.

The application must be able to tolerate delays between the actual edge occurrence and the time that the signal is propagated through the filter logic. Because the delays are constants defined by the detection thresholds, application software may compensate for them, provided little or no noise occurs on the detected edge.

55.6.2 Application use case 2: windowing filter

The windowing filter type is particularly useful for removing noise bounce produced by a switch or sensor when its signal changes state. In this case, there is no propagation delay (except for the filter input synchronization logic and output register) between the filter input and filter output signals. This type of filter would not necessarily provide much immunity to spurious noise that occurred during the steady state portion of the signal. In order to optimize the characteristics of this filter, the blanking period should be of the same magnitude as the expected input signal rate. Signals that change frequency can be accommodated by software by dynamically updating the blanking period.

55.6.3 Application use case 3: windowing filter

Safety applications may need to compare the inputs obtained from different input pins, but derived from a single external source. This form of redundancy may detect non-common mode faults that may occur in the portions of the SoC that route and process the incoming signal. Having two different instances of windowing filter used on each input pin will ensure that the signal edge timing for both input paths is equal. Applying different filter characteristics for each input path can enhance the ability to detect SoC fault conditions.

55.6.4 Application use case 4: combined filter

Some applications may have rising edge signals that exhibit different characteristics to falling edge signals which might require different filtering to optimize the filtering effect. For example the “first” rising edge may represent a true real time event with a fast slew rate that must be captured without delay, while the falling edge signal may have a slow slew rate with many noisy transitions. The Input Glitch Filter can apply, for example, a windowing filter on the rising edge to ensure no loss of real time information and an integrating filter on the falling edge to eliminate noise from being detected as a new rising transition.

55.6.5 Application use case 5: prescaler settings in windowing filter

The prescaler settings influence the timing for an edge to propagate through the filter. In windowing filter the IMM bit in the MCR register controls the way an edge is propagated through the filter. The figure below describes the windowing filter operation with regard to the IMM bit settings.

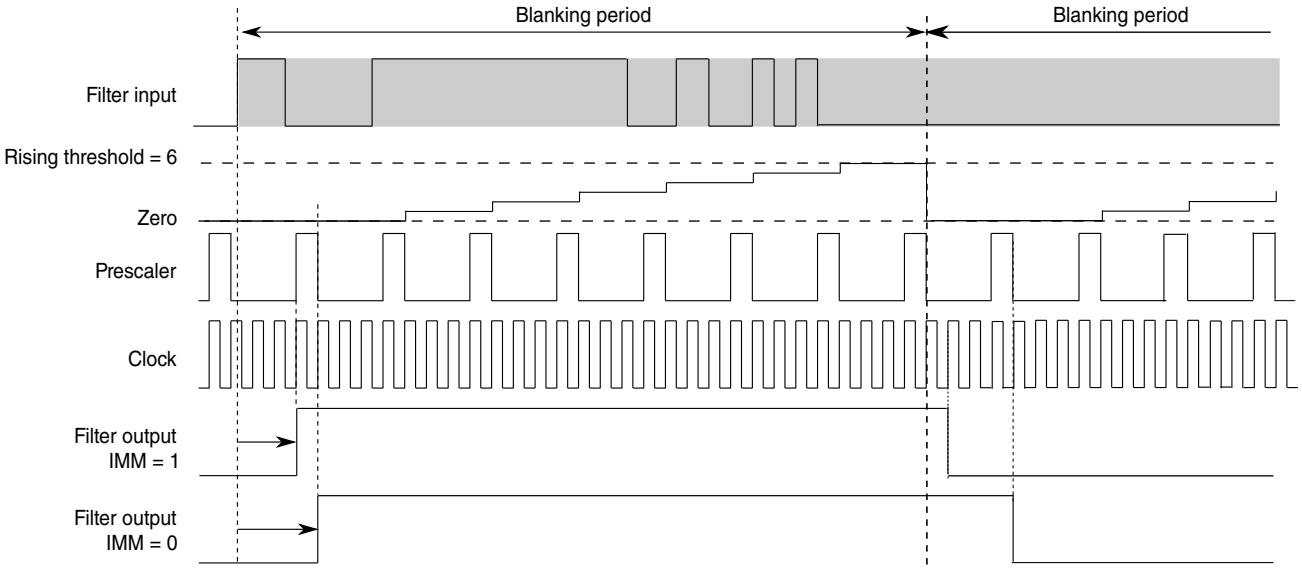


Figure 233. Input signal propagation through the filter in windowing filter type

If IMM = 0 then the input signal edges are propagated according to the prescaler ticks. If IMM = 1 then the input edges are propagated immediately (within 3 clock cycles) to the filter output.

55.6.6 Application use case 6: prescaler settings in bypass

The prescaler settings settings of the external prescaler influence the timing for an input signal edge to propagate through the filter. In bypass, the IMM bit in the MCR register controls the way an edge is propagated through the filter. If IMM= 0, the prescaled clock is used to sample the input filter signal. The resolution the input signal is sampled is therefore related to the prescaler frequency. Glitches narrower than the prescaler period that are not aligned with the prescaler clock are not captured by the filter. If IMM = 1, the system clock is used to sample the filter input signal instead of the prescaled clock. In this case, the resolution of the sampled input signal is the system clock.

The figure below describes the filter input signal sampling behavior for IMM = 0 and IMM = 1.

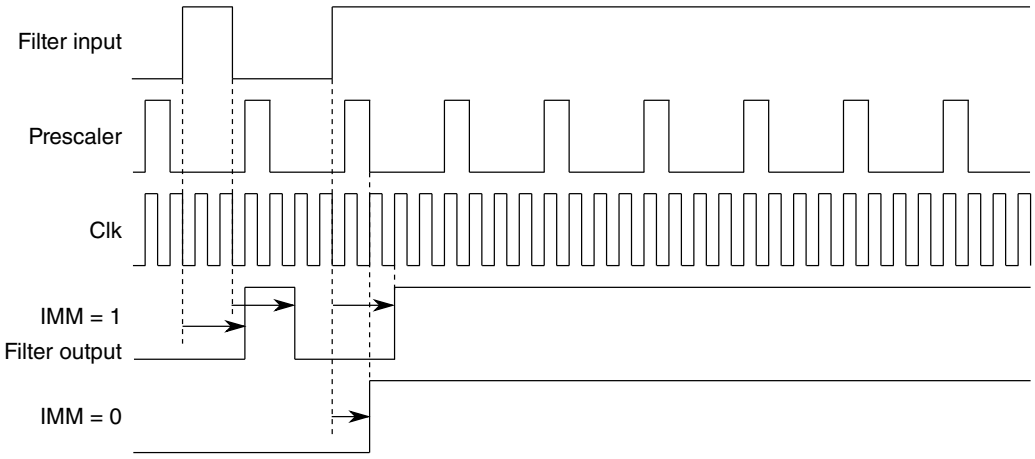


Figure 234. Input signal propagation through the filter in bypass

55.7 IGF register descriptions

The Input Glitch Filter registers are implemented in 32-bit. 8-bit write operations are allowed. The coherency in case of 8-bit access must be provided by the application software since there is no coherence mechanism built into the hardware.

NOTE

RESERVED bit registers, when available for write operations, should be written always with logic '0'. Read access does not return meaningful data from RESERVED bit registers.

55.7.1 IGF memory map

IGF base address: 406B_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration Register (MCR0)	32	RW	0000_0000h
4h	Module Status Register (MSR0)	32	RW	0000_0000h
10h	Prescaler Register (PRESR0)	32	RW	0000_0000h
1Ch	Rising edge Threshold Register (RTHR0)	32	RW	0000_0000h
20h	Falling edge Threshold Register (FTHR0)	32	RW	0000_0000h
40h	Module Configuration Register (MCR1)	32	RW	0000_0000h
44h	Module Status Register (MSR1)	32	RW	0000_0000h
5Ch	Rising edge Threshold Register (RTHR1)	32	RW	0000_0000h
60h	Falling edge Threshold Register (FTHR1)	32	RW	0000_0000h
80h	Module Configuration Register (MCR2)	32	RW	0000_0000h
84h	Module Status Register (MSR2)	32	RW	0000_0000h
9Ch	Rising edge Threshold Register (RTHR2)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
A0h	Falling edge Threshold Register (FTHR2)	32	RW	0000_0000h
C0h	Module Configuration Register (MCR3)	32	RW	0000_0000h
C4h	Module Status Register (MSR3)	32	RW	0000_0000h
DCh	Rising edge Threshold Register (RTHR3)	32	RW	0000_0000h
E0h	Falling edge Threshold Register (FTHR3)	32	RW	0000_0000h
100h	Module Configuration Register (MCR4)	32	RW	0000_0000h
104h	Module Status Register (MSR4)	32	RW	0000_0000h
11Ch	Rising edge Threshold Register (RTHR4)	32	RW	0000_0000h
120h	Falling edge Threshold Register (FTHR4)	32	RW	0000_0000h
140h	Module Configuration Register (MCR5)	32	RW	0000_0000h
144h	Module Status Register (MSR5)	32	RW	0000_0000h
15Ch	Rising edge Threshold Register (RTHR5)	32	RW	0000_0000h
160h	Falling edge Threshold Register (FTHR5)	32	RW	0000_0000h
180h	Module Configuration Register (MCR6)	32	RW	0000_0000h
184h	Module Status Register (MSR6)	32	RW	0000_0000h
19Ch	Rising edge Threshold Register (RTHR6)	32	RW	0000_0000h
1A0h	Falling edge Threshold Register (FTHR6)	32	RW	0000_0000h
1C0h	Module Configuration Register (MCR7)	32	RW	0000_0000h
1C4h	Module Status Register (MSR7)	32	RW	0000_0000h
1DCh	Rising edge Threshold Register (RTHR7)	32	RW	0000_0000h
1E0h	Falling edge Threshold Register (FTHR7)	32	RW	0000_0000h
200h	Module Configuration Register (MCR8)	32	RW	0000_0000h
204h	Module Status Register (MSR8)	32	RW	0000_0000h
21Ch	Rising edge Threshold Register (RTHR8)	32	RW	0000_0000h
220h	Falling edge Threshold Register (FTHR8)	32	RW	0000_0000h
240h	Module Configuration Register (MCR9)	32	RW	0000_0000h
244h	Module Status Register (MSR9)	32	RW	0000_0000h
25Ch	Rising edge Threshold Register (RTHR9)	32	RW	0000_0000h
260h	Falling edge Threshold Register (FTHR9)	32	RW	0000_0000h
280h	Module Configuration Register (MCR10)	32	RW	0000_0000h
284h	Module Status Register (MSR10)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
29Ch	Rising edge Threshold Register (RTHR10)	32	RW	0000_0000h
2A0h	Falling edge Threshold Register (FTHR10)	32	RW	0000_0000h
2C0h	Module Configuration Register (MCR11)	32	RW	0000_0000h
2C4h	Module Status Register (MSR11)	32	RW	0000_0000h
2DCh	Rising edge Threshold Register (RTHR11)	32	RW	0000_0000h
2E0h	Falling edge Threshold Register (FTHR11)	32	RW	0000_0000h
300h	Module Configuration Register (MCR12)	32	RW	0000_0000h
304h	Module Status Register (MSR12)	32	RW	0000_0000h
31Ch	Rising edge Threshold Register (RTHR12)	32	RW	0000_0000h
320h	Falling edge Threshold Register (FTHR12)	32	RW	0000_0000h
340h	Module Configuration Register (MCR13)	32	RW	0000_0000h
344h	Module Status Register (MSR13)	32	RW	0000_0000h
35Ch	Rising edge Threshold Register (RTHR13)	32	RW	0000_0000h
360h	Falling edge Threshold Register (FTHR13)	32	RW	0000_0000h
380h	Module Configuration Register (MCR14)	32	RW	0000_0000h
384h	Module Status Register (MSR14)	32	RW	0000_0000h
39Ch	Rising edge Threshold Register (RTHR14)	32	RW	0000_0000h
3A0h	Falling edge Threshold Register (FTHR14)	32	RW	0000_0000h
3C0h	Module Configuration Register (MCR15)	32	RW	0000_0000h
3C4h	Module Status Register (MSR15)	32	RW	0000_0000h
3DCh	Rising edge Threshold Register (RTHR15)	32	RW	0000_0000h
3E0h	Falling edge Threshold Register (FTHR15)	32	RW	0000_0000h
400h	Module Configuration Register (MCR16)	32	RW	0000_0000h
404h	Module Status Register (MSR16)	32	RW	0000_0000h
410h	Prescaler Register (PRESR16)	32	RW	0000_0000h
41Ch	Rising edge Threshold Register (RTHR16)	32	RW	0000_0000h
420h	Falling edge Threshold Register (FTHR16)	32	RW	0000_0000h
440h	Module Configuration Register (MCR17)	32	RW	0000_0000h
444h	Module Status Register (MSR17)	32	RW	0000_0000h
45Ch	Rising edge Threshold Register (RTHR17)	32	RW	0000_0000h
460h	Falling edge Threshold Register (FTHR17)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
480h	Module Configuration Register (MCR18)	32	RW	0000_0000h
484h	Module Status Register (MSR18)	32	RW	0000_0000h
49Ch	Rising edge Threshold Register (RTHR18)	32	RW	0000_0000h
4A0h	Falling edge Threshold Register (FTHR18)	32	RW	0000_0000h
4C0h	Module Configuration Register (MCR19)	32	RW	0000_0000h
4C4h	Module Status Register (MSR19)	32	RW	0000_0000h
4DCh	Rising edge Threshold Register (RTHR19)	32	RW	0000_0000h
4E0h	Falling edge Threshold Register (FTHR19)	32	RW	0000_0000h
500h	Module Configuration Register (MCR20)	32	RW	0000_0000h
504h	Module Status Register (MSR20)	32	RW	0000_0000h
51Ch	Rising edge Threshold Register (RTHR20)	32	RW	0000_0000h
520h	Falling edge Threshold Register (FTHR20)	32	RW	0000_0000h
540h	Module Configuration Register (MCR21)	32	RW	0000_0000h
544h	Module Status Register (MSR21)	32	RW	0000_0000h
55Ch	Rising edge Threshold Register (RTHR21)	32	RW	0000_0000h
560h	Falling edge Threshold Register (FTHR21)	32	RW	0000_0000h
580h	Module Configuration Register (MCR22)	32	RW	0000_0000h
584h	Module Status Register (MSR22)	32	RW	0000_0000h
59Ch	Rising edge Threshold Register (RTHR22)	32	RW	0000_0000h
5A0h	Falling edge Threshold Register (FTHR22)	32	RW	0000_0000h
5C0h	Module Configuration Register (MCR23)	32	RW	0000_0000h
5C4h	Module Status Register (MSR23)	32	RW	0000_0000h
5DCh	Rising edge Threshold Register (RTHR23)	32	RW	0000_0000h
5E0h	Falling edge Threshold Register (FTHR23)	32	RW	0000_0000h
600h	Module Configuration Register (MCR24)	32	RW	0000_0000h
604h	Module Status Register (MSR24)	32	RW	0000_0000h
61Ch	Rising edge Threshold Register (RTHR24)	32	RW	0000_0000h
620h	Falling edge Threshold Register (FTHR24)	32	RW	0000_0000h
640h	Module Configuration Register (MCR25)	32	RW	0000_0000h
644h	Module Status Register (MSR25)	32	RW	0000_0000h
65Ch	Rising edge Threshold Register (RTHR25)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
660h	Falling edge Threshold Register (FTHR25)	32	RW	0000_0000h
680h	Module Configuration Register (MCR26)	32	RW	0000_0000h
684h	Module Status Register (MSR26)	32	RW	0000_0000h
69Ch	Rising edge Threshold Register (RTHR26)	32	RW	0000_0000h
6A0h	Falling edge Threshold Register (FTHR26)	32	RW	0000_0000h
6C0h	Module Configuration Register (MCR27)	32	RW	0000_0000h
6C4h	Module Status Register (MSR27)	32	RW	0000_0000h
6DCh	Rising edge Threshold Register (RTHR27)	32	RW	0000_0000h
6E0h	Falling edge Threshold Register (FTHR27)	32	RW	0000_0000h
700h	Module Configuration Register (MCR28)	32	RW	0000_0000h
704h	Module Status Register (MSR28)	32	RW	0000_0000h
71Ch	Rising edge Threshold Register (RTHR28)	32	RW	0000_0000h
720h	Falling edge Threshold Register (FTHR28)	32	RW	0000_0000h
740h	Module Configuration Register (MCR29)	32	RW	0000_0000h
744h	Module Status Register (MSR29)	32	RW	0000_0000h
75Ch	Rising edge Threshold Register (RTHR29)	32	RW	0000_0000h
760h	Falling edge Threshold Register (FTHR29)	32	RW	0000_0000h
780h	Module Configuration Register (MCR30)	32	RW	0000_0000h
784h	Module Status Register (MSR30)	32	RW	0000_0000h
79Ch	Rising edge Threshold Register (RTHR30)	32	RW	0000_0000h
7A0h	Falling edge Threshold Register (FTHR30)	32	RW	0000_0000h
7C0h	Module Configuration Register (MCR31)	32	RW	0000_0000h
7C4h	Module Status Register (MSR31)	32	RW	0000_0000h
7DCh	Rising edge Threshold Register (RTHR31)	32	RW	0000_0000h
7E0h	Falling edge Threshold Register (FTHR31)	32	RW	0000_0000h

55.7.2 Module Configuration Register (MCR0 - MCR31)

Offset

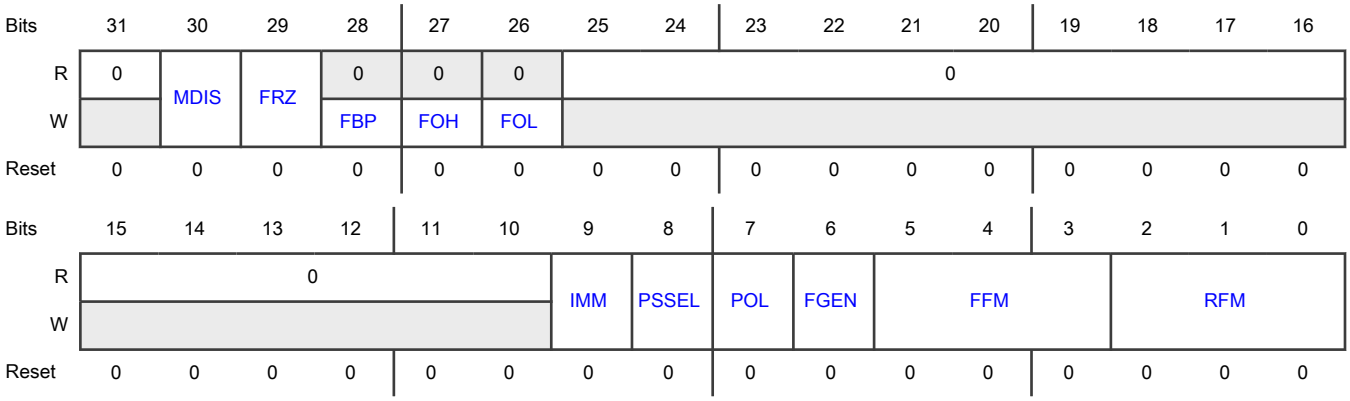
For n = 0 to 31:

Register	Offset
MCRn	0h + (n × 40h)

Function

The Module Configuration register (MCR) provides access to low power, debug, and filter control bits.

Diagram



Fields

Field	Function
31 —	Reserved
30 MDIS	Module Disable The MDIS bit forces the filter to enter a low power state. After this bit is asserted the clock for the module is removed thus filter operation is not possible. The access to filter registers is allowed. 0b - Input Glitch Filter is not in low power mode due to MDIS bit 1b - Input Glitch Filter is in low power mode
29 FRZ	Freeze bit for debug operation The FRZ bit enables the Input Glitch Filter to enter freeze mode (debug mode) when a system level signal request the module enters freeze (debug) mode. Once in freeze mode the filter operation is disabled meaning that transitions on the input signal will not propagate through the filter output. The bypass FBP bit can be used by the software to force the filter output to be the same as the filter input. In this mode FOH and FOL also can be used to define the filter output state. 0b - Freeze mode disabled 1b - Freeze mode enabled
28 FBP	Force Bypass This bit is self-negated thus is only read as zero. Writing 1 to this bit while in freeze mode forces the filter to bypass the value in the input to the filter output, thus allowing a software control on the filter. This bit is functional only in freeze mode. 0b - no filter bypass 1b - transfer input signal value to the filter output
27	Force filter output high

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Field	Function
FOH	If set, this bit forces the Input Glitch Filter output to ‘1’. This bit is functional only in debug mode. It is self-negated thus always read as zero. 0b - no action 1b - forces the filter output to ‘1’
26 FOL	Force filter output low If set this bit forces the Input Glitch Filter output to ‘0’. This bit is functional only in debug mode. It is self-negated thus always read as zero. 0b - no action 1b - forces the filter output to ‘0’
25-10 —	Reserved
9 IMM	Immediate edge propagation control bit The IMM bit controls the propagation of an edge through the filter. If asserted, this bit defines that an edge at the filter input propagates through the filter output independent of the prescaler settings. In bypass mode the propagation delay is three system clock cycles. If negated, the signal propagation depends upon the prescaler settings. The filter hardware will only allow changes to this bit if the filter is disabled, FGEN = 0 0b - edge propagation depends on prescaler 1b - edge propagation within three system clock cycles
8 PSSEL	Prescaler selection bit The PSSEL selects if the prescaler used by the Input Glitch Filter is from internal source (internal prescaler counter) or from external source. The filter hardware will only allow changes to this bit if the filter is disabled, FGEN=0. 0b - Internal prescaler selected 1b - external prescaler selected
7 POL	Output polarity bit This bit sets the polarity of the filter output to inverted or not inverted. The polarity control implemented by the POL bit is applied at the filter output stage thus also changing the reset state of the output, even if the filter is disabled by the FGEN bit. The filter hardware will only allow changes to this bit if the filter is disabled, FGEN=0. 0b - not inverted output 1b - inverted output
6 FGEN	Filter global enable This control bit enables the filter operation, meaning that if the filter is enabled the filtering selected types are applied to the rising and falling edges of the input signal. If the filter is not enabled, then the filter output remains unchanged independent of the filter input signal. Note that the filter output state is affected by the POL bit when the filter is disabled.

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Field	Function
	0b - filter is disabled: filter output keeps current state. 1b - filter is enabled: filtering is applied to selected edges.
5-3 FFM	Falling edge filter type selection This bit field selects the filter type for the filter input signal falling edge. The filter hardware will only allow changes to this bit if the filter is disabled, FGEN=0. 000b - bypass: edge is propagated to filter output without any filtering in three system clock cycles 001b - windowing: windowing filter is selected for the falling edge 010b - integrating: integrating filter is selected for the falling edge 011b - integrating-hold: integrating-hold filter is selected for the falling edge 100b - windowing with post sample: windowing filter with post sample is selected for the falling edge
2-0 RFM	Rising edge filter type selection This bit field selects the filter type for the input signal rising edge. The filter hardware will only allow changes to this bit if the filter is disabled, FGEN=0. 000b - bypass: edge is propagated to filter output without any filtering in three system clock cycles 001b - windowing: windowing filter is selected for the rising edge 010b - integrating: integrating filter is selected for the rising edge 011b - integrating-hold: integrating-hold filter is selected for the rising edge 100b - windowing with post sample: windowing filter with post sample is selected for the rising edge

55.7.3 Module Status Register (MSR0 - MSR31)

Offset

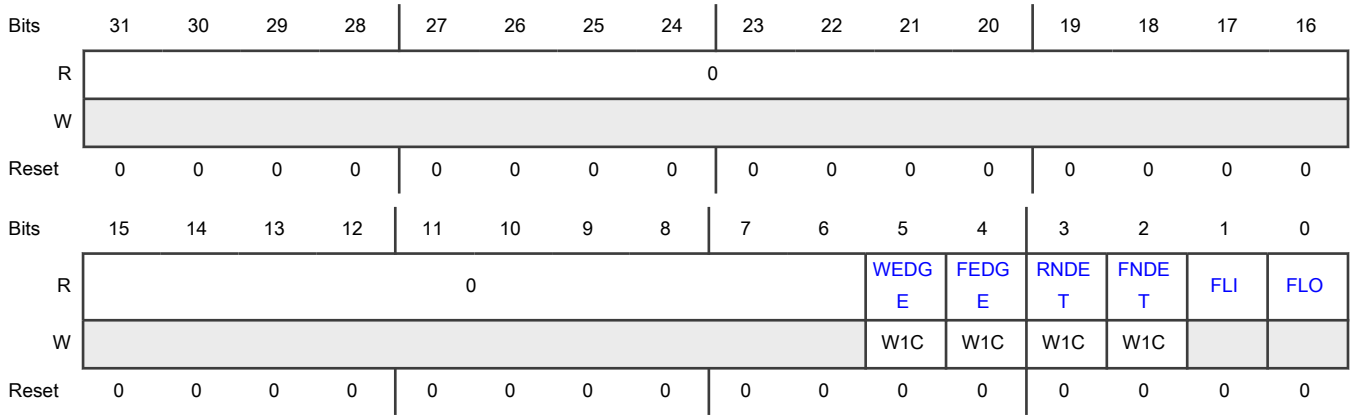
For n = 0 to 31:

Register	Offset
MSRn	4h + (n × 40h)

Function

The Module status register (MSR) provides access to filter status bits and corresponding clear bits as well as access to the state of filter input and output signals.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 WEDGE	Filter is active waiting for an edge This bit is set when the filter is enabled but the internal counter is not active. It indicates that the filter is waiting for an edge to occur at the filter input. It is set by the Input Glitch Filter hardware and cleared by the software by writing 1 to the bit. Since the intention of this bit is to capture the dynamic of the filter hardware, it should be cleared after the read thus being able to capture a new event. 0b - Input Glitch Filter is disabled or the internal counter is active 1b - Input Glitch Filter is waiting for an edge
4 FEDGE	Filter is active processing an edge This bit is set during the filter active state thus when the filter internal counter is counting, processing an edge in a filtering mode. It is cleared by the software by writing 1 to the bit. Since the intention of this bit is to capture the dynamic of the filter hardware, it should be cleared after the read thus being able to capture a new event. 0b - Input Glitch Filter internal counter is not active 1b - Input Glitch Filter internal counter is active
3 RNDET	Rise noise detected bit This bit indicates that the filter filtered out noise in the input signal after a rising edge was detected. The criteria to set this bit is when a rising edge is detected thus starting the filter counter and before this edge pass through the filter (if filter is in integrating filter types) or during a window (if filter is in windowing filter types) another edge occurs in the input signal. This bit is set by a noise detection and cleared by the software by writing 1 to this bit. 0b - noise was not detected 1b - noise was detected after a rising edge
2	Fall noise detected bit

Table continues on the next page...

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Field	Function
FNDET	This bit indicates that the filter filtered out noise in the input signal after a falling edge was detected. The criteria to set this bit is when a falling edge is detected, thus starting the filter counter, and, if the filter is in integrating types, before this edge passes through the filter, or, in windowing types, when another edge occurs in the input signal during a window. This bit is set by a noise detection and cleared by the software by writing 1 to this bit. 0b - noise was not detected 1b - noise was detected after a falling edge
1 FLI	Filter input The FLI bit follows the state of the filter input value as captured by the filter input logic, which is affected by the IMM bit and prescaler settings.
0 FLO	Filter output The FLO bit follows the state of the filter output value considering the POL bit state.

55.7.4 Prescaler Register (PRESR0 - PRESR16)

Offset

Register	Offset
PRESR0	10h
PRESR16	410h

Function

The prescaler register (PRESR) provides access to the prescaler bits.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0						FPRE									
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-10 —	Reserved
9-0 FPRE	Filter prescaler The prescaler defines the rate of the filter counter FCOUNT. The filter counter clock rate is defined by the formula: Filter counter clock = module clock / (FPRE + 1).

55.7.5 Rising edge Threshold Register (RTHR0 - RTHR31)

Offset

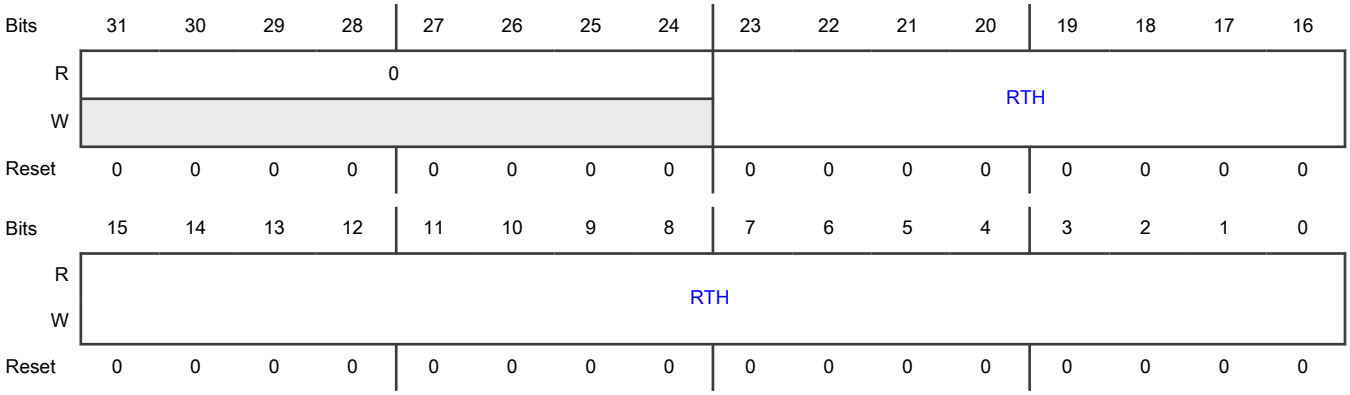
For n = 0 to 31:

Register	Offset
RTHRn	1Ch + (n × 40h)

Function

The Rising edge Threshold register (RTHR) provides access to the rising edge threshold bits.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 RTH	Rising edge threshold This bit field defines the filter counter threshold when a rising edge occurs is being filtered.

55.7.6 Falling edge Threshold Register (FTHR0 - FTHR31)

Offset

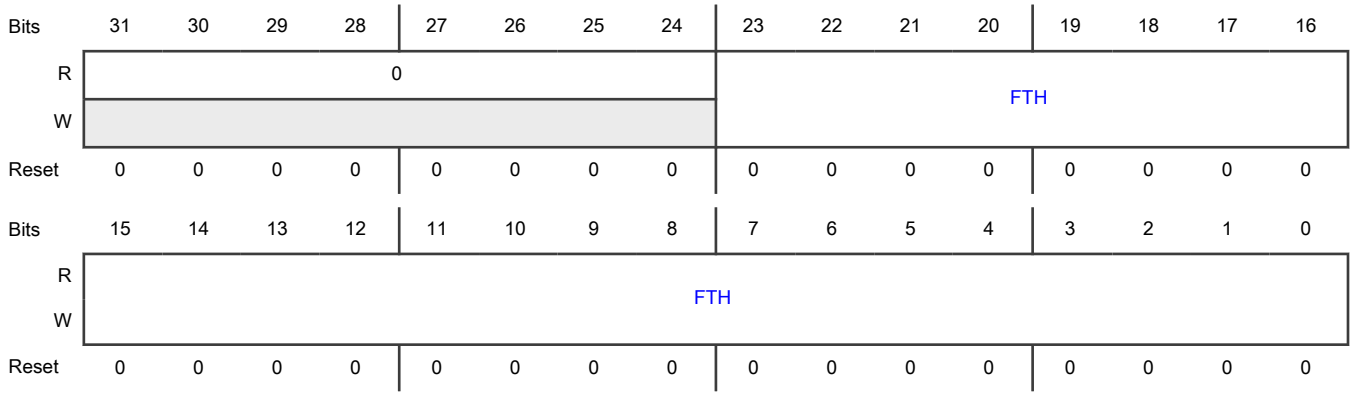
For n = 0 to 31:

Register	Offset
FTHRn	20h + (n × 40h)

Function

The Falling edge Threshold register (FTHR) provides access to the falling edge threshold bits.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 FTH	Falling edge threshold This bit field defines the filter counter threshold when a falling edge is being filtered.

Chapter 56
Enhanced Flex Pulse Width Modulator (eFlexPWM)

56.1 Chip specific eFlexPWM information

56.1.1 eFlexPWM instances and configuration

The chip supports two instances of eFlexPWM.

Table 263. eFlexPWM configuration

Parameter	eFlexPWM_0	eFlexPWM_1
FIFO_DEPTH (Input capture FIFO depth)	4	4
CYC_WIDTH (Width of capture value cycle)	4	4
FNUM (Number of fault inputs)	4	4

56.2 Overview

eFlexPWM contains PWM submodules, each set up to control a single half-bridge power stage. eFlexPWM also provides fault channel support.

- AC Induction Motor (ACIM)
- Permanent Magnet AC (PMAC) Motor
- Brush DC (BDC) Motor
- Brushless DC (BLDC) motor
- Switched Reluctance Motor (SRM)
- Variable Reluctance Motor (VRM)
- Stepper Motors

eFlexPWM can generate various switching patterns, including highly sophisticated waveforms. You can use it to control all known motor types and is ideal for controlling different Switched Mode Power Supply (SMPS) topologies as well.

56.2.1 Block diagram

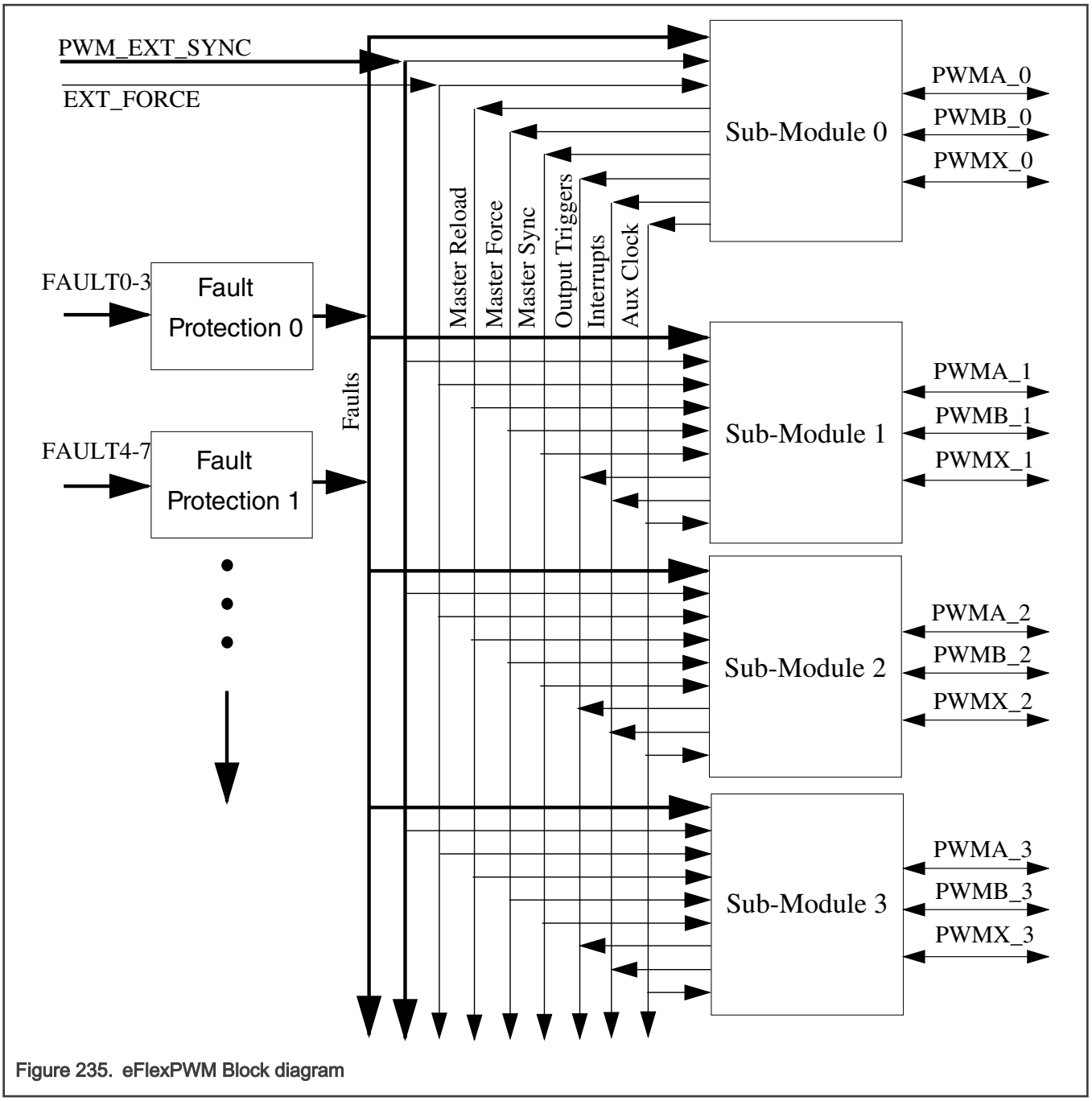


Figure 235. eFlexPWM Block diagram

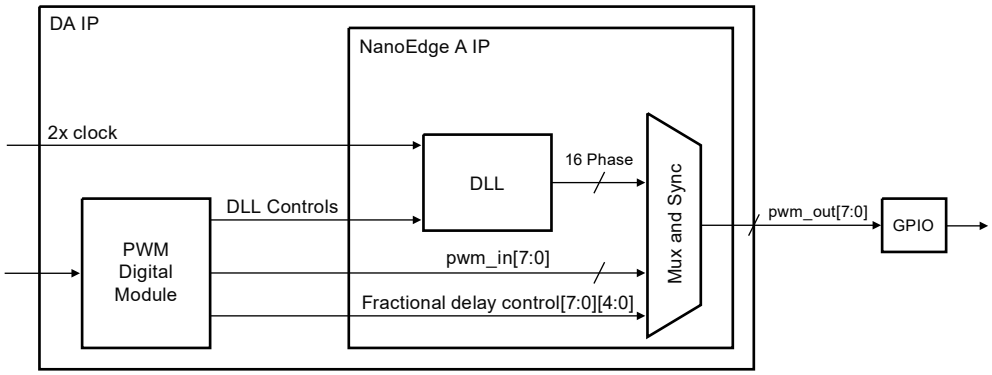


Figure 236. NanoEdge Block diagram

56.2.2 Features

56.2.2.1 eFlexPWM features

- 16 bits of resolution for center, edge-aligned, and asymmetrical PWMs
- Fractional PWM clock generation for enhanced resolution of the PWM timing values
- PWM outputs that can operate as complementary pairs or independent channels
- Ability to accept signed numbers for PWM generation
- Independent control of both edges of each PWM output
- Support for synchronization with external hardware or other PWM, including:
  - Crossbar module outputs
  - External ADC input, taking into account values set in ADC high and low limit registers
- Double buffered PWM registers
  - Integral reload rates from 1 to 16
  - Half-cycle reload capability
- Multiple output trigger events per PWM period via hardware
- Support for double switching PWM outputs
- Ability to assign fault inputs to control multiple PWM outputs
- Programmable filters for fault inputs
- Independently programmable PWM output polarity
- Independent top and bottom deadtime insertion
- Complementary pair output that can operate with its own PWM frequency and deadtime values
- Individual software control for each PWM output
- Programmable output transitions triggered by a FORCE_OUT event
- PWM_X pin for an optional third PWM output signal from each submodule
- Unused PWM channels available for buffered output compare functions
- Unused PWM channels available for input capture functions
- Enhanced dual-edge capture functionality

- Selectable controls for each complementary PWM signal pair

56.2.2.2 NanoEdge features

- Programs and generates 8 PWM outputs in parallel.
- Digital module generates PWM on 1x clock and analog module adjusts it by 1/32 period of the same clock.
- 2x clock is 320 MHz - 400 MHz.
- Provides smaller incremental shifts.
- Generates 32 system clock replicas separated by 156.25pS.

56.3 Functional description

56.3.1 PWM submodule

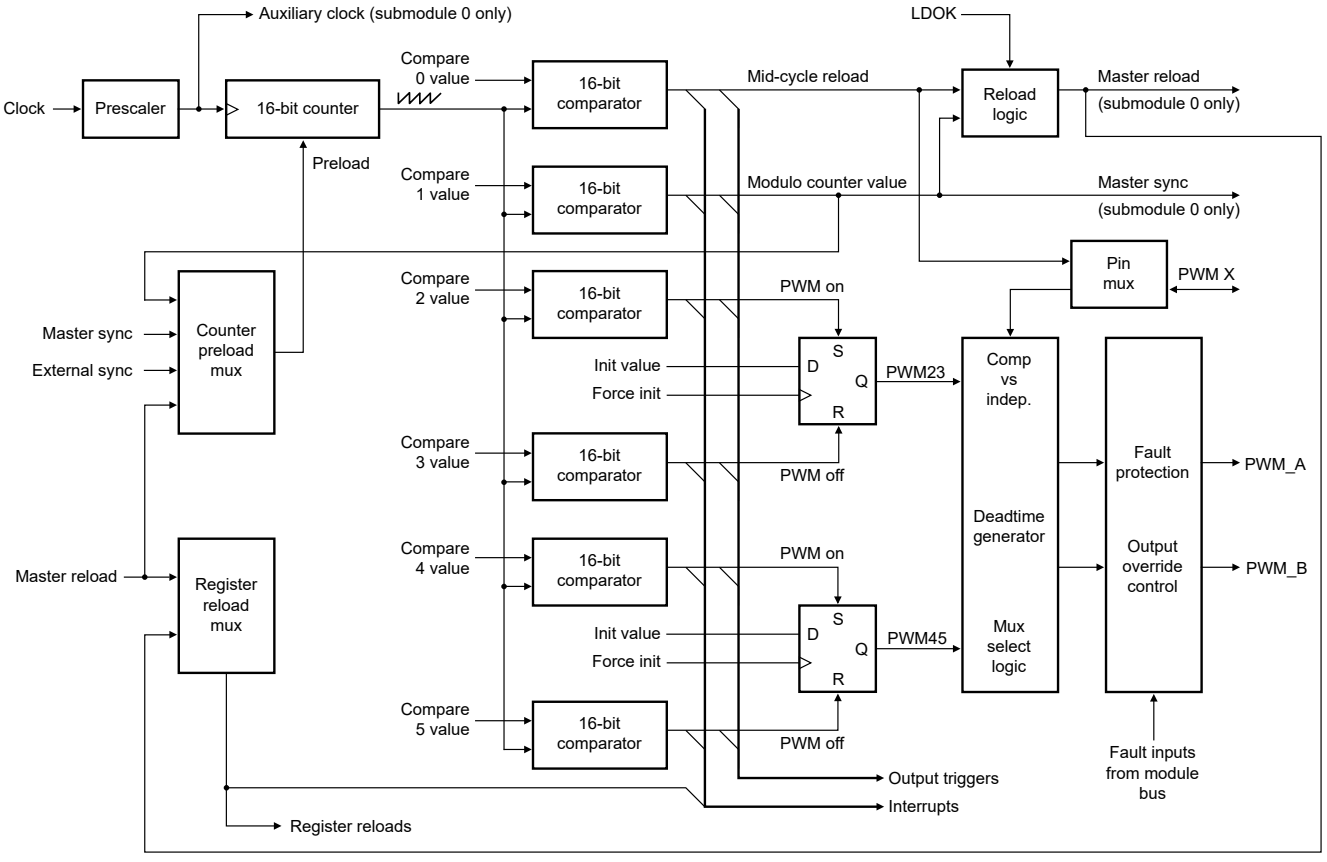


Figure 237. PWM submodule

56.3.2 PWM operation

This section provides information about how eFlexPWM operates and how to control that operation. It is followed by sections that explain how to use eFlexPWM to produce different kinds of PWM pulses for particular use cases.

56.3.2.1 PWM operation overview

eFlexPWM has a number of submodules. Each submodule generates three pulse outputs: PWM*n*_A, PWM*n*_B, and PWM*n*_X. You can control several characteristics of submodule operation, including:

- submodule counter frequency
- length of the submodule PWM period:
  - initial count value
  - counter reload timing
- turn-on and turn-off timing of the outputs to create PWM pulses within that PWM period
- polarity of the outputs

You can use the PWM outputs from a single submodule individually or in combination to create different types of output pulses, and you can align those pulses within the PWM period. You can also coordinate the outputs from more than one submodule. eFlexPWM provides additional controls to meet the requirements for many PWM use cases.

56.3.2.2 Pulse width and alignment

Unlike other PWMs that may use only a single value to specify the pulse width, eFlexPWM controls pulse width using two timing values: the turn-on edge and the turn-off edge. This double-action edge generation provides precise control of the pulse width as well as the alignment of the pulse within the PWM period for each PWM output. As a result, eFlexPWM does not need to support separate PWM alignment modes because pulse width and alignment are inherent in the turn-on and turn-off edge values.

See Pulse characteristics and Pulse control for information about the pulse timing values for all of the PWM output edges.

56.3.2.3 Pulse characteristics

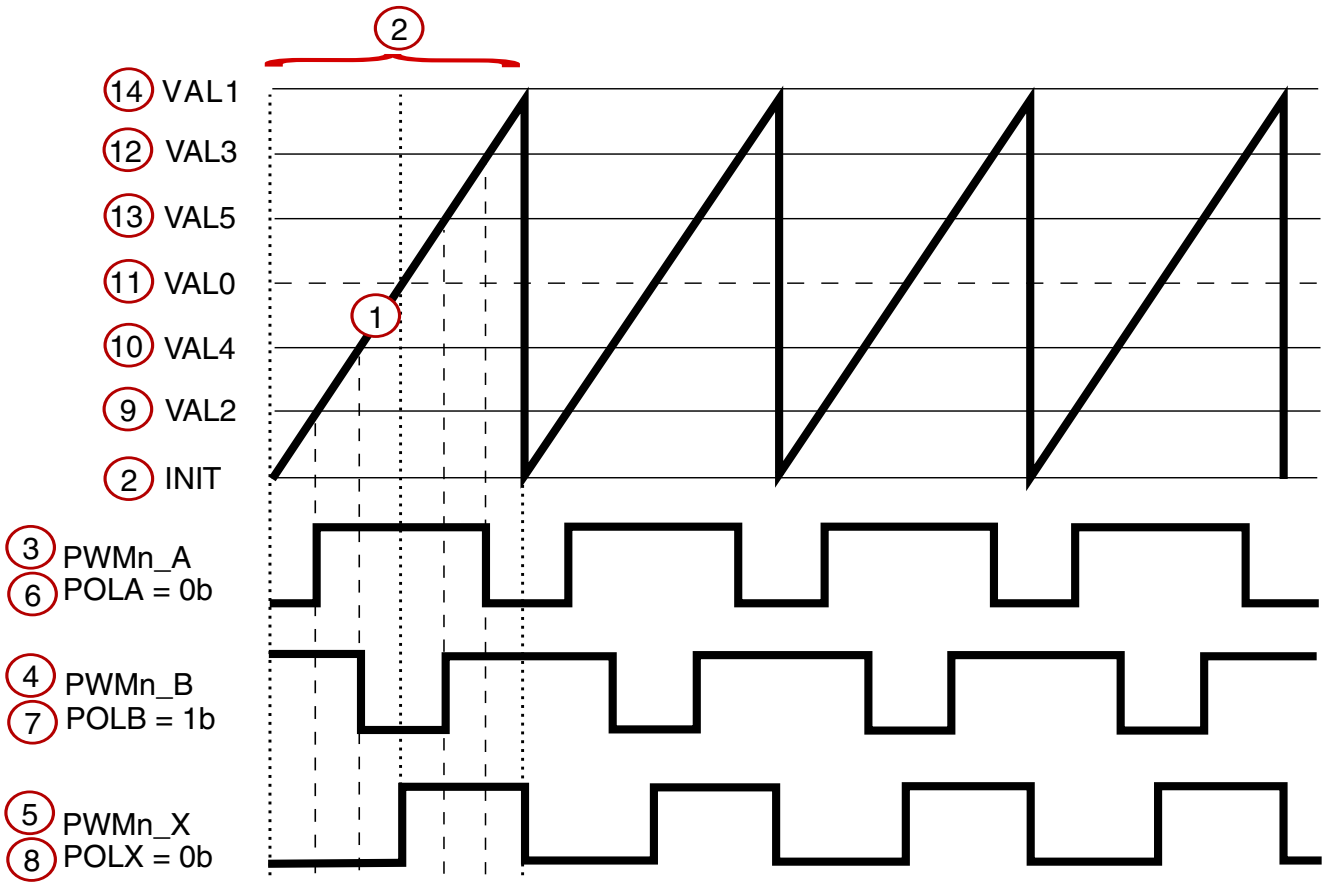


Figure 238. Pulse characteristics

56.3.2.4 Pulse control

The following table describes several characteristics of submodule operation. Call outs refer to Pulse characteristics:

Call out	Characteristic	Description	Control or read
—	Source clock	The clock signal source that drives the PWM submodule counter and prescaler circuit.	SM*n*_CTRL2[CLK_SEL]
—	Prescaler	A clock divider that interacts with the source clock to determine the number of source clock cycles represented by each increment of the submodule counter. The range is 1 to 128, by powers of 2.	SM*n*_CTRL[PRSC]
1	Submodule counter	A countup rollover timer that the PWM generator compares against timing values to determine when to turn on or turn off the PWM outputs or to reload the submodule counter. The counter represents source clock cycles divided by the prescaler. In other words, if the prescaler is Divide by 16, the counter increments one unit every 16 clock cycles.	SM*n*_CNT[CNT]
2	PWM period	The length in counter units from the start of counting to reload of the counter. To begin operation, the submodule loads the initial count into the counter. The counter increments every *n* clock cycles, where *n* is the prescaler factor, until the counter matches the reload point, specified in timing value 1, at which time the submodule reloads the counter. Therefore, the PWM period is (VAL1 – INIT) counter units long. **NOTE** Other events can cause reinitialization of the counter before the end of the full PWM period.	SM*n*_INIT[INIT], SM*n*_VAL1[VAL1]
3 4 5	PWM outputs	The submodule outputs that provide the PWM pulses. Each submodule can generate up to three pulse outputs. These outputs have the following characteristics: • Polarity • Turn-on edge • Turn-off edge	
6 7 8	PWM output polarity	The polarity (active low or active high) of the output signal when it is asserted or turned on.	SM*n*_OCTRL[POLA] SM*n*_OCTRL[POLB] SM*n*_OCTRL[POLX]
9 10 11	PWM output turn-on edge	The assertion of the PWM output at the beginning of a pulse, controlled by the relevant timing value.	PWM*n*_A: SM*n*_VAL2[VAL2] PWM*n*_B: SM*n*_VAL4[VAL4] PWM*n*_X: SM*n*_VAL0[VAL0]
12	PWM output turn-off edge	The deassertion of the PWM output at the end of a pulse, controlled by the relevant timing value.	PWM*n*_A: SM*n*_VAL3[VAL3]

Table continues on the next page...

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Call out	Characteristic	Description	Control or read
13 14			PWM*n*_B: SM*n*_VAL5[VAL5] PWM*n*_X: SM*n*_VAL1[VAL1]

56.3.2.5 Rollover submodule counter

When generating different kinds of pulse alignments, some applications benefit from aligning or timing the pulse edges relative to the mid-point of the PWM period. To make the timing value calculations for such alignments easier, each submodule uses a rollover countup timer, called the submodule counter, for period and pulse timing.

When the submodule counter (SM*n*_CNT[CNT]) reaches FFFFh, it rolls over to 0000h and continues counting up from there. You can take advantage of this rollover to treat the counter value as a two's-complement signed integer. If you specify a two's-complement negative value for the Initial Count (SM*n*_INIT[INIT]) and a positive value for the counter reload point, timing value 1 (SM*n*_VAL1[VAL1]), you can view the counter as counting from the negative initial value up through zero and on to the positive reload value.

Therefore, to create a PWM period whose mid-point occurs when the submodule counter is 0000h, specify a positive integer value for timing value 1 and the two's-complement negative of that value for the initial count.

56.3.2.6 Rollover submodule counter example

The following diagram illustrates initializing the submodule counter with the two's complement negative of the reload timing value, resulting in a PWM period mid-point of 0000h. As is typical, the half-period timing value, timing value 0 (SM*n*_VAL0[VAL0])VAL0, is set to match the period mid-point.

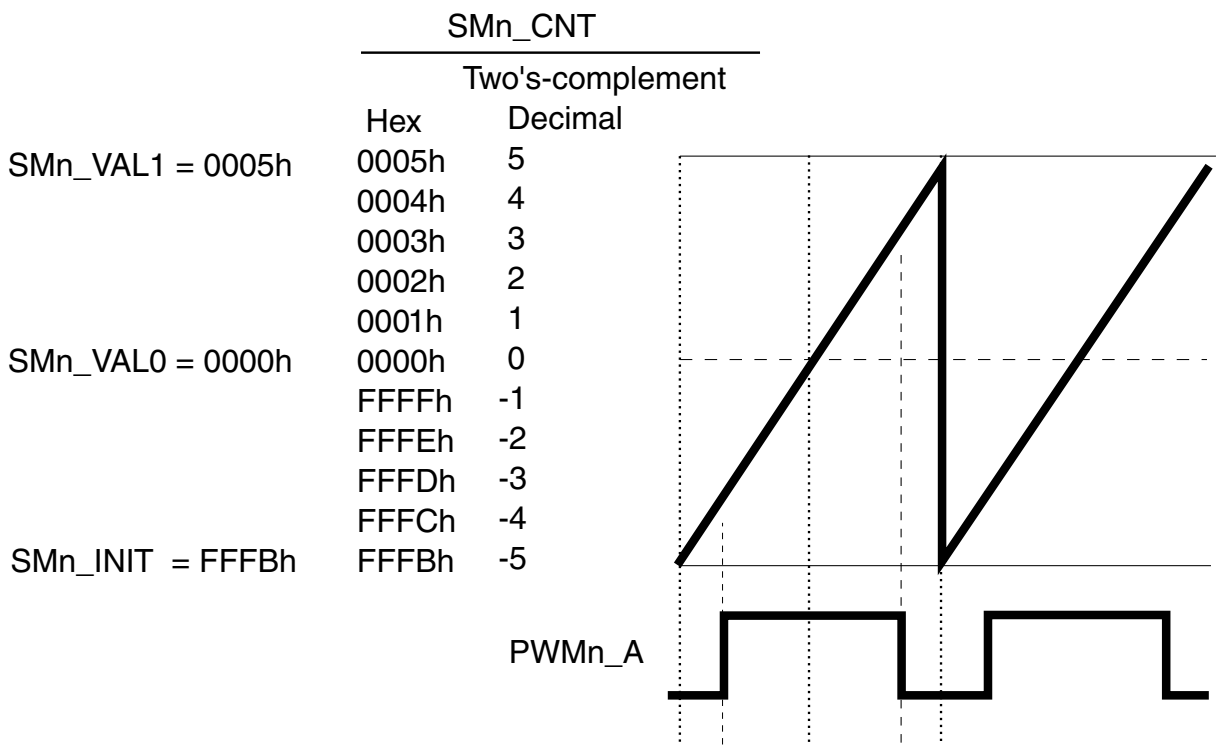

Figure 239. Rollover submodule counter example

56.3.3 Modes of operation

The following table describes eFlexPWM behavior during the listed operational modes.

CAUTION

Be careful when using eFlexPWM in Stop, Wait, and Debug operating modes.

Some applications (such as three-phase AC motors) require regular software updates for proper operation. Failure to provide regular software updates could result in destroying the hardware setup.

To accommodate this situation, eFlexPWM places PWM outputs in their inactive states in stop mode, and you can optionally placed them in inactive states in wait and debug (EOnCE) modes. Upon exiting these modes, eFlexPWM reactivates PWM outputs that were active before entering the mode.

Table 264. PMW restrictions is operational modes

Mode	Description
Stop	PWM outputs are inactive.
Wait	PWM outputs are driven or inactive depending on run in wait enable (SM*n*_CTRL2[WAITEN]).
Debug	PWM outputs are driven or inactive depending on run in debug enable (SM*n*_CTRL2[DBGEN]).

56.3.4 High-level PWM generation output diagram

This figure is a high-level block diagram of PWM generation output.

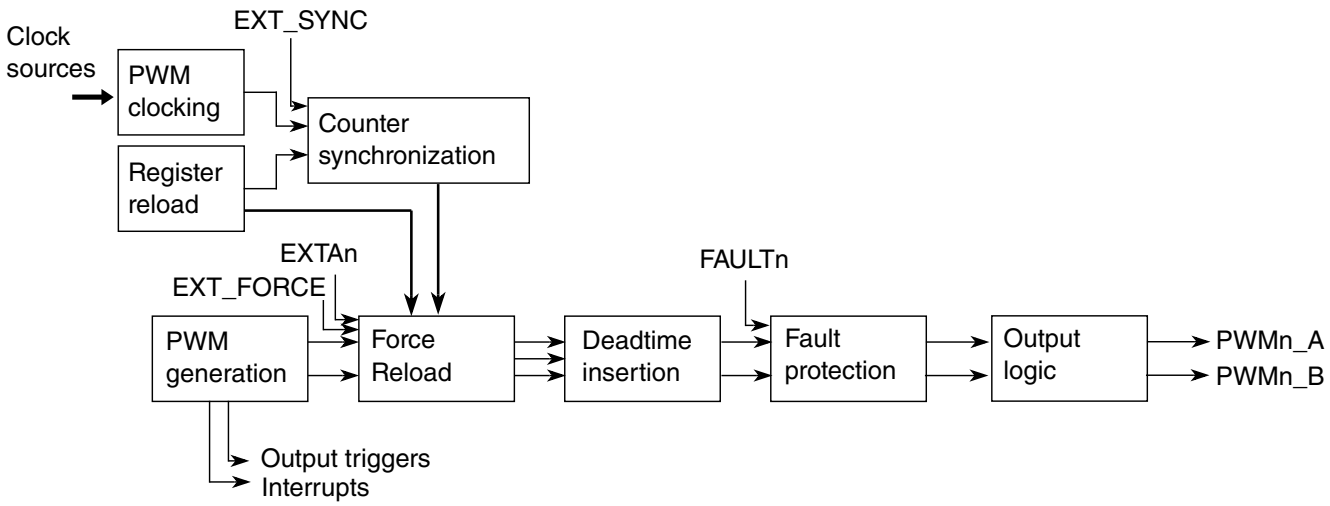

Figure 240. High-level PWM generation output

56.3.5 Register reload

The register reload logic determines when the submodule transfers the contents of the outer set of registers for all double-buffered register pairs to the inner set of registers. You schedule register reload to occur after a certain number of PWM opportunities. Specify the number of PWM opportunities between each reload with load frequency (SM*n*_CTRL[LDFQ]).

If you enable half-period reload (SM*n*_CTRL[HALF]), every half-period point, defined by timing value 0 (SM*n*_VAL0[VAL0]) counts as one PWM opportunity.

If you enable full-period reload (SM*n*_CTRL[FULL]), every PWM period, defined by timing value 1 (SM*n*_VAL1[VAL1]), counts as a PWM opportunity.

NOTE

The half-period point does not necessarily occur at the precise half-way point in the PWM period.

As illustrated in Register reload logic, you can use the reload signal from submodule 0 as a master reload signal to trigger reload in the other submodules.

56.3.5.1 Register reload logic

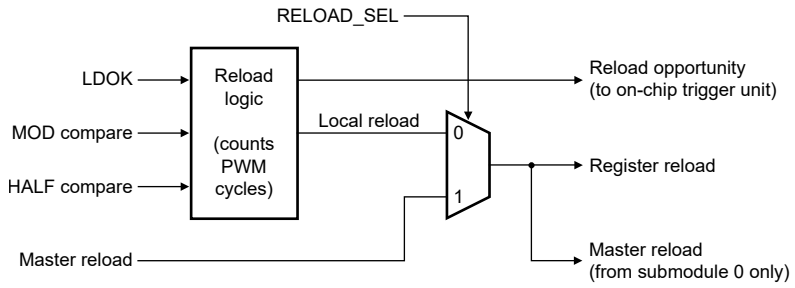

Figure 241. Register reload logic

56.3.6 Counter synchronization

56.3.6.1 Counter synchronization overview

As illustrated in Submodule counter synchronization logic, the 16-bit submodule counter, which counts up from the initial count (SM*n*_INIT[INIT]) to timing value 1 (SM*n*_VAL1[VAL1]), begins counting when it receives the initialization signal. You can select one of four sources for the counter initialization signal (SM*n*_CTRL2[INIT_SEL]) and force reload (assertion of the FORCE_OUT signal) can also start the counter.

56.3.6.1.1 Submodule counter synchronization logic

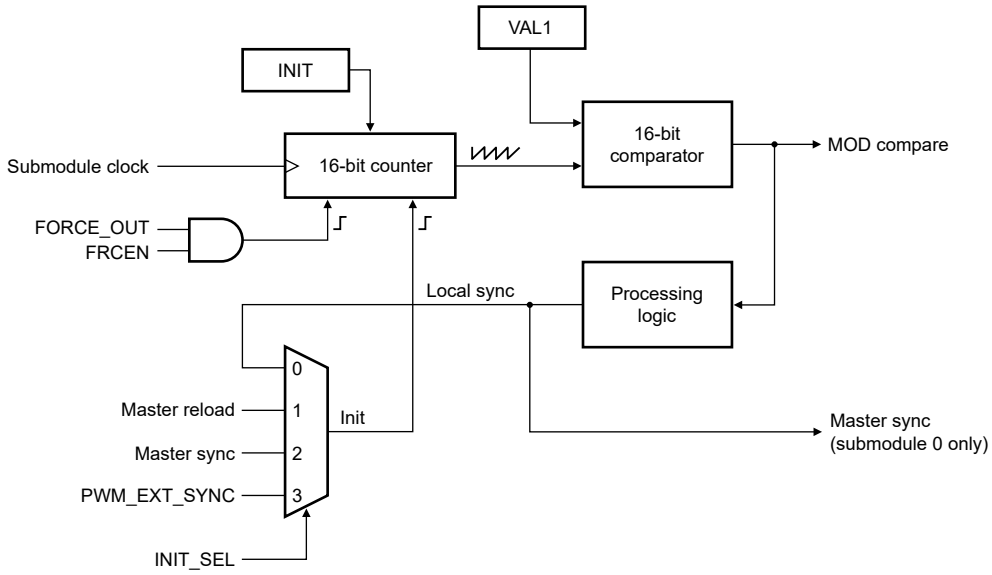

Figure 242. Submodule counter synchronization logic

56.3.6.2 Local synchronization

When you select Local Sync as the initialization source, the submodule operates at the local level. When the counter equals the submodule's own timing value 1 (SM*n*_VAL1[VAL1]), the submodule reloads the counter with the initial count (SM*n*_INIT[INIT]) and asserts local sync, which starts the counter. Therefore, SM*n*_INIT[INIT] and VAL1 determine the PWM period (and therefore the PWM frequency of the submodule).

56.3.6.3 Master synchronization

The master sync signal is the local sync output from submodule 0. When you select master sync as the initialization source for a submodule other than submodule 0, you lock the PWM period of that submodule to the submodule 0 PWM period.

56.3.6.4 External synchronization

When you select the external initialization source, the submodule counter begins counting on assertion of the PWM_EXT_SYNC signal.

PWM_EXT_SYNC can originate on- or off-chip, depending on the system architecture. See eFlexPWM chip configuration information for the source of PWM_EXT_SYNC.

56.3.6.5 Master reload synchronization

The master reload signal is the register reload output from submodule 0. When you select master reload as the initialization source for a submodule other than submodule 0, you lock the submodule PWM period to the register reload frequency of submodule 0. If the master reload frequency is controlled by the sampling frequency of a software control algorithm, the submodule PWM period equals the sampling period. As a result, you can use this submodule's counter to generate output compares or output triggers over the entire sampling period, which may consist of several submodule 0 PWM periods.

56.3.6.6 Force reload synchronization

Each submodule counter has the FORCE_OUT signal as an optional initialization input. If you enable force reload (SM*n*_CTRL2[FRCEN]), assertion of FORCE_OUT starts the counter regardless of the selected initialization source. If you enable load okay (MCTRL[LDOK]), a forced initialization also causes a register reload.

56.3.6.7 Force reload and commutated applications

Force reload (assertion of the FORCE_OUT signal) supports commutated applications. When you commutate the PWM outputs on an inverter that controls a brushless DC motor, you must restart the PWM period at the beginning of the commutation interval. This action effectively resynchronizes the PWM waveform to the commutation timing. Otherwise, the average voltage applied to a motor winding integrated over the entire commutation interval is a function of the timing between the asynchronous commutation event with respect to the PWM period. The effect is more critical at higher motor speeds where each commutation interval may consist of only a few PWM periods. If the counter is not started at the start of each commutation interval, the result is an oscillation caused by the beating between the PWM frequency and the commutation frequency.

56.3.7 PWM generation

56.3.7.1 PWM generation overview

Each submodule can generate three PWM outputs, two primary PWM signals and the local sync signal, with complete software control over the rising and falling edges of each signal.

For each output, the submodule compares a pair of timing values (SM*n*VALm) against the submodule counter to control the output pulse, one timing value to control the turn-on edge and one to control the turn-off edge.

You can also specify the polarity of each output as not inverted or inverted (SM*n*_OCTRL[POL*m*]). An inverted signal goes low on the rising-edge timing value and high on the falling-edge value.

PWM generation logic illustrates PWM generation in each submodule.

56.3.7.1.1 PWM generation logic

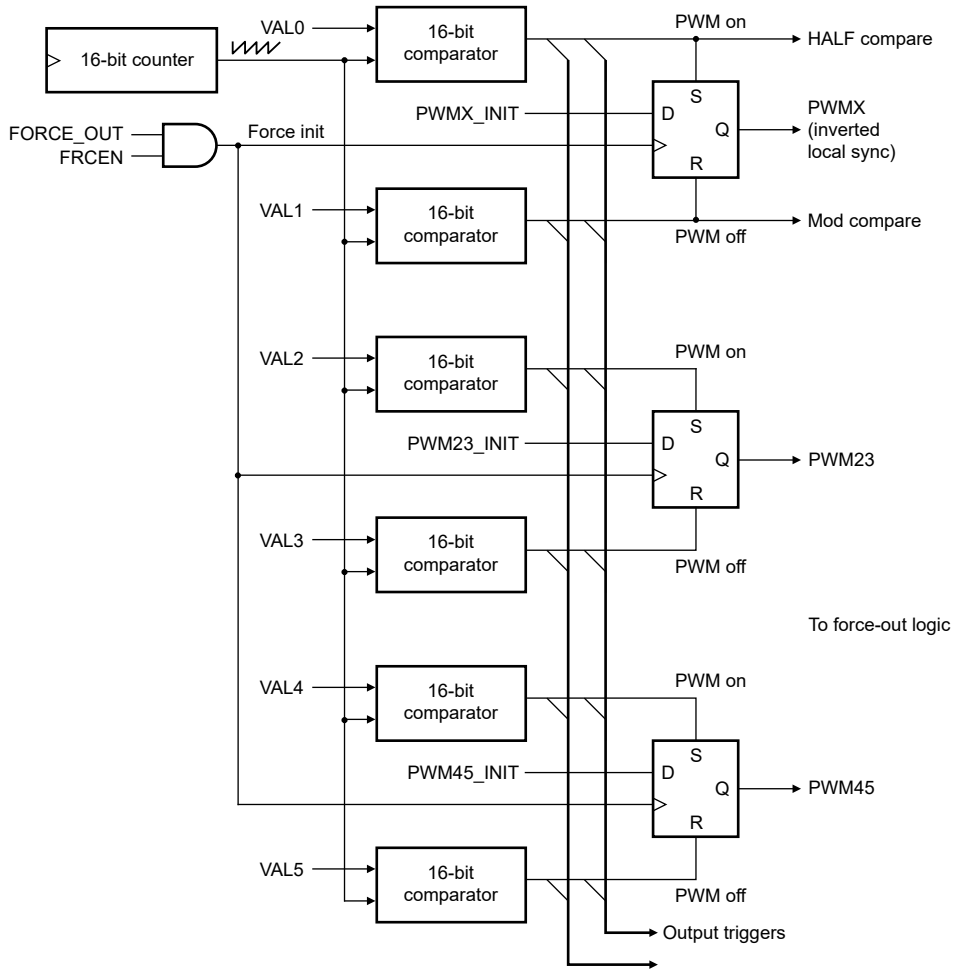

Figure 243. PWM generation logic

56.3.7.2 Comparator and flip-flop operation

The 16-bit comparators shown in PWM generation logic are "equal to" comparators. In other words, when the submodule counter value is equal to the specified timing value, the comparator asserts its signal to the output flip-flop. In addition, if both the set and reset are asserted to the flip-flop, the flip-flop output goes to 0.

56.3.7.3 Local synchronization and reload

The submodule generates its local sync signal in the same way as the other PWM output signals. The comparator for timing value 0 causes a falling edge of the local sync signal and the comparator for timing value 1 generates a rising edge. The timing value 1 comparator also drives the reload logic to generate the full-period reload indicator.

56.3.7.4 Local sync as auxiliary PWM output (PWM*n*_X)

Timing value 1 (SM*n*_VAL1[VAL1]) determines the modulus counter value that triggers reinitialization of the counter and asserts local sync. Timing value 0 (SM*n*_VAL0[VAL0]) determines the half-period point and deasserts local sync. Therefore, if you don't need VAL0 and VAL1 to trigger register reload or counter initialization, you can use them to modulate the duty cycle of the local sync signal, as long as you are not using it for another purpose, such as input capture or deadtime distortion correction. The submodule outputs the inversion of local sync as the auxiliary PWM signal (PWM*n*_X).

For example, if VAL0, the half-period point, is half of VAL1 minus the initial count (SM*n*_INIT[INIT]), then the half-period reload pulse occurs exactly halfway through the PWM period and the local sync has a 50% duty cycle.

56.3.7.5 Optional uses for PWM outputs

If you do not need a set of edge timing values for PWM output, you can use it for other functions such as output-compare events, generating output triggers, or generating interrupts at timed intervals.

56.3.8 Output-compare events

56.3.8.1 Output-compare events overview

You can use individual timing values to create programmed buffered output-compare events with no additional hardware required. Specifically, you can:

- Drive an output high
- Drive an output low
- Generate an interrupt
- Generate an output trigger

56.3.8.2 Program an output-compare event

To generate an output-compare event, program one of a pair of timing values with the counter value for the moment in the PWM period you want the event to occur, and program the other timing value in the pair with a value outside the modulus range of the submodule counter. Depending on which timing value you use, the output-compare event (the moment the submodule counter equals the timing value) causes the output of the flip-flop to either set or reset.

56.3.8.3 Output-compare high

For example, if you want an output compare on the PWM*n*_A output to set it high, program timing value 2 (SM*n*_VAL2[VAL2]) with the counter value for when you want the output compare to take place. However, to prevent the D flip-flop from being reset again after the compare occurs, program timing value 3 (SM*n*_VAL3[VAL3]) to a value outside of the modulus range of the counter, that is, a value greater than timing value 1 (SM*n*_VAL1[VAL1])and lower than the initial count (SM*n*_INIT[INIT]). Therefore, a compare that would reset the D flip-flop output never occurs.

56.3.8.4 Output-compare low

Conversely, if you want an output compare on the PWM*n*_A output to set it low, program timing value 3 (SM*n*_VAL3[VAL3]) with the desired count value and program timing value 2 (SM*n*_VAL2[VAL2]) with a value outside the counter modulus range.

56.3.8.5 Output-compare interrupt

Regardless of whether you program an output high or low compare event, you can generate an interrupt when the event occurs.

To generate an interrupt request to the CPU on the occurrence of an output-compare event, enable the appropriate Compare Interrupt (SM*n*_INTEN[CMPIE]). After compare interrupt occurs, you must clear the corresponding compare flag (SM*n*_STS[CMPF]).

56.3.8.6 Output-compare trigger

As with interrupts generated by output-compare events, you can also generate an output trigger when the event occurs.

To generate an output trigger on the occurrence of an output-compare event, enable output trigger for the specific output signal (SM*n*_TCTRL[OUT_TRIG_EN]).

56.3.9 Force reload

56.3.9.1 Force reload overview

Before the PWM signals reach the output pins, they pass through force reload logic that can switch all submodule outputs simultaneously. You select a source trigger from one of several external signals or local events. The selected trigger causes assertion of the internal FORCE_OUT signal, which in turn causes all PWM generator parameters to be reloaded synchronously (simultaneously) from the register buffers.

56.3.9.2 Force reload sources

For each submodule, you can select one of the following sources (SM*n*_CTRL2[FORCE_SEL]) to assert force reload (FORCE_OUT):

- Local force (SM*n*_CTRL2[FORCE], for all submodules)
- Master force (the local Force from submodule 0)
- Local reload (for all submodules)
- Master reload (local reload from submodule 0)
- Local sync
- Master sync (local sync from submodule 0)
- External force signal (EXT_FORCE)
- External sync signal (EXT_SYNC)

56.3.9.3 Local control

Use the local signals when you do not need to synchronize the submodule output signals with another submodule. However, to change the output signals on more than one submodule at the same time, use the Master or external signal sources.

56.3.9.4 Master control

You can use the submodule 0 local force signal (SM*n*_CTRL2[FORCE]) as the master force signal to other submodules. This ability allows submodule 0 to force the synchronous update of some or all submodule outputs.

56.3.9.5 External control

The external signals can come from on- or off-chip, depending on the chip architecture. See eFlexPWM chip-configuration information for the source of the external force and sync signals. A common technique is to connect EXT_FORCE to an input signal from an external timer channel configured for output compare, or from digital comparators from an ADC.

56.3.9.6 Force reload logic

As illustrated in Force reload logic, submodule 0 PWM23 and PWM45 control select (DTSRCSEL[SM*n*SEL23] and DTSRCSEL[SM*n*SEL45]) each select from one of the following signals to be supplied to the submodule outputs:

- Internal PWM signal (PWM23 or PWM45)
- Inversion of PWM23 or PWM45
- Software-controlled output (SWCOUT[SM*n*OUT23] or SWCOUT[SM*n*OUT45])
- Alternate PWM control signal (PWMn_EXTA or PWMn_EXTB)

56.3.9.6.1 Force reload logic

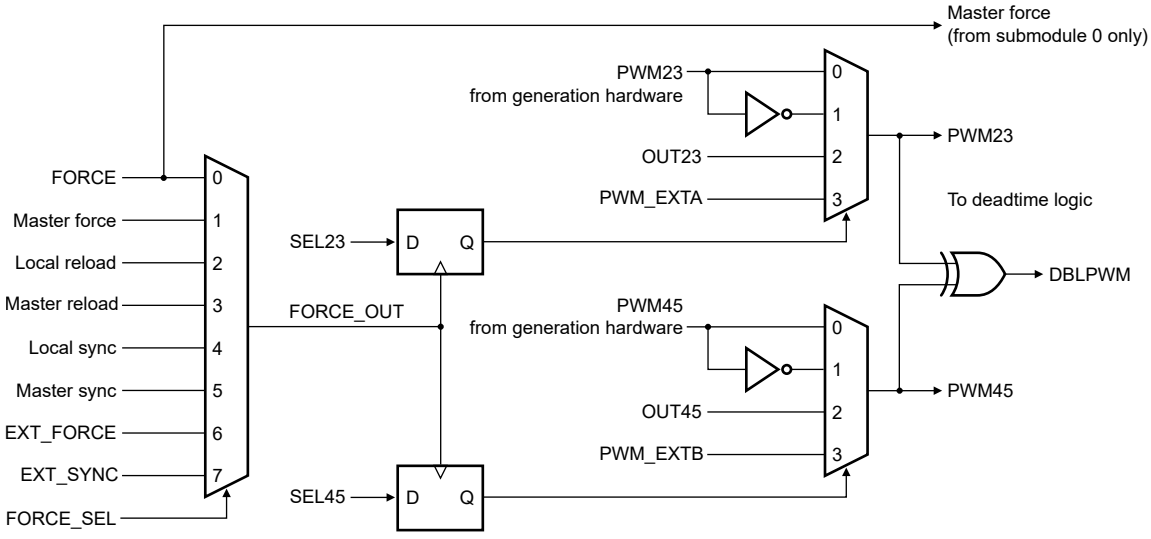

Figure 244. Force reload logic

56.3.9.7 Synchronous output switching with force reload

Force reload is useful in commutated motor applications. You can configure the next commutation state ahead of time and then immediately switch the outputs when the appropriate condition or time is reached. Not only do all the changes occur synchronously on all configured submodule outputs, they occur immediately after the trigger event thus eliminating any interrupt latency.

56.3.9.8 Typical force reload application

In a typical application, you set up the desired states of the output pins in preparation for the next force reload event (FORCE_OUT assertion). When the force reload event occurs, the submodule loads all of the PWM generation registers from the buffers and the outputs switch simultaneously. This signal switching occurs upstream from the deadtime generator to ensure that any abrupt changes do not violate deadtime on the power stage when operating the submodule in complementary mode.

56.3.9.9 Sensorless BLDC commutation with force reload

Sensorless BLDC commutation using force reload illustrates a popular application that benefits from force reload. On a brushless DC motor, you often want to spin the motor without the need of hall-effect sensor feedback. Instead, you monitor the back EMF of the motor phases and use that information to schedule the next commutation event.

In the diagram, the top waveforms are a simplified representation of these back EMF signals. Output-compare events, represented by the long vertical lines, are scheduled based on the zero crossings of the back-EMF waveforms. You configure the PWM submodule ahead of time with the next state of the PWM pins to anticipate the compare event. When it happens, the output compare of the timer asserts the FORCE_OUT signal, which immediately switches the PWM pins to the next commutation state with no software latency.

56.3.9.9.1 Sensorless BLDC commutation using force reload

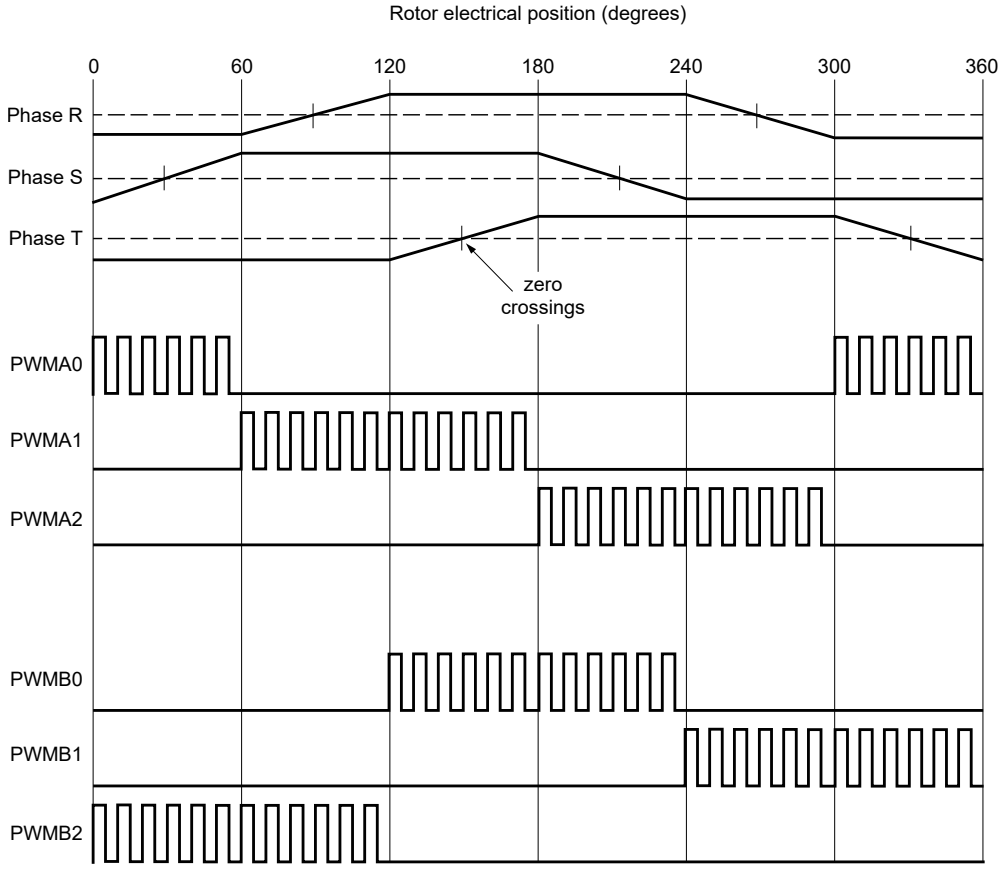

Figure 245. Sensorless BLDC commutation using force reload

56.3.10 Independent or complementary channel operation

You can operate the primary submodule PWM outputs (PWMn_A and PWMn_B) as independent channels or as a complementary pair.

56.3.10.1 Independent operation

In independent operation (write 1 to SM*n*_CTRL2[INDEP]), you control each PWM output with its own timing value pair: PWM23 controlled by timing value 2 (VAL2) and 3 (VAL3); PWM45 controlled by timing value 4 (VAL4) and 5 (VAL5).

56.3.10.2 Complementary operation

In complementary operation (write 0 to SM*n*_CTRL2[INDEP]), when one of the pair of signals is high, the other is low. Complementary channel pair illustrates the pairing of signals. You select whether to connect the internally generated PWM23 or PWM45 signal to the output pins (MCTRL[IPOL]).

Complementary channel operation can drive the top and bottom transistors in a motor drive circuit, as illustrated in Typical 3-phase AC motor drive.

Complementary operation allows the use of the deadtime insertion feature. See Deadtime insertion.

56.3.10.2.1 Complementary channel pair

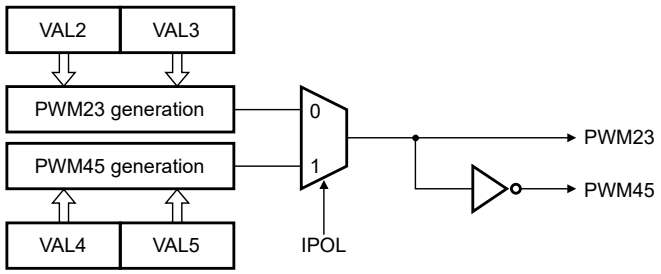

Figure 246. Complementary channel pair

56.3.10.2.2 Typical 3-phase AC motor drive

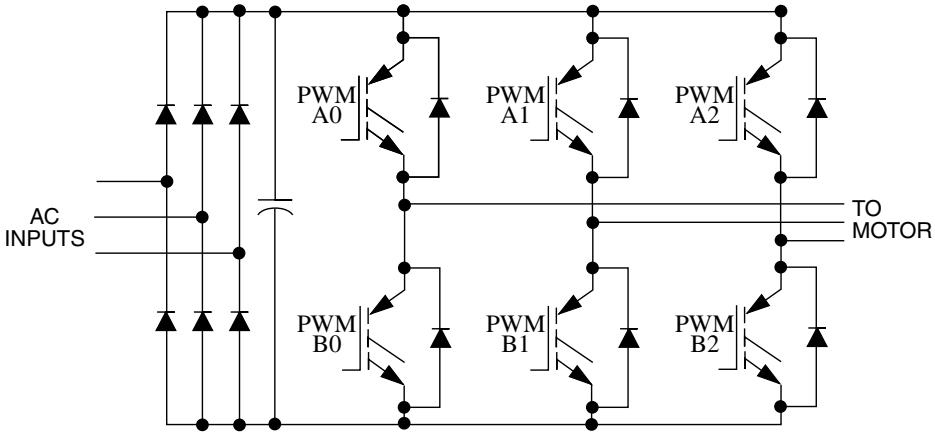

Figure 247. Typical 3-phase AC motor drive

56.3.11 Deadtime insertion

56.3.11.1 Deadtime insertion overview

Deadtime insertion allows you to create non-overlapping complementary PWM outputs. In complementary mode, when one PWM output (or channel) is active, the other PWM output is inactive, and vice versa. Deadtime insertion logic illustrates the deadtime insertion logic.

56.3.11.1.1 Deadtime insertion logic

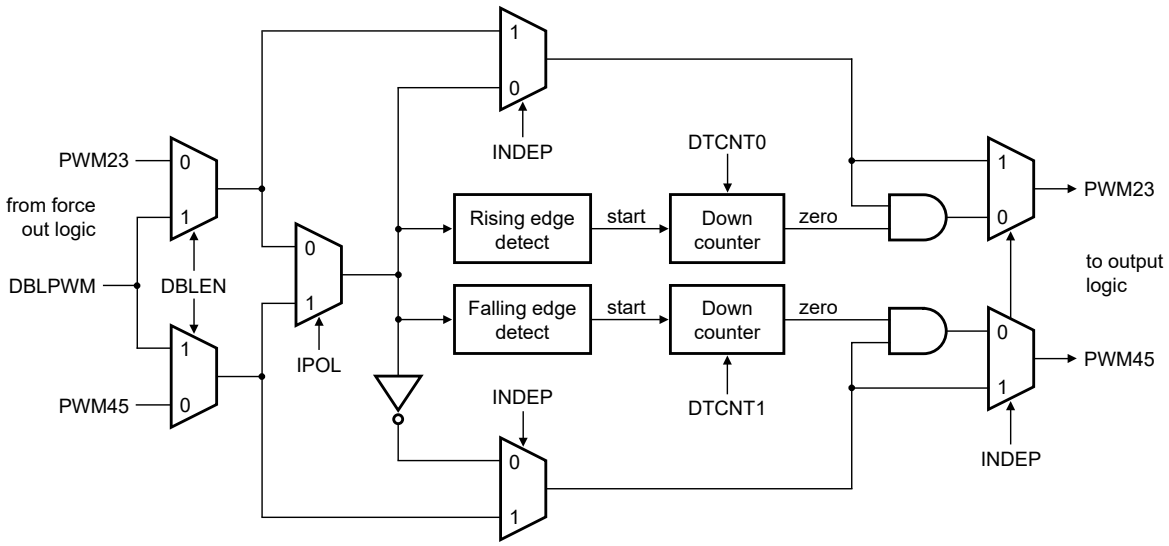

Figure 248. Deadtime insertion logic

56.3.11.2 Deadtime insertion operation

When you specify a deadtime delay (SM*n*_DTCNT0[DTCNT0] or SM*n*_DTCNT1[DTCNT1]), the deadtime generator inserts an activation delay of the specified number of IPBus clock cycles into the edge timing of the PWM outputs. Every time an input to the deadtime generator changes state, the generator inserts the deadtime delay before passing that signal on. Deadtime forces both PWM outputs of the pair to the inactive state, as illustrated in Deadtime insertion timing.

56.3.11.2.1 Deadtime insertion timing

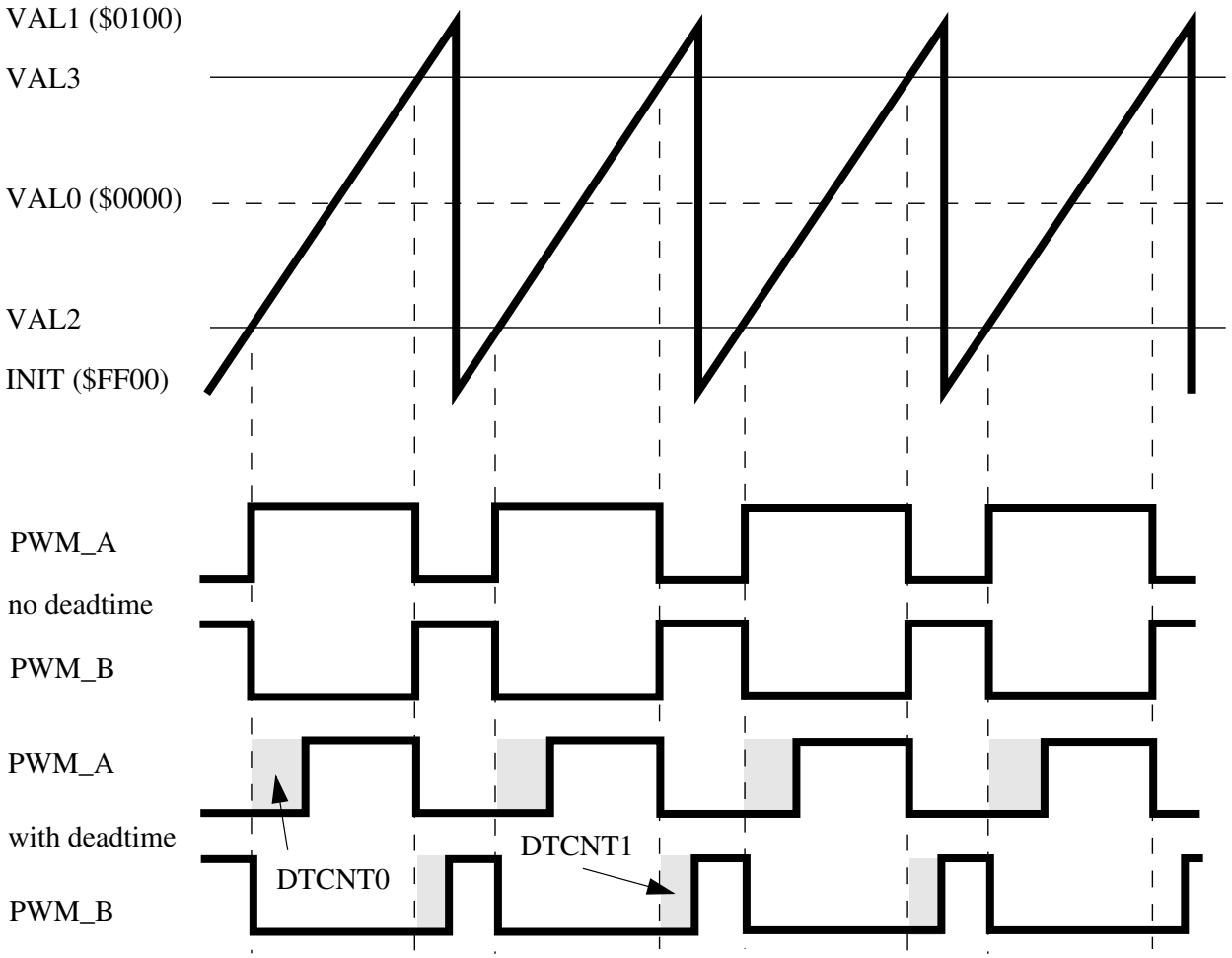

Figure 249. Deadtime insertion timing

56.3.11.3 Deadtime use case: avoiding overlapping conduction

A typical application for complementary channel operation is to use the pair of PWM outputs to drive a top/bottom transistor pair. However, when driving a top/bottom transistor pair, the transistor's characteristics may result in its switch-off time being longer than its switch-on time. This difference can cause overlapping conducting intervals which short circuit the DC bus and possibly damage the transistors.

To avoid overlapping conducting intervals, you must insert deadtime in the switching period.

56.3.11.4 Output voltage distortion resulting from deadtime insertion

When you connect a complementary pair of PWM outputs to an inverter to drive an inductive load, either the top or the bottom transistor controls the output voltage. you must insert a deadtime delay to avoid overlapping conducting intervals and the resulting DC bus short circuits. Deadtime drives both signals inactive and therefore turns both transistors off. With both transistors off, the output voltage is determined by the current load status, which in turn causes the waveform on the inverter output to have a different duty cycle than what appears on the output pins of the PWM module. This condition introduces distortion in the output voltage applied to the load.

See Deadtime distortion. On AC induction motors running open-loop, the distortion typically manifests itself as poor low-speed performance, such as torque ripple and rough operation.

During deadtime, load inductance distorts the output voltage by keeping current flowing through the diodes. This deadtime current flow creates a load voltage that varies with current direction. With a positive current flow, the load voltage during deadtime equals the bottom supply, putting the top transistor in control. With a negative current flow, the load voltage during deadtime equals the top supply, putting the bottom transistor in control.

56.3.11.4.1 Deadtime distortion

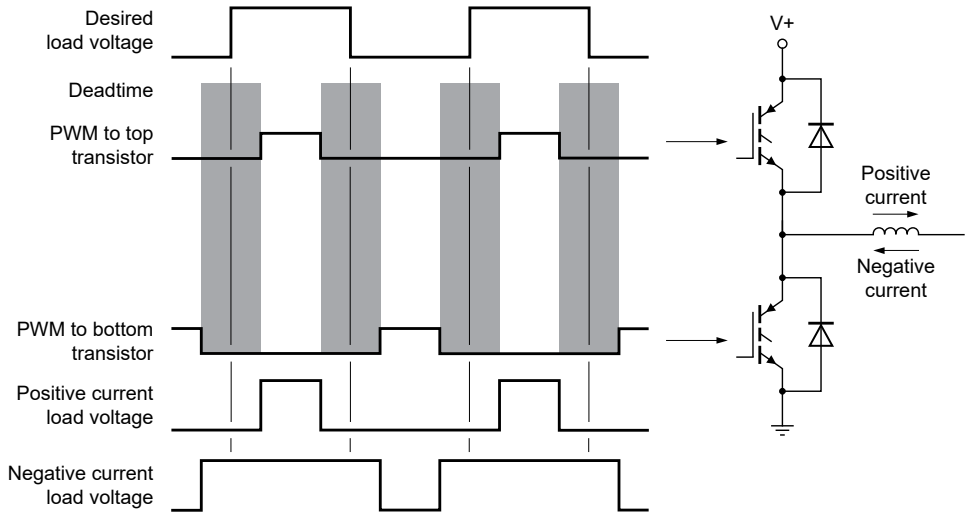

Figure 250. Deadtime distortion

56.3.11.5 Correcting deadtime-induced voltage distortion

One method for correcting deadtime-induced voltage distortion is to add or subtract a correction factor to or from the PWM timing values.

Remember that the original PWM pulse widths were shortened by deadtime insertion, and the averaged sinusoidal output is less than the desired value. However, inserting deadtime creates a distortion in the motor current waveform. This distortion is aggravated by dissimilar turn-on and turn-off delays of each of the transistors. By giving the submodule information about which transistor is in control at a given time, you can correct the distortion.

For a typical circuit in complementary channel operation, only one of the transistors control the output voltage at any given time, depending on the direction of the motor inverter current for that pair, as shown in Deadtime distortion. To correct the distortion, you must add one of two different factors to the appropriate timing value, depending on whether the top or bottom transistor controls the output voltage. Therefore, you must calculate both compensated timing values before writing them to the timing value registers.

Either the timing value 2-3 pair (SM*n*_VAL2[VAL2] and SM*n*_VAL3[VAL3]) or the Timing Value 4-5 pair (SM*n*_VAL4[VAL4] and SM*n*_VAL5[VAL5]) controls the pulse width at any given time. For a given pair, whether the pair is active depends on either:

- PWM*n*_X
- Corresponding bit of submodule current polarity (MCTRL[IPOL])

To correct deadtime distortion, decrease or increase the appropriate timing value:

- In edge-aligned operation, decrease or increase the timing value by a correction value equal to the deadtime.
- In center-aligned operation, decrease or increase the timing value by a correction value equal to one-half the deadtime.

56.3.11.6 Manual correction of output distortion

To detect the current deadtime status, poll deadtime (SM*n*_CTRL[DT]). The submodule samples the voltage of PWM*n*_X twice in each PWM period, at the end of each inserted deadtime, and stores the values in the deadtime bits. These bits provide a

timing marker to indicate when to toggle between PWM value registers. You poll the bits to know when to set current polarity (MCTRL[IPOL]) to switch between the timing value 2-3 (VAL2 and VAL3) and timing value 4-5 (VAL4 and VAL5) pairs.

56.3.11.7 Best time for switching between timing value pairs

If current is large and flowing out of the complementary circuit, both deadtime flip-flops latch low (SM*n*_CTRL[DT] equals 00b), during deadtime periods. If current is large and flowing into the complementary circuit, both flip-flops latch high (SM*n*_CTRL[DT] equals 11b) during deadtime periods. See Current status sense scheme for deadtime correction.

However, under low current, the output voltage of the complementary circuit during deadtime is somewhere between the high and low levels. The current cannot freewheel through the opposition anti-body diode, regardless of polarity, giving additional distortion when the current crosses zero. In this situation, the sampled Deadtime bits (SM*n*_CTRL[DT]) read 10b. Therefore, the best time to change one PWM value register to another is just before the current zero crossing. See Output voltage waveforms.

56.3.11.7.1 Current status sense scheme for deadtime correction

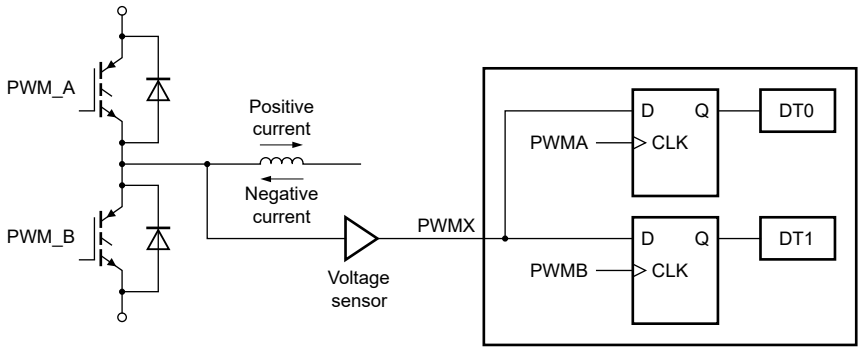

Figure 251. Current status sense scheme for deadtime correction

56.3.11.7.2 Output voltage waveforms

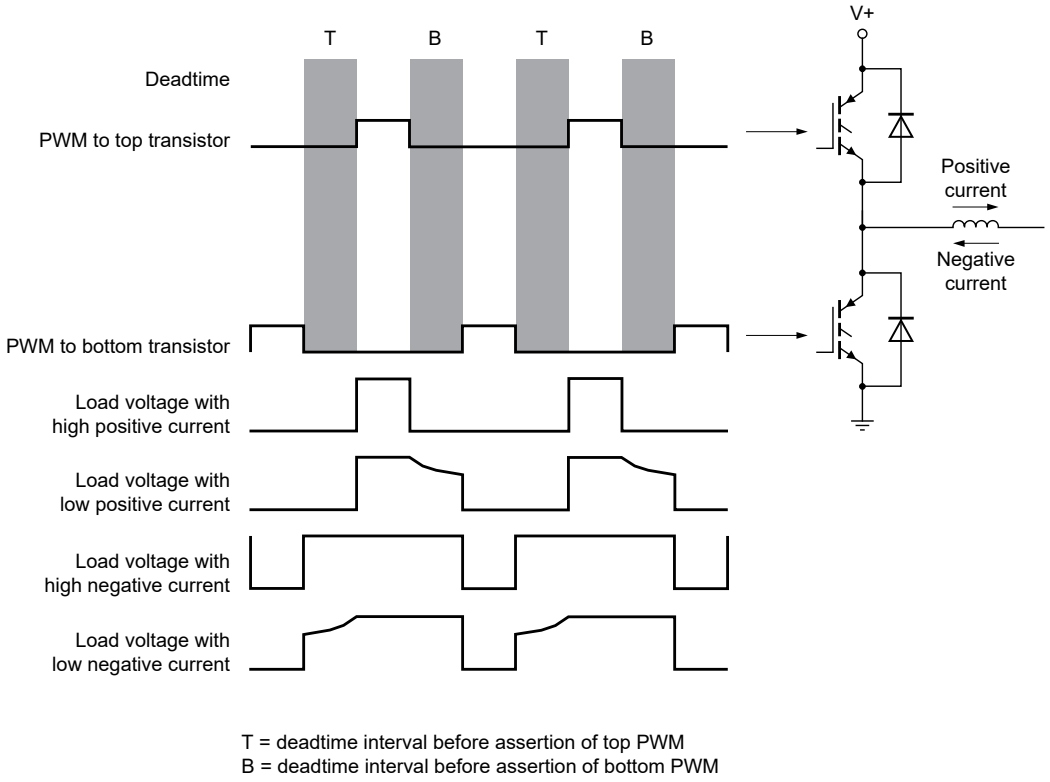

Figure 252. Output voltage waveforms

56.3.12 Fractional delay

56.3.12.1 Fractional delay overview

Fractional delay provides greater resolution for rising or falling edge timing, or for the PWM period width, than is possible with the submodule counter value by itself. When you enable fractional cycle placement (SM*n*_FRCTRL[FRAC*mm*_EN]), the submodule adds the fractional value to the corresponding timing value. See Fractional delay control.

56.3.12.2 Fractional delay control

Table 265. Fractional delay control

Output	Timing event	Enable fractional delay	Timing value	Fractional value
—	PWM period	SM*n*_FRCTRL[FRAC1_EN]	VAL1	SM*n*_FRACVAL1[FRACVAL1]
PWM*n*_A	Turn-on edge	SM*n*_FRCTRL[FRAC2 3_EN]	VAL2	SM*n*_FRACVAL2[FRACVAL2]
PWM*n*_A	Turn-off edge	SM*n*_FRCTRL[FRAC2 3_EN]	VAL3	SM*n*_FRACVAL3[FRACVAL3]
PWM*n*_B	Turn-on edge	SM*n*_FRCTRL[FRAC4 5_EN]	VAL4	SM*n*_FRACVAL4[FRACVAL4]

Table continues on the next page...

Table 265. Fractional delay control (continued)

Output	Timing event	Enable fractional delay	Timing value	Fractional value
PWM*n*_B	Turn-off edge	SM*n*_FRCTRL[FRAC45_EN]	VAL5	SM*n*_FRACVAL5[FRACVAL5]

56.3.12.3 Fractional delay behavior with NanoEdge placement

NanoEdge placement allows you to control every timing event—the rising or falling edge of a PWM pulse or the PWM period—to a granularity of 1/32 of the input clock cycle for every occurrence of the timing event.

To use NanoEdge placement:

1. Select no divider (000b) for the prescaler (SM*n*_CTRL[PRSC]).
2. Power up the submodule NanoEdge placer (SM*n*_FRCTRL[FRAC_PU])
3. Enable fractional placement for the selected timing events (SM*n*_FRCTRL[FRAC23_EN]).
4. Specify a fractional value for the corresponding event.

   The fractional value specifies how many 32nds of an input clock cycle to add to the timing value for the corresponding timing event.

Example 1: To cause the rising edge of the PWM*n*_A output to occur at 12.25 clock cycles into the PWM period, specify Ch (12d) for Timing Value 2 (VAL2) and 8h (8/32 equals .25) for fractional value 2 (SM*n*_FRACVAL2[FRACVAL2]).

Example 2: To cause the PWM period to be 20.5 clock cycles long, specify 14h (20d) for timing value 1 (VAL1) and 10h (16/32 equals .5) for Fractional Value 1 (SM*n*_FRACVAL1[FRACVAL1]).

NOTE

Check the data sheet for this chip to determine the necessary clock frequency for proper NanoEdge operation. Submodules that do not support the NanoEdge placer have no clock frequency restrictions.

If all submodule NanoEdge placers are powered down (SM*n*_FRCTRL[FRAC_PU] is 0000b), eFlexPWM can operate at alternate clock frequencies.

56.3.12.4 Fractional delay behavior without NanoEdge placement

If NanoEdge is powered down (SM*n*_FRCTRL[FRAC_PU] is 0000b), fractional delay uses dithering to specify the average time for timing events—the rising or falling edge of a PWM pulse or the PWM period—to a granularity of 1/32 of a submodule counter unit. Dithering involves accumulating the specified fractional delay value until it equals a full submodule counter unit. When the accumulated delay equals a full counter unit, the submodule adds one count to the corresponding timing value for a single event and clears the accumulated delay. Over time, the dithered (periodic) addition of a counter unit causes the timing to average out to the specified timing value plus fractional delay.

Example: To generate a PWM period of 50.25 counts, specify 32h (50d) for timing value 1 (VAL1) and 8h (8/32 equals .25) for fractional value 1 (SM*n*_FRACVAL1[FRACVAL1]). The PWM period is 50 counts for three periods, then 51 counts for one period. In other words, the PWM period is 51 counts every fourth period, for an average over time of 50.25 counts.

56.3.13 Output logic

For maximum flexibility, each PWM output has individual fault disabling, polarity control, and output enable. Output logic illustrates the output logic of each submodule.

The PWM23 and PWM45 signals coming from the deadtime logic are positive true signals. In other words, a high level on one of these signals causes the corresponding transistor in the PWM inverter to be turned on. The voltage level required at the PWM output pin to turn the transistor on or off is a function of the logic between the pin and the transistor. Therefore, you must program the output polarity (SM*n*_OCTRL[POLA] and SM*n*_OCTRL[POLB]) before enabling the output pins. A fault condition can cause the PWM output to be tristated, forced to a logic 1, or forced to a logic 0, depending on the corresponding fault state (SM*n*_OCTRL[PWMAFS]).

56.3.13.1 Output logic

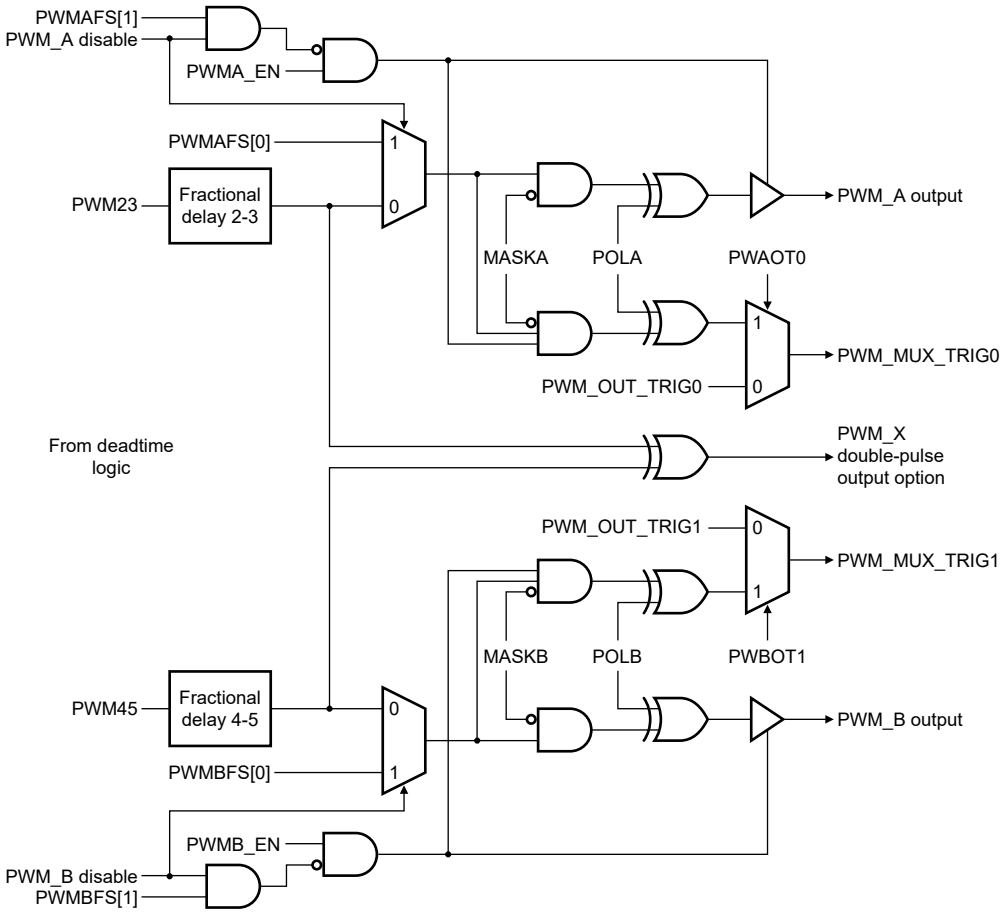

Figure 253. Output logic

56.3.14 Enhanced capture (E-Capture)

56.3.14.1 E-Capture overview

Each eFlexPWM submodule uses a counter and several timing value registers to generate the rising and falling edges of pulses on the PWM*n*_A, PWM*n*_B, PWM*n*_X signals. If you do not use one of these signals for PWM output, you can use that signal as an input to the Enhanced Capture (E-Capture) logic to detect and capture the rising and falling edges of pulses on a PWM input signal. You can use that information to measure the period or pulse width, count the number of edges, and trigger CPU Interrupt Requests (IRQs) or DMA read requests based on those edges.

See E-Capture logic and E-Capture capabilities.

56.3.14.1.1 E-Capture logic

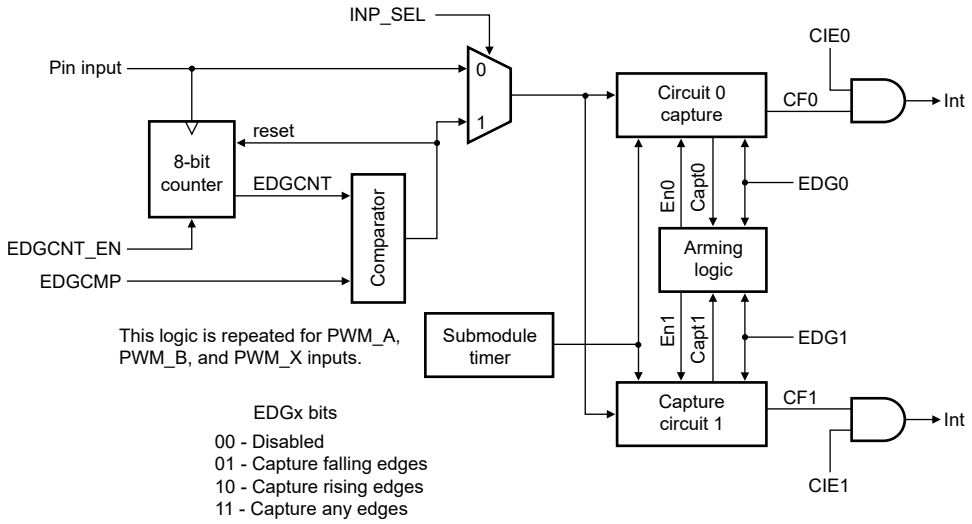

Figure 254. E-Capture logic

56.3.14.1.2 E-Capture capabilities

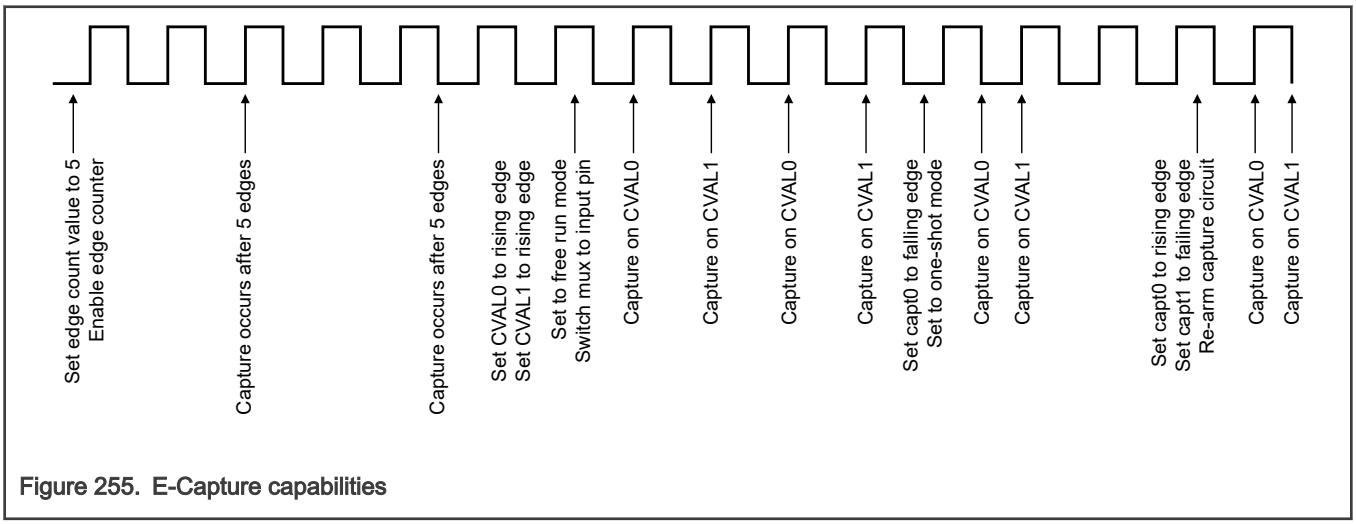

Figure 255. E-Capture capabilities

56.3.14.2 Capture circuits and input selection

As illustrated in E-Capture logic, you can route the raw input signal directly to a pair of capture circuits (SM*n*_CAPTCTRL*m*[INP_SEL*m*]). The capture circuits work singly or in tandem to capture sequential edges on the input signal. Each circuit can capture:

- Only rising edges
- Only falling edges
- Both rising and falling edges

To select which edges each capture circuit is to capture or to disable the circuit, use the edge fields (SM*n*_CAPTCTRL*m*[EDG*m*0] and SM*n*_CAPTCTRL*m*[EDG*m*1]).

By selecting the edges to be captured by each circuit, you can measure the PWM period (for example, from first rising edge to next rising edge) or pulse width (from rising edge to next falling edge) of an input signal.

56.3.14.3 Edge counter

Before the input signal reaches the capture circuits, you can route it through an 8-bit edge counter and specify a target count value. The counter increments on every edge of the input signal. When the target number of edges occur, the counter arms the capture circuits and resets. For example, if the target count value is five, the counter arms the capture circuits every five edges.

56.3.14.4 Enabling and arming edge capture

To capture edges on the input signal, you must enable one or both capture circuits (SM*n*_CAPTCTRL*m*[EDG*m*0] or SM*n*_CAPTCTRL*m*[EDG*m*1]) and arm the capture logic (SM*n*_CAPTCTRL*m*[ARM*m*]).

56.3.14.5 Edge capture action

When you enable and arm a capture circuit, it detects and captures the type of edge that you configure it to capture. The capture action saves the submodule counter value and the number of PWM periods (SM*n*_CVAL*m*CYC) and reloads the submodule counter with the initial count (SM*n*_INIT[INIT]).

56.3.14.5.1 One-shot capture operation

The pair of capture circuits supports one-shot or free-running (continuous) operation (SM*n*_CAPTCTRL*m*[ONESHOT*m*]).

In one-shot operation, the circuits capture one or two edges, depending on which capture circuits you enable.

If you enable only one capture circuit and arm the capture logic, the enabled circuit captures the next edge of the type it is configured to capture and then disarms.

If you enable both capture circuits and arm the capture logic, capture circuit 0 arms first. When it captures an edge, it becomes disarmed and arms capture circuit 1. When capture circuit 1 captures an edge, it also becomes disarmed.

After a one-shot capture operation occurs, you must re-arm the logic for another capture operation.

56.3.14.5.2 Enabling and arming edge capture

For free-running operation, you must enable both capture circuits, select free-running mode, and arm the capture logic. Capture circuit 0 becomes armed first. When it has captured an edge, it becomes disarmed and arms capture circuit 1. When capture circuit 1 captures an edge, it becomes disarmed and rearms circuit 0. In this way, the two circuits continue taking turns capturing edges until you disarm them.

56.3.14.6 Begin E-Capture process

To being capture operation:

1. Select the raw input signal or the edge-counter-and-compare output for capturing (SM*n*_CAPTCTRL*m*[INP_SEL*m*]).
2. On each capture circuit, disable the circuit or select which edges to capture (SM*n*_CAPTCTRL*m*[EDG*m*1] and SM*n*_CAPTCTRL*m*[EDG*m*0]).
3. To enable CPU interrupt requests, see Enable E-Capture CPU interrupt requests.
4. To enable DMA read requests, see Enable E-Capture DMA read requests.

> **NOTE**
>
> Do not enable both CPU interrupt requests and DMA read requests on the same capture circuit.

5. Select free-running or one-shot operation (SM*n*_CAPTCTRL*m*[ONESHOT*m*]).
6. Arm the input capture process (write 1 to SM*n*_CAPTCTRL*m*[ARM*m*]).

56.3.14.6.1 Enable E-Capture CPU interrupt requests

To trigger an interrupt request (IRQ) to the CPU on the occurrence of a capture event:

- Enable capture interrupt on the desired PWM signal and capture circuit (SM*n*_INTEN[CA1IE], SM*n*_INTEN[CA0IE], SM*n*_INTEN[CB1IE], SM*n*_INTEN[CB0IE], SM*n*_INTEN[CX1IE] or SM*n*_INTEN[CX0IE]).

When the associated capture FIFO (SM*n*_CAPTCTRL*m*[C*m*1CNT] or SM*n*_CAPTCTRL*m*[C*m*0CNT]) exceeds the capture FIFOs watermark (SM*n*_CAPTCTRL*m*[CF*m*WM]), the submodule sets the associated capture flag (SM*n*_STS[CFA1], SM*n*_STS[CFA0], SM*n*_STS[CFB1], SM*n*_STS[CFB0], SM*n*_STS[CFX1] or SM*n*_STS[CFX0]), which in turn triggers an IRQ to the CPU.

56.3.14.6.2 Enable E-Capture DMA read requests

To trigger a DMA read request on the occurrence of a capture event:

1. Specify the logic operation for FIFO watermark control (SM*n*_DMAEN[FAND]).

   The logic operation determines if exceeding any enabled FIFO watermark (OR operation) triggers the request, of if all enabled FIFO watermarks (AND operation) must be exceeded to trigger the request.

2. Select "exceeding a FIFO watermark" for the capture DMA enable source (SM*n*_DMAEN[CAPTDE]).
3. Enable FIFO DMA request for the required PWM signals and capture circuits (SM*n*_DMAEN[CA1DE], SM*n*_DMAEN[CA0DE], SM*n*_DMAEN[CB1DE], SM*n*_DMAEN[CB0DE], SM*n*_DMAEN[CX1DE] or SM*n*_DMAEN[CX0DE]).

When the capture FIFO word count (SM*n*_CAPTCTRL*m*[C*m*1CNT] or SM*n*_CAPTCTRL*m*[C*m*0CNT]) exceeds the capture FIFOs watermark (SM*n*_CAPTCTRL*m*[CF*m*WM]), the submodule sets the associated capture flag (SM*n*_STS[CFA1], SM*n*_STS[CFA0], SM*n*_STS[CFB1], SM*n*_STS[CFB0], SM*n*_STS[CFX1] or SM*n*_STS[CFX0]), which in turn triggers the DMA read request.

56.3.14.7 Measuring output period or pulse width

When you use a submodule for PWM generation, the submodule loads the submodule counter (SM*n*_CNT[CNT]) with the initial counter value (SM*n*_INIT[INIT]) and the counter counts up to timing value 1 (SM*n*_VAL1[VAL1]), the modulo value that specifies the PWM period. When the counter reaches VAL1, the submodule reloads the counter with INIT. Therefore, using this counter for input captures on one of the other outputs (for example, PWM*n*_X) has limited utility because it does not count through the full range of the 16-bit counter value.

However, the submodule counter modulus range is perfectly suited to measuring a signal that is synchronous to the PWM frequency. See E-Capture output pulse width measurement for an illustration. In this application the output of a PWM power stage is connected to the PWM*n*_X pin, which in turn is routed to the capture circuits for free-running captures. Specifically, capture circuit 0 (SM0_CVAL0[CAPTVAL0]) is capturing rising edges and capture circuit 1 (SM0_CVAL1[CAPTVAL1]) is capturing falling edges. Between the two circuits, they capture new pulse width data every PWM period. To calculate the pulse width, simply subtract CAPTVAL0 from CAPTVAL1.

This measurement is extremely helpful when performing dead-time distortion correction on a half-bridge circuit driving an inductive load. Also, you can measure system propagation delays by comparing these values to the timing value registers (SMnVALm) that control the PWM output.

56.3.14.7.1 E-Capture output pulse width measurement

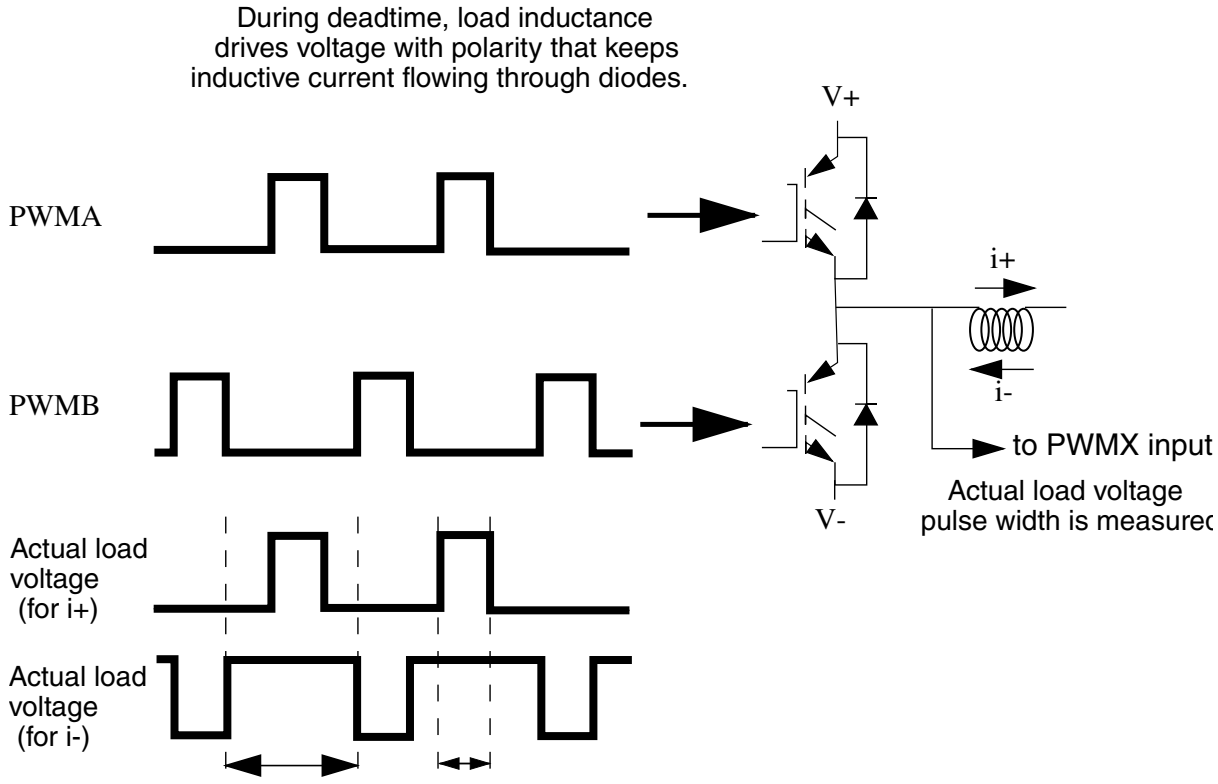

Figure 256. E-Capture output pulse width measurement

56.3.15 Fault protection

eFlexPWM provides a fault protection mechanism that can control any combination of PWM output pins based on fault signal inputs.

56.3.15.1 Fault protection overview

Either a logic 0 or a logic 1 on any FAULT*m* pin generates a fault, depending on the Fault Level (FP*n*_CTRL[FLVL]).

Use the Submodule Fault Channel Mapping (Submodule a Fault Disable Mapping (SM0_DISMAP0 - SM3_DISMAP0) or Submodule a Fault Disable Mapping (SM0_DISMAP1 - SM3_DISMAP1)) registers to map each FAULT*m* pin to any of the PWM outputs. Each field of Submodule a Fault Disable Mapping (SM0_DISMAP0 - SM3_DISMAP0) or Submodule a Fault Disable Mapping (SM0_DISMAP1 - SM3_DISMAP1) controls the mapping for a single PWM pin.

When the fault decoder detects a triggering level on one of the FAULT*m* pins, the PWM generator continues to run but the fault decoder forces the mapped output pins to logic 0, logic 1, or tristated, based on the PWM*n*_A, PWM*n*_B, and PWM*n*_X Fault States (SM*n*_OCTRL[PWMAFS]).

See Fault decoder for PWM*n*_A for an example of the fault disable logic.

Fault protection operates even when the PWM generator is not running; therefore, to prevent an interrupt when a PWM generator starts, you must clear any latched-in faults before starting the PWM generator.

56.3.15.1.1 Fault decoder for PWM*n*_A

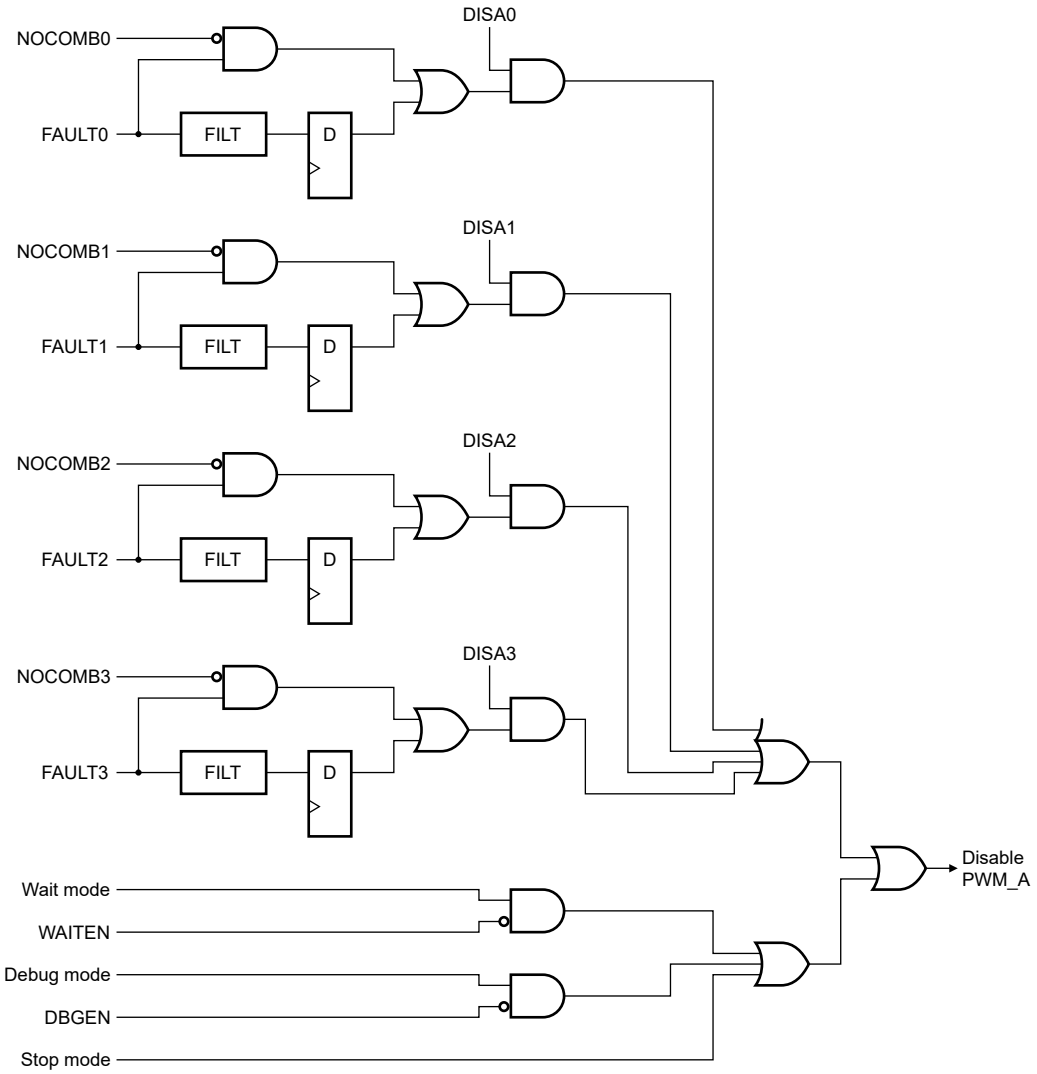

Figure 257. Fault decoder for PWMn_A

56.3.15.2 Fault pin filter

Each fault pin has a programmable filter with the following controls:

Control	Description	Register[field]
Fault level	The polarity (logic 0 or 1) of a FAULT*m* pin that triggers a fault	FP*n*_CTRL[FLVL]
Fault filter sampling period	The filter sampling period in clock cycles	FP*n*_FILT[FILT_PER] > 00h
Fault filter count	The number of consecutive samples minus three that must agree before the input filter accepts an input transition	FP*n*_FILT[FILT_CNT]
Filter bypass	The fault channel bypasses the input filter	FP*n*_FILT[FILT_CNT] = 00h

When eFlexPWM detects a logic 0 or logic 1 on the filtered FAULT*m* pin, depending on the corresponding Fault Level bit (FP*n*_CTRL[FLVL], it sets the corresponding Filtered Fault Pin (FP*n*_STS[FFPIN]) and Fault Flag (FP*n*_STS[FFLAG]). The Filtered Fault Pin bit remains set as long as the filtered FAULT*m* pin remains at the triggering level.

Clear the Fault Flag (FP*n*_STS[FFLAG]) by writing 1 to it.

If the corresponding Fault Interrupt Enable (FP*n*_CTRL[FIE]) is enabled, a Fault Flag generates a CPU interrupt request. The interrupt request remains latched until one of the following conditions occurs:

- You clear the corresponding Fault Flag (FP*n*_STS[FFLAG]) by writing 1 to it.
- You disable the corresponding Fault Interrupt (FP*n*_CTRL[FIE]) by writing 0 to it.
- The system resets.

NOTE

Even with the filter enabled, there is a combinational path from the FAULT*m* inputs to the PWM pins. This logic can also hold a fault condition in the event of loss of clock to eFlexPWM.

56.3.15.3 Automatic fault clearing

To automatically clear faults triggered by a FAULT*m* pin, enable automatic fault clearing (FP*n*_CTRL[FAUTO]) for that pin. Each bit of FAUTO corresponds to the like-numbered fault.

If you enable automatic fault clearing, eFlexPWM clears faults and re-enables any disabled PWM pins when the FAULT*m* pin returns to logic 1 and:

- If full period fault recovery (FP*n*_STS[FFULL]) is enabled, at the beginning of a full period.
- If half period fault recovery (FP*n*_STS[FHALF]) is enabled, at the beginning of a half period.

If you enable automatic fault clearing, clearing a fault flag (FP*n*_STS[FFLAG]) does not affect disabled PWM pins.

See Automatic fault clearing.

56.3.15.3.1 Automatic fault clearing

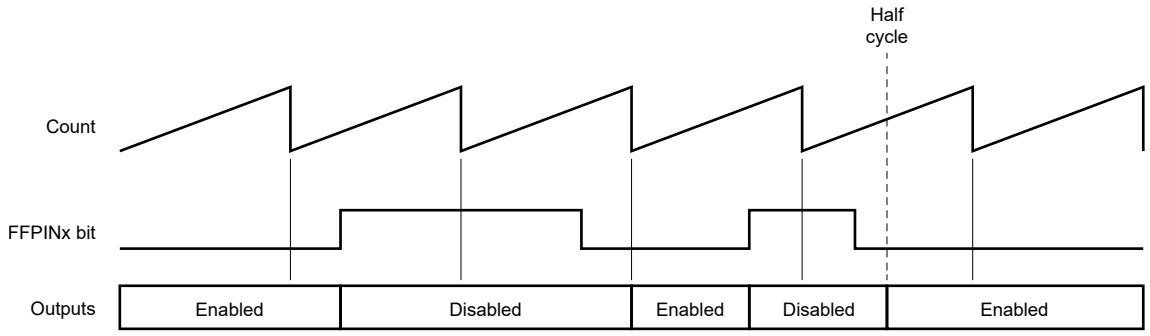

Figure 258. Automatic fault clearing

56.3.15.4 Manual fault clearing

To manually clear faults triggered by FAULT*m* pin, disable automatic fault clearing (FP*n*_CTRL[FAUTO]) for that pin. Each bit of FAUTO corresponds to the like-numbered fault.

If you disable automatic fault clearing, when eFlexPWM clears faults depends on the fault safety Mode (FP*n*_CTRL[FSAFE]):

- In Normal mode, eFlexPWM re-enables FAULT-disabled PWM pins:
  - When you clear the corresponding fault flag (FP*n*_STS[FFLAG])

— If the corresponding full period fault recovery bit (FP*n*_STS[FFULL]) is 1, at the start of a full period, regardless of the logic level detected by the filter at the FAULT*m* pin (see Manual fault clearing in normal mode).

— If the corresponding half period fault recovery bit (FP*n*_STS[FHALF]) is 1, at the start of a half period, regardless of the logic level detected by the filter at the FAULT*m* pin (see Manual fault clearing in normal mode).

- In Safe mode, eFlexPWM re-enables FAULT-disabled PWM pins:
  — When you clear the corresponding fault flag (FP*n*_STS[FFLAG])
  — The filter detects a logic zero on the FAULT*m* pin at the start of the next PWM full-period boundary and the corresponding full period fault recovery bit (FP*n*_STS[FFULL]) is 1 (see Manual fault clearing in safe mode).
  — The filter detects a logic zero on the FAULT*m* pin at the start of the next PWM half-period boundary and the corresponding half period fault recovery bit (FP*n*_STS[FHALF]) is 1 (see Manual fault clearing in safe mode).

NOTE

Fault protection also applies during software output control (DTSRCSEL[SM*n*SEL23] is 10b; DTSRCSEL[SM*n*SEL45] is 10b) or external signal control (DTSRCSEL[SM*n*SEL23] is 11b; DTSRCSEL[SM*n*SEL45] is 11b). Fault clearing still occurs at half-period boundaries while the PWM generator is enabled (MCTRL[RUN]). But SWCOUT[SM*n*OUT23] or SWCOUT[SM*n*OUT45] can control the PWM pins while the PWM generator is disabled. Therefore, fault clearing occurs at IPBus cycles while the PWM generator is off and at the start of PWM periods when the generator is running.

56.3.15.4.1 Manual fault clearing in normal mode

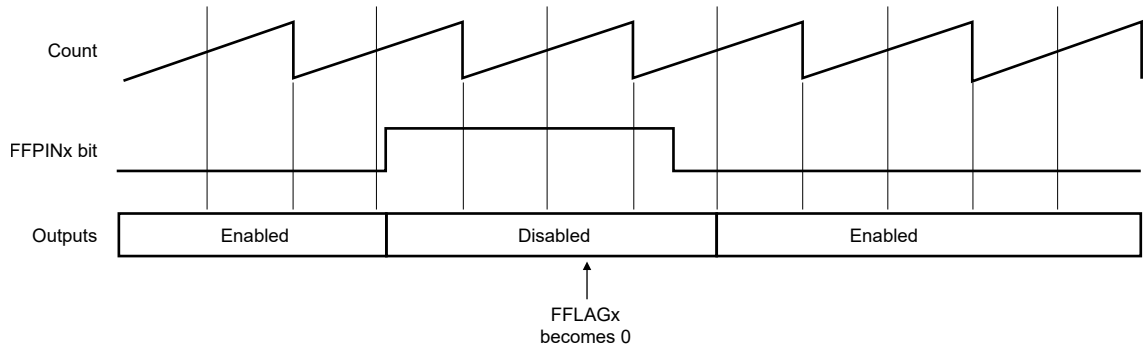

Figure 259. Manual fault clearing in normal mode

56.3.15.4.2 Manual fault clearing in safe mode

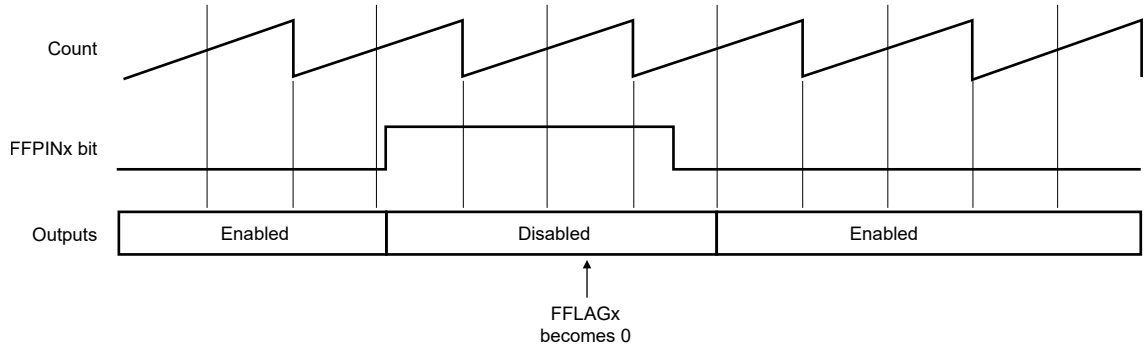

Figure 260. Manual fault clearing in safe mode

56.3.15.4.3 Fault testing

Use fault test (FP*n*_TST[FTEST]) to simulate a fault condition on each of the fault inputs within the fault channel.

56.3.16 PWM generator loading

56.3.16.1 Load PWM generator parameters

eFlexPWM provides a mechanism to update all of the PWM generator parameters for a specific submodule synchronously.

To load the submodule PWM generator parameters:

1. Select the submodule load mode (SM*n*_CTRL[LDMOD]).

   Load mode determines when to load the registers from their buffers, either on the next PWM reload or on load okay assertion.

2. If you select next PWM reload, you can also select half-period reload (HALF), full-period reload (FULL), or both.

   Half-period reload loads the buffered data into the PWM generator registers when the submodule counter matches timing value 0.

   Full-period reload loads the buffered data when the counter matches timing value 1.

3. Calculate and write values for the following submodule parameters to their respective buffered registers:
   - Prescaler divisor (SM*n*_CTRL[PRSC])
   - Initial count (SM*n*_INIT[INIT])
   - Timing values (VAL0, VAL1, VAL2, VAL3, VAL4, VAL5)
   - Fractional timing values (SM*n*_FRACVAL1[FRACVAL1], SM*n*_FRACVAL2[FRACVAL2], SM*n*_FRACVAL3[FRACVAL3], SM*n*_FRACVAL4[FRACVAL4], SM*n*_FRACVAL5[FRACVAL5])
4. Read the submodule load okay bit (MCTRL[LDOK]). If it is zero, proceed to step 5.
5. Write 1 to the submodule load okay bit (MCTRL[LDOK]).

   Bit 0 controls submodule 0 loading, bit 1 controls submodule 1, and so on.

   When you set the bit, eFlexPWM transfers the buffered values to the registers as specified by the load mode (see step 1).

56.3.16.2 Select load frequency

eFlexPWM allows you to specify the load frequency, or how often to load the PWM generator parameters. The frequency is specified in PWM opportunities.

You determine the PWM opportunities by enabling half-period reload (SM*n*_CTRL[HALF]), full-period reload (SM*n*_CTRL[FULL]), or both. If you enable only half-period reload, the PWM opportunity happens once every PWM period at the half-period, when the submodule counter matches timing value 0 (SM*n*_VAL0[VAL0]). See Half-period reload. Note that the half-period point is not necessarily half of the PWM period.

If you enable only full-period reload, the PWM opportunity happens once at the end of every PWM period, when the submodule counter matches Timing Value 1 (SM*n*_VAL1[VAL1]). See Full-period reload.

If you enable both half-period and full-period reload, you have two PWM opportunities per PWM period. See Full- and half-period reload.

When you have specified the PWM opportunities, you then specify the load frequency (SM*n*_CTRL[LDFQ]), anywhere from every opportunity to every 16 opportunities. When you specify the load frequency, it takes effect at the next PWM reload opportunity, regardless the state of load okay (MCTRL[LDOK]).

56.3.16.2.1 Half-period reload

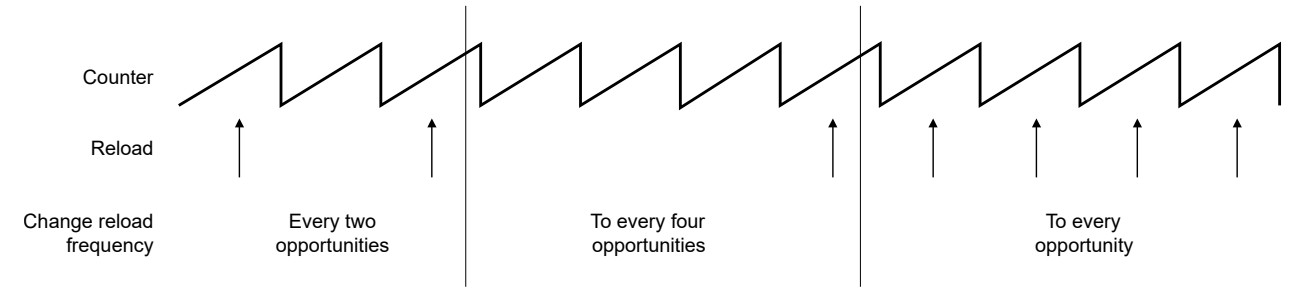

Figure 261. Half-period reload

56.3.16.2.2 Full-period reload

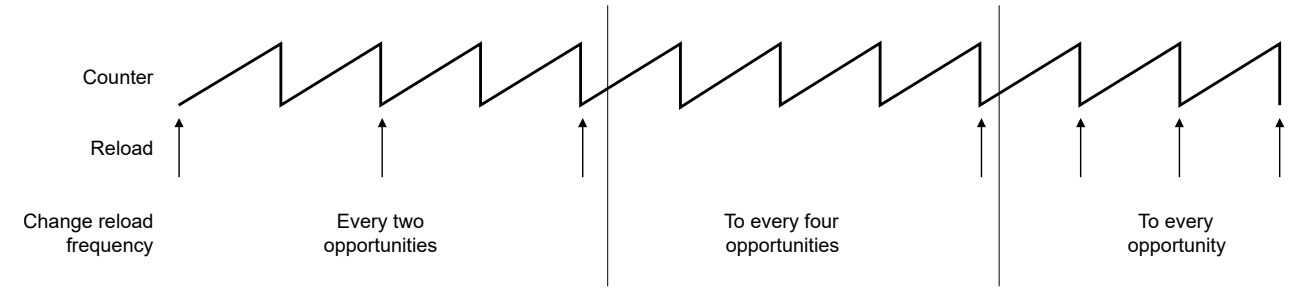

Figure 262. Full-period reload

56.3.16.2.3 Full- and half-period reload

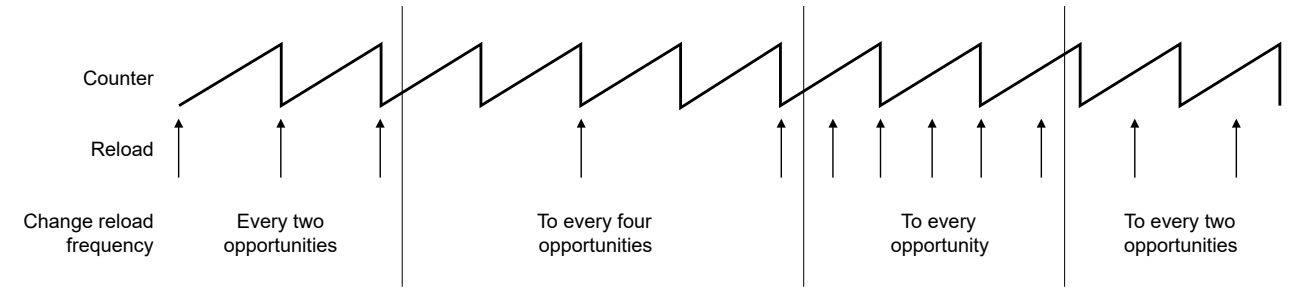

Figure 263. Full- and half-period reload

56.3.16.3 Reload interrupt requests

At every reload opportunity, the submodule sets the reload flag (SM*n*_STS[RF]), even if load okay (MCTRL[LDOK]) is zero. If reload interrupt enable (SM*n*_INTEN[RIE]) is enabled and the reload flag is set, the submodule sends reload interrupt requests to the CPU allowing software to calculate new PWM parameters in real time. If reload interrupt is not enabled, the submodule still reloads PWM parameters at the selected reload frequency without generating CPU interrupt requests, as illustrated in the following figure.

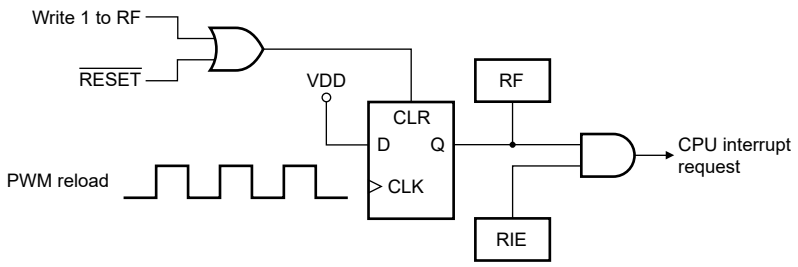

Figure 264. Reload interrupt requests

56.3.16.3.1 Reload interrupt logic

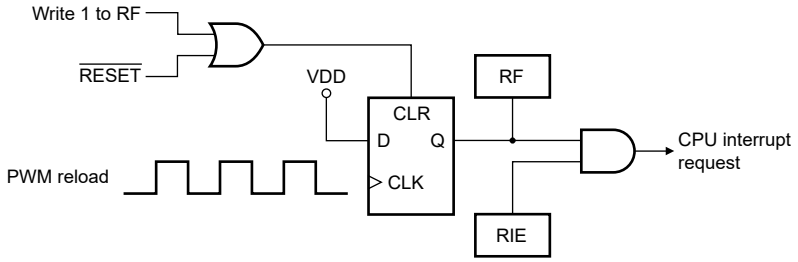

Figure 265. Reload interrupt logic

56.3.16.4 Reload errors

Whenever you update a timing value, a fractional timing value, or the prescaler divisor, the submodule sets the registers updated flag (SM*n*_STS[RUF]) to indicate that the PWM generator data is not coherent. The data is not coherent when there are values in the register buffers that have not yet been loaded into the registers. The submodule clears the registers updated flag when a successful reload occurs, that is, when the reload flag (SM*n*_STS[RF]) is set and load okay is enabled at a PWM opportunity. If the registers updated flag is set and load okay (MCTRL[LDOK]) is zero when the reload signal occurs, a reload error occurs and the submodule sets the reload error flag (SM*n*_STS[REF]). If the registers updated flag is clear when a reload signal asserts, then the data is coherent and no error occurs.

56.3.16.5 Start the PWM generator

You should initialize all of the PWM generator registers and enable load okay (MCTRL[LDOK]) before you start the PWM generator (MCTRL[RUN]).

NOTE

Even if load okay is not enabled, starting the PWM generator also sets the reload flag (SM*n*_STS[RF]). To prevent a CPU interrupt request caused by the reload flag, disable reload interrupt enable (SM*n*_INTEN[RIE]) before starting the PWM generator.

If you stop the PWM generator and then start it again while load okay is disabled, the PWM generator uses the last loaded values.

When you stop the PWM generator (write 0 to MCTRL[RUN]):

- The reload flag (SM*n*_STS[RF]) and pending CPU interrupt requests are not cleared.
- All fault circuitry remains active.
- Software and external output control remains active.
- Deadtime insertion continues during software and external output control.

56.3.17 Hardware ADC triggering

56.3.17.1 Hardware ADC triggering overview

The timing of ADC triggers is critical and therefore they must be scheduled as hardware events rather than be activated by software. eFlexPWM can generate multiple hardware triggers per PWM period or across multiple PWM periods without the need for another timer module.

56.3.17.2 Multiple triggers within a single PWM period

Multiple output triggers within a single PWM period illustrates the generation of multiple output triggers that must occur within the same PWM period. Using one submodule in complementary mode operation, you need only two timing values (VAL2 and VAL3 in the example) to generate a PWM output signal. This leaves the other timing values free to perform other functions. Software is not needed to generate triggers after the first conversion.

56.3.17.2.1 Multiple output triggers within a single PWM period

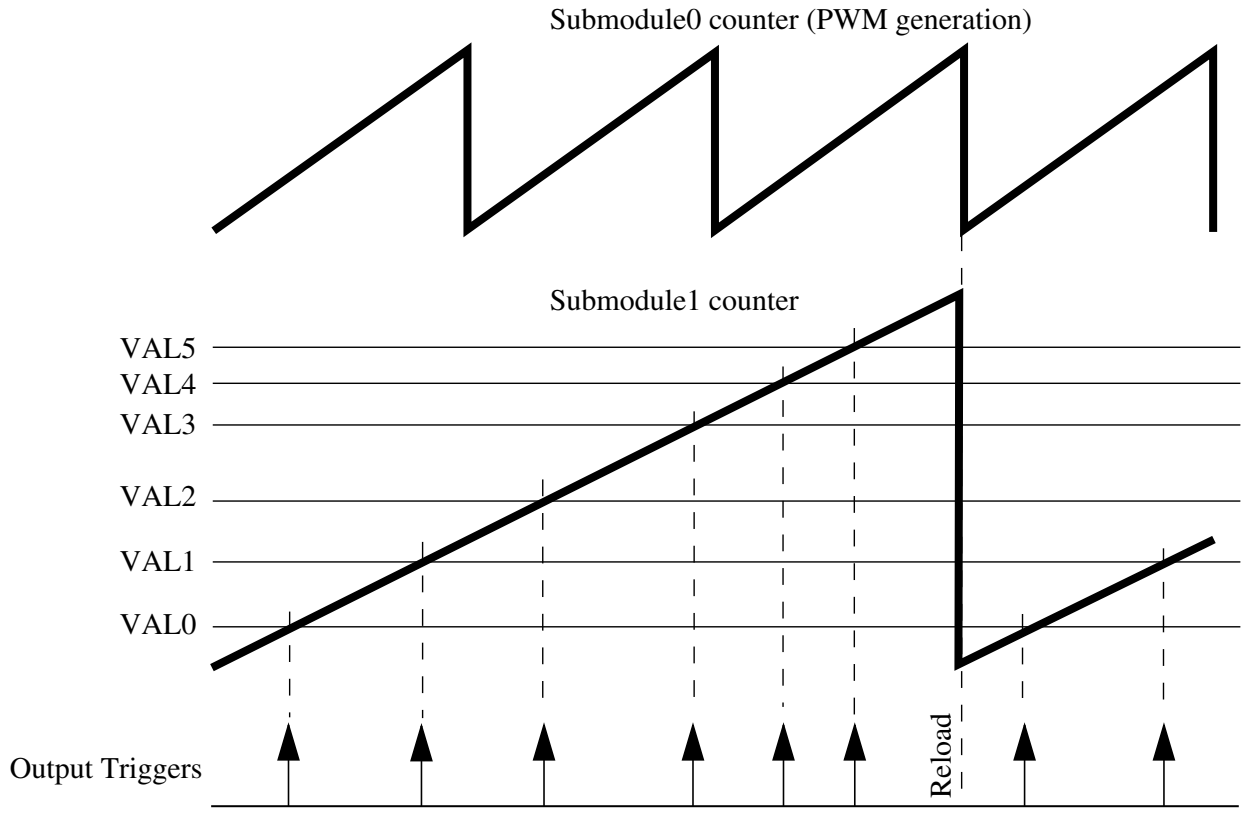

Figure 266. Multiple output triggers within a single PWM period

56.3.17.3 Multiple triggers across multiple PWM periods

Because each submodule has its own counter, it can run at a different PWM frequency from the other submodules. Therefore, one or more submodules can run at a lower frequency than submodule 0 but still be synchronized to the submodule 0 counter. Multiple output triggers over several PWM periods shows how to schedule hardware triggers over multiple PWM cycles. One application for this configuration is to use the lower-frequency submodule to control the sampling frequency of the software control algorithm and schedule multiple hardware triggers over the entire sampling period. This example uses all of the timing values of the lower-frequency submodule for ADC trigger generation.

56.3.17.3.1 Multiple output triggers over several PWM periods

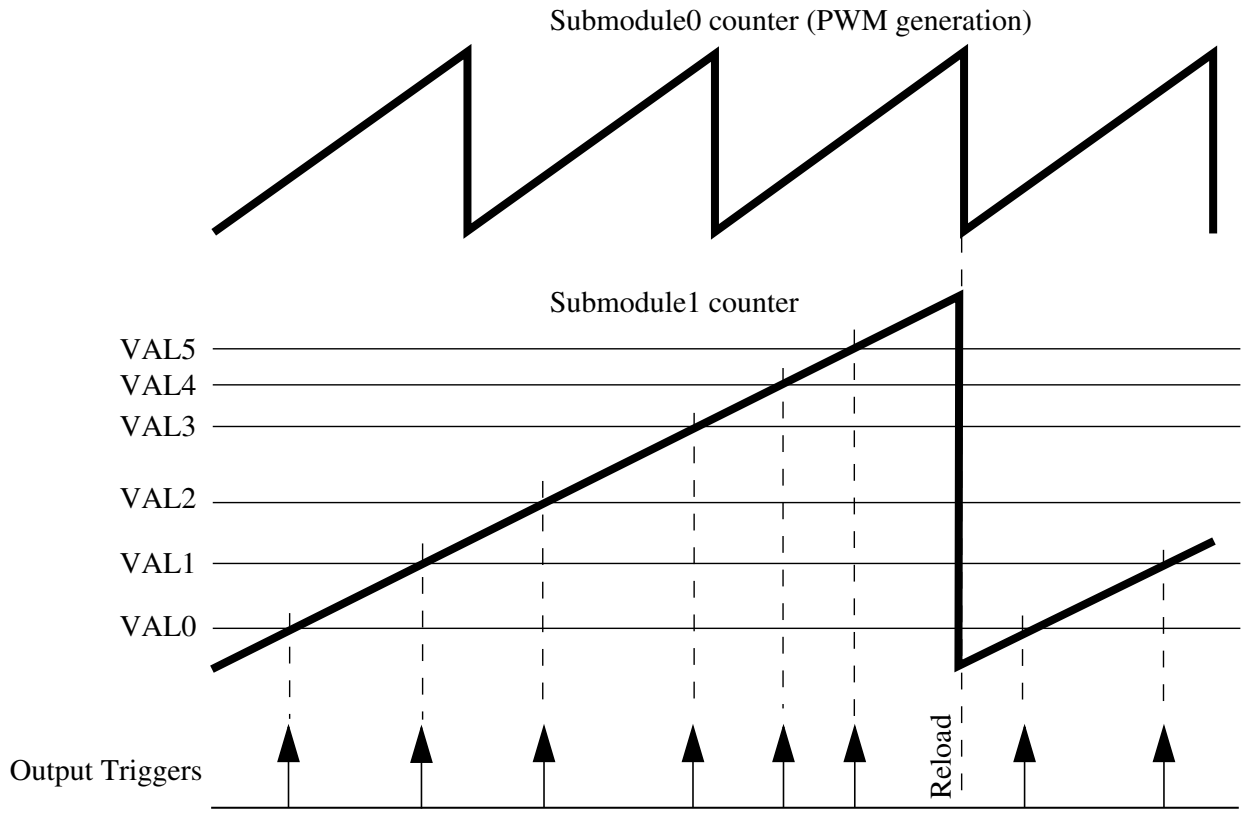

Figure 267. Multiple output triggers over several PWM periods

56.3.18 PWM clocking

56.3.18.1 PWM clocking overview

As illustrated in Clocking for each PWM submodule, you can select between three clock sources for each submodule:

- the IPBus clock
- an external clock (EXT_CLK)
- the submodule 0 counter (AUX_CLK)

The IPBus and external clocks are available to all submodules. The AUX_CLK signal is output from the submodule 0 counter and is available to the other submodules. AUX_CLK allows the submodule 0 counter (either the IPBus or the external clock divided by the submodule 0 prescaler) and submodule 0 Run (bit 0 of MCTRL[RUN]) to control the other submodules.

56.3.18.1.1 Clocking for each PWM submodule

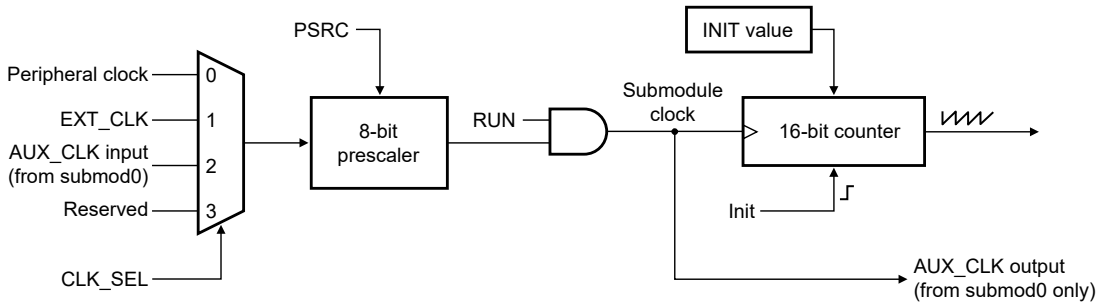

Figure 268. Clocking for each PWM submodule

56.3.18.2 Prescaler buffering

The submodule prescaler is buffered. The PWM generator does not use it until you enable load okay (MCTRL[LDOK]) for the submodule and a new PWM reload cycle begins or you assert load okay (SM*n*_CTRL[LDMOD]).

56.3.18.3 Running a submodule at a lower frequency than submodule 0

The submodule counter operates at the frequency of the selected clock source divided by the submodule prescaler (SM*n*_CTRL[PRSC]). Therefore, if you select the submodule 0 counter (AUX_CLK) as the clock source for another submodule and specify a prescaler for that submodule greater than 1, that submodule operates at a lower frequency than submodule 0.

56.3.19 Resets

All eFlexPWM registers reset to their default values upon any system reset. The reset forces all registers to their reset states and tristates the PWM outputs.

56.3.20 Interrupts

Each of the submodules within eFlexPWM module can generate an interrupt from several sources. The fault logic can also generate interrupts. The interrupt service routine (ISR) must check the related interrupt enables and interrupt flags to determine the actual cause of the interrupt.

Table 266. Interrupt Summary

Core interrupt	Interrupt flag	Interrupt enable	Name	Description
PWM_CMP0	SM0_STS[CMPF]	SM0_INTEN[CMPIE]	Submodule 0 compare interrupt	Compare event has occurred
PWM_CAP0	SM0_STS[CFA1] SM0_STS[CFA0] SM0_STS[CFB1] SM0_STS[CFB0] SM0_STS[CFX1] SM0_STS[CFX0]	SM0_INTEN[CA1IE] SM0_INTEN[CA0IE] SM0_INTEN[CB1IE] SM0_INTEN[CB0IE] SM0_INTEN[CX1IE] SM0_INTEN[CX0IE]	Submodule 0 input capture interrupt	Input capture event has occurred

Table continues on the next page...

Table 266. Interrupt Summary (continued)

Core interrupt	Interrupt flag	Interrupt enable	Name	Description
PWM_RELOAD0	SM0_STS[RF]	SM0_INTEN[RIE]	Submodule 0 reload interrupt	Reload event has occurred
PWM_CMP1	SM1_STS[CMPF]	SM1_INTEN[CMPIE]	Submodule 1 compare interrupt	Compare event has occurred
PWM_CAP1	SM1_STS[CFA1] SM1_STS[CFA0] SM1_STS[CFB1] SM1_STS[CFB0] SM1_STS[CFX1] SM1_STS[CFX0]	SM1_INTEN[CA1IE] SM1_INTEN[CA0IE] SM1_INTEN[CB1IE] SM1_INTEN[CB0IE] SM1_INTEN[CX1IE] SM1_INTEN[CX0IE]	Submodule 1 input capture interrupt	Input capture event has occurred
PWM_RELOAD1	SM1_STS[RF]	SM1_INTEN[RIE]	Submodule 1 reload interrupt	Reload event has occurred
PWM_CMP2	SM2_STS[CMPF]	SM2_INTEN[CMPIE]	Submodule 2 compare interrupt	Compare event has occurred
PWM_CAP2	SM2_STS[CFA1] SM2_STS[CFA0] SM2_STS[CFB1] SM2_STS[CFB0] SM2_STS[CFX1] SM2_STS[CFX0]	SM2_INTEN[CA1IE] SM2_INTEN[CA0IE] SM2_INTEN[CB1IE] SM2_INTEN[CB0IE] SM2_INTEN[CX1IE] SM2_INTEN[CX0IE]	Submodule 2 input capture interrupt	Input capture event has occurred
PWM_RELOAD2	SM2_STS[RF]	SM2_INTEN[RIE]	Submodule 2 reload interrupt	Reload event has occurred
PWM_CMP3	SM3_STS[CMPF]	SM3_INTEN[CMPIE]	Submodule 3 compare interrupt	Compare event has occurred
PWM_CAP3	SM3_STS[CFA1] SM3_STS[CFA0] SM3_STS[CFB1] SM3_STS[CFB0] SM3_STS[CFX1] SM3_STS[CFX0]	SM3_INTEN[CA1IE] SM3_INTEN[CA0IE] SM3_INTEN[CB1IE] SM3_INTEN[CB0IE] SM3_INTEN[CX1IE] SM3_INTEN[CX0IE]	Submodule 3 input capture interrupt	Input capture event has occurred
PWM_RELOAD3	SM3_STS[RF]	SM3_INTEN[RIE]	Submodule 3 reload interrupt	Reload event has occurred

Table continues on the next page...

Table 266. Interrupt Summary (continued)

Core interrupt	Interrupt flag	Interrupt enable	Name	Description
PWM_RERR	SM0_STS[REF]	SM0_INTEN[REIE]	Submodule 0 reload error interrupt	Reload error has occurred
	SM1_STS[REF]	SM1_INTEN[REIE]	Submodule 1 reload error interrupt	
	SM2_STS[REF]	SM2_INTEN[REIE]	Submodule 2 reload error interrupt	
	SM3_STS[REF]	SM3_INTEN[REIE]	Submodule 3 reload error interrupt	
PWM_FAULT	FP0_STS[FFLAG]	FP0_CTRL[FIE]	Fault input interrupt	Fault condition has been detected

56.3.21 DMA

Each submodule can request a DMA read access for its capture FIFOs and a DMA write request for its double buffered SM*n*VAL*m* registers.

Table 267. DMA Summary

DMA request	DMA enable	Name	Description
Submodule *n* read request	SM*n*_DMAEN[CX0DE]	Submodule *n* Capture FIFO X0 read request	SM*n*_CVAL0 and SM*n*_CVAL0CYC contains a value to be read
	SM*n*_DMAEN[CX1DE]	Submodule *n* Capture FIFO X1 read request	SM*n*_CVAL1 and SM*n*_CVAL1CYC contains a value to be read
	SM*n*_DMAEN[CA0DE]	Submodule *n* Capture FIFO A0 read request	SM*n*_CVAL2 and SM*n*_CVAL2CYC contains a value to be read
	SM*n*_DMAEN[CA1DE]	Submodule *n* Capture FIFO A1 read request	SM*n*_CVAL3 and SM*n*_CVAL3CYC contains a value to be read
	SM*n*_DMAEN[CB0DE]	Submodule *n* Capture FIFO B0 read request	SM*n*_CVAL4 and SM*n*_CVAL4CYC contains a value to be read
	SM*n*_DMAEN[CB1DE]	Submodule *n* Capture FIFO B1 read request	SM*n*_CVAL5 and SM*n*_CVAL5CYC contains a value to be read
	SM*n*_DMAEN[CAPTDE]	Submodule *n* Capture FIFO read request source select	Selects the source of the submodule read DMA request

Table continues on the next page...

Table 267. DMA Summary (continued)

DMA request	DMA enable	Name	Description
Submodule *n* write request	SM*n*_DMAEN[VALDE]	SM*n*_VAL*m* write request	SM*n*_VAL*m* registers need to be updated

Initialization sequence for DMA when writing on val registers.

- DMA Write Seq for LDMOD=0
  1. Configure SM*n*_INIT and SM*n*_VAL*m* then clear faults FP0_STS[FFLAG] and FP1_STS[FFLAG].
  2. Configure SM*n*_INIT and SM*n*_CTRL2 to initialize specific counter mode.

     Specify LDMOD=0 and FULL/Half reload mode.
  3. Configure MCTRL to assert MCTRL[LDOK] and MCTRL[RUN].
  4. Enable outputs from Output Enable (OUTEN) .
  5. Check DMA write request for all submodule must be disabled.
  6. Set SM*n*_DMAEN[VALDE].
  7. Wait for the corresponding submodule's DMA write request to set.
  8. Read MCTRL to verify LDOK is clear.
  9. Write on SMn_INIT and SMn_VALm using DMA bus. The new values are updated on PWM at the next reload opportunity.
  10. Wait for DMA request to disable, which indicates your request has been completed.
  11. Check corresponding PWM outputs for the changes to reflect on it.
- DMA Write Seq for LDMOD=1
  1. Configure SM*n*_INIT and SM*n*_VAL*m* then clear faults FP0_STS[FFLAG] and FP1_STS[FFLAG].
  2. Configure SM*n*_INIT and SM*n*_CTRL2 to initialize specific counter mode.

     Specify LDMOD=1.
  3. Configure MCTRL to assert MCTRL[LDOK] and MCTRL[RUN].
  4. Enable outputs from Output Enable (OUTEN) .
  5. Check DMA write request for all submodule must be disabled.
  6. Set SM*n*_DMAEN[VALDE].
  7. Wait for corresponding submodule's DMA write request to set.
  8. Read MCTRL to verify LDOK is clear.
  9. Write on SMn_INIT and SMn_VALm using DMA bus.
  10. Wait for DMA request to disable, which indicates your request has been completed.
  11. Read MCTRL to verify LDOK is set.
  12. New values are loaded on SMn_VALm at the next clock cycle when LDOK is automatically de-asserted.

56.4 Internal signals

The following table describes eFlexPWM signals.

Table 268. Internal signals

Signal	Input/Output	Function
PWM*n*_A	Input/Output	PWM channel output pair. These signals operate as independent PWM outputs or as complementary pairs (SM*n*_CTRL2[INDEP]). When not needed as outputs, they can be inputs to the input capture circuitry (SM*n*_CAPTCOMPA, SM*n*_CAPTCOMPB).
PWM*n*_B	Input/Output	
PWM*n*_X	Input/Output	Auxiliary PWM channel output. These signals operate as PWM outputs. When not needed as outputs, they can be inputs to the input capture circuitry (SM*n*_CAPTCOMPA, SM*n*_CAPTCOMPB) or they can detect the polarity of the current flowing through the complementary circuit at deadtime correction.
FAULT*n*	Input	Fault pins. Disable selected PWM outputs, as controlled by Fault Disable Mapping (Submodule a Fault Disable Mapping (SM0_DISMAP0 - SM3_DISMAP0) or Submodule a Fault Disable Mapping (SM0_DISMAP1 - SM3_DISMAP1)).
PWM*n*_OUT_TRIG0	Output	Output triggers. Allow PWM submodules to control the timing of ADC conversions. See SM*n*_TCTRL[OUT_TRIG_EN] for information about how to enable these outputs and how the compare registers match up to the output triggers.
PWM*n*_OUT_TRIG1	Output	
PWM*n*_MUX_TRIG0	Output	Multiplexed output triggers. Allow PWM submodules to control the timing of ADC conversions. See SM*n*_TCTRL[PWAOT0] and SM*n*_TCTRL[PWBOT1] for information about how to enable these outputs.
PWM*n*_MUX_TRIG1	Output	

56.5 External signals

The following table describes eFlexPWM signals.

Table 269. External signals

Signal	Input/Output	Function
PWM*n*_EXT_SYNC	Input	External synchronization. Allow an external input to initialize the submodule PWM counter. These signals support the synchronization of the PWM to external circuitry.
EXT_FORCE	Input	External output force. Allows an external input to force an update of the PWM outputs. These signals support the synchronization of the PWM to external circuitry.
PWM*n*_EXTA	Input	Alternate PWM control. Allow an alternate source to control the PWM*n*_A and PWM*n*_B outputs. Typically either PWM23 or PWM45, depending on the Current Polarity (MCTRL[IPOL]), generates the complementary pair. Examples of external control signals include ADC conversion high/low limits, TMR outputs, GPIO inputs, and comparator outputs.
PWM*n*_EXTB	Input	
EXT_CLK	Input	External clock signal. Allows an external source, typically a timer or an off-chip source, to control the PWM clocking. This input allows the PWM to be synchronized to the timer or multiple chips to be synchronized to each other. The maximum allowed external frequency should be less than the module clock frequency.

56.6 Initialization

56.6.1 Generate center-aligned PWM pulses

56.6.1.1 Center-aligned overview

A center-aligned pulse is timed relative to a center point within the PWM period, typically the mid-point, rather than from the beginning of the PWM period. In other words, the turn-on edge of the pulse occurs a specified time before the center point and the turn-off edge occurs a specified time after the center point.

56.6.1.2 Using the rollover submodule counter

To support center-aligned pulses, you can take advantage of the rollover submodule counter. See Rollover submodule counter.

To create a symmetrical center-aligned pulse aligned to the PWM period mid-point, you first specify the period with a positive integer value for the reload point (VAL1) and a two's complement negative value for the Initial Count. Then you need to calculate only one timing value, for half of the pulse width, and use that value for the pulse turn-off timing and its two's complement negative for the pulse turn-on timing. See Generate a center-aligned pulse for step-by-step instructions.

If you use this capability for both sets of PWM output edge calculations (PWM*n*_A and PWM*n*_B), then both PWM pulses are center-aligned with respect to each other.

NOTE

A side effect of this technique for center-aligned operation is that it always results in a pulse width of an odd number of counter units.

56.6.1.3 Generate a center-aligned pulse

To generate a center-aligned pulse using the PWM*n*_A output, as illustrated in Center-aligned example:

1. Select the source clock (SM0_CTRL2[CLK_SEL]).
2. Determine the desired length of the PWM period in source clock cycles.

   Example: For illustration, assume a PWM period of 288 source clock cycles.
3. Select the largest prescaler that divides evenly into the PWM period clock cycles (SM*n*_CTRL[PRSC]).

   Example: A prescaler of 32 divides into 288 clock cycles nine times with no remainder. Depending on your application, you may choose to use a smaller prescaler.
4. Calculate the total number of counter units for the desired PWM period: (clock cycles/prescaler) = counter units.

   Example: The number of counter units is nine: (288/32 = 9). See Center-aligned example.
5. Divide the calculated PWM period counter units by 2 and write the integer result to timing value 1 (SM*n*_VAL1[VAL1]).

   Example: 9/2 = 4.5. Use the integer result value of 0004h. Remember, center-aligned operation always results in a pulse width of an odd number of counter units.
6. Calculate the two's complement of the value you just wrote to VAL1 and write the result to the initial count (SM*n*_INIT[INIT]).

   Example: The two's-complement of 004h is FFFCh.
7. Determine the desired pulse period in source clock cycles. This value should be less than or equal to the PWM period. If it is equal to the PWM period, the result is a 100% duty cycle pulse.

   Example: Assume a pulse width of 160 source clock cycles.
8. Calculate the total number of counter increments for the desired pulse width.

   Example: 160/32 = 5.
9. Divide the calculated pulse width counter units by 2 and write the rounded-up integer result to timing value 3 (SM*n*_VAL3[VAL3]).

   Example: For 5/2 = 2.5, the rounded-up integer result is 0003h.

10. Calculate the two's complement of the rounded-up value you calculated in the previous step and write the result to timing value 2 (SM*n*_VAL2[VAL2]).

    Example: The two's complement of 0002h is FFFEh.

11. To synchronize half-period reload with the pulse center point, write zero to timing value 0 (SM*n*_VAL0[VAL0]).

The example values in this procedure create a five-unit (160 clock cycles) pulse aligned precisely around the center of a nine-unit (288 clock cycles) PWM period. eFlexPWM does not restrict you to symmetry around the period mid-point. By adjusting the VAL2 and VAL3 values (or VAL4 and VAL5 for a PWM*n*_B pulse), you can align the pulse anywhere within the PWM period. However, centering the pulse in the PWM period provides the greatest range for pulse width and simplifies the timing calculations.

56.6.1.4 Center-aligned example

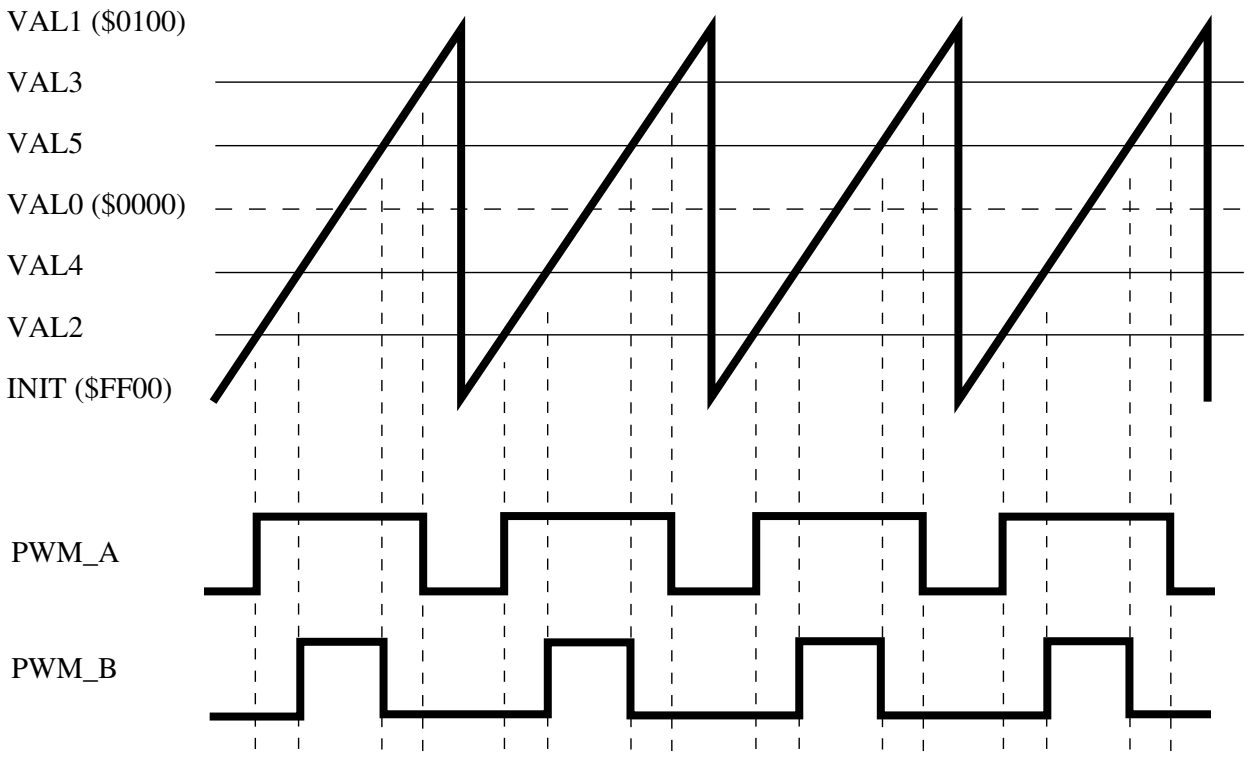

Figure 269. Center-aligned example

56.6.2 Generate edge-aligned PWM pulses

56.6.2.1 Edge-aligned overview

In edge-aligned operation, the PWM pulse turns on at the beginning of the PWM period. In other words, the timing value for the leading edge of the pulse is the same as the initial count. You change the pulse width by periodically updating the turn-off edge timing.

56.6.2.2 Edge-aligned use case: H bridge

A common technique for driving an H bridge is bipolar pulses, where a 50% duty cycle results in zero volts on the load, duty cycles less than 50% result in negative load voltages, and duty cycles greater than 50% generate positive load voltages. You use edge-aligned pulses and the rollover submodule counter to produce these bipolar pulses.

If the Initial Count (SM*n*_INIT[INIT]) is the two's-complement negative of timing value 1 (SM*n*_VAL1[VAL1]), then the turn-off timing value for a 50% duty cycle, edge-aligned pulse is 0000h. A positive integer value gives a greater than 50% duty cycle, and

a two's-complement negative value gives a less than 50% duty cycle. Therefore, when using the pulse to drive an H bridge, the turn-off edge timing is directly proportional to the motor inverter voltage, including the sign. As with center-aligned pulses, treating the submodule counter as a signed value simplifies the process because you don't need offset calculations to translate the output variable control algorithm to the voltage on an H bridge load.

Edge-aligned example illustrates edge-aligned bipolar pulses created with Generate an edge-aligned bipolar pulse.

56.6.2.3 Generate an edge-aligned bipolar pulse

To generate an edge-aligned bipolar pulse using the PWM*n*_A output, as illustrated in Edge-aligned example:

1. Select the source clock (SM0_CTRL2[CLK_SEL]).
2. Determine the desired length of the PWM period in source clock cycles.

   Example: For illustration, assume a PWM period of 320 source clock cycles.
3. Select the largest prescaler that divides evenly into the PWM period clock cycles (SM*n*_CTRL[PRSC]).

   Example: A prescaler of 32 divides into 320 clock cycles ten times with no remainder. Depending on your application, you may choose to use a smaller prescaler.
4. Calculate the total number of counter units for the desired PWM period: (clock cycles/prescaler) = counter units.

   Example: The number of counter units is ten: (320/32 = 10). See Edge-aligned example.
5. Divide the calculated PWM period counter units by 2 and write the integer result to timing value 1 (SM*n*_VAL1[VAL1]).

   Example: 10/2 = 5. Use the integer result value of 0005h. Remember, center-aligned operation always results in a pulse width of an odd number of counter units, where VAL1 = 0004h.
6. Calculate the two's complement of the value you calculated in the previous step and write the result to the initial count (SM*n*_INIT[INIT]).

   Example: The two's complement of 0005h is FFFBh.
7. To edge align the pulse with the PWM period, write the same value to timing value 2 (SM*n*_VAL2[VAL2]).
8. To start the pulse width at a 50% duty cycle, write 0000h to timing value 3 (SM*n*_VAL3[VAL3]).
9. To synchronize half-period reload with the PWM period mid-point, write zero to timing value 0 (SM*n*_VAL0[VAL0]).

The example values in this procedure create a 50% duty cycle pulse (160 clock cycles) edge-aligned to the beginning of a 10 counter unit (320 clock cycles) PWM period. By adjusting timing value 3 (VAL3), you can control the output above (positive VAL3 value) or below (negative VAL3 value) the 50% duty cycle.

56.6.2.4 Edge-aligned example

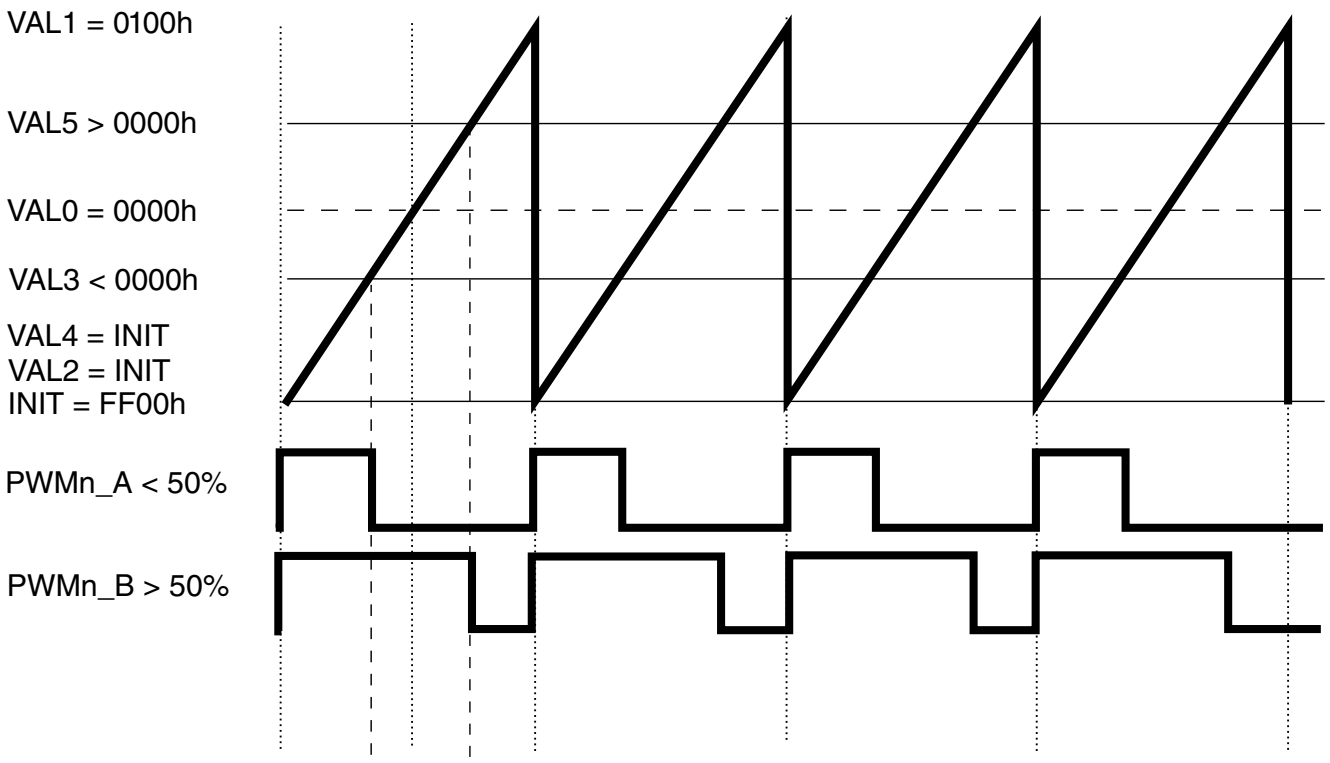

Figure 270. Edge-aligned example

56.6.3 Generate phase-shifted PWM pulses

56.6.3.1 Phase-shifted overview

Some PWM applications benefit from the ability to have one PWM pulse turn on and off at a set interval or delay from the turn on and off of another pulse. This controlled delay is called phase shifting.

Within a single submodule, you can calculate the turn-on and turn-off timing values for one pulse output, then add a bias or offset value to those timings before using them to program the other pulse output. See Phase-shifted example: within the same submodule for an illustration of this form of phase shifting. See Phase-shifted use case: multi-phase inverter for an application of this technique to operating a multi-phase inverter.

eFlexPWM also supports phase shifting across submodules. You can select the master sync from submodule 0 as the initialization source for another submodule (SM*n*_CTRL2[INIT_SEL]) and specify a non-zero phase delay value for that submodule (SM*n*_PHASEDLY[PHASEDLY]). The phase delay is the delay in counter units from assertion of master sync to submodule 0 to when the other submodule recognizes master sync. This method allows you to program all involved submodules with the same turn-on and turn-off timing values but to phase shift each subordinate submodule from submodule 0 by a submodule-specific number of counter units. See Phase-shifted example: across submodules for an illustration of this form of phase shifting.

56.6.3.1.1 Phase-shifted example: within the same submodule

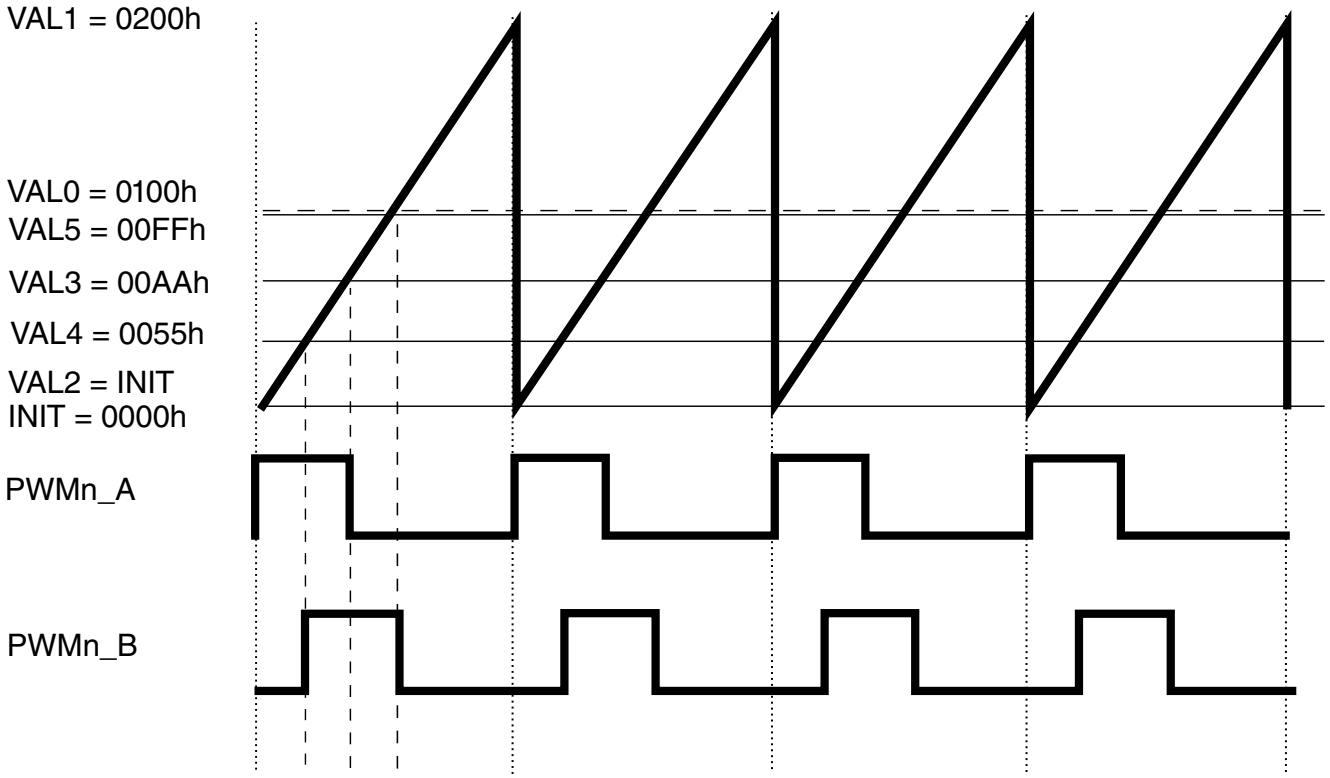

Figure 271. Phase-shifted example: within the same submodule

56.6.3.1.2 Phase-shifted example: across submodules

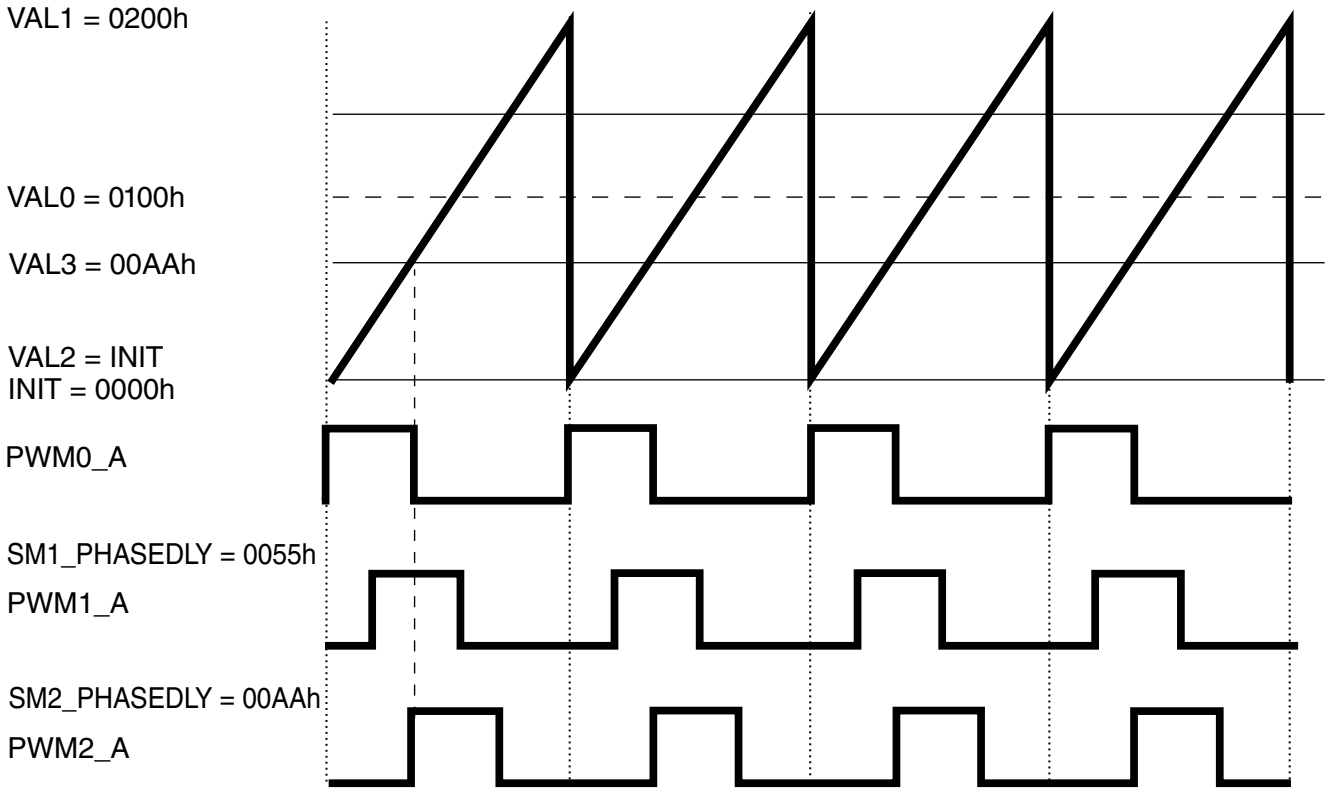

Figure 272. Phase-shifted example: across submodules

56.6.3.2 Phase-shifted use case: multi-phase inverter

When operating a multi-phase inverter at a low modulation index, all of the PWM switching edges from the different phases occur at nearly the same time. This proximity in time of the edges can be troublesome from a noise standpoint, especially if you need to schedule ADC readings near those times. Phase shifting the PWM pulses can open up timing windows between the switching edges to allow the ADC to sample a signal without noise from the other edges. However, phase shifting does not affect the duty cycle so it does not have an impact on the average load voltage.

56.6.3.3 Phase-shifted use case: transformer primary

To drive a transformer through an H bridge, you can phase shift two sets of complementary pulses. Use the complementary pulses from one submodule drive the left-side transistors of the H bridge, and the complementary pulses from another submodule to drive the right side, as illustrated in Drive a transformer primary.

56.6.3.3.1 Drive a transformer primary

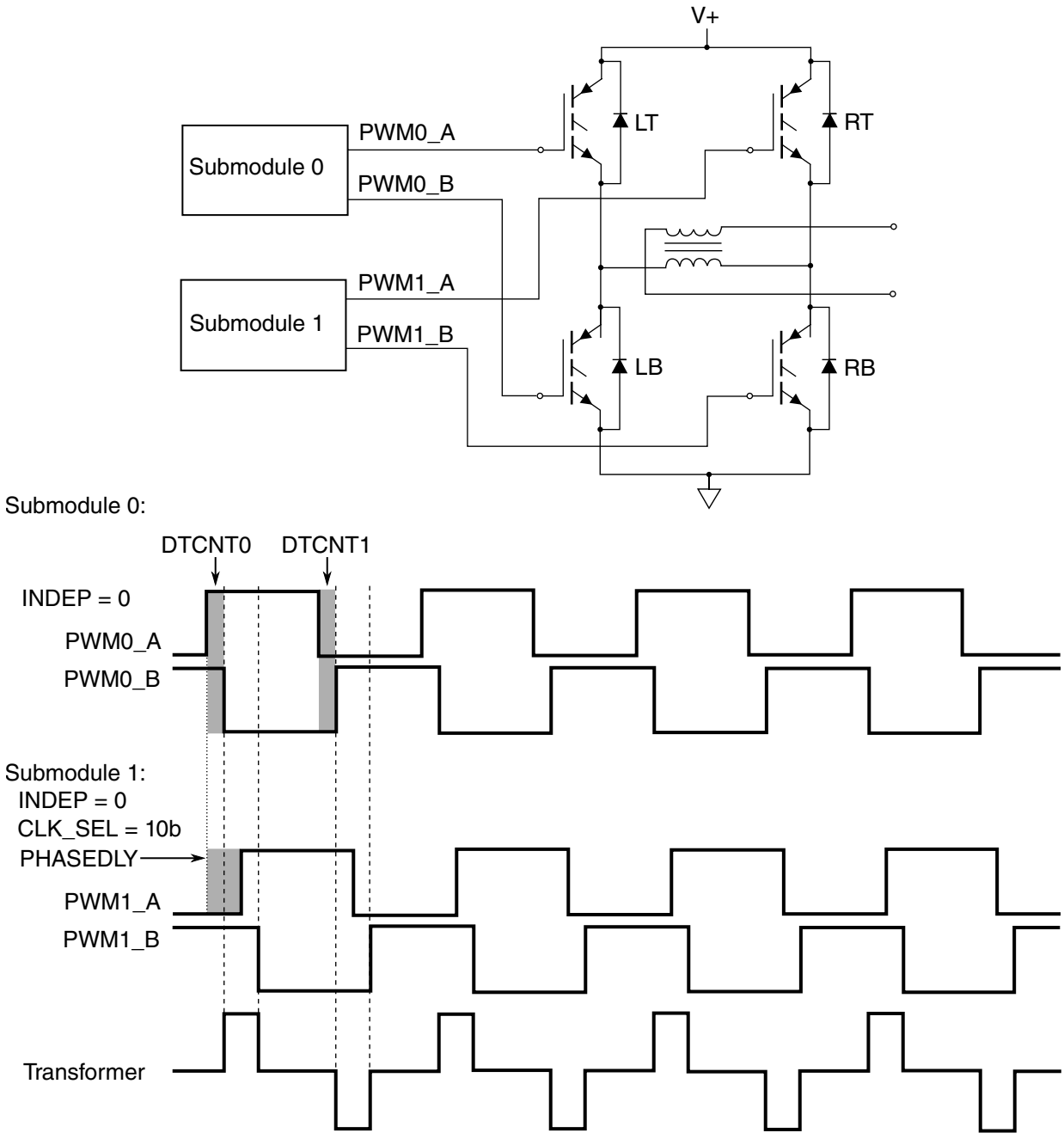

Figure 273. Drive a transformer primary

56.6.4 Generate double-switching PWM pulses

56.6.4.1 Double-switching overview

Some PWM applications require two independent serial pulses per PWM period. eFlexPWM supports double-switching pulses (SM*n*_CTRL[DBLEN]) by combining the PWM*n*_A and PWM*n*_B signals with XOR logic (force out logic) to generate the DBLPWM output. See Double-switching example.

You specify the even channel using timing values 2 and 3 (VAL2 and VAL3), and the odd channel using timing values 4 and 5 (VAL4 and VAL5). The DBLPWM output appears on PWM*n*_X. You can route the DBLPWM output through the deadtime insertion logic.

Split DBLPWM (SM*n*_CTRL[SPLIT]) causes each channel to appear on separate outputs. The pulse generated by the assertion of PWM*n*_A and deassertion of PWM*n*_B, the even channel, appears on the PWM*n*_A output. The pulse generated by the assertion of PWM*n*_B and deassertion of PWM*n*_A, the odd channel, appears on the PWM*n*_A output.

56.6.4.2 Double-switching example

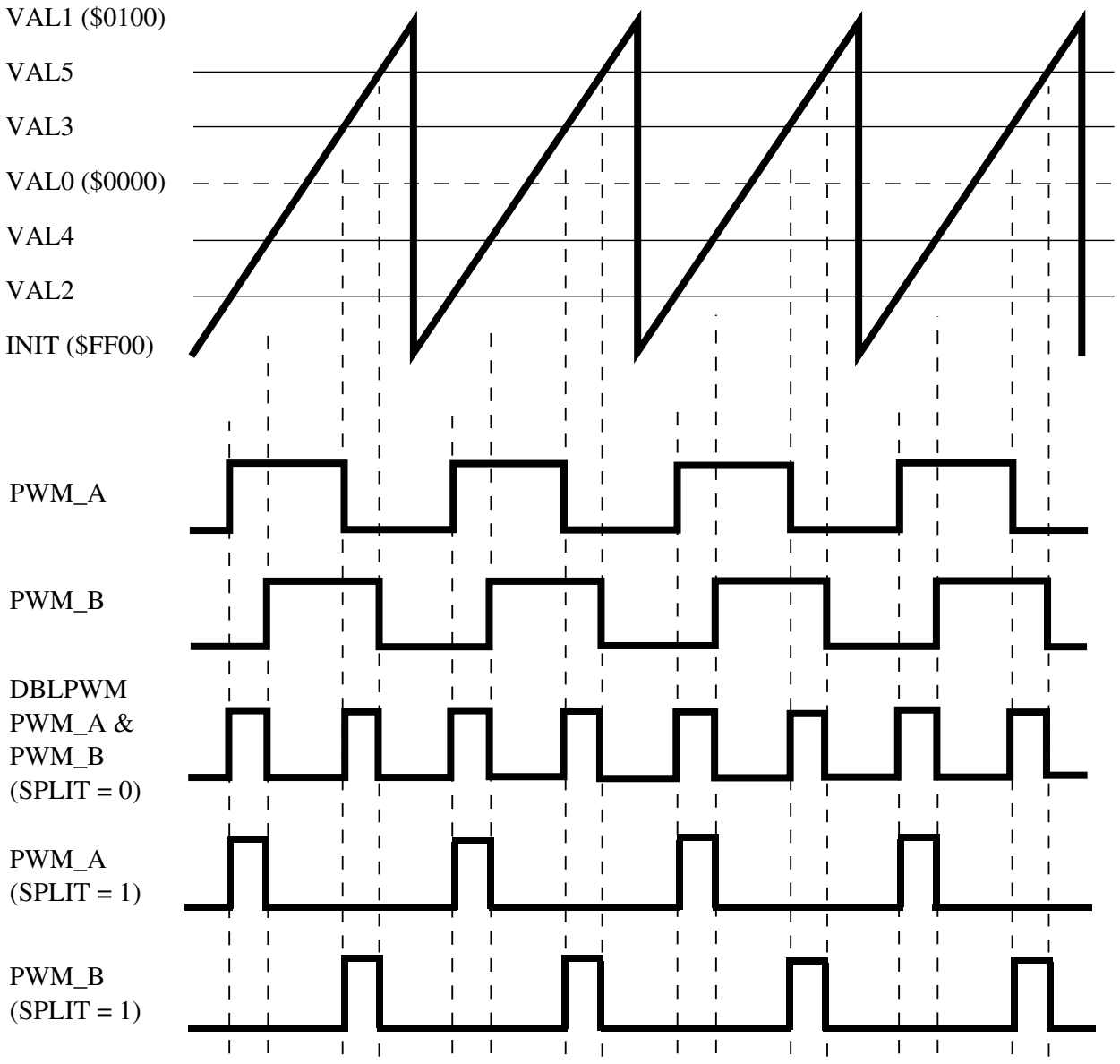

Figure 274. Double-switching example

56.7 PWM register descriptions

eFlexPWM contains a set of registers for each PWM submodule, for the configuration logic, and for each fault channel. The registers are 16-bit wide and 8-bit access is not supported.

To designate the submodule, submodule register names contain a prefix: SM0, SM1, SM2, or SM3. The base address of submodule 0 is the same as the module base address for eFlexPWM as a whole. The base address of submodule 1 is offset 60h from the module base address, and each subsequent module adds another 60h offset for its base address.

The base address of the configuration registers is offset 180h from the module base address.

To designate the fault channel, fault channel register names contain the prefix F0 or F1. The base address of fault channel 0 is equal to the module base address plus an offset of 18Ch. Fault channel 1 adds another 4h.

56.7.1 eFlexPWM memory map

eFlexPWM_0 base address: 406B_8000h

eFlexPWM_1 base address: 406B_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Submodule 0 Counter (SM0_CNT)	16	R	0000h
2h	Submodule 0 Initial Count (SM0_INIT)	16	RW	0000h
4h	Submodule 0 Control 2 (SM0_CTRL2)	16	RW	0000h
6h	Submodule 0 Control (SM0_CTRL)	16	RW	0400h
Ah	Submodule 0 Value 0 (SM0_VAL0)	16	RW	0000h
Ch	Submodule 0 Fractional Value 1 (SM0_FRACVAL1)	16	RW	0000h
Eh	Submodule 0 Value 1 (SM0_VAL1)	16	RW	0000h
10h	Submodule 0 Fractional Value 2 (SM0_FRACVAL2)	16	RW	0000h
12h	Submodule 0 Value 2 (SM0_VAL2)	16	RW	0000h
14h	Submodule 0 Fractional Value 3 (SM0_FRACVAL3)	16	RW	0000h
16h	Submodule 0 Value 3 (SM0_VAL3)	16	RW	0000h
18h	Submodule 0 Fractional Value 4 (SM0_FRACVAL4)	16	RW	0000h
1Ah	Submodule 0 Value 4 (SM0_VAL4)	16	RW	0000h
1Ch	Submodule 0 Fractional Value 5 (SM0_FRACVAL5)	16	RW	0000h
1Eh	Submodule 0 Value 5 (SM0_VAL5)	16	RW	0000h
20h	Submodule 0 Fractional Control (SM0_FRCTRL)	16	RW	0000h
22h	Submodule 0 Output Control (SM0_OCTRL)	16	RW	0000h
24h	Submodule 0 Status (SM0_STS)	16	RW	0000h
26h	Submodule 0 Interrupt Enable (SM0_INTEN)	16	RW	0000h
28h	Submodule 0 DMA Enable (SM0_DMAEN)	16	RW	0000h
2Ah	Submodule 0 Output Trigger Control (SM0_TCTRL)	16	RW	0000h
2Ch	Submodule 0 Fault Disable Mapping (SM0_DISMAP0)	16	RW	FFFFh
2Eh	Submodule 0 Fault Disable Mapping (SM0_DISMAP1)	16	RW	FFFFh
30h	Submodule 0 Deadtime Count 0 (SM0_DTCNT0)	16	RW	07FFh

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Offset	Register	Width (In bits)	Access	Reset value
32h	Submodule 0 Deadtime Count 1 (SM0_DTCNT1)	16	RW	07FFh
34h	Submodule 0 Capture Control A (SM0_CAPTCTRLA)	16	RW	0000h
36h	Submodule 0 Capture Compare A (SM0_CAPTCOMPA)	16	RW	0000h
38h	Submodule 0 Capture Control B (SM0_CAPTCTRLB)	16	RW	0000h
3Ah	Submodule 0 Capture Compare B (SM0_CAPTCOMPB)	16	RW	0000h
3Ch	Submodule 0 Capture Control X (SM0_CAPTCTRLX)	16	RW	0000h
3Eh	Submodule 0 Capture Compare X (SM0_CAPTCOMPX)	16	RW	0000h
40h	Submodule 0 Capture Value 0 (SM0_CVAL0)	16	R	0000h
42h	Submodule 0 Capture Value 0 Cycle (SM0_CVAL0CYC)	16	R	0000h
44h	Submodule 0 Capture Value 1 (SM0_CVAL1)	16	R	0000h
46h	Submodule 0 Capture Value 1 Cycle (SM0_CVAL1CYC)	16	R	0000h
48h	Submodule 0 Capture Value 2 (SM0_CVAL2)	16	R	0000h
4Ah	Submodule 0 Capture Value 2 Cycle (SM0_CVAL2CYC)	16	R	0000h
4Ch	Submodule 0 Capture Value 3 (SM0_CVAL3)	16	R	0000h
4Eh	Submodule 0 Capture Value 3 Cycle (SM0_CVAL3CYC)	16	R	0000h
50h	Submodule 0 Capture Value 4 (SM0_CVAL4)	16	R	0000h
52h	Submodule 0 Capture Value 4 Cycle (SM0_CVAL4CYC)	16	R	0000h
54h	Submodule 0 Capture Value 5 (SM0_CVAL5)	16	R	0000h
56h	Submodule 0 Capture Value 5 Cycle (SM0_CVAL5CYC)	16	R	0000h
60h	Submodule 1 Counter (SM1_CNT)	16	R	0000h
62h	Submodule 1 Initial Count (SM1_INIT)	16	RW	0000h
64h	Submodule 1 Control 2 (SM1_CTRL2)	16	RW	0000h
66h	Submodule 1 Control (SM1_CTRL)	16	RW	0400h
6Ah	Submodule 1 Value 0 (SM1_VAL0)	16	RW	0000h
6Ch	Submodule 1 Fractional Value 1 (SM1_FRACVAL1)	16	RW	0000h
6Eh	Submodule 1 Value 1 (SM1_VAL1)	16	RW	0000h
70h	Submodule 1 Fractional Value 2 (SM1_FRACVAL2)	16	RW	0000h
72h	Submodule 1 Value 2 (SM1_VAL2)	16	RW	0000h
74h	Submodule 1 Fractional Value 3 (SM1_FRACVAL3)	16	RW	0000h
76h	Submodule 1 Value 3 (SM1_VAL3)	16	RW	0000h
78h	Submodule 1 Fractional Value 4 (SM1_FRACVAL4)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
7Ah	Submodule 1 Value 4 (SM1_VAL4)	16	RW	0000h
7Ch	Submodule 1 Fractional Value 5 (SM1_FRACVAL5)	16	RW	0000h
7Eh	Submodule 1 Value 5 (SM1_VAL5)	16	RW	0000h
80h	Submodule 1 Fractional Control (SM1_FRCTRL)	16	RW	0000h
82h	Submodule 1 Output Control (SM1_OCTRL)	16	RW	0000h
84h	Submodule 1 Status (SM1_STS)	16	RW	0000h
86h	Submodule 1 Interrupt Enable (SM1_INTEN)	16	RW	0000h
88h	Submodule 1 DMA Enable (SM1_DMAEN)	16	RW	0000h
8Ah	Submodule 1 Output Trigger Control (SM1_TCTRL)	16	RW	0000h
8Ch	Submodule 1 Fault Disable Mapping (SM1_DISMAP0)	16	RW	FFFFh
8Eh	Submodule 1 Fault Disable Mapping (SM1_DISMAP1)	16	RW	FFFFh
90h	Submodule 1 Deadtime Count 0 (SM1_DTCNT0)	16	RW	07FFh
92h	Submodule 1 Deadtime Count 1 (SM1_DTCNT1)	16	RW	07FFh
94h	Submodule 1 Capture Control A (SM1_CAPTCTRLA)	16	RW	0000h
96h	Submodule 1 Capture Compare A (SM1_CAPTCOMPA)	16	RW	0000h
98h	Submodule 1 Capture Control B (SM1_CAPTCTRLB)	16	RW	0000h
9Ah	Submodule 1 Capture Compare B (SM1_CAPTCOMPB)	16	RW	0000h
9Ch	Submodule 1 Capture Control X (SM1_CAPTCTRLX)	16	RW	0000h
9Eh	Submodule 1 Capture Compare X (SM1_CAPTCOMPX)	16	RW	0000h
A0h	Submodule 1 Capture Value 0 (SM1_CVAL0)	16	R	0000h
A2h	Submodule 1 Capture Value 0 Cycle (SM1_CVAL0CYC)	16	R	0000h
A4h	Submodule 1 Capture Value 1 (SM1_CVAL1)	16	R	0000h
A6h	Submodule 1 Capture Value 1 Cycle (SM1_CVAL1CYC)	16	R	0000h
A8h	Submodule 1 Capture Value 2 (SM1_CVAL2)	16	R	0000h
AAh	Submodule 1 Capture Value 2 Cycle (SM1_CVAL2CYC)	16	R	0000h
ACh	Submodule 1 Capture Value 3 (SM1_CVAL3)	16	R	0000h
AEh	Submodule 1 Capture Value 3 Cycle (SM1_CVAL3CYC)	16	R	0000h
B0h	Submodule 1 Capture Value 4 (SM1_CVAL4)	16	R	0000h
B2h	Submodule 1 Capture Value 4 Cycle (SM1_CVAL4CYC)	16	R	0000h
B4h	Submodule 1 Capture Value 5 (SM1_CVAL5)	16	R	0000h
B6h	Submodule 1 Capture Value 5 Cycle (SM1_CVAL5CYC)	16	R	0000h

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Offset	Register	Width (In bits)	Access	Reset value
B8h	Submodule 1 Phase Delay (SM1_PHASEDLY)	16	RW	0000h
C0h	Submodule 2 Counter (SM2_CNT)	16	R	0000h
C2h	Submodule 2 Initial Count (SM2_INIT)	16	RW	0000h
C4h	Submodule 2 Control 2 (SM2_CTRL2)	16	RW	0000h
C6h	Submodule 2 Control (SM2_CTRL)	16	RW	0400h
CAh	Submodule 2 Value 0 (SM2_VAL0)	16	RW	0000h
CCh	Submodule 2 Fractional Value 1 (SM2_FRACVAL1)	16	RW	0000h
CEh	Submodule 2 Value 1 (SM2_VAL1)	16	RW	0000h
D0h	Submodule 2 Fractional Value 2 (SM2_FRACVAL2)	16	RW	0000h
D2h	Submodule 2 Value 2 (SM2_VAL2)	16	RW	0000h
D4h	Submodule 2 Fractional Value 3 (SM2_FRACVAL3)	16	RW	0000h
D6h	Submodule 2 Value 3 (SM2_VAL3)	16	RW	0000h
D8h	Submodule 2 Fractional Value 4 (SM2_FRACVAL4)	16	RW	0000h
DAh	Submodule 2 Value 4 (SM2_VAL4)	16	RW	0000h
DCh	Submodule 2 Fractional Value 5 (SM2_FRACVAL5)	16	RW	0000h
DEh	Submodule 2 Value 5 (SM2_VAL5)	16	RW	0000h
E0h	Submodule 2 Fractional Control (SM2_FRCTRL)	16	RW	0000h
E2h	Submodule 2 Output Control (SM2_OCTRL)	16	RW	0000h
E4h	Submodule 2 Status (SM2_STS)	16	RW	0000h
E6h	Submodule 2 Interrupt Enable (SM2_INTEN)	16	RW	0000h
E8h	Submodule 2 DMA Enable (SM2_DMAEN)	16	RW	0000h
EAh	Submodule 2 Output Trigger Control (SM2_TCTRL)	16	RW	0000h
ECh	Submodule 2 Fault Disable Mapping (SM2_DISMAP0)	16	RW	FFFFh
EEh	Submodule 2 Fault Disable Mapping (SM2_DISMAP1)	16	RW	FFFFh
F0h	Submodule 2 Deadtime Count 0 (SM2_DTCNT0)	16	RW	07FFh
F2h	Submodule 2 Deadtime Count 1 (SM2_DTCNT1)	16	RW	07FFh
F4h	Submodule 2 Capture Control A (SM2_CAPTCTRLA)	16	RW	0000h
F6h	Submodule 2 Capture Compare A (SM2_CAPTCOMPA)	16	RW	0000h
F8h	Submodule 2 Capture Control B (SM2_CAPTCTRLB)	16	RW	0000h
FAh	Submodule 2 Capture Compare B (SM2_CAPTCOMPB)	16	RW	0000h
FCh	Submodule 2 Capture Control X (SM2_CAPTCTRLX)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
FEh	Submodule 2 Capture Compare X (SM2_CAPTCOMPX)	16	RW	0000h
100h	Submodule 2 Capture Value 0 (SM2_CVAL0)	16	R	0000h
102h	Submodule 2 Capture Value 0 Cycle (SM2_CVAL0CYC)	16	R	0000h
104h	Submodule 2 Capture Value 1 (SM2_CVAL1)	16	R	0000h
106h	Submodule 2 Capture Value 1 Cycle (SM2_CVAL1CYC)	16	R	0000h
108h	Submodule 2 Capture Value 2 (SM2_CVAL2)	16	R	0000h
10Ah	Submodule 2 Capture Value 2 Cycle (SM2_CVAL2CYC)	16	R	0000h
10Ch	Submodule 2 Capture Value 3 (SM2_CVAL3)	16	R	0000h
10Eh	Submodule 2 Capture Value 3 Cycle (SM2_CVAL3CYC)	16	R	0000h
110h	Submodule 2 Capture Value 4 (SM2_CVAL4)	16	R	0000h
112h	Submodule 2 Capture Value 4 Cycle (SM2_CVAL4CYC)	16	R	0000h
114h	Submodule 2 Capture Value 5 (SM2_CVAL5)	16	R	0000h
116h	Submodule 2 Capture Value 5 Cycle (SM2_CVAL5CYC)	16	R	0000h
118h	Submodule 2 Phase Delay (SM2_PHASEDLY)	16	RW	0000h
120h	Submodule 3 Counter (SM3_CNT)	16	R	0000h
122h	Submodule 3 Initial Count (SM3_INIT)	16	RW	0000h
124h	Submodule 3 Control 2 (SM3_CTRL2)	16	RW	0000h
126h	Submodule 3 Control (SM3_CTRL)	16	RW	0400h
12Ah	Submodule 3 Value 0 (SM3_VAL0)	16	RW	0000h
12Ch	Submodule 3 Fractional Value 1 (SM3_FRACVAL1)	16	RW	0000h
12Eh	Submodule 3 Value 1 (SM3_VAL1)	16	RW	0000h
130h	Submodule 3 Fractional Value 2 (SM3_FRACVAL2)	16	RW	0000h
132h	Submodule 3 Value 2 (SM3_VAL2)	16	RW	0000h
134h	Submodule 3 Fractional Value 3 (SM3_FRACVAL3)	16	RW	0000h
136h	Submodule 3 Value 3 (SM3_VAL3)	16	RW	0000h
138h	Submodule 3 Fractional Value 4 (SM3_FRACVAL4)	16	RW	0000h
13Ah	Submodule 3 Value 4 (SM3_VAL4)	16	RW	0000h
13Ch	Submodule 3 Fractional Value 5 (SM3_FRACVAL5)	16	RW	0000h
13Eh	Submodule 3 Value 5 (SM3_VAL5)	16	RW	0000h
140h	Submodule 3 Fractional Control (SM3_FRCTRL)	16	RW	0000h
142h	Submodule 3 Output Control (SM3_OCTRL)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
144h	Submodule 3 Status (SM3_STS)	16	RW	0000h
146h	Submodule 3 Interrupt Enable (SM3_INTEN)	16	RW	0000h
148h	Submodule 3 DMA Enable (SM3_DMAEN)	16	RW	0000h
14Ah	Submodule 3 Output Trigger Control (SM3_TCTRL)	16	RW	0000h
14Ch	Submodule 3 Fault Disable Mapping (SM3_DISMAP0)	16	RW	FFFFh
14Eh	Submodule 3 Fault Disable Mapping (SM3_DISMAP1)	16	RW	FFFFh
150h	Submodule 3 Deadtime Count 0 (SM3_DTCNT0)	16	RW	07FFh
152h	Submodule 3 Deadtime Count 1 (SM3_DTCNT1)	16	RW	07FFh
154h	Submodule 3 Capture Control A (SM3_CAPTCTRLA)	16	RW	0000h
156h	Submodule 3 Capture Compare A (SM3_CAPTCOMPA)	16	RW	0000h
158h	Submodule 3 Capture Control B (SM3_CAPTCTRLB)	16	RW	0000h
15Ah	Submodule 3 Capture Compare B (SM3_CAPTCOMPB)	16	RW	0000h
15Ch	Submodule 3 Capture Control X (SM3_CAPTCTRLX)	16	RW	0000h
15Eh	Submodule 3 Capture Compare X (SM3_CAPTCOMPX)	16	RW	0000h
160h	Submodule 3 Capture Value 0 (SM3_CVAL0)	16	R	0000h
162h	Submodule 3 Capture Value 0 Cycle (SM3_CVAL0CYC)	16	R	0000h
164h	Submodule 3 Capture Value 1 (SM3_CVAL1)	16	R	0000h
166h	Submodule 3 Capture Value 1 Cycle (SM3_CVAL1CYC)	16	R	0000h
168h	Submodule 3 Capture Value 2 (SM3_CVAL2)	16	R	0000h
16Ah	Submodule 3 Capture Value 2 Cycle (SM3_CVAL2CYC)	16	R	0000h
16Ch	Submodule 3 Capture Value 3 (SM3_CVAL3)	16	R	0000h
16Eh	Submodule 3 Capture Value 3 Cycle (SM3_CVAL3CYC)	16	R	0000h
170h	Submodule 3 Capture Value 4 (SM3_CVAL4)	16	R	0000h
172h	Submodule 3 Capture Value 4 Cycle (SM3_CVAL4CYC)	16	R	0000h
174h	Submodule 3 Capture Value 5 (SM3_CVAL5)	16	R	0000h
176h	Submodule 3 Capture Value 5 Cycle (SM3_CVAL5CYC)	16	R	0000h
178h	Submodule 3 Phase Delay (SM3_PHASEDLY)	16	RW	0000h
180h	Output Enable (OUTEN)	16	RW	0000h
182h	Mask (MASK)	16	RW	0000h
184h	Software Controlled Output (SWCOUT)	16	RW	0000h
186h	PWM Source Select (DTSRCSEL)	16	RW	0000h

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Offset	Register	Width (In bits)	Access	Reset value
188h	Master Control (MCTRL)	16	RW	0000h
18Ah	Master Control 2 (MCTRL2)	16	RW	0000h
18Ch	Fault Protection 0 Control (FP0_CTRL)	16	RW	F000h
18Eh	Fault Protection 0 Status (FP0_STS)	16	RW	0000h
190h	Fault Protection 0 Filter (FP0_FILT)	16	RW	0000h
192h	Fault Protection 0 Test (FP0_TST)	16	RW	0000h
194h	Fault Protection 0 Control 2 (FP0_CTRL2)	16	RW	0000h
1B0h	DLL Status (DLLSR)	16	RW	0000h
1B8h	Submodule 0 BIST Control (SM0_BIST_CTRL)	16	RW	1F00h
1BAh	Submodule 0 BIST Control (SM0_BIST_CTRL1)	16	RW	1F00h
1BCh	Submodule 1 BIST Control (SM1_BIST_CTRL)	16	RW	1F00h
1BEh	Submodule 1 BIST Control (SM1_BIST_CTRL1)	16	RW	1F00h
1C0h	Submodule 2 BIST Control (SM2_BIST_CTRL)	16	RW	1F00h
1C2h	Submodule 2 BIST Control (SM2_BIST_CTRL1)	16	RW	1F00h
1C4h	Submodule 3 BIST Control (SM3_BIST_CTRL)	16	RW	1F00h
1C6h	Submodule 3 BIST Control (SM3_BIST_CTRL1)	16	RW	1F00h
1C8h	Submodule 0 BIST Status (SM0_BIST_STATUS)	16	R	0000h
1CAh	Submodule 0 BIST Status (SM0_BIST_STATUS1)	16	R	0000h
1CCh	Submodule 1 BIST Status (SM1_BIST_STATUS)	16	R	0000h
1CEh	Submodule 1 BIST Status (SM1_BIST_STATUS1)	16	R	0000h
1D0h	Submodule 2 BIST Status (SM2_BIST_STATUS)	16	R	0000h
1D2h	Submodule 2 BIST Status (SM2_BIST_STATUS1)	16	R	0000h
1D4h	Submodule 3 BIST Status (SM3_BIST_STATUS)	16	R	0000h
1D6h	Submodule 3 BIST Status (SM3_BIST_STATUS1)	16	R	0000h

56.7.2 Submodule a Counter (SM0_CNT - SM3_CNT)

Offset

Register	Offset
SM0_CNT	0h
SM1_CNT	60h

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Register	Offset
SM2_CNT	C0h
SM3_CNT	120h

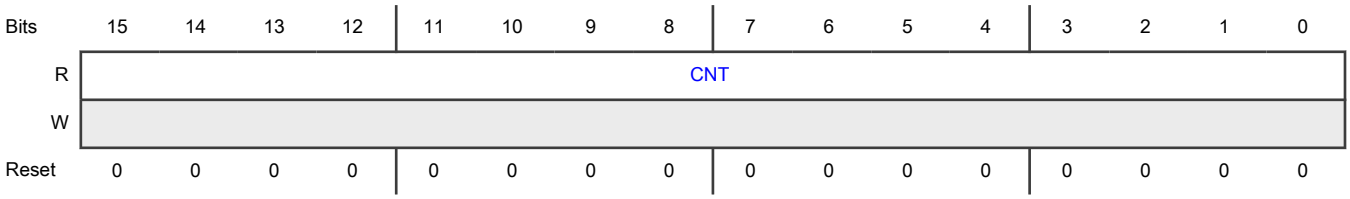
Function

Indicates the current value of the signed 16-bit submodule counter in PWM counter units. This register is not byte accessible.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (SM*n*_CTRL[LDMOD]). This register cannot be written when submodule Load Okay is asserted. Reading INIT returns the value in the buffer and not necessarily the value the PWM generator is currently using.

Diagram



Fields

Field	Function
15-0 CNT	Counter Value Specifies the Initial Count for the submodule in PWM counter units. This field is not byte accessible.

56.7.3 Submodule a Initial Count (SM0_INIT - SM3_INIT)

Offset

Register	Offset
SM0_INIT	2h
SM1_INIT	62h
SM2_INIT	C2h
SM3_INIT	122h

Function

Specifies the Initial Count for the submodule in PWM counter units. This register is not byte accessible.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (SM*n*_CTRL[LDMOD]). This register cannot be written when submodule Load Okay is asserted. Reading INIT returns the value in the buffer and not necessarily the value the PWM generator is currently using.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	INIT															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-0 INIT	Initial Count The submodule loads this value into the counter at the start of every PWM period and on assertion of local sync, master sync, or master reload (SM*n*_CTRL2[INIT_SEL]), or on a forced initialization (SM*n*_CTRL2[FORCE]) with Force Init enabled (SM*n*_CTRL2[FRCEN]). This field is not byte accessible.

56.7.4 Submodule a Control 2 (SM0_CTRL2 - SM3_CTRL2)

Offset

Register	Offset
SM0_CTRL2	4h
SM1_CTRL2	64h
SM2_CTRL2	C4h
SM3_CTRL2	124h

Function

Provides control of submodule functions.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DBGEN	WAITEN	INDEP	PWM23_I...	PWM45_I...	PWMX_IN...	INIT_SEL		FRCEN	0	FORCE_SEL			RELOAD_...	CLK_SEL	
W										FORCE						
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 DBGEN	Run In Debug Enable Specifies whether eFlexPWM continues to run while the chip is in Debug mode. If enabled, eFlexPWM continues to run in Debug mode. If disabled, when the chip enters Debug mode, eFlexPWM disables outputs. When the chip exits Debug mode, eFlexPWM resumes operation as programmed. **CAUTION** For certain types of motors (such as 3-phase AC), you must disable Run In Debug because failure to do so could result in damage to the motor or inverter. For other types of motors (example: DC motors), you may safely enable Run In Debug, but PWM parameter updates do not occur during Run In Debug. If you are using a motor that requires such updates, disable Run In Debug. If in doubt, leave it disabled. 0b - Disabled 1b - Enabled
14 WAITEN	Run In Wait Enable Specifies whether eFlexPWM continues to run while the chip is in Wait mode. If enabled, in Wait mode the peripheral clock continues to run but the CPU clock does not. If not enabled, when the chip enters Wait mode eFlexPWM disables outputs. When the chip exits Wait mode, eFlexPWM resumes operation as programmed. **CAUTION** For certain types of motors (such as 3-phase AC), you must disable Run In Wait because failure to do so could result in damage to the motor or inverter. For other types of motors (example: DC motors), you may safely enable Run In Wait, but PWM parameter updates do not occur during Run In Wait. If you are using a motor that requires such updates, disable Run In Wait. If in doubt, leave it disabled. 0b - Disabled 1b - Enabled
13 INDEP	Independent Operation Specifies whether the PWM*n*_A and PWM*n*_B channels are independent PWMs or a complementary PWM pair.

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Field	Function
	0b - Complementary PWM pair 1b - Independent PWMs
12 PWM23_INIT	PWM23 Initial Value Specifies the initial value for PWM23 and the value it is forced to by assertion of FORCE_INIT.
11 PWM45_INIT	PWM45 Initial Value Specifies the initial value for PWM45 and the value it is forced to by assertion of FORCE_INIT.
10 PWMX_INIT	PWMn_X Initial Value Specifies the initial value for PWM*n*_X and the value it is forced to by assertion of FORCE_INIT.
9-8 INIT_SEL	Initialization Source Select Specifies the source of initialization (the INIT signal) to the counter. 00b - Local sync (PWMn_X) 01b - Master reload (from submodule 0). Master reload (from submodule 0). This setting should not be used in submodule 0 as it will force the INIT signal to logic 0. 10b - Master sync from submodule 0. Master sync from submodule 0. Do not use this source for submodule 0 because it forces the INIT signal to logic 0. 11b - External sync (EXT_SYNC)
7 FRCEN	Force Initialization Enable Enables Force Initialization (SM*n*_CTRL2[FORCE]) to initialize the counter without regard for Initialization Control Select (SM*n*_CTRL2[INIT_SEL]). This is a software controlled initialization. If the submodule Load Okay (MCTRL[LDOK]) is asserted, forced initialization also asserts the local reload. 0b - Disabled 1b - Enabled
6 FORCE	Force Initialization If the local force signal is selected (SM*n*_CTRL2[FORCE_SEL] is 000b), writing 1 to this bit triggers a FORCE_OUT event, which involves the following actions: • The PWM*n*_A and PWM*n*_B output pins assume values based on the selected sources (DTSRCSEL[SM*n*SEL23] and DTSRCSEL[SM*n*SEL45]). • If Force Initialization is enabled (SM*n*_CTRL2[FRCEN]), eFlexPWM loads the INIT value into the counter. 0b - No effect 1b - Force initialization
5-3 FORCE_SEL	Force Output Source Select

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Field	Function
	Specifies the source of the FORCE OUTPUT signal for the submodule. Assertion of the selected signal forces an update. 000b - Local force signal (FORCE) 001b - Master force signal (from submodule 0). Master force signal (from submodule 0). Do not use this source for submodule 0 because it forces the FORCE OUTPUT signal to logic 0. 010b - Local reload signal. Local reload signal. Forces update without regard for the state of MCTRL[LDOK]. 011b - Master reload signal (from submodule 0). Master reload signal (from submodule 0). Forces updates if Load Okay (MCTRL[LDOK]) is set. Do not use this source for submodule 0 because it forces the FORCE OUTPUT signal to logic 0. 100b - Local sync signal 101b - Master sync signal (from submodule 0). Master sync signal (from submodule 0). Do not use this source for submodule 0 because it forces the FORCE OUTPUT signal to logic 0. 110b - External force signal (EXT_FORCE) 111b - External sync signal (EXT_SYNC)
2 RELOAD_SEL	Reload Source Select Specifies the source of the RELOAD signal for the submodule. Assertion of the selected signal triggers a reload. **NOTE** For submodules 1, 2, and 3: If you specify the Master RELOAD signal, you must also use the submodule 0 bit in MCTRL[LDOK] because the LDOK bits for these submodules are ignored. 0b - Local RELOAD signal 1b - Master RELOAD signal (from submodule 0). Master RELOAD signal (from submodule 0). Do not use this source for submodule 0 because it forces the RELOAD signal to logic 0.
1-0 CLK_SEL	Clock Source Select Specifies the clock signal source for the submodule prescaler and counter. 00b - IPBus clock 01b - EXT_CLK 10b - Submodule 0 clock (AUX_CLK). Submodule 0 clock (AUX_CLK). Do not use this source for submodule 0 because it forces the clock to logic 0. 11b - Reserved

56.7.5 Submodule a Control (SM0_CTRL - SM3_CTRL)

Offset

Register	Offset
SM0_CTRL	6h
SM1_CTRL	66h
SM2_CTRL	C6h
SM3_CTRL	126h

Function

Provides control of submodule functions.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	LDFQ				HALF	FULL	DT		COMP MODE	PRSC			SPLIT	LDMOD	DBLX	DBLEN
Reset	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-12 LDFQ	Load Frequency Selects the PWM load frequency. Reset clears LDFQ to the default of loading every PWM opportunity. HALF and FULL determine the PWM opportunities. **NOTE** LDFQ takes effect when the current load cycle is complete, regardless of the state of Load Okay (MCTRL[LDOK]). Reading LDFQ returns the buffered value and not necessarily the value currently in effect. 0000b - Every PWM opportunity 0001b - Every 2 PWM opportunities 0010b - Every 3 PWM opportunities 0011b - Every 4 PWM opportunities 0100b - Every 5 PWM opportunities 0101b - Every 6 PWM opportunities 0110b - Every 7 PWM opportunities 0111b - Every 8 PWM opportunities 1000b - Every 9 PWM opportunities

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Field	Function
	1001b - Every 10 PWM opportunities 1010b - Every 11 PWM opportunities 1011b - Every 12 PWM opportunities 1100b - Every 13 PWM opportunities 1101b - Every 14 PWM opportunities 1110b - Every 15 PWM opportunities 1111b - Every 16 PWM opportunities
11 HALF	Half-Period Reload Enables half-period reloads. A half period is defined by when the submodule counter matches Timing Value 0 (SM*n*_VAL0[VAL0]) and does not have to be half-way through the PWM period. 0b - Disabled 1b - Enabled
10 FULL	Full-Period Reload Enables full-period reloads. A full period is defined as when the submodule counter matches Timing Value 1 (SM*n*_VAL1[VAL1]). You must enable either half-period (HALF) or full-period (FULL) reloads to move the buffered data into the PWM generator registers, or you must assert Load Mode (LDMOD). If you assert both half- and full-period reloads, then reloads can occur twice per period. 0b - Disabled 1b - Enabled
9-8 DT	Deadtime Indicates the sampled values of the PWM*n*_X input at the end of each deadtime. Sampling occurs at the end of deadtime 0 for DT[0] and the end of deadtime 1 for DT[1]. Reset clears these bits.
7 COMPMODE	Compare Mode Specifies how comparisons are made between the timing value (SM*n*_VAL*m*) registers and the submodule counter. **NOTE** You can write to this field only one time. After you write to it, you must reset to release the bit for writing again. 0b - Equal to. Produces PWM edges only when the counter is equal to one of the timing values. This implies that a PWM*n*_A output that is high at the end of a period maintains this state until a match with VAL3 clears the output in the following period. 1b - Equal to or greater than. Produces PWM edges only when the counter is equal to or greater than one of the timing values. This implies that a PWM*n*_A output that is high at the end of a period could go low at the start of the next period if the starting counter value is greater than (but not necessarily equal to) the new VAL3 value.
6-4	Prescaler

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Field	Function
PRSC	Selects the divide ratio of the selected PWM source clock frequency (CLK_SEL). This value determines the number of source clock cycles that occur for every increment of the submodule counter (SM*n*_CNT[CNT]). **NOTE** Reading Prescaler returns the buffered value and not necessarily the value currently in effect. The Prescaler selection takes effect at the beginning of the next PWM period and only when Load Okay (MCTRL[LDOK]) is asserted or when you select Load Okay assertion for the Load Mode (SM*n*_CTRL[LDMOD]). You cannot write to this field when Load Okay (MCTRL[LDOK]) is asserted. 000b - No divider 001b - Divide by 2 010b - Divide by 4 011b - Divide by 8 100b - Divide by 16 101b - Divide by 32 110b - Divide by 64 111b - Divide by 128
3 SPLIT	Split DBLPWM Splits the DBLPWM signal to PWMA and PWMB. Applies only if double switching is enabled. When Split DBLPMW is enabled, one PWM pulse generated by double switching appears on PWMA and the other on PWMB. PWM creates the two pulses within the same PWM period by an XOR function of the PWMA and PWMB sources. The splitting function causes PWMA to output the pulse that occurs when the PWMA source is 1 and the PWMB source is 0. The PWMB output occurs when the PWMB source is 1 and the PWMA source is 0. (See Generate double-switching PWM pulses.) 0b - Not split. PWMA and PWMB each have double pulses. 1b - Split to PWMA and PWMB.
2 LDMOD	Load Mode Select Selects the timing for loading the buffered registers in the submodule. 0b - Next PWM reload, if submodule Load Okay is asserted. Next PWM reload, if submodule Load Okay is asserted (MCTRL[LDOK]). 1b - Load Okay assertion. Load Okay assertion (MCTRL[LDOK]). This case ignores FULL or HALF.
1 DBLX	PWMX Double Switching Enable Enables double switching behavior on PWMX. When enabled, the PWMX output is the exclusive-OR combination of PWMA and PWMB before polarity and masking considerations. 0b - Disabled 1b - Enabled

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Field	Function
0 DBLEN	Double Switching Enable Enables double switching PWM behavior (see Generate double-switching PWM pulses). **NOTE** Double switching is not compatible with fractional PWM clock generation. If you enable any fractional cycle capability (SM*n*_FRCTRL[FRAC23_EN], SM*n*_FRCTRL[FRAC45_EN], or SM*n*_FRCTRL[FRAC1_EN]), you must also disable double switching. 0b - Disabled 1b - Enabled

56.7.6 Submodule a Value 0 (SM0_VAL0 - SM3_VAL0)

Offset

Register	Offset
SM0_VAL0	Ah
SM1_VAL0	6Ah
SM2_VAL0	CAh
SM3_VAL0	12Ah

Function
See SM*n*_VAL0[VAL0].

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	VAL0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-0 VAL0	Timing Value 0 Specifies the mid-period reload point for the PWM submodule in PWM counter units. This value also specifies when to assert the PWM*n*_X signal and reset the local sync signal. This field is not byte accessible.

Table continues on the next page...

Field	Function
	NOTE This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading VAL0 returns the value in the buffer and not necessarily the value the PWM generator is currently using.

56.7.7 Submodule a Fractional Value 1 (SM0_FRACVAL1 - SM3_FRACVAL1)

Offset

Register	Offset
SM0_FRACVAL1	Ch
SM1_FRACVAL1	6Ch
SM2_FRACVAL1	CCh
SM3_FRACVAL1	12Ch

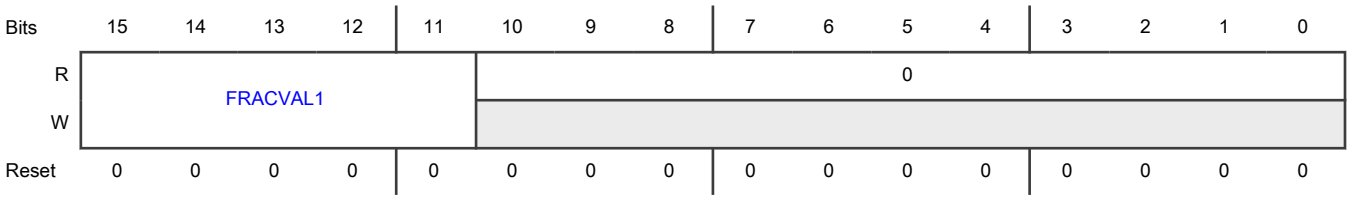
Function

Specifies the fractional addition to Submodule a Value 1 (SM0_VAL1 - SM3_VAL1) value for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (SM*n*_CTRL[LDMOD]). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-11 FRACVAL1	Fractional Timing Value 1 Specifies a fractional addition to Timing Value 1 (VAL1), in source clock cycles, that controls the PWM period width.

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Field	Function
	The PWM period is computed in source clock cycles divided by the selected prescaler. For example, if the prescaler is Divide by 16 (SM*n*_CTRL[PRSC] is 100b), the submodule counter, initial value, and all timing values represent multiples of 16 clock cycles. The submodule accumulates the fractional portion specified in FRACVAL1 at the end of every PWM period until the accumulated value is equal to or greater than the prescaler. Then, for one period, the PWM period is one counter unit longer to compensate for the accumulated fractional values. After that period, the submodule resets the fractional accumulator to zero.
10-0 —	Reserved

56.7.8 Submodule a Value 1 (SM0_VAL1 - SM3_VAL1)

Offset

Register	Offset
SM0_VAL1	Eh
SM1_VAL1	6Eh
SM2_VAL1	CEh
SM3_VAL1	12Eh

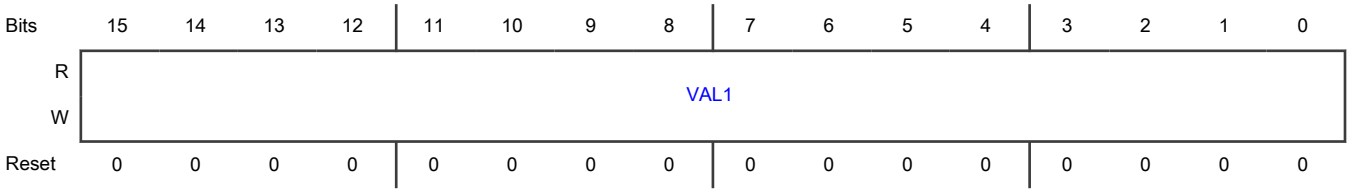
Function

Specifies the modulo count value 1 (maximum count) for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (SM*n*_CTRL[LDMOD]). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-0 VAL1	Timing Value 1 Specifies the modulo count value (maximum count) for the submodule counter. Upon reaching this count value, the counter reloads itself with the Initial Count (SM*n*_INIT[INIT]), asserts the local sync signal, and resets PWM*n*_X. This field is not byte accessible. **NOTE** When using SM*n*_FRACVAL1[FRACVAL1], limit the maximum value of VAL1 to 0xFFFE for unsigned operation (INIT is a positive integer) or to 0x7FFE for signed operation (INIT is a two's-complement negative integer) to avoid counter rollovers caused by accumulating the fractional period defined by SM*n*_FRACVAL1[FRACVAL1]. If VAL1 defines the counter period (Local Sync is selected as the counter initialization signal), you cannot achieve a 100% duty cycle on the PWM*n*_X output. After the count reaches VAL1, the PWM*n*_X output is low for a minimum of one count every cycle. When you use the Master Sync signal (only originated by the Local Sync from sub-module 0) to control the counter period, VAL1 is free for other functions such as PWM generation without the duty cycle limitation.

56.7.9 Submodule a Fractional Value 2 (SM0_FRACVAL2 - SM3_FRACVAL2)

Offset

Register	Offset
SM0_FRACVAL2	10h
SM1_FRACVAL2	70h
SM2_FRACVAL2	D0h
SM3_FRACVAL2	130h

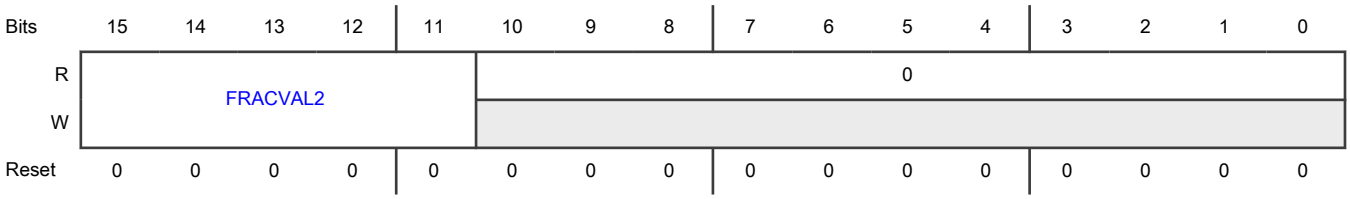
Function

Specifies the fractional addition to Submodule a Value 2 (SM0_VAL2 - SM3_VAL2) value for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-11 FRACVAL2	Fractional Timing Value 2 Specifies a fractional addition to Timing Value 2 (VAL2), in source clock cycles, that controls the PWM*n*_A turn-on timing. In complementary mode (SM*n*_CTRL2[INDEP] equal to 0) using PWM23 (submodule bit of MCTRL[IPOL] equal to 0), the submodule also adds the fractional value to the turn-off delay of PWM*n*_B. **NOTE** When the values of VAL2 and SM*n*_VAL3[VAL3] cause the high or low time of the PWM output to be three counter units or less, you should disable fractional edge placement of PWM*n*_A using SM*n*_FRACVAL2[FRACVAL2] and SM*n*_FRACVAL3[FRACVAL3] (SM*n*_FRCTRL[FRAC23_EN]).
10-0 —	Reserved

56.7.10 Submodule a Value 2 (SM0_VAL2 - SM3_VAL2)

Offset

Register	Offset
SM0_VAL2	12h
SM1_VAL2	72h
SM2_VAL2	D2h
SM3_VAL2	132h

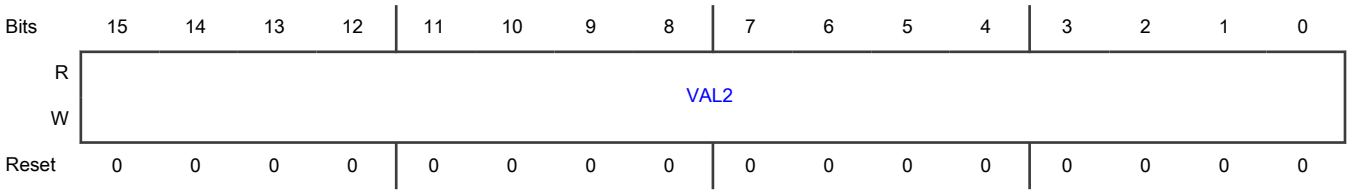
Function

Specifies the modulo count value 2 (maximum count) for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-0 VAL2	Timing Value 2 Specifies the count value to set PWM23 high. This field is not byte accessible.

56.7.11 Submodule a Fractional Value 3 (SM0_FRACVAL3 - SM3_FRACVAL3)

Offset

Register	Offset
SM0_FRACVAL3	14h
SM1_FRACVAL3	74h
SM2_FRACVAL3	D4h
SM3_FRACVAL3	134h

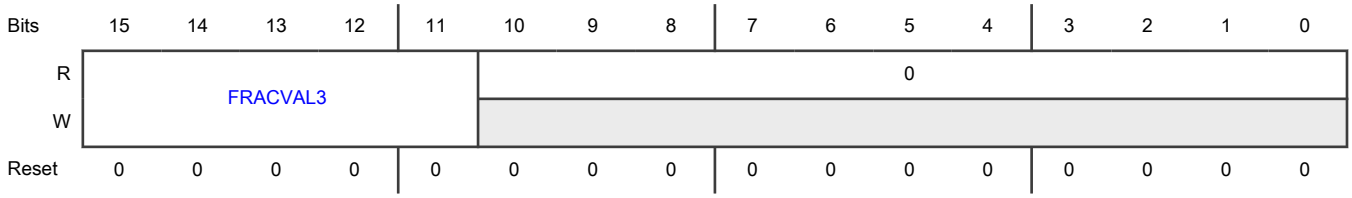
Function

Specifies the fractional addition to Submodule a Value 3 (SM0_VAL3 - SM3_VAL3) value for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-11 FRACVAL3	Fractional Timing Value 3 Specifies a fractional addition to Timing Value 3 (VAL3) that controls the PWM*n*_A turn-off timing. In complementary mode (SM*n*_CTRL2[INDEP] equal to 0) and using PWM23 (MCTRL[IPOL] equal to 0), the submodule also adds the fractional value to the turn-on delay of PWM*n*_B. **NOTE** When the values of SM*n*_VAL2[VAL2] and VAL3 cause the high or low time of the PWM output to be three counter units or less, you should disable fractional edge placement of PWM*n*_A using SM*n*_FRACVAL2[FRACVAL2] and FRACVAL3 (SM*n*_FRCTRL[FRAC23_EN]).
10-0 —	Reserved

56.7.12 Submodule a Value 3 (SM0_VAL3 - SM3_VAL3)

Offset

Register	Offset
SM0_VAL3	16h
SM1_VAL3	76h
SM2_VAL3	D6h
SM3_VAL3	136h

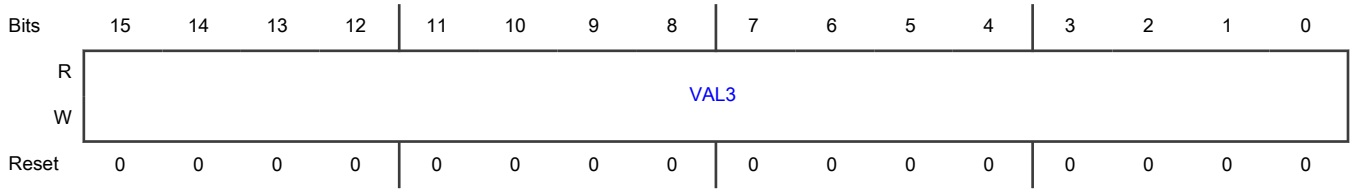
Function

Specifies the modulo count value 3 (maximum count) for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-0 VAL3	Timing Value 3 Specifies the count value to set PWM23 low. This field is not byte accessible.

56.7.13 Submodule a Fractional Value 4 (SM0_FRACVAL4 - SM3_FRACVAL4)

Offset

Register	Offset
SM0_FRACVAL4	18h
SM1_FRACVAL4	78h
SM2_FRACVAL4	D8h
SM3_FRACVAL4	138h

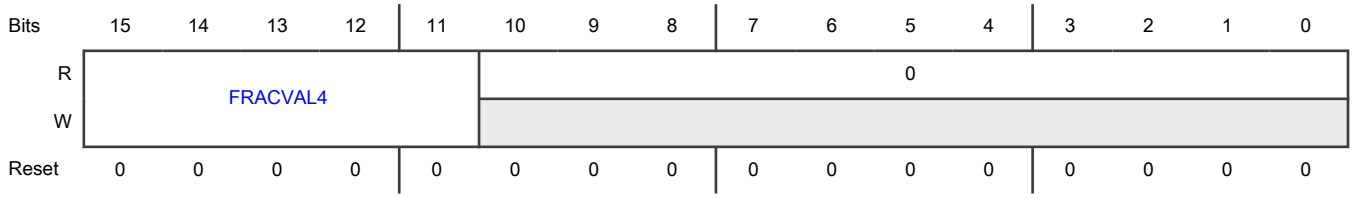
Function

Specifies the fractional addition to Submodule a Value 4 (SM0_VAL4 - SM3_VAL4) value for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-11 FRACVAL4	Fractional Timing Value 4 Specifies a fractional addition to Timing Value 4 (VAL4) that controls the PWM*n*_B turn-on timing. In complementary mode (SM*n*_CTRL2[INDEP] equal to 0) and using PWM45 (MCTRL[IPOL] equal to 1), the submodule also adds the fractional value to the turn-off delay of PWM*n*_A. **NOTE** When the values of VAL4 and SM*n*_VAL5[VAL5] cause the high or low time of the PWM output to be 3 counter units or less, you should disable fractional edge placement of PWM*n*_A using SM*n*_FRACVAL4[FRACVAL4] and SM*n*_FRACVAL5[FRACVAL5] (SM*n*_FRCTRL[FRAC45_EN]).
10-0 —	Reserved

56.7.14 Submodule a Value 4 (SM0_VAL4 - SM3_VAL4)

Offset

Register	Offset
SM0_VAL4	1Ah
SM1_VAL4	7Ah
SM2_VAL4	DAh
SM3_VAL4	13Ah

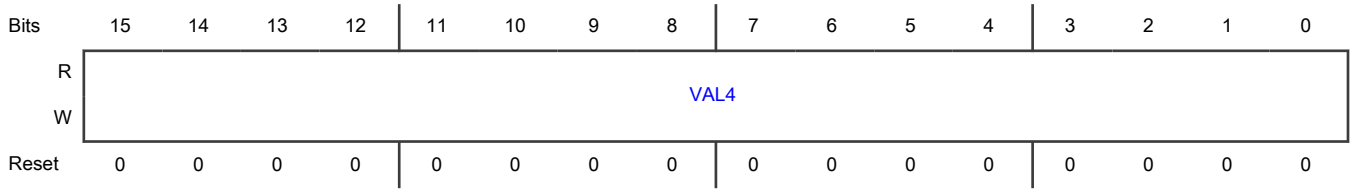
Function

Specifies the modulo count value 4 (maximum count) for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-0 VAL4	Timing Value 4 Specifies the count value to set PWM45 high. This field is not byte accessible.

56.7.15 Submodule a Fractional Value 5 (SM0_FRACVAL5 - SM3_FRACVAL5)

Offset

Register	Offset
SM0_FRACVAL5	1Ch
SM1_FRACVAL5	7Ch
SM2_FRACVAL5	DCh
SM3_FRACVAL5	13Ch

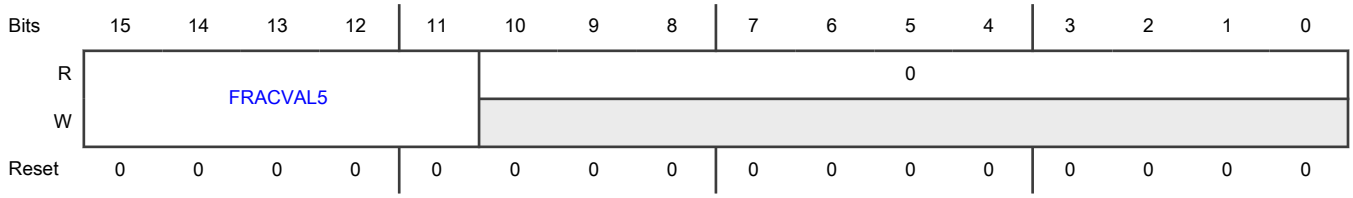
Function

Specifies the fractional addition to Submodule a Value 5 (SM0_VAL5 - SM3_VAL5) value for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[IPOL]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-11 FRACVAL5	Fractional Timing Value 5 Specifies a fractional addition to Value 5 (VAL5) that controls the PWM*n*_B turn-off timing. In complementary mode (SM*n*_CTRL2[INDEP] equal to 0) and using PWM45 (MCTRL[IPOL] equal to 1), the submodule also adds the fractional value to the turn-on delay of PWM*n*_A. **NOTE** When the values of SM*n*_VAL4[VAL4] and VAL5 cause the high or low time of the PWM output to be three counter units or less, you should disable fractional edge placement of PWM*n*_A using SM*n*_FRACVAL4[FRACVAL4] and SM*n*_FRACVAL5[FRACVAL5].
10-0 —	Reserved

56.7.16 Submodule a Value 5 (SM0_VAL5 - SM3_VAL5)

Offset

Register	Offset
SM0_VAL5	1Eh
SM1_VAL5	7Eh
SM2_VAL5	DEh
SM3_VAL5	13Eh

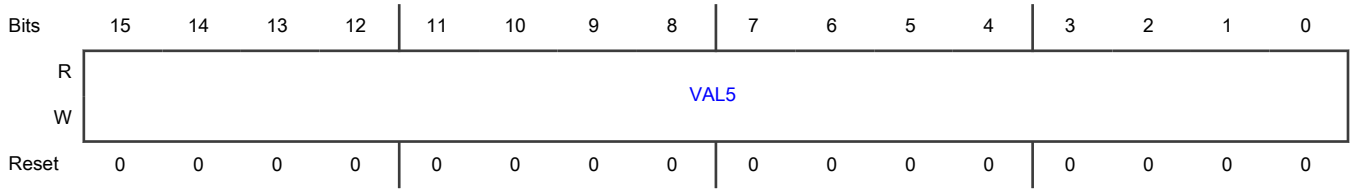
Function

Specifies the modulo count value 5 (maximum count) for the submodule counter.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[IPOL]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading this register returns the values in the buffer and not necessarily the values the PWM generator is currently using.

Diagram



Fields

Field	Function
15-0 VAL5	Timing Value 5 Specifies the count value to set PWM45 low. This field is not byte accessible.

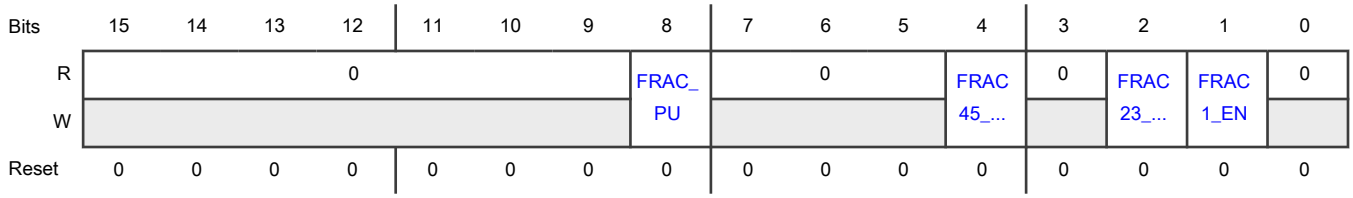
56.7.17 Submodule a Fractional Control (SM0_FRCTRL - SM3_FRCTRL)

Offset

Register	Offset
SM0_FRCTRL	20h
SM1_FRCTRL	80h
SM2_FRCTRL	E0h
SM3_FRCTRL	140h

Function
Provides control of fractional cycling.

Diagram



Fields

Field	Function
15-9 —	Reserved
8	Fractional Delay Power Up

Table continues on the next page...

Table continued from the previous page...

Field	Function
FRAC_PU	Powers up the fractional delay analog block to support fractional placement. The fractional delay block takes 25 µs to power up after writing the first FRAC_PU bit in any submodule. The fractional delay block powers down only when all submodule FRAC_PU fields are 0. The fractional delay logic can operate only when the IPBus clock runs at 100 MHz. When you turn off the fractional delay analog block, fractional placement is disabled. Before using fractional delay, you must clear the state of the analog block. 1. Power up the fractional delay analog block. 2. Wait 25 µs. 3. Load the PWM timing values to create a PWM output with greater than 0% duty cycle. 4. Run the PWM for at least one PWM period. You can do this without enabling outputs. 0b - Off 1b - On
7-5 —	Reserved
4 FRAC45_EN	Fractional Cycle Placement Enable for PWMn_B Enables fractional cycle edge placement for PWM*n*_B period using Fractional Value 4 and 5 (SM*n*_FRACVAL4[FRACVAL4] and SM*n*_FRACVAL5[FRACVAL5]). When disabled, the submodule bypasses the fractional cycle edge placement of PWM*n*_B. **NOTE** This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading FRAC45_EN returns the value in the buffer and not necessarily the value the PWM generator is currently using. 0b - Disable 1b - Enable
3 —	Reserved
2 FRAC23_EN	Fractional Cycle Placement Enable for PWMn_A Enables fractional cycle edge placement for PWM*n*_A period using Fractional Value 2 and 3 (SM*n*_FRACVAL2[FRACVAL2] and SM*n*_FRACVAL3[FRACVAL3]). When disabled, the submodule bypasses the fractional cycle edge placement of PWM*n*_A.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading FRAC23_EN returns the value in the buffer and not necessarily the value the PWM generator is currently using. 0b - Disable 1b - Enable
1 FRAC1_EN	Fractional Cycle PWM Period Enable Enables fractional cycle length for the PWM period using Fractional Value 1 (SM*n*_FRACVAL1[FRACVAL1]). When disabled, the submodule bypasses the fractional cycle length of the PWM period. **NOTE** This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading FRAC1_EN returns the value in the buffer and not necessarily the value the PWM generator is currently using. 0b - Disable 1b - Enable
0 —	Reserved

56.7.18 Submodule a Output Control (SM0_OCTRL - SM3_OCTRL)

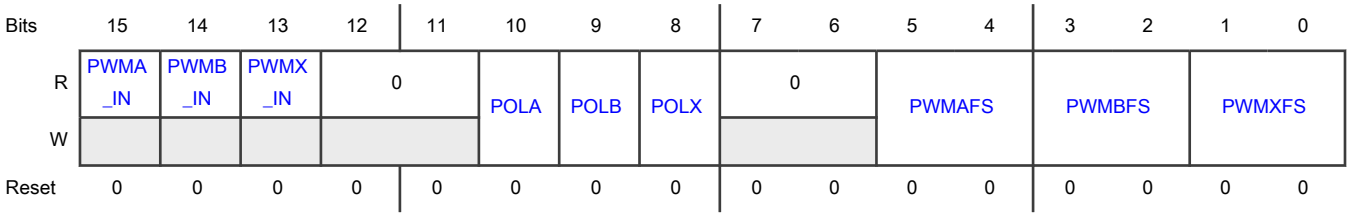
Offset

Register	Offset
SM0_OCTRL	22h
SM1_OCTRL	82h
SM2_OCTRL	E2h
SM3_OCTRL	142h

Function

Provides control of PWM output functioning.

Diagram



Fields

Field	Function
15 PWMA_IN	PWMn_A Input Indicates the logic value currently being driven into the PWM*n*_A input. The field reset state is undefined.
14 PWMB_IN	PWMn_B Input Indicates the logic value currently being driven into the PWMn_B input. The field reset state is undefined.
13 PWMX_IN	PWMn_X Input Indicates the logic value currently being driven into the PWM*n*_X input. The field reset state is undefined.
12-11 —	Reserved
10 POLA	PWMn_A Output Polarity Inverts the PWM*n*_A output polarity. 0b - Not inverted. PWMn_A is active high. 1b - Inverted. PWMn_A is active low.
9 POLB	PWMn_B Output Polarity Inverts the PWM*n*_B output polarity. 0b - Not inverted. PWMn_B is active high. 1b - Inverted. PWMn_B is active low.
8 POLX	PWMn_X Output Polarity Inverts the PWM*n*_X output polarity. 0b - Not inverted. PWMn_X is active high. 1b - Inverted. PWMn_X is active low.
7-6 —	Reserved
5-4 PWMAFS	PWMn_A Fault State

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Specifies the fault state for the PWM*n*_A output during fault conditions and STOP mode. It may also specify the output state during Wait and Debug modes depending on Wait Enable (SM*n*_CTRL2[WAITEN]) and Debug Enable (SM*n*_CTRL2[DBGEN]). 00b - Forced to logic 0 before consideration of output polarity control 01b - Forced to logic 1 before consideration of output polarity control 10b - Tristated 11b - Tristated
3-2 PWMBFS	PWMn_B Fault State Specifies the fault state for the PWM*n*_B output during fault conditions and STOP mode. It may also specify the output state during Wait and Debug modes depending on Wait Enable (SM*n*_CTRL2[WAITEN]) and Debug Enable (SM*n*_CTRL2[DBGEN]). 00b - Forced to logic 0 before consideration of output polarity control 01b - Forced to logic 1 before consideration of output polarity control 10b - Tristated 11b - Tristated
1-0 PWMXFS	PWMn_X Fault State Specifies the fault state for the PWM*n*_X output during fault conditions and Stop mode. It may also specify the output state during Wait and Debug modes depending on Wait Enable (SM*n*_CTRL2[WAITEN]) and Debug Enable (SM*n*_CTRL2[DBGEN]). 00b - Forced to logic 0 before consideration of output polarity control 01b - Forced to logic 1 before consideration of output polarity control 10b - Tristated 11b - Tristated

56.7.19 Submodule a Status (SM0_STS - SM3_STS)

Offset

Register	Offset
SM0_STS	24h
SM1_STS	84h
SM2_STS	E4h
SM3_STS	144h

Function

Provides access to several status flags of compare, capture, and reload error interrupts.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	RUF	REF	RF	CFA1	CFA0	CFB1	CFB0	CFX1	CFX0	CMPF					
W			W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C					
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15 —	Reserved
14 RUF	Registers Updated Flag Indicates that the Initial Count, one of the timing values, one of the fractional timing values, or the prescaler has been written, which indicates potentially non-coherent data in the set of double-buffered registers. Clear this bit by a proper reload sequence consisting of a reload signal with Load Okay enabled (MCTRL[LDOK]). 0b - No register update since last reload 1b - At least one double-buffered register updated since last reload
13 REF	Reload Error Flag Indicates a reload occurred while Load Okay is disabled (MCTRL[LDOK]) and the double-buffered registers are in a non-coherent state (SM*n*_STS[RUF] = 1). Clear this field by writing one to it. 0b - No reload error 1b - Reload error
12 RF	Reload Flag Indicates a reload has occurred since the last time the field was cleared. The submodule sets this flag at the beginning of every reload regardless of the state of Load Okay (MCTRL[LDOK]). If Value Registers DMA (SM*n*_DMAEN[VALDE]) is disabled, clear this flag by writing one to it. Otherwise, the DMA done signal clears this bit.. 0b - No new reload since last clearing 1b - New reload since last clearing
11 CFA1	Capture A1 Flag Indicates a capture event has occurred on the Capture A1 circuit. If Capture A1 FIFO DMA (SM*n*_DMAEN[CA1DE]) is not enabled, clear the field by writing one to it. Otherwise, the DMA done signal clears this field.
10 CFA0	Capture A0 Flag Indicates a capture event has occurred on the Capture A0 circuit. If Capture A0 FIFO DMA (SM*n*_DMAEN[CA0DE]) is not enabled, clear the field by writing one to it. Otherwise, the DMA done signal clears this field.
9	Capture B1 Flag

Table continues on the next page...

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Field	Function
CFB1	Indicates a capture event has occurred on the Capture B1 circuit. If Capture B1 FIFO DMA (SM*n*_DMAEN[CB1DE]) is not enabled, clear the field by writing one to it. Otherwise, the DMA done signal clears this field.
8 CFB0	Capture B0 Flag Indicates a capture event has occurred on the Capture B0 circuit. If Capture B0 FIFO DMA (SM*n*_DMAEN[CB0DE]) is not enabled, clear the field by writing one to it. Otherwise, the DMA done signal clears this field.
7 CFX1	Capture X1 Flag Indicates a capture event has occurred on the Capture X1 circuit. If Capture X1 FIFO DMA (SM*n*_DMAEN[CX1DE]) is not enabled, clear the field by writing one to it. Otherwise, the DMA done signal clears this field.
6 CFX0	Capture X0 Flag Indicates a capture event has occurred on the Capture X0 circuit. If Capture X0 FIFO DMA (SM*n*_DMAEN[CX0DE]) is not enabled, clear the field by writing one to it. Otherwise, the DMA done signal clears this field.
5-0 CMPF	Compare Flags Indicate when the submodule counter value matches the value of one of the timing values. Each bit position of the field corresponds to the like-numbered timing value (SM*n*_VAL*m*) register. Clear a bit by writing a 1 to the bit position. 00_0000b - No compare event has occurred. 00_0001b - A compare event has occurred.

56.7.20 Submodule a Interrupt Enable (SM0_INTEN - SM3_INTEN)

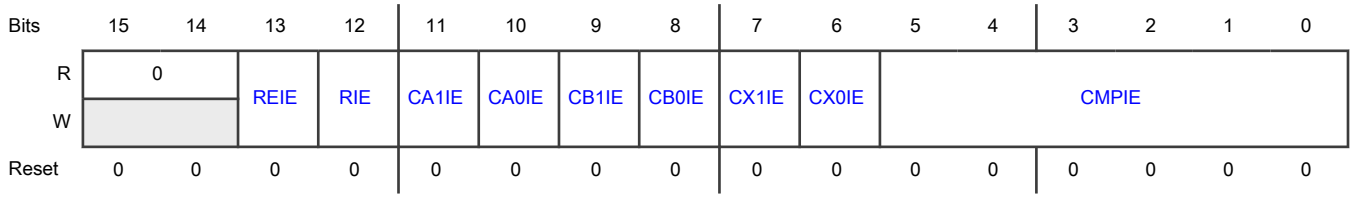
Offset

Register	Offset
SM0_INTEN	26h
SM1_INTEN	86h
SM2_INTEN	E6h
SM3_INTEN	146h

Function

Provides access to enabling of compare, capture, and reload error interrupts.

Diagram



Fields

Field	Function
15-14 —	Reserved
13 REIE	Reload Error Interrupt Enable Enables the reload error flag (SM*n*_STS[REF]) to trigger an IRQ to the CPU. 0b - Disable 1b - Enable
12 RIE	Reload Interrupt Enable Enables the reload flag (SM*n*_STS[RF]) to trigger an IRQ to the CPU. 0b - Disable 1b - Enable
11 CA1IE	Capture A1 Interrupt Enable Enables Capture A1 Flag (SM*n*_STS[CFA1]) to trigger an IRQ to the CPU. **NOTE** Do not enable both Capture A1 Interrupt and Capture A1 FIFO DMA (SM*n*_DMAEN[CA1DE]) at the same time. 0b - Disable 1b - Enable
10 CA0IE	Capture A0 Interrupt Enable Enables Capture A0 Flag (SM*n*_STS[CFA0]) to trigger an IRQ to the CPU. **NOTE** Do not enable both Capture A0 Interrupt and Capture A0 FIFO DMA (SM*n*_DMAEN[CA0DE]) at the same time. 0b - Disable 1b - Enable
9 CB1IE	Capture B1 Interrupt Enable Enables Capture B1 Flag (SM*n*_STS[CFB1]) to trigger an IRQ to the CPU.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE Do not enable both Capture B1 Interrupt and Capture B1 FIFO DMA (SM*n*_DMAEN[CB1DE]) at the same time. 0b - Disable 1b - Enable
8 CB0IE	Capture B0 Interrupt Enable Enables Capture B0 Flag (SM*n*_STS[CFB0]) to trigger an IRQ to the CPU. **NOTE** Do not enable both Capture B0 Interrupt and Capture B0 FIFO DMA (SM*n*_DMAEN[CB0DE]) at the same time. 0b - Disable 1b - Enable
7 CX1IE	Capture X1 Interrupt Enable Enables Capture X1 Flag (SM*n*_STS[CFX1]) to trigger an IRQ to the CPU. **NOTE** Do not enable both Capture X1 Interrupt and Capture X1 FIFO DMA (SM*n*_DMAEN[CX1DE]) at the same time. 0b - Disable 1b - Enable
6 CX0IE	Capture X0 Interrupt Enable Enables Capture X0 Flag (SM*n*_STS[CFX0]) to trigger an IRQ to the CPU. **NOTE** Do not enable both Capture X0 Interrupt and Capture X0 FIFO DMA (SM*n*_DMAEN[CX0DE]) at the same time. 0b - Disable 1b - Enable
5-0 CMPIE	Compare Interrupt Enables Enables the Compare Flags (SM*n*_STS[CMPF]) to trigger a compare IRQ to the CPU. Each bit position in the field corresponds to the like-numbered timing value register (SM*n*VAL*m*). 00_0000b - Disable 00_0001b - Enable

56.7.21 Submodule a DMA Enable (SM0_DMAEN - SM3_DMAEN)

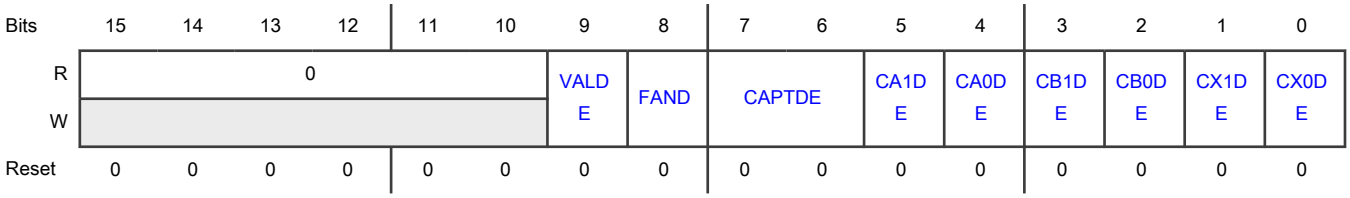
Offset

Register	Offset
SM0_DMAEN	28h
SM1_DMAEN	88h
SM2_DMAEN	E8h
SM3_DMAEN	148h

Function

Provides enabling of DMA interrupts.

Diagram



Fields

Field	Function
15-10 —	Reserved
9 VALDE	Value Registers DMA Enable Enables DMA write requests for the timing and fractional timing value (SM*n*_VAL*m*) registers when the Reload Flag (SM*n*_STS[RF]) is set. 0b - Disable 1b - Enable
8 FAND	FIFO Watermark AND Control Specifies the logic operation applied to the capture FIFO DMA enables to set the DMA request when the capture DMA source is watermark mode (SM*n*_DMAEN[CAPTDE] equal to 01b). 0b - OR: Any enabled FIFO watermark exceeded sets the DMA request 1b - AND: All enabled FIFO watermarks must be exceeded to set the DMA request
7-6 CAPTDE	Capture DMA Enable Source Select Selects the source for enabling DMA read requests for the capture FIFOs. 00b - Disable read DMA requests

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Field	Function
	01b - Exceeding a FIFO watermark. Exceeding a FIFO watermark. At least one of SM*n*_DMAEN[CA1DE], SM*n*_DMAEN[CA0DE], SM*n*_DMAEN[CB1DE], SM*n*_DMAEN[CB0DE], SM*n*_DMAEN[CX1DE], or SM*n*_DMAEN[CX0DE] must also be enabled to determine which watermarks set the DMA request. 10b - Local sync. Local sync occurs when the counter matches SM*n*_VAL1[VAL1]). 11b - Local reload. Local reload is signaled by the reload flag (SM*n*_STS[RF]).
5 CA1DE	Capture A1 FIFO DMA Enable Enables DMA read requests for the Capture A1 FIFO data when the Capture A1 flag (SM*n*_STS[CFA1]) is set. **NOTE** Do not enable both Capture A1 Interrupt (SM*n*_INTEN[CA1IE]) and Capture A1 FIFO DMA at the same time. 0b - Disable 1b - Enable
4 CA0DE	Capture A0 FIFO DMA Enable Enables DMA read requests for the Capture A0 FIFO data when the Capture A0 flag (SM*n*_STS[CFA0]) is set. **NOTE** Do not enable both Capture A0 Interrupt (SM*n*_INTEN[CA0IE]) and Capture A0 FIFO DMA at the same time. 0b - Disable 1b - Enable
3 CB1DE	Capture B1 FIFO DMA Enable Enables DMA read requests for the Capture B1 FIFO data when the Capture B1 flag (SM*n*_STS[CFB1]) is set. **NOTE** Do not enable both Capture B1 Interrupt (SM*n*_INTEN[CB1IE]) and Capture B1 FIFO DMA at the same time. 0b - Disable 1b - Enable
2 CB0DE	Capture B0 FIFO DMA Enable Enables DMA read requests for the Capture B0 FIFO data when the Capture B0 flag (SM*n*_STS[CFB0]) is set.

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Field	Function
	NOTE Do not enable both Capture B0 Interrupt (SM*n*_INTEN[CB0IE]) and Capture B0 FIFO DMA at the same time. 0b - Disable 1b - Enable
1 CX1DE	Capture X1 FIFO DMA Enable Enables DMA read requests for the Capture X1 FIFO data when the Capture X1 flag (SM*n*_STS[CFX1]) is set. **NOTE** Do not enable both Capture X1 Interrupt (SM*n*_INTEN[CX1IE]) and Capture X1 FIFO DMA at the same time. 0b - Disable 1b - Enable
0 CX0DE	Capture X0 FIFO DMA Enable Enables DMA read requests for the Capture X0 FIFO data when the Capture X0 flag (SM*n*_STS[CFX0]) is set. **NOTE** Do not enable both Capture X0 Interrupt (SM*n*_INTEN[CX0IE]) and Capture X0 FIFO DMA at the same time. 0b - Disable 1b - Enable

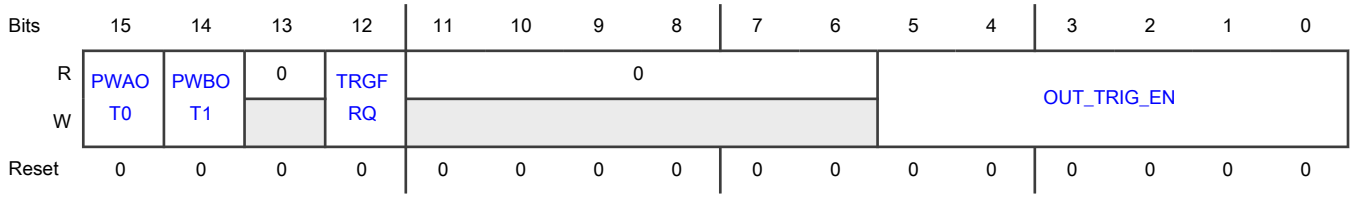
56.7.22 Submodule a Output Trigger Control (SM0_TCTRL - SM3_TCTRL)

Offset

Register	Offset
SM0_TCTRL	2Ah
SM1_TCTRL	8Ah
SM2_TCTRL	EAh
SM3_TCTRL	14Ah

Function
Specifies the behavior of the output triggers.

Diagram



Fields

Field	Function
15 PWAOT0	Mux Output Trigger 0 Source Select Selects which signal to route to the PWM*n*_MUX_TRIG0 port. 0b - Route PWMn_OUT_TRIG0 signal to PWMn_MUX_TRIG0 port. 1b - Route PWMn_A output to PWMn_MUX_TRIG0 port.
14 PWBOT1	Mux Output Trigger 1 Source Select Selects which signal to route to the PWM*n*_MUX_TRIG1 port. 0b - Route PWMn_OUT_TRIG1 signal to PWMn_MUX_TRIG1 port. 1b - Route PWMn_B output to PWMn_MUX_TRIG1 port.
13 —	Reserved
12 TRGFRQ	Trigger Frequency Enables control of the frequency of the trigger outputs when using non-zero load frequency (SM*n*_CTRL[LDFQ]) values. 0b - Every period. Trigger outputs generated during every PWM period, even if the PWM is not reloaded every period due to non-zero load frequency (SM*n*_CTRL[LDFQ]). 1b - Final period. Trigger outputs generated only during the final PWM period before a reload opportunity when the PWM is not reloaded every period due to non-zero load frequency (SM*n*_CTRL[LDFQ]).
11-6 —	Reserved
5-0 OUT_TRIG_EN	Output Trigger Enables Enables the generation of the PWM*n*_OUT_TRIG0 and PWM*n*_OUT_TRIG1 outputs when the counter value matches one or more of the timing values (SM*n*_VAL*m*). **NOTE** Due to delays in creating the PWM outputs, the output trigger signals lead the PWM output edges by 2-3 clock cycles depending on the fractional cycle value. 1x_xxxxb - PWMn_OUT_TRIG1 set by Timing Value 5. PWMn_OUT_TRIG1 set by Timing Value 5 (SM*n*_VAL5[VAL5])

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Field	Function
	x1_xxxxb - PWMn_OUT_TRIG0 set by Timing Value 4. PWMn_OUT_TRIG0 set by Timing Value 4 (SM*n*_VAL4[VAL4]) xx_1xxxb - PWMn_OUT_TRIG1 set by Timing Value 3. PWMn_OUT_TRIG1 set by Timing Value 3 (SM*n*_VAL3[VAL3]) xx_x1xxb - PWMn_OUT_TRIG0 set by Timing Value 2. PWMn_OUT_TRIG0 set by Timing Value 2 (SM*n*_VAL2[VAL2]) xx_xx1xb - PWMn_OUT_TRIG1 set by Timing Value 1. PWMn_OUT_TRIG1 set by Timing Value 1 (SM*n*_VAL1[VAL1]) xx_xxx1b - PWMn_OUT_TRIG0 set by Timing Value 0. PWMn_OUT_TRIG0 set by Timing Value 0 (SM*n*_VAL0[VAL0])

56.7.23 Submodule a Fault Disable Mapping (SM0_DISMAP0 - SM3_DISMAP0)

Offset

Register	Offset
SM0_DISMAP0	2Ch
SM1_DISMAP0	8Ch
SM2_DISMAP0	ECh
SM3_DISMAP0	14Ch

Function

Specifies which fault protection inputs on the fault channel 0 turn off the PWM outputs. Reset sets all bits to 1.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	1				DIS0X				DIS0B				DIS0A			
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
15-12 —	Reserved
11-8	PWMn_X Fault Disable Mask 0

Table continues on the next page...

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Field	Function
DIS0X	Selects which fault inputs on fault channel 0 turn off the PWM*n*_X output. Each bit position in the field corresponds to the like-numbered FAULTn input on fault channel 0. If you write 1 to one of these bits, then assertion of the corresponding FAULTn input turns off the PWM*n*_X output. Reset sets all bits in this field.
7-4 DIS0B	PWMn_B Fault Disable Mask 0 Selects which fault inputs on fault channel 0 turn off the PWM*n*_B output. Each bit position in the field corresponds to the like-numbered FAULTn input on fault channel 0. If you write 1 to one of these bits, then assertion of the corresponding FAULTn input turns off the PWM*n*_B output. Reset sets all bits in this field.
3-0 DIS0A	PWMn_A Fault Disable Mask 0 Selects which fault inputs on fault channel 0 turn off the PWM*n*_A output. Each bit position in the field corresponds to the like-numbered FAULTn input on fault channel 0. If you write 1 to one of these bits, then assertion of the corresponding FAULTn input turns off the PWM*n*_A output. Reset sets all bits in this field.

56.7.24 Submodule a Fault Disable Mapping (SM0_DISMAP1 - SM3_DISMAP1)

Offset

Register	Offset
SM0_DISMAP1	2Eh
SM1_DISMAP1	8Eh
SM2_DISMAP1	EEh
SM3_DISMAP1	14Eh

Function

Specifies which fault protection inputs on the fault channel 1 turn off the PWM outputs. Reset sets all bits to 1.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	1				DIS1X				DIS1B				DIS1A			
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
15-12 —	Reserved

Table continues on the next page...

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Field	Function
11-8 DIS1X	PWMn_X Fault Disable Mask 1 Selects which fault inputs on fault channel 1 turn off the PWM*n*_X output. Each bit position in the field corresponds to the like-numbered FAULTn input on fault channel 1. If you write 1 to one of these bits, then assertion of the corresponding FAULTn input turns off the PWM*n*_X output. Reset sets all bits in this field.
7-4 DIS1B	PWMn_B Fault Disable Mask 1 Selects which fault inputs on fault channel 1 turn off the PWM*n*_B output. Each bit position in the field corresponds to the like-numbered FAULTn input on fault channel 1. If you write 1 to one of these bits, then assertion of the corresponding FAULTn input turns off the PWM*n*_B output. Reset sets all bits in this field.
3-0 DIS1A	PWMn_A Fault Disable Mask 1 Selects which fault inputs on fault channel 1 turn off the PWM*n*_A output. Each bit position in the field corresponds to the like-numbered FAULTn input on fault channel 1. If you write 1 to one of these bits, then assertion of the corresponding FAULTn input turns off the PWM*n*_A output. Reset sets all bits in this field.

56.7.25 Submodule a Deadtime Count 0 (SM0_DTCNT0 - SM3_DTCNT0)

Offset

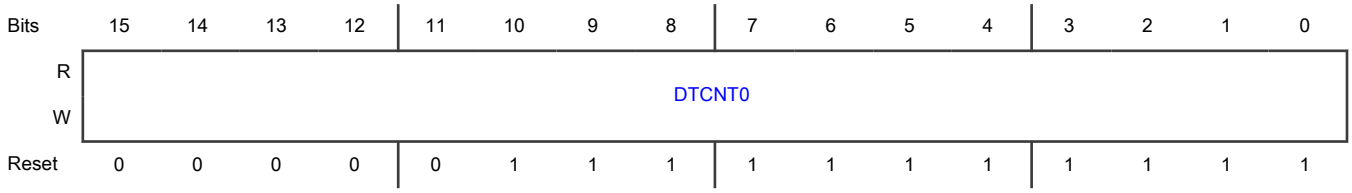
Register	Offset
SM0_DTCNT0	30h
SM1_DTCNT0	90h
SM2_DTCNT0	F0h
SM3_DTCNT0	150h

Function

Specifies the deadtime in IPBus clock cycles during the transition from deassertion to assertion of the PWM*n*_A output (assuming normal polarity).

Deadtime operation applies only to complementary channel operation. The deadtime value represents IPBus clock cycles regardless of the prescaler value (SM*n*_CTRL[PRSC]) or the selected clock source (SM0_CTRL2[CLK_SEL]). Reset sets the deadtime count for each output to a default value of 07FFh, or 2047 IPBus clock cycles.

Diagram



Fields

Field	Function
15-0 DTCNT0	Deadtime Count 0 Specifies the deadtime in IPBus clock cycles during the transition from deassertion to assertion of the PWM*n*_A output (assuming normal polarity). If you disable fractional delays (SM*n*_FRCTRL[FRAC23_EN]), then the submodule ignores the upper 5 bits and uses the lower 11 bits to specify the number of cycles of deadtime. In this case, the maximum value is 07FFh, which indicates 2047 cycles of deadtime. If you enable fractional delays, then the upper 11 bits represent the number of whole cycles of deadtime and the lower 5 bits represent the fractional cycle added to the whole number. In this case, the maximum value is 0xFFFF, which represents 2047 31/32 cycles of deadtime. This field is not byte accessible.

56.7.26 Submodule a Deadtime Count 1 (SM0_DTCNT1 - SM3_DTCNT1)

Offset

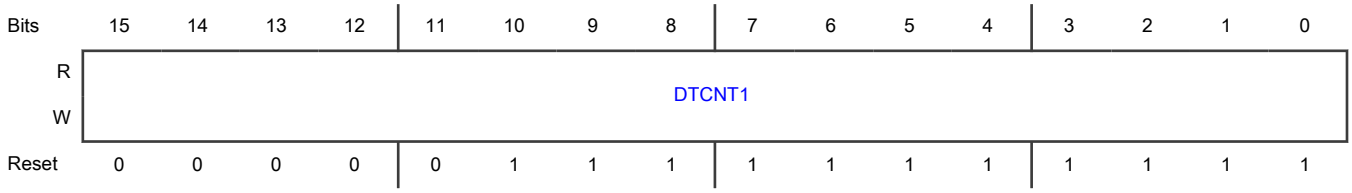
Register	Offset
SM0_DTCNT1	32h
SM1_DTCNT1	92h
SM2_DTCNT1	F2h
SM3_DTCNT1	152h

Function

Specifies the deadtime in IPBus clock cycles during the transition from deassertion to assertion of the PWM*n*_B output (assuming normal polarity).

Deadtime operation applies only to complementary channel operation. The deadtime value represents IPBus clock cycles regardless of the prescaler value (SM*n*_CTRL[PRSC]) or the selected clock source (SM0_CTRL2[CLK_SEL]). Reset sets the deadtime count for each output to a default value of 07FFh, or 2047 IPBus clock cycles.

Diagram



Fields

Field	Function
15-0 DTCNT1	Deadtime Count 1 Specifies the deadtime in IPBus clock cycles during the transition from deassertion to assertion of the PWM*n*_B output (assuming normal polarity). If you disable fractional delays (SM*n*_FRCTRL[FRAC45_EN]), then the submodule ignores the upper 5 bits and uses the lower 11 bits to specify the number of cycles of deadtime. In this case, the maximum value is 07FFh, which indicates 2047 cycles of deadtime. If you enable fractional delays, then the upper 11 bits represent the number of whole cycles of deadtime and the lower 5 bits represent the fractional cycle added to the whole number. In this case, the maximum value is 0xFFFF, which represents 2047 31/32 cycles of deadtime. This field is not byte accessible.

56.7.27 Submodule a Capture Control A (SM0_CAPTCTRLA - SM3_CAPTCTRLA)

Offset

Register	Offset
SM0_CAPTCTRLA	34h
SM1_CAPTCTRLA	94h
SM2_CAPTCTRLA	F4h
SM3_CAPTCTRLA	154h

Function

Controls the input capture process for PWM*n*_A.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CA1CNT				CA0CNT				EDGCNTA...	INP_SELA	EDGA1		EDGA0		ONESHOTA	ARMA
W							CFAWM									
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-13 CA1CNT	Capture A1 FIFO Word Count Indicates the number of words in the Capture A1 FIFO (FIFO depth is 1).
12-10 CA0CNT	Capture A0 FIFO Word Count Indicates the number of words in the Capture A0 FIFO (FIFO depth is 1).
9-8 CFAWM	Capture A FIFOs Watermark Specifies the watermark level for capture A FIFOs. The submodule sets the capture flags (SM*n*_STS[CFA1] and SM*n*_STS[CFA0]) when the word count of the corresponding FIFO is greater than this value (FIFO depth is 1).
7 EDGCNTA_EN	Edge Counter A Enable Enables the edge counter that counts rising and falling edges on the PWM*n*_A input signal. 0b - Disable and hold in reset 1b - Enable
6 INP_SELA	Input Select A Selects between the raw PWM*n*_A input signal and the output of the edge counter/compare circuitry as the source for the input capture circuit. 0b - Raw PWMn_A input signal 1b - Output of edge counter/compare. Output of edge counter/compare. Enables the internal edge counter and ignores the rising or falling edges specified by SM*n*_CAPTCTRLA[EDGA0] and SM*n*_CAPTCTRLA[EDGA1]. To enable one or both of the capture registers, you must still place a non-zero value in either or both EDGA0 and EDGA1.
5-4 EDGA1	Edge A 1 Specifies which input edges cause a capture event for the input capture 1 circuit. 00b - Disable 01b - Capture falling edges 10b - Capture rising edges 11b - Capture any edge
3-2	Edge A 0 Specifies which input edges cause a capture event for the input capture 0 circuit.

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Field	Function
EDGA0	00b - Disable 01b - Capture falling edges 10b - Capture rising edges 11b - Capture any edge
1 ONESHOTA	One Shot Mode A Selects free-running or one-shot mode for the input capture circuits. If you enable both capture circuits (SM*n*_CAPTCTRLA[EDGA0] and SM*n*_CAPTCTRLA[EDGA1]) and arm input capture (SM*n*_CAPTCTRLA[ARMA]), the submodule arms capture circuit 0 first. When capture circuit 0 performs a capture, the submodule disarms capture circuit 0 and arms capture circuit 1. In free-running mode, when capture circuit 1 performs a capture, the submodule disarms capture circuit 1 and rearms capture circuit 0. The process continues indefinitely. If you enable only one capture circuit, then captures continue indefinitely on the enabled capture circuit. In one-shot mode, when capture circuit 1 performs a capture, the submodule disarms capture circuit 1 and disarms input capture (SM*n*_CAPTCTRLA[ARMA]). The submodule performs no more captures until you rearm input capture (SM*n*_CAPTCTRLA[ARMA]). If you enable only one of the capture circuits, the submodule performs a single capture on the enabled capture circuit and then disarms input capture (ARMA). 0b - Free-running 1b - One-shot
0 ARMA	Arm A Arms or disarms the input capture process. In one-shot mode, the submodule terminates input capture when either capture circuit detects a capture event. 0b - Disarm input capture 1b - Arm input capture as specified by the input edges. Arm input capture as specified by the input edges (SM*n*_CAPTCTRLA[EDGA0] and SM*n*_CAPTCTRL*m*[EDGA1]).

56.7.28 Submodule a Capture Compare A (SM0_CAPTCOMPA - SM3_CAPTCOMPA)

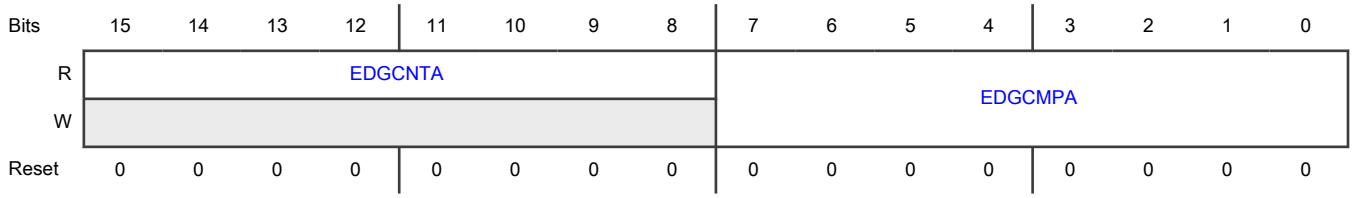
Offset

Register	Offset
SM0_CAPTCOMPA	36h
SM1_CAPTCOMPA	96h
SM2_CAPTCOMPA	F6h
SM3_CAPTCOMPA	156h

Function

Specifies the behavior of capture compare A.

Diagram



Fields

Field	Function
15-8 EDGCNTA	Edge Counter A Indicates the edge counter value for the PWM*n*_A input capture circuitry.
7-0 EDGCMPA	Edge Compare A Specifies the compare value associated with the edge counter for the PWM*n*_A input capture circuitry.

56.7.29 Submodule a Capture Control B (SM0_CAPTCTRLB - SM3_CAPTCTRLB)

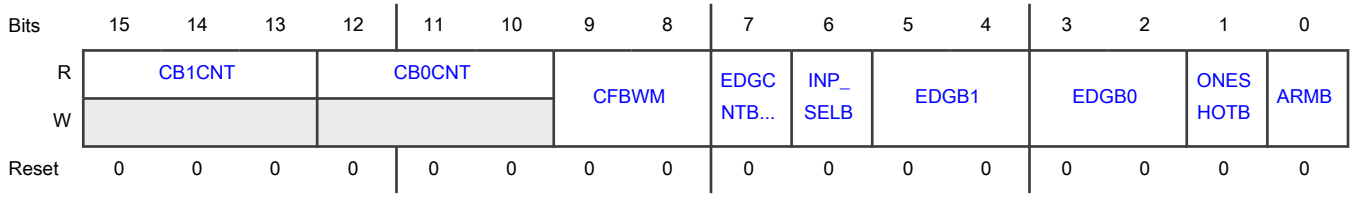
Offset

Register	Offset
SM0_CAPTCTRLB	38h
SM1_CAPTCTRLB	98h
SM2_CAPTCTRLB	F8h
SM3_CAPTCTRLB	158h

Function

Controls the input capture process for PWM*n*_B.

Diagram



Fields

Field	Function
15-13 CB1CNT	Capture B1 FIFO Word Count Indicates the number of words in the Capture B1 FIFO (FIFO depth is 1).

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Field	Function
12-10 CB0CNT	Capture B0 FIFO Word Count Indicates the number of words in the Capture B0 FIFO (FIFO depth is 1).
9-8 CFBWM	Capture B FIFOs Watermark Specifies the watermark level for capture B FIFOs. The submodule sets the capture flags (SM*n*_STS[CFB1] and SM*n*_STS[CFB0]) when the word count of the corresponding FIFO is greater than this value (FIFO depth is 1).
7 EDGCNTB_EN	Edge Counter B Enable Enables the edge counter that counts rising and falling edges on the PWM*n*_B input signal. 0b - Disable and hold in reset 1b - Enable
6 INP_SELB	Input Select B Selects between the raw PWM*n*_B input signal and the output of the edge counter/compare circuitry as the source for the input capture circuit. 0b - Raw PWMn_B input signal 1b - Output of edge counter/compare. Output of edge counter/compare. Enables the internal edge counter and ignores the rising or falling edges specified by SM*n*_CAPTCTRLB[EDGB0] and SM*n*_CAPTCTRLB[EDGB1]. To enable one or both of the capture registers, you must still place a non-zero value in either or both SM*n*_CAPTCTRLB[EDGB0] and SM*n*_CAPTCTRLB[EDGB1].
5-4 EDGB1	Edge B 1 Specifies which input edges cause a capture event for the input capture 1 circuit. 00b - Disable 01b - Capture falling edges 10b - Capture rising edges 11b - Capture any edge
3-2 EDGB0	Edge B 0 Specifies which input edges cause a capture event for the input capture 0 circuit. 00b - Disable 01b - Capture falling edges 10b - Capture rising edges 11b - Capture any edge
1 ONESHOTB	One Shot Mode B Selects free-running or one-shot mode for the input capture circuits.

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Field	Function
	If you enable both capture circuits (SM*n*_CAPTCTRLB[EDGB0] and SM*n*_CAPTCTRLB[EDGB1]) and arm input capture (ARMB), the submodule arms capture circuit 0 first. When capture circuit 0 performs a capture, the submodule disarms capture circuit 0 and arms capture circuit 1. In free-running mode, when capture circuit 1 performs a capture, the submodule disarms capture circuit 1 and rearms capture circuit 0. The process continues indefinitely. If you enable only one capture circuit, then captures continue indefinitely on the enabled capture circuit. In one-shot mode, when capture circuit 1 performs a capture, the submodule disarms capture circuit 1 and disarms input capture (SM*n*_CAPTCTRLB[ARMB]). The submodule performs no more captures until you rearm input capture (SM*n*_CAPTCTRLB[ARMB]). If you enable only one of the capture circuits, the submodule performs a single capture on the enabled capture circuit and then disarms input capture (ARMB). 0b - Free-running 1b - One-shot
0 ARMB	Arm B Arms or disarms the input capture process. In one-shot mode, the submodule terminates input capture when either capture circuit detects a capture event. 0b - Disarm input capture 1b - Arm input capture as specified by EDGBn

56.7.30 Submodule a Capture Compare B (SM0_CAPTCOMPB - SM3_CAPTCOMPB)

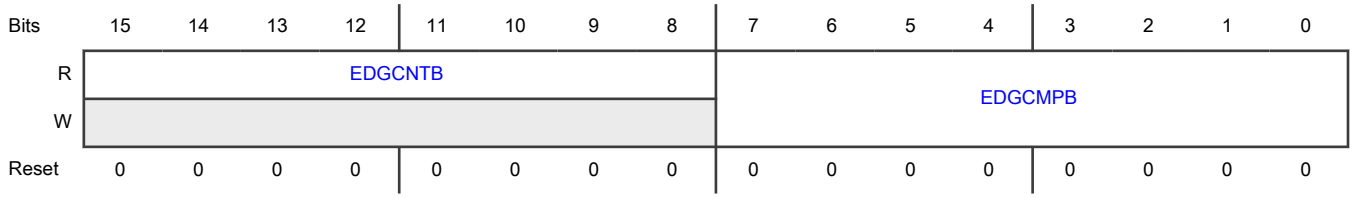
Offset

Register	Offset
SM0_CAPTCOMPB	3Ah
SM1_CAPTCOMPB	9Ah
SM2_CAPTCOMPB	FAh
SM3_CAPTCOMPB	15Ah

Function

Specifies the behavior of capture compare B.

Diagram



Fields

Field	Function
15-8 EDGCNTB	Edge Counter B Indicates the edge counter value for the PWM*n*_B input capture circuitry.
7-0 EDGCMPB	Edge Compare B Specifies the compare value associated with the edge counter for the PWM*n*_B input capture circuitry.

56.7.31 Submodule a Capture Control X (SM0_CAPTCTRLX - SM3_CAPTCTRLX)

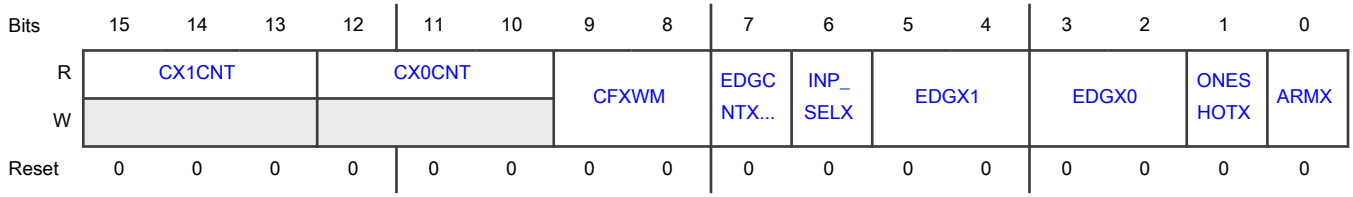
Offset

Register	Offset
SM0_CAPTCTRLX	3Ch
SM1_CAPTCTRLX	9Ch
SM2_CAPTCTRLX	FCh
SM3_CAPTCTRLX	15Ch

Function

Controls the input capture process for PWM*n*_X.

Diagram



Fields

Field	Function
15-13 CX1CNT	Capture X1 FIFO Word Count Indicates the number of words in the Capture X1 FIFO (FIFO depth is 1).

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Field	Function
12-10 CX0CNT	Capture X0 FIFO Word Count Indicates the number of words in the Capture X0 FIFO (FIFO depth is 1).
9-8 CFXWM	Capture X FIFOs Watermark Specifies the watermark level for capture X FIFOs. The submodule sets the capture flags (SM*n*_STS[CFX1] and SM*n*_STS[CFX0]) when the word count of the corresponding FIFO is greater than this value (FIFO depth is 1).
7 EDGCNTX_EN	Edge Counter X Enable Enables the edge counter that counts rising and falling edges on the PWM*n*_X input signal. 0b - Disable and hold in reset 1b - Enable
6 INP_SELX	Input Select X Selects between the raw PWM*n*_X input signal and the output of the edge counter/compare circuitry as the source for the input capture circuit. 0b - Raw PWMn_X input signal 1b - Output of edge counter/compare. Output of edge counter/compare. Enables the internal edge counter and ignores the rising or falling edges specified by SM*n*_CAPTCTRLX[EDGX0] and SM*n*_CAPTCTRLX[EDGX1]. To enable one or both of the capture registers, you must still place a non-zero value in either or both SM*n*_CAPTCTRLX[EDGX0] and SM*n*_CAPTCTRLX[EDGX1].
5-4 EDGX1	Edge X 1 Specifies which input edges cause a capture event for the input capture 1 circuit. 00b - Disable 01b - Capture falling edges 10b - Capture rising edges 11b - Capture any edge
3-2 EDGX0	Edge X 0 Specifies which input edges cause a capture event for the input capture 0 circuit. 00b - Disable 01b - Capture falling edges 10b - Capture rising edges 11b - Capture any edge
1 ONESHOTX	One Shot Mode X Selects free-running or one-shot mode for the input capture circuits.

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Field	Function
	If you enable both capture circuits (SM*n*_CAPTCTRLX[EDGX0] and SM*n*_CAPTCTRLX[EDGX1]) and arm input capture (SM*n*_CAPTCTRLX[ARMX]), the submodule arms capture circuit 0 first. When capture circuit 0 performs a capture, the submodule disarms capture circuit 0 and arms capture circuit 1. In free-running mode, when capture circuit 1 performs a capture, the submodule disarms capture circuit 1 and rearms capture circuit 0. The process continues indefinitely. If you enable only one capture circuit, then captures continue indefinitely on the enabled capture circuit. In one-shot mode, when capture circuit 1 performs a capture, the submodule disarms capture circuit 1 and disarms input capture (SM*n*_CAPTCTRLX[ARMX]). The submodule performs no more captures until you rearm input capture (SM*n*_CAPTCTRLX[ARMX]). If you enable only one of the capture circuits, the submodule performs a single capture on the enabled capture circuit and then disarms input capture (ARMX). 0b - Free-running 1b - One-shot
0 ARMX	Arm X Arms or disarms the input capture process. In one-shot mode, the submodule terminates input capture when either capture circuit detects a capture event. 0b - Disarm input capture 1b - Arm input capture as specified by EDGAn

56.7.32 Submodule a Capture Compare X (SM0_CAPTCOMPX - SM3_CAPTCOMPX)

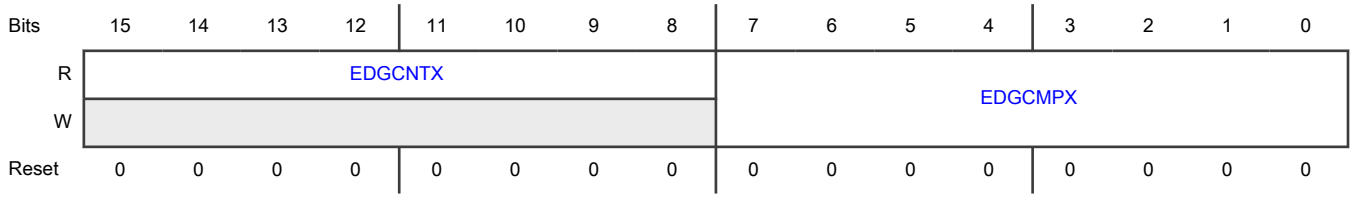
Offset

Register	Offset
SM0_CAPTCOMPX	3Eh
SM1_CAPTCOMPX	9Eh
SM2_CAPTCOMPX	FEh
SM3_CAPTCOMPX	15Eh

Function

Specifies the behavior of capture compare X.

Diagram



Fields

Field	Function
15-8 EDGCNTX	Edge Counter X Indicates the edge counter value for the PWM*n*_X input capture circuitry.
7-0 EDGCMPX	Edge Compare X Specifies the compare value associated with the edge counter for the PWM*n*_X input capture circuitry.

56.7.33 Submodule a Capture Value 0 (SM0_CVAL0 - SM3_CVAL0)

Offset

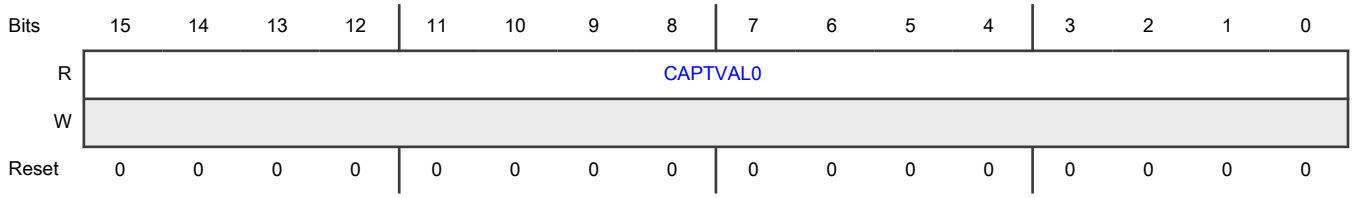
Register	Offset
SM0_CVAL0	40h
SM1_CVAL0	A0h
SM2_CVAL0	100h
SM3_CVAL0	160h

Function

Stores the value captured from the submodule counter. Edge X 0 (SM*n*_CAPTCTRLX[EDGX0]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLX[CX0CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-0 CAPTVAL0	Capture Value 0 Stores the value captured from the submodule counter. This field is not byte accessible.

56.7.34 Submodule a Capture Value 0 Cycle (SM0_CVAL0CYC - SM3_CVAL0CYC)

Offset

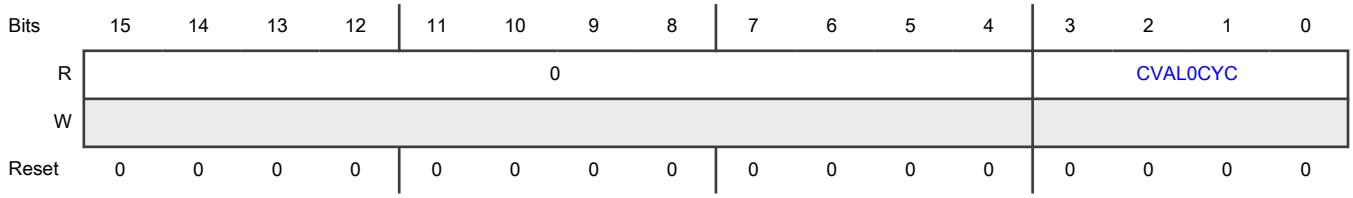
Register	Offset
SM0_CVAL0CYC	42h
SM1_CVAL0CYC	A2h
SM2_CVAL0CYC	102h
SM3_CVAL0CYC	162h

Function

Stores the value of the cycle number corresponding to the value captured. Edge X 0 (SM*n*_CAPTCTRLX[EDGX0]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLX[CX0CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-4 —	Reserved
3-0 CVAL0CYC	Capture Value 0 Cycle Stores the cycle number corresponding to the value captured in SM0_CVAL0[CAPTVAL0]. Each load of INIT into the counter at the end of a PWM modulo cycle increments this field. This field is not byte accessible.

56.7.35 Submodule a Capture Value 1 (SM0_CVAL1 - SM3_CVAL1)

Offset

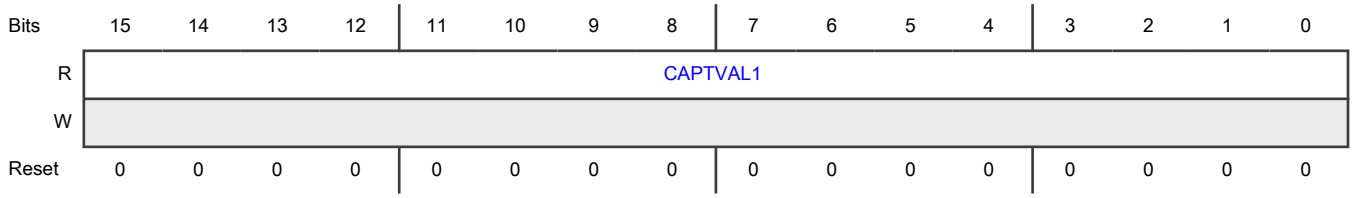
Register	Offset
SM0_CVAL1	44h
SM1_CVAL1	A4h
SM2_CVAL1	104h
SM3_CVAL1	164h

Function

Stores the value captured from the submodule counter. Edge X 1 (SM*n*_CAPTCTRLX[EDGX1]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLX[CX1CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-0 CAPTVAL1	Capture Value 1 Stores the value captured from the submodule counter. This field is not byte accessible.

56.7.36 Submodule a Capture Value 1 Cycle (SM0_CVAL1CYC - SM3_CVAL1CYC)

Offset

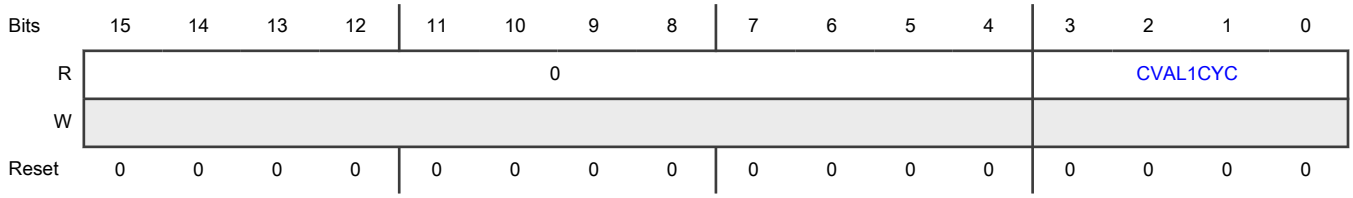
Register	Offset
SM0_CVAL1CYC	46h
SM1_CVAL1CYC	A6h
SM2_CVAL1CYC	106h
SM3_CVAL1CYC	166h

Function

Stores the value of the cycle number corresponding to the value captured. Edge X 1 (SM*n*_CAPTCTRLX[EDGX1]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLX[CX1CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-4 —	Reserved
3-0 CVAL1CYC	Capture Value 1 Cycle Stores the cycle number corresponding to the value captured in SM0_CVAL1[CAPTVAL1]. Each load of INIT into the counter at the end of a PWM modulo cycle increments this field. This field is not byte accessible.

56.7.37 Submodule a Capture Value 2 (SM0_CVAL2 - SM3_CVAL2)

Offset

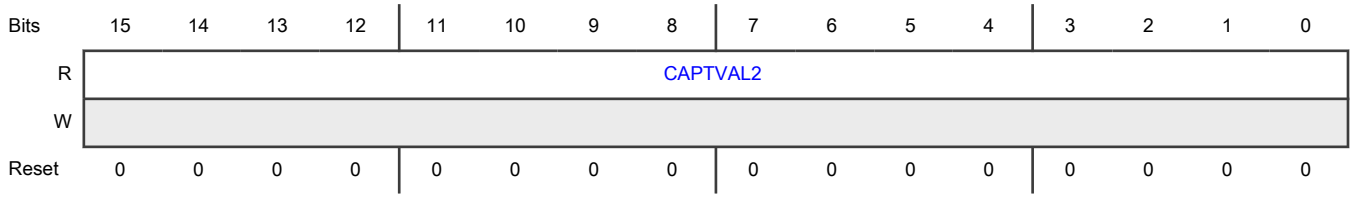
Register	Offset
SM0_CVAL2	48h
SM1_CVAL2	A8h
SM2_CVAL2	108h
SM3_CVAL2	168h

Function

Stores the value captured from the submodule counter. Edge A 0 (SM*n*_CAPTCTRL*m*[EDGA0]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRL*m*[CA0CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-0 CAPTVAL2	Capture Value 2 Stores the value captured from the submodule counter. This field is not byte accessible.

56.7.38 Submodule a Capture Value 2 Cycle (SM0_CVAL2CYC - SM3_CVAL2CYC)

Offset

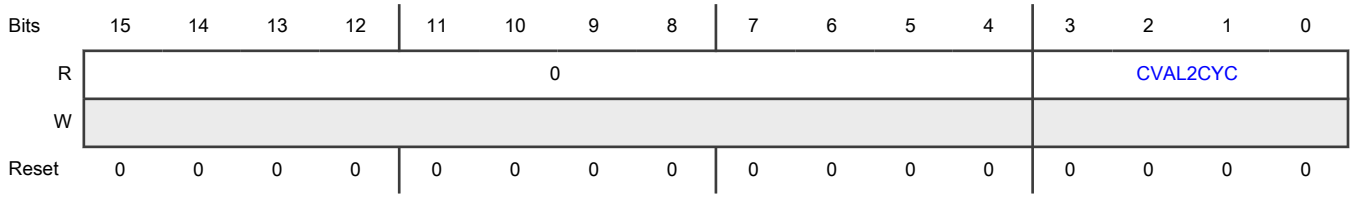
Register	Offset
SM0_CVAL2CYC	4Ah
SM1_CVAL2CYC	AAh
SM2_CVAL2CYC	10Ah
SM3_CVAL2CYC	16Ah

Function

Stores the value of the cycle number corresponding to the value captured. Edge A 0 (SM*n*_CAPTCTRL*m*[EDGA0]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRL*m*[CA0CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-4 —	Reserved
3-0 CVAL2CYC	Capture Value 2 Cycle Stores the cycle number corresponding to the value captured in SM*n*_CVAL2[CAPTVAL2]. Each load of INIT into the counter at the end of a PWM modulo cycle increments this field. This field is not byte accessible.

56.7.39 Submodule a Capture Value 3 (SM0_CVAL3 - SM3_CVAL3)

Offset

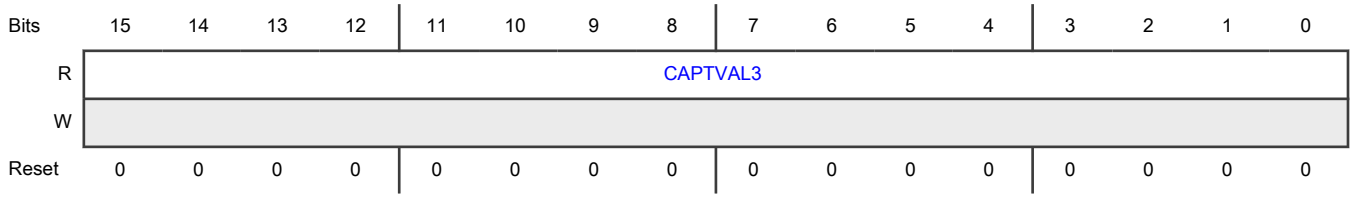
Register	Offset
SM0_CVAL3	4Ch
SM1_CVAL3	ACh
SM2_CVAL3	10Ch
SM3_CVAL3	16Ch

Function

Stores the value captured from the submodule counter. Edge A 1 (SM*n*_CAPTCTRLA[EDGA1]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLA[CA1CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-0 CAPTVAL3	Capture Value 3 Stores the value captured from the submodule counter. This field is not byte accessible.

56.7.40 Submodule a Capture Value 3 Cycle (SM0_CVAL3CYC - SM3_CVAL3CYC)

Offset

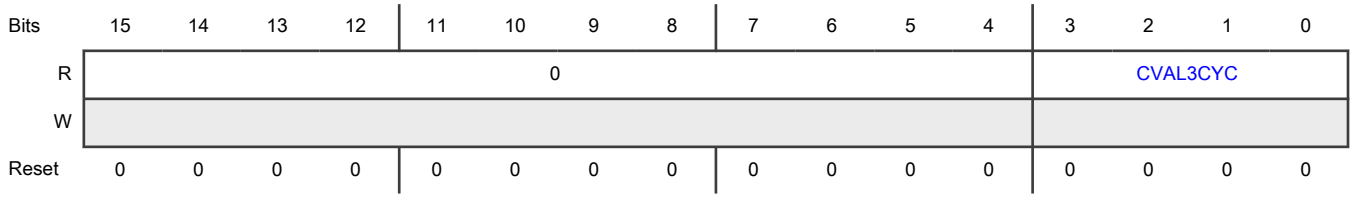
Register	Offset
SM0_CVAL3CYC	4Eh
SM1_CVAL3CYC	AEh
SM2_CVAL3CYC	10Eh
SM3_CVAL3CYC	16Eh

Function

Stores the value of the cycle number corresponding to the value captured. Edge A 1 (SM*n*_CAPTCTRLA[EDGA1]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLA[CA1CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-4 —	Reserved
3-0 CVAL3CYC	Capture Value 3 Cycle Stores the cycle number corresponding to the value captured in SM*n*_CVAL3[CAPTVAL3]. Each load of INIT into the counter at the end of a PWM modulo cycle increments this field. This field is not byte accessible.

56.7.41 Submodule a Capture Value 4 (SM0_CVAL4 - SM3_CVAL4)

Offset

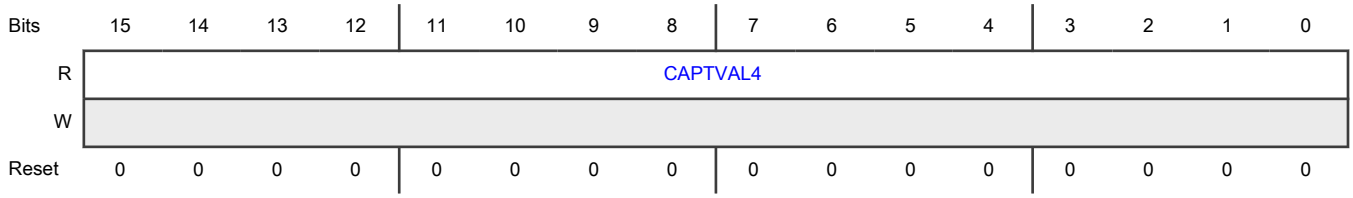
Register	Offset
SM0_CVAL4	50h
SM1_CVAL4	B0h
SM2_CVAL4	110h
SM3_CVAL4	170h

Function

Stores the value captured from the submodule counter. Edge B 0 (SM*n*_CAPTCTRLB[EDGB0]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLB[CB0CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-0 CAPTVAL4	Capture Value 4 Stores the value captured from the submodule counter. This field is not byte accessible.

56.7.42 Submodule a Capture Value 4 Cycle (SM0_CVAL4CYC - SM3_CVAL4CYC)

Offset

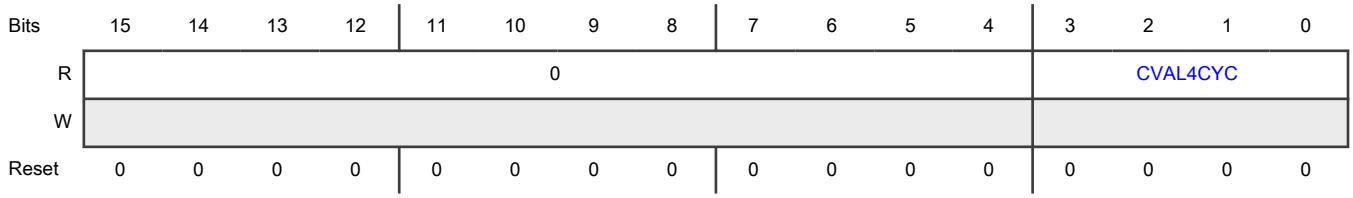
Register	Offset
SM0_CVAL4CYC	52h
SM1_CVAL4CYC	B2h
SM2_CVAL4CYC	112h
SM3_CVAL4CYC	172h

Function

Stores the value of the cycle number corresponding to the value captured. Edge B 0 (SM*n*_CAPTCTRLB[EDGB0]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLB[CB0CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-4 —	Reserved
3-0 CVAL4CYC	Capture Value 4 Cycle Stores the cycle number corresponding to the value captured in SM*n*_CVAL4[CAPTVAL4]. Each load of INIT into the counter at the end of a PWM modulo cycle increments this field. This field is not byte accessible.

56.7.43 Submodule a Capture Value 5 (SM0_CVAL5 - SM3_CVAL5)

Offset

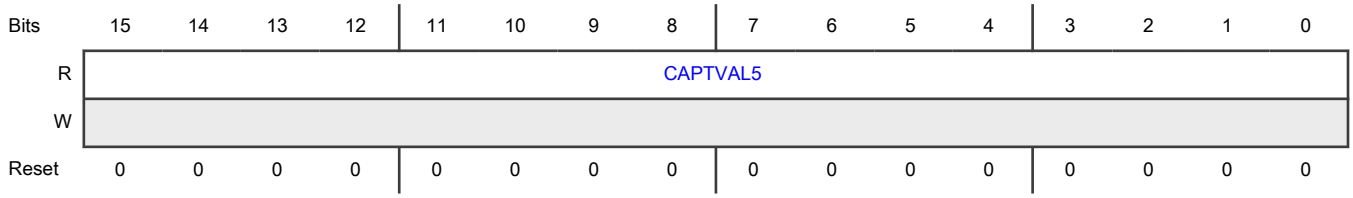
Register	Offset
SM0_CVAL5	54h
SM1_CVAL5	B4h
SM2_CVAL5	114h
SM3_CVAL5	174h

Function

Stores the value captured from the submodule counter. Edge B 1 (SM*n*_CAPTCTRLB[EDGB1]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLB[CB1CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram



Fields

Field	Function
15-0 CAPTVAL5	Capture Value 5 Stores the value captured from the submodule counter. This field is not byte accessible.

56.7.44 Submodule a Capture Value 5 Cycle (SM0_CVAL5CYC - SM3_CVAL5CYC)

Offset

Register	Offset
SM0_CVAL5CYC	56h
SM1_CVAL5CYC	B6h
SM2_CVAL5CYC	116h
SM3_CVAL5CYC	176h

Function

Stores the value of the cycle number corresponding to the value captured. Edge B 1 (SM*n*_CAPTCTRLB[EDGB1]) specifies when this capture occurs. Each capture increments the capture count (SM*n*_CAPTCTRLB[CB1CNT]) until it reaches the maximum value. Each read of this register decrements the capture count until it reaches 0.

Attempting to write this register generates a transfer error.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												CVAL5CYC			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-4 —	Reserved
3-0 CVAL5CYC	Capture Value 5 Cycle Stores the cycle number corresponding to the value captured in SM*n*_CVAL5[CAPTVAL5]. Each load of INIT into the counter at the end of a PWM modulo cycle increments this field. This field is not byte accessible.

56.7.45 Submodule a Phase Delay (SM1_PHASEDLY - SM3_PHASEDLY)

Offset

Register	Offset
SM1_PHASEDLY	B8h
SM2_PHASEDLY	118h
SM3_PHASEDLY	178h

Function

Specifies the delay from the master sync signal of submodule 0 to the time that this submodule recognizes the master sync in PWM counter cycles. You must select master sync as the source for initialization (SM*n*_CTRL2[INIT_SEL]) when using this register. Setting this register with a non-zero value and using the master sync signal as the initialization source allows the output of this submodule to be a fixed number of cycles delayed from submodule 0. For PWM operation, the submodule updates this register at the start of every PWM period.

NOTE

This register is buffered. The written value takes effect when software asserts submodule Load Okay (MCTRL[LDOK]) and the next PWM load cycle begins or immediately on assertion of Load Okay, depending on Load Mode Select (LDMOD). You cannot write this register when submodule Load Okay (MCTRL[LDOK]) is asserted. Reading PHASEDLY returns the value in the buffer and not necessarily the value the PWM generator is currently using.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PHASEDLY															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-0 PHASEDLY	Phase Delay This field is not byte accessible. **NOTE** You should not specify a value larger than the period specified for submodule 0.

56.7.46 Output Enable (OUTEN)

Offset

Register	Offset
OUTEN	180h

Function

Enables and masks the PWM outputs.

NOTE

The mask fields in this register are buffered. The written value takes effect when a FORCE_OUT event occurs within the appropriate submodule. Reading the mask fields returns the value in the buffer and not necessarily the value currently in effect. You can override the buffering using the UPDATE_MASK field.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				PWMA_EN				PWMB_EN				PWMX_EN			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-12	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
11-8 PWMA_EN	PWMn_A Output Enables Enables the PWM*n*_A outputs. Each bit position in the field corresponds to the like-numbered submodule. **NOTE** If you use a PWM*n*_A pin for input capture or deadtime correction, you must disable PWM*n*_A output for that submodule (write 0 to the corresponding bit in this field). 0000b - Disable 0001b - Enable
7-4 PWMB_EN	PWMn_B Output Enables Enables the PWM*n*_B outputs. Each bit position in the field corresponds to the like-numbered submodule. **NOTE** If you use a PWM*n*_B pin for input capture or deadtime correction, you must disable PWM*n*_B output for that submodule (write 0 to the corresponding bit in this field). 0000b - Disable 0001b - Enable
3-0 PWMX_EN	PWMn_X Output Enables Enables the PWM*n*_X outputs. Each bit position in the field corresponds to the like-numbered submodule. **NOTE** If you use a PWM*n*_X pin for input capture or deadtime correction, you must disable PWM*n*_X output for that submodule (write 0 to the corresponding bit in this field). 0000b - Disable 0001b - Enable

56.7.47 Mask (MASK)

Offset

Register	Offset
MASK	182h

Function

Enables and masks the PWM outputs.

NOTE

The mask fields in this register are buffered. The written value takes effect when a FORCE_OUT event occurs within the appropriate submodule. Reading the mask fields returns the value in the buffer and not necessarily the value currently in effect. You can override the buffering using the UPDATE_MASK field.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R					MASKA				MASKB				MASKX			
W	UPDATE_MASK															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-12 UPDATE_MASK	Update Mask Bits Immediately Forces the mask bits to be updated immediately (on the following clock edge) without waiting for a FORCE_OUT event. Each bit position in the field corresponds to the like-numbered submodule. These self-clearing bits always read as zero. Software may write to any or all of these bits and may do so in the same write operation that updates MASK[MASKA], MASK[MASKB], or MASK[MASKX]. 0000b - Buffered operation 0001b - Immediate update
11-8 MASKA	PWMn_A Masks Masks the PWM*n*_A outputs. Each bit position in the field corresponds to the like-numbered submodule. Masking an output forces the output to logic 0 before consideration of the output polarity. 0000b - Output normal 0001b - Output masked
7-4 MASKB	PWMn_B Masks Masks the PWM*n*_B outputs. Each bit position in the field corresponds to the like-numbered submodule. Masking an output forces the output to logic 0 before consideration of the output polarity. 0000b - Output normal 0001b - Output masked
3-0 MASKX	PWMn_X Masks Masks the PWM*n*_X outputs. Each bit position in the field corresponds to the like-numbered submodule. Masking an output forces the output to logic 0 before consideration of the output polarity. 0000b - Output normal 0001b - Output masked

56.7.48 Software Controlled Output (SWCOUT)

Offset

Register	Offset
SWCOUT	184h

Function

Enables software control of output signals to the submodules deadtime generators.

NOTE

This register is buffered. The written value takes effect when a FORCE_OUT event occurs within the appropriate submodule. Reading SWCOUT returns the value in the buffer and not necessarily the value currently in effect.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								SM3OUT23	SM3OUT45	SM2OUT23	SM2OUT45	SM1OUT23	SM1OUT45	SM0OUT23	SM0OUT45
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-8 —	Reserved
7 SM3OUT23	Submodule 3 Software Controlled Output 23 Specifies the output signal supplied to the submodule 3 deadtime generator, overriding the PWM23 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL23] is equal to 10b). 0b - Logic 0 1b - Logic 1
6 SM3OUT45	Submodule 3 Software Controlled Output 45 Specifies the output signal supplied to the submodule 3 deadtime generator, overriding the PWM45 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL45] is equal to 10b). 0b - Logic 0 1b - Logic 1
5 SM2OUT23	Submodule 2 Software Controlled Output 23 Specifies the output signal supplied to the submodule 2 deadtime generator, overriding the PWM23 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL23] is equal to 10b).

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Logic 0 1b - Logic 1
4 SM2OUT45	Submodule 2 Software Controlled Output 45 Specifies the output signal supplied to the submodule 2 deadtime generator, overriding the PWM45 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL45] is equal to 10b). 0b - Logic 0 1b - Logic 1
3 SM1OUT23	Submodule 1 Software Controlled Output 23 Specifies the output signal supplied to the submodule 1 deadtime generator, overriding the PWM23 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL23] is equal to 10b). 0b - Logic 0 1b - Logic 1
2 SM1OUT45	Submodule 1 Software Controlled Output 45 Specifies the output signal supplied to the submodule 1 deadtime generator, overriding the PWM45 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL45] is equal to 10b). 0b - Logic 0 1b - Logic 1
1 SM0OUT23	Submodule 0 Software Controlled Output 23 Specifies the output signal supplied to the submodule 0 deadtime generator, overriding the PWM23 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL23] is equal to 10b). 0b - Logic 0 1b - Logic 1
0 SM0OUT45	Submodule 0 Software Controlled Output 45 Specifies the output signal supplied to the submodule 0 deadtime generator, overriding the PWM45 signal. This field applies only when it is selected for output override (DTSRCSEL[SM*n*SEL45] is equal to 10b). 0b - Logic 0 1b - Logic 1

56.7.49 PWM Source Select (DTSRCSEL)

Offset

Register	Offset
DTSRCSEL	186h

Function

Selects the sources of input to each of the submodule deadtime generators.

NOTE

This register is buffered. The written value takes effect when a FORCE_OUT event occurs within the appropriate submodule. Reading SWCOUT returns the value in the buffer and not necessarily the value currently in effect.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SM3SEL23		SM3SEL45		SM2SEL23		SM2SEL45		SM1SEL23		SM1SEL45		SM0SEL23		SM0SEL45	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-14 SM3SEL23	Submodule 3 PWM23 Control Select Selects between the generated SM3PWM23 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM3PWM23 signal 01b - Inverted SM3PWM23 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT23]). 11b - PWM3_EXTA signal
13-12 SM3SEL45	Submodule 3 PWM45 Control Select Selects between the generated SM3PWM45 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM3PWM45 signal 01b - Inverted SM3PWM45 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT45]). 11b - PWM3_EXTB signal
11-10 SM2SEL23	Submodule 2 PWM23 Control Select Selects between the generated SM2PWM23 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM2PWM23 signal 01b - Inverted SM2PWM23 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT23]). 11b - PWM2_EXTA signal
9-8	Submodule 2 PWM45 Control Select

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Field	Function
SM2SEL45	Selects between the generated SM2PWM45 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM2PWM45 signal 01b - Inverted SM2PWM45 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT45]). 11b - PWM2_EXTB signal
7-6 SM1SEL23	Submodule 1 PWM23 Control Select Selects between the generated SM1PWM23 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM1PWM23 signal 01b - Inverted SM1PWM23 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT23]). 11b - PWM1_EXTA signal
5-4 SM1SEL45	Submodule 1 PWM45 Control Select Selects between the generated SM1PWM45 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM1PWM45 signal 01b - Inverted SM1PWM45 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT45]). 11b - PWM1_EXTB signal
3-2 SM0SEL23	Submodule 0 PWM23 Control Select Selects between the generated SM0PWM23 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM0PWM23 signal 01b - Inverted SM0PWM23 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT23]) 11b - PWM0_EXTA signal
1-0 SM0SEL45	Submodule 0 PWM45 Control Select Selects between the generated SM0PWM45 signal or one of its possible overrides as the source of input to the submodule deadtime generator on the occurrence of a FORCE_OUT event in that submodule. 00b - Generated SM0PWM45 signal 01b - Inverted SM0PWM45 signal 10b - Software control. Software control (SWCOUT[SM*n*OUT45]). 11b - PWM0_EXTB signal

56.7.50 Master Control (MCTRL)

Offset

Register	Offset
MCTRL	188h

Function

Controls various aspects of eFlexPWM operation.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	IPOL				RUN				0				LDOK			
W									CLDOK							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-12 IPOL	Current Polarity Selects between PWM23 and PWM45 as the source for the generation of the complementary PWM pair output for the corresponding submodule. This does not apply in independent mode. Each bit position corresponds to the like-numbered submodule. Therefore, the description refers to the effect of an individual bit. **NOTE** This register is buffered. The written value takes effect when a FORCE_OUT event occurs within the appropriate submodule. Reading IPOL returns the value in the buffer and not necessarily the value currently in effect. 0000b - PWM23 0001b - PWM45
11-8 RUN	Run Starts the PWM generator by enabling its clock. If you enable input capture for a submodule or select local reload as the reload source for a submodule, you must write 1 to the corresponding RUN bit for that submodule. Writing 0 to the Run bit resets the submodule counter. Each bit position corresponds to the like-numbered submodule. Therefore, the description refers to the effect of an individual bit. 0000b - Stop PWM generator 0001b - Start PWM generator
7-4	Clear Load Okay

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Field	Function
CLDOK	Turns off (clears) Load Okay for a particular submodule by clearing the corresponding LDOK bit. If a reload occurs in a submodule with Load Okay enabled at the same time software writes 1 to the corresponding bit in CLDOK, then the submodule does not perform the reload and clears Load Okay. The CLDOK field is self-clearing and always reads 0. Each bit position corresponds to the like-numbered submodule. Therefore, the description refers to the effect of an individual bit. 0000b - No effect 0001b - Turn off Load Okay. Turn off Load Okay. Clears the corresponding bit in LDOK.
3-0 LDOK	Load Okay Loads the prescaler (SM*n*_CTRL[PRSC]), Initial Count (SM*n*_INIT[INIT]), fractional timing values, and timing values (SM*n*_VAL*m*) of the corresponding submodule into a set of buffers. The buffered prescaler divisor, submodule counter modulus value, and PWM pulse width take effect at the next PWM reload or immediately, depending on the Load Mode setting (LDMOD). Set the corresponding LDOK bit by reading it when it is zero and then writing one to it. You cannot write the prescaler, initial count, fractional values, or values for the corresponding submodule when LDOK equals one. Each bit position corresponds to the like-numbered submodule. Therefore, the description refers to the effect of an individual bit. In Master Reload Mode (SM*n*_CTRL2[RELOAD_SEL]), you only need to write the LDOK bit for submodule 0. However, you should also write the LDOK bits for the slave submodules to prevent unwanted writes to the slave submodule registers. You cannot write zero to LDOK bits. The submodule automatically writes zero to its corresponding LDOK bit after loading the new values, or you can manually clear an LDOK bit before a reload by writing one to the corresponding CLDOK bit. You can write one to LDOK in DMA mode when the DMA indicates that it has completed updating all the prescaler, Initial Count, fractional values, and values for the corresponding submodule. 0000b - Do not load new values 0001b - Load new values

56.7.51 Master Control 2 (MCTRL2)

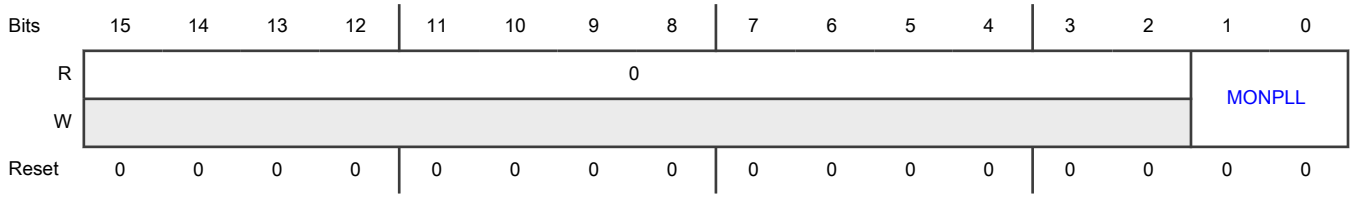
Offset

Register	Offset
MCTRL2	18Ah

Function

Controls various aspects of eFlexPWM operation.

Diagram



Fields

Field	Function
15-2 —	Reserved
1-0 MONPLL	Monitor PLL State Enables disabling of the fractional delay block when the chip PLL is unlocked or missing its input reference. The fractional delay block requires a continuous 200 MHz clock from the PLL. If this clock turns off while the fractional delay block is in use, then the output of the fractional delay block can be stuck high or low even if the PLL restarts. When you enable Monitor PLL State, PLL problems disable the fractional delay block until the PLL returns to a locked state. When the PLL is again receiving a proper reference and is locked, the fractional delay block requires 25 µs startup time just as if fractional cycle had been disabled and re-enabled (SM*n*_FRCTRL[FRAC23_EN] or SM*n*_FRCTRL[FRAC45_EN]). If you disable PLL monitoring, then when the PLL loses its reference or loses lock, software should manually disable and re-enable fractional cycle to properly restart the functional delay block. This field does not apply if you are not using the fractional delay block. 00b - PLL not locked, do not monitor PLL operation. If the PLL loses lock, software must restart the fractional delay block. 01b - PLL not locked, monitor PLL operation. If the PLL encounters problems, disable the fractional delay block automatically. 10b - PLL locked, do not monitor PLL operation. If the PLL loses lock, software must restart the fractional delay block. This field is write-protected until the next reset. 11b - PLL locked, monitor PLL operation. If the PLL encounters problems, disable the fractional delay block automatically. This field is write-protected until the next reset.

56.7.52 Fault Protection 0 Control (FP0_CTRL)

Offset

Register	Offset
FP0_CTRL	18Ch

Function

Controls fault channel operation.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	FLVL				FAUTO				FSAFE				FIE			
Reset	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-12 FLVL	Fault Level Specifies the level of the fault input that indicates a fault condition. Each bit position corresponds to the like-numbered fault input. Therefore, the description refers to the effect of an individual bit. 0000b - Logic 0 0001b - Logic 1
11-8 FAUTO	Automatic Fault Clearing Enables automatic fault clearing. Each bit position corresponds to the like-numbered fault input. Therefore, the description refers to the effect of an individual bit. 0000b - Manual fault clearing. Manual fault clearing. The fault channel does not re-enable PWM outputs disabled by this fault until the corresponding fault flag (FP*n*_STS[FFLAG]) is clear at the start of a half period or full period, depending on the state of half-period recovery (FP*n*_STS[FHALF]) and full-period recovery (FP*n*_STS[FFULL]). If neither full- nor half-period recovery is enabled, then the fault channel cannot clear the fault condition. Software must also take Safe mode selection (FP*n*_CTRL[FSAFE]) into account. 0001b - Automatic fault clearing. Automatic fault clearing. The fault channel re-enables PWM outputs disabled by this fault when the fault filter pin (FP*n*_STS[FFPIN]) is clear at the start of a half period or full period depending on the state of half-period recovery (FP*n*_STS[FHALF]) and full-period recovery (FP*n*_STS[FFULL]), without regard for the fault status flag (FP*n*_STS[FFLAG]). If you enable neither full- nor half-period recovery, then the fault channel cannot clear the fault condition.
7-4 FSAFE	Fault Safety Mode Selects the safety mode during manual fault clearing. Each bit position corresponds to the like-numbered fault input. Therefore, the description refers to the effect of an individual bit. In normal mode, the fault channel does not re-enable PWM outputs disabled by this fault until the corresponding fault flag (FP*n*_STS[FFLAG]) is clear at the start of a half period or full period, depending on the state of half-period recovery FP*n*_STS[FHALF]) and full-period recovery (FP*n*_STS[FFULL]), without regard to fault filtering (FP*n*_STS[FFPIN]). If you enable neither full- nor half-period recovery, then the fault channel cannot clear the fault condition.

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Field	Function
	NOTE The fault channel does not re-enable PWM outputs disabled by this fault input until the actual FAULTn input signal de-asserts because the fault input combinationally disables the PWM outputs as programmed by fault disable mapping (SM*n*_DISMAP*n*). In safe mode, the fault channel does not re-enable PWM outputs disabled by this fault until the corresponding fault flag (FP*n*_STS[FFLAG]) and filtered fault pin (FP*n*_STS[FFPIN]) are both clear at the start of a half period or full period, depending on the state of half-period recovery (FP*n*_STS[FHALF]) and full-period recovery (FP*n*_STS[FFLAG]). If you enable neither full- nor half-period recovery, then the fault channel cannot clear the fault condition. **NOTE** Because of fault filter latency, the Filtered Fault Pin bit (FP*n*_STS[FFPIN]) may indicate that a fault condition still exists even though the actual fault signal is clear. 0000b - Normal mode 0001b - Safe mode
3-0 FIE	Fault Interrupt Enables Enables CPU interrupt requests generated by the FAULT*n* inputs. Each bit position corresponds to the like-numbered fault input. Therefore, the description refers to the effect of an individual bit. **NOTE** The fault protection circuit is independent of FP*n*_CTRL[FIE] and is always active. If the fault channel detects a fault, it disables the PWM outputs according to the Fault Disable Mapping (SM*n*_DISMAP*n*) registers. 0000b - Disable 0001b - Enable

56.7.53 Fault Protection 0 Status (FP0_STS)

Offset

Register	Offset
FP0_STS	18Eh

Function

Provides fault status and additional fault behavior control.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	FHALF				FFPIN				FFULL				FFLAG			
W													W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-12 FHALF	Half-Period Fault Recovery Specifies the timing for re-enabling the PWM outputs after a fault condition. These bits apply to both automatic and manual clearing of a fault condition. **NOTE** You can enable both half-period (FP*n*_STS[FHALF]) and full-period fault recovery (FP*n*_STS[FFULL]) so that fault recovery occurs at the start of a full period and at the half-period point, as defined by Timing Value 0 (SM*n*_VAL0[VAL0]). If you enable neither full- nor half-period recovery, then the fault channel cannot clear the fault condition. 0000b - Not re-enabled at the start of a half period 0001b - Re-enabled at the start of a half period
11-8 FFPIN	Filtered Fault Pins Indicates the current state of the filtered FAULTn pin converted to high polarity. Reset has no effect on this field. 0000b - No fault condition 0001b - Fault condition
7-4 FFULL	Full-Period Fault Recovery Specifies the timing for re-enabling the PWM outputs after a fault condition. These bits apply to both automatic and manual clearing of a fault condition. **NOTE** You can enable both half-period (FP*n*_STS[FHALF]) and full-period fault recovery (FP*n*_STS[FFULL]) so that fault recovery occurs at the start of a full period and at the half-period point, as defined by Timing Value 0 (SM*n*_VAL0[VAL0]). If you enable neither full- nor half-period recovery, then the fault channel cannot clear the fault condition. 0000b - Not re-enabled at the start of a full period 0001b - Re-enabled at the start of a full period
3-0 FFLAG	Fault Flags Indicates a fault on the corresponding fault input. Each bit position corresponds to the like-numbered fault. The fault channel sets the flag within two CPU cycles after a transition to active on the FAULTn pin. Clear this bit by writing one to it. The reset value is 0, but these bits may be 1 by the time software can read them depending on the state of the fault input signals.

Table continues on the next page...

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Field	Function
	0000b - No fault present 0001b - Fault is present

56.7.54 Fault Protection 0 Filter (FP0_FILT)

Offset

Register	Offset
FP0_FILT	190h

Function

Controls fault filter operation.

The settings in fields are shared among each of the fault input filters within the fault channel.

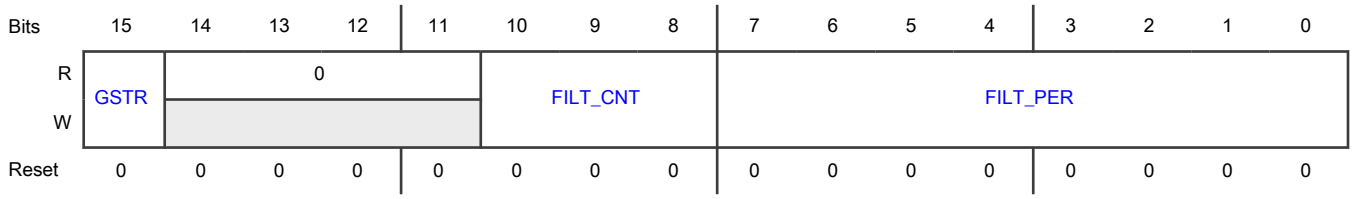
When setting these values, take the following considerations into account:

- To ensure a noise spike corrupts only one sample, you should define the fault filter period (FILT_PER) to be longer than the period of the expected noise. You should choose a fault filter count (FP*n*_FILT[FILT_CNT]) that reduces the probability of noisy samples causing detection of an incorrect transition. The probability of an incorrect transition is defined as the probability of an incorrect sample raised to the (FILT_CNT + 3) power.
- The fault filter period (FILT_PER) and fault filter count (FILT_CNT) both affect input latency for recognizing input transitions. Turning on the input filter (setting FILT_PER to a non-zero value) introduces a latency of ((FILT_CNT + 4) x FILT_PER x IPBus clock period). Note that even when the filter is enabled, there is a combinational path to disable the PWM outputs. This path ensures rapid response to fault conditions and also to ensure fault response if the PWM module loses its clock. The latency induced by the filter is seen in the time to set the fault flags (FP*n*_STS[FFLAG]) and filtered fault pins (FP*n*_STS[FFPIN]).

NOTE

When FILT_PER is small, the fault can be filtered one period earlier, hence, introduces a latency of ((FILT_CNT + 3) x FILT_PER x IPBus clock period).

Diagram



Fields

Field	Function
15	Fault Glitch Stretch Enable

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Field	Function
GSTR	Enables the fault glitch stretching logic, which stretches narrow fault glitches to ensure they are at least 2 IPBus clock cycles wide. In some cases, a narrow fault input can cause problems due to the short PWM output shutdown and re-activation time. The stretching logic ensures that when the fault filter is disabled, a glitch on the fault input registers in the fault flags. 0b - Disable 1b - Enable
14-11 —	Reserved
10-8 FILT_CNT	Fault Filter Count Specifies the number of consecutive samples minus three that must agree before the input filter accepts an input transition. In other words, a FILT_CNT value of 0 means 3 samples, and a value of 7 means 10 samples. This value affects the input latency.
7-0 FILT_PER	Fault Filter Period Specifies the sampling period, in IPBus clock cycles, of the fault pin input filter. The fault channel samples each input multiple times at this rate. If FILT_PER is 00h (default), then the fault channel bypasses the input filter. This value affects the input latency. This field applies universally to all fault inputs. **NOTE** When changing values for FILT_PER from one non-zero value to another non-zero value, you must first write zero to clear the filter.

56.7.55 Fault Protection 0 Test (FP0_TST)

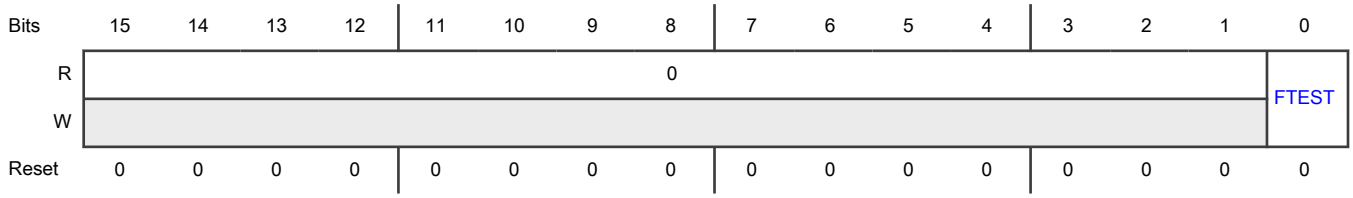
Offset

Register	Offset
FP0_TST	192h

Function

Simulates a fault condition by sending a simulated fault into all of the fault filters.

Diagram



Fields

Field	Function
15-1 —	Reserved
0 FTEST	Fault Test Simulates a fault condition by sending a simulated fault into all of the fault filters. The condition propagates to the fault flags and possibly the PWM outputs depending on the fault channel mapping (SM*n*_DISMAP*n*). Clearing this bit removes the simulated fault condition. 0b - No fault 1b - Cause a simulated fault

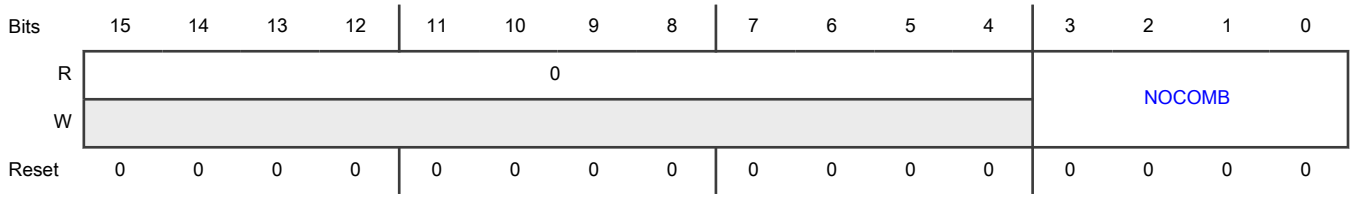
56.7.56 Fault Protection 0 Control 2 (FP0_CTRL2)

Offset

Register	Offset
FP0_CTRL2	194h

Function
See NOCOMB.

Diagram



Fields

Field	Function
15-4	Reserved

Table continues on the next page...

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Field	Function
—	
3-0 NOCOMB	No Combinational Path Disables the combinational path from the fault inputs to the PWM outputs. When you turn off No Combinational Path (default), the corresponding fault inputs have a combinational path to the PWM outputs that is sensitive to these fault inputs as defined by the fault channel mapping (SM*n*_DISMAP*n*). This combinational path is a safety feature that ensures the output is disabled even if the SOC clocking system fails. The combinational path also means that a pulse on the fault input can cause brief disabling of the PWM output even if the fault pulse is not wide enough to pass through the input filter and be latched in the fault logic. Turning on No Combinational Path removes the combinational path and uses the filtered and latched fault signals as the fault source for disabling the PWM outputs, which eliminate fault glitches from creating PWM output glitches but also increases the latency to respond to a real fault. 0000b - Combinational path 0001b - No combinational path

56.7.57 DLL Status (DLLSR)

Offset

Register	Offset
DLLSR	1B0h

Function

Indicates the DLL status.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0														LOL	LOCK
W															W1C	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-2 —	Reserved
1 LOL	Loss-Of-Lock flag Indicates the current DLL lock status.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No loss of lock detected 1b - Loss of lock detected
0 LOCK	Lock status Indicates that DLL has acquired lock. 0b - Unlocked 1b - Locked

56.7.58 Submodule a BIST Control (SM0_BIST_CTRL - SM3_BIST_CTRL)

Offset

Register	Offset
SM0_BIST_CTRL	1B8h
SM1_BIST_CTRL	1BCh
SM2_BIST_CTRL	1C0h
SM3_BIST_CTRL	1C4h

Function

Provides control of the submodule BIST operation.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	COUNTER_THRESHOLD			CLK_FINAL					MANUAL_...	TOGGLE_...	CLK_INITIAL					BIST_EN...
Reset	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0

Fields

Field	Function
15-13 COUNTER_THRESHOLD	Counter Threshold Specifies the minimum gap between the clock counter and the data counter.
12-8 CLK_FINAL	Clock Counter Final Specifies the final value for the CLK counter.

Table continues on the next page...

Table continued from the previous page...

Field	Function
7 MANUAL_TOGGLE	Manual Toggle Switch When in manual toggle mode, selects frac_test or frac_test_reverse for sequence detection. 0b - frac_test 1b - frac_test_reverse
6 TOGGLE_MODE	Toggle Mode Specifies the toggle mode between frac_test and frac_test_reverse. 0b - Automatic 1b - Manual
5-1 CLK_INITIAL	Initial Value for BIST CLK Counter
0 BIST_ENABLE	Enable BIST Logic 0b - Disables 1b - Enables

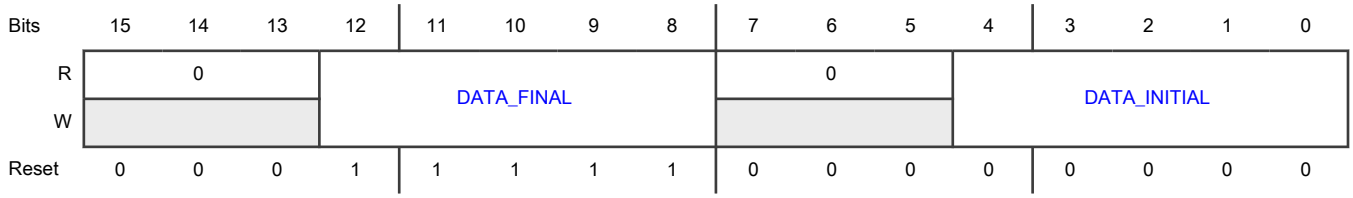
56.7.59 Submodule a BIST Control (SM0_BIST_CTRL1 - SM3_BIST_CTRL1)

Offset

Register	Offset
SM0_BIST_CTRL1	1BAh
SM1_BIST_CTRL1	1BEh
SM2_BIST_CTRL1	1C2h
SM3_BIST_CTRL1	1C6h

Function
Provides control of the submodule BIST operation.

Diagram



Fields

Field	Function
15-13 —	Reserved
12-8 DATA_FINAL	Final Data Counter Specifies the final value for the data counter.
7-5 —	Reserved
4-0 DATA_INITIAL	Initial Data Counter Specifies the initial value for the BIST data counter.

56.7.60 Submodule a BIST Status (SM0_BIST_STATUS - SM3_BIST_STATUS)

Offset

Register	Offset
SM0_BIST_STATUS	1C8h
SM1_BIST_STATUS	1CCh
SM2_BIST_STATUS	1D0h
SM3_BIST_STATUS	1D4h

Function

Indicates operational status of the submodule BIST.

Diagram

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				FAIL_CLK				0						BIST_PA...	BIST_DO...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
15-13 —	Reserved
12-8 FAIL_CLK	Fail Clock Indicates the clock counter value when BIST failed.
7-2 —	Reserved
1 BIST_PASS	BIST Pass Indicates the pass/fail status of the BIST. 0b - Fail 1b - Pass
0 BIST_DONE	BIST Completion Indicates that the BIST operation is completion.

56.7.61 Submodule a BIST Status (SM0_BIST_STATUS1 - SM3_BIST_STATUS1)

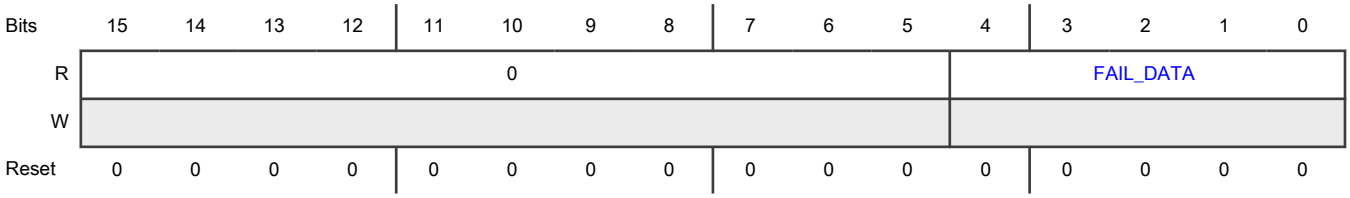
Offset

Register	Offset
SM0_BIST_STATUS1	1CAh
SM1_BIST_STATUS1	1CEh
SM2_BIST_STATUS1	1D2h
SM3_BIST_STATUS1	1D6h

Function

Indicates operational status of the submodule BIST.

Diagram



Fields

Field	Function
15-5 —	Reserved
4-0 FAIL_DATA	Fail Data Indicates the data counter value when BIST failed.

56.8 Glossary

EOnCE Enhanced On-Chip Emulation

H bridge An electronic circuit that switches the polarity of a voltage applied to a load.

Chapter 57
Analog-to-Digital Converter (ADC)

57.1 Chip-specific ADC information

57.1.1 Configuration and supported instances

Table 270. Configuration and supported instances

Feature	ADC_0[1]	ADC_1[1]	ADC_2[1]	ADC_3	ADC_4	ADC_5	ADC_6
Resolution	15 bits	15 bits	15 bits	15 bits	15 bits	15 bits	15 bits
Number of precision channels	8	8	8	8	8	8	8
Number of standard channels	16	16	16	4	4	4	4
Number of external channels	32	32	0	0	0	0	0
DMA support included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of watchdogs	4	4	4	4	4	4	4

1. ADC_0/ADC_1/ADC_2 are not available in S32K36x.

57.1.2 Channel mapping

Table 271. Channel mapping

Channel number	ADC_0	ADC_1	ADC_2	ADC_3	ADC_4	ADC_5	ADC_6
0	ADC0_P0	ADC1_P0	ADC2_P0	ADC3_P0	ADC4_P0	ADC5_P0	ADC6_P0
1	ADC0_P1	ADC1_P1	ADC2_P1	ADC3_P1	ADC4_P1	ADC5_P1	ADC6_P1
2	ADC0_P2	ADC1_P2	ADC2_P2	ADC3_P2	ADC4_P2	ADC5_P2	ADC6_P2
3	ADC0_P3	ADC1_P3	ADC2_P3	ADC3_P3	ADC4_P3	ADC5_P3	ADC6_P3
4	ADC0_P4	ADC1_P4	ADC2_P4	ADC3_P4	ADC4_P4	ADC5_P4	ADC6_P4
5	ADC0_P5	ADC1_P5	ADC2_P5	ADC3_P5	ADC4_P5	ADC5_P5	ADC6_P5
6	ADC0_P6	ADC1_P6	ADC2_P6	ADC3_P6	ADC4_P6	ADC5_P6	ADC6_P6
7	ADC0_P7	ADC1_P7	ADC2_P7	ADC3_P7	ADC4_P7	ADC5_P7	ADC6_P7
8	—[1]	—	—	—	—	—	—
9	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—

Table continues on the next page...

Table 271. Channel mapping (continued)

15	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—
17	—	—	—	—	—	—	—
18	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—
21	—	—	—	—	—	—	—
22	—	—	—	—	—	—	—
23	—	—	—	—	—	—	—
24	—	—	—	—	—	—	—
25	—	—	—	—	—	—	—
26	—	—	—	—	—	—	—
27	—	—	—	—	—	—	—
28	—	—	—	—	—	—	—
29	—	—	—	—	—	—	—
30	—	—	—	—	—	—	—
31	—	—	—	—	—	—	—
32	ADC0_S[8]	ADC1_S[8]	ADC2_S[8]	ADC3_S[8]	ADC4_S[8]	ADC5_S[8]	ADC6_S[8]
33	ADC0_S[9]	ADC1_S[9]	ADC2_S[9]	ADC3_S[9]	ADC4_S[9]	ADC5_S[9]	ADC6_S[9]
34	ADC0_S[10]	ADC1_S[10]	ADC2_S[10]	ADC3_S[10]	ADC4_S[10]	ADC5_S[10]	ADC6_S[10]
35	ADC0_S[11]	ADC1_S[11]	ADC2_S[11]	ADC3_S[11]	ADC4_S[11]	ADC5_S[11]	ADC6_S[11]
36	ADC0_S[12]	ADC1_S[12]	ADC2_S[12]	—	—	—	—
37	ADC0_S[13]	ADC1_S[13]	ADC2_S[13]	—	—	—	—
38	ADC0_S[14]	ADC1_S[14]	ADC2_S[14]	—	—	—	—
39	ADC0_S[15]	ADC1_S[15]	ADC2_S[15]	—	—	—	—
40	ADC0_S[16]	ADC1_S[16]	ADC2_S[16]	—	—	—	—
41	ADC0_S[17]	ADC1_S[17]	ADC2_S[17]	—	—	—	—
42	ADC0_S[18]	ADC1_S[18]	ADC2_S[18]	—	—	—	—
43	ADC0_S[19]	ADC1_S[19]	ADC2_S[19]	—	—	—	—
44	ADC0_S[20]	ADC1_S[20]	ADC2_S[20]	—	—	—	—
45	ADC0_S[21]	ADC1_S[21]	ADC2_S[21]	—	—	—	—
46	ADC0_S[22]	ADC1_S[22]	ADC2_S[22]	—	—	—	—
47	ADC0_S[23]	ADC1_S[23]	ADC2_S[23]	—	—	—	—

Table continues on the next page...

Table 271. Channel mapping (continued)

48	Bandgap	Bandgap	Bandgap	Bandgap	Bandgap	Bandgap	Bandgap
49	Temperature sensor output	Temperature sensor output	Temperature sensor output	Temperature sensor output	Temperature sensor output	Temperature sensor output	Temperature sensor output
50	VREFL	VREFL	VREFL	VREFL	VREFL	VREFL	VREFL
51	VREFH	VREFH	VREFH	VREFH	VREFH	VREFH	VREFH
54	ANAMUX_OUT[2]	ANAMUX_OUT1[3]	—	—	—	—	—
55	—	—	—	—	—	—	—
56	—	—	—	—	—	—	—
57	—	—	—	—	—	—	—
58	—	—	—	—	—	—	—
59	—	—	—	—	—	—	—
60	—	—	—	—	—	—	—
61	—	—	—	—	—	—	—
62	—	—	—	—	—	—	—
63	—	—	—	—	—	—	—
64	ADC0_X[0] ADC0_MA[2:0] = 0h[4]	ADC1_X[0] ADC1_MA[2:0] = 0h	—	—	—	—	—
65	ADC0_X[0] ADC0_MA[2:0] = 1h	ADC1_X[0] ADC1_MA[2:0] = 1h	—	—	—	—	—
66	ADC0_X[0] ADC0_MA[2:0] = 3h	ADC1_X[0] ADC1_MA[2:0] = 3h	—	—	—	—	—
67	ADC0_X[0] ADC0_MA[2:0] = 2h	ADC1_X[0] ADC1_MA[2:0] = 2h	—	—	—	—	—
68	ADC0_X[0] ADC0_MA[2:0] = 6h	ADC1_X[0] ADC1_MA[2:0] = 6h	—	—	—	—	—
69	ADC0_X[0] ADC0_MA[2:0] = 7h	ADC1_X[0] ADC1_MA[2:0] = 7h	—	—	—	—	—
70	ADC0_X[0] ADC0_MA[2:0] = 5h	ADC1_X[0] ADC1_MA[2:0] = 5h	—	—	—	—	—

Table continues on the next page...

Table 271. Channel mapping (continued)

71	ADC0_X[0] ADC0_MA[2:0] = 4h	ADC1_X[0] ADC1_MA[2:0] = 4h	—	—	—	—	—
72	ADC0_X[1] ADC0_MA[2:0] = 0h	ADC1_X[1] ADC1_MA[2:0] = 0h	—	—	—	—	—
73	ADC0_X[1] ADC0_MA[2:0] = 1h	ADC1_X[1] ADC1_MA[2:0] = 1h	—	—	—	—	—
74	ADC0_X[1] ADC0_MA[2:0] = 3h	ADC1_X[1] ADC1_MA[2:0] = 3h	—	—	—	—	—
75	ADC0_X[1] ADC0_MA[2:0] = 2h	ADC1_X[1] ADC1_MA[2:0] = 2h	—	—	—	—	—
76	ADC0_X[1] ADC0_MA[2:0] = 6h	ADC1_X[1] ADC1_MA[2:0] = 6h	—	—	—	—	—
77	ADC0_X[1] ADC0_MA[2:0] = 7h	ADC1_X[1] ADC1_MA[2:0] = 7h	—	—	—	—	—
78	ADC0_X[1] ADC0_MA[2:0] = 5h	ADC1_X[1]	—	—	—	—	—
79	ADC0_X[1] ADC0_MA[2:0] = 4h	ADC1_X[1] ADC1_MA[2:0] = 4h	—	—	—	—	—
80	ADC0_X[2] ADC0_MA[2:0] = 0h	ADC1_X[2] ADC1_MA[2:0] = 0h	—	—	—	—	—
81	ADC0_X[2] ADC0_MA[2:0] = 1h	ADC1_X[2] ADC1_MA[2:0] = 1h	—	—	—	—	—
82	ADC0_X[2] ADC0_MA[2:0] = 3h	ADC1_X[2] ADC1_MA[2:0] = 3h	—	—	—	—	—
83	ADC0_X[2] ADC0_MA[2:0] = 2h	ADC1_X[2] ADC1_MA[2:0] = 2h	—	—	—	—	—
84	ADC0_X[2] ADC0_MA[2:0] = 6h	ADC1_X[2] ADC1_MA[2:0] = 6h	—	—	—	—	—

Table continues on the next page...

Table 271. Channel mapping (continued)

85	ADC0_X[2] ADC0_MA[2:0] = 7h	ADC1_X[2] ADC1_MA[2:0] = 7h	—	—	—	—	—
86	ADC0_X[2] ADC0_MA[2:0] = 5h	ADC1_X[2] ADC1_MA[2:0] = 5h	—	—	—	—	—
87	ADC0_X[2] ADC0_MA[2:0] = 4h	ADC1_X[2] ADC1_MA[2:0] = 4h	—	—	—	—	—
88	ADC0_X[3] ADC0_MA[2:0] = 0h	ADC1_X[3] ADC1_MA[2:0] = 0h	—	—	—	—	—
89	ADC0_X[3] ADC0_MA[2:0] = 1h	ADC1_X[3] ADC1_MA[2:0] = 1h	—	—	—	—	—
90	ADC0_X[3] ADC0_MA[2:0] = 3h	ADC1_X[3] ADC1_MA[2:0] = 3h	—	—	—	—	—
91	ADC0_X[3] ADC0_MA[2:0] = 2h	ADC1_X[3] ADC1_MA[2:0] = 2h	—	—	—	—	—
92	ADC0_X[3] ADC0_MA[2:0] = 6h	ADC1_X[3] ADC1_MA[2:0] = 6h	—	—	—	—	—
93	ADC0_X[3] ADC0_MA[2:0] = 7h	ADC1_X[3] ADC1_MA[2:0] = 7h	—	—	—	—	—
94	ADC0_X[3] ADC0_MA[2:0] = 5h	ADC1_X[3] ADC1_MA[2:0] = 5h	—	—	—	—	—
95	ADC0_X[3] ADC0_MA[2:0] = 4h	ADC1_X[3] ADC1_MA[2:0] = 4h	—	—	—	—	—

1. Channels indicating "—" are reserved, and access to any reserved channel may result in inappropriate data.
2. Use DCM_GPR.DCMRWF1[SUPPLY_MON_SEL] to select the value of ANAMUX_OUT.
3. Use DCM_GPR.DCMRWF2[SUPPLY2_MON_EN] to select the value of ANAMUX_OUT1.
4. The decoding signals for the selection of external ADC channels (ADC_X) use Gray encoding.

57.1.3 ANAMUX for internal supply monitoring

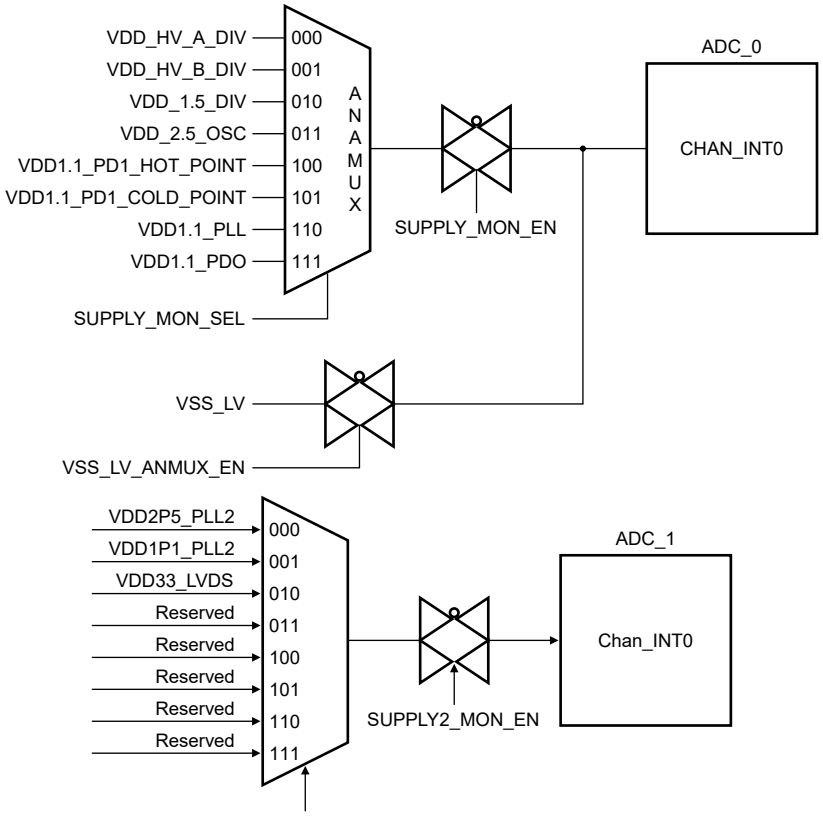


Figure 275. ANAMUX for internal supply monitoring

57.1.4 BCTU interface

ADC instances shown in the following figure are triggered from BCTU, which provides channel-conversion commands, including channel number information, to ADC. Next, ADC provides the conversion result back to BCTU.

BCTU provides a trigger pulse to all 72 channels of ADC to initiate a conversion based on the BCTU channel number.

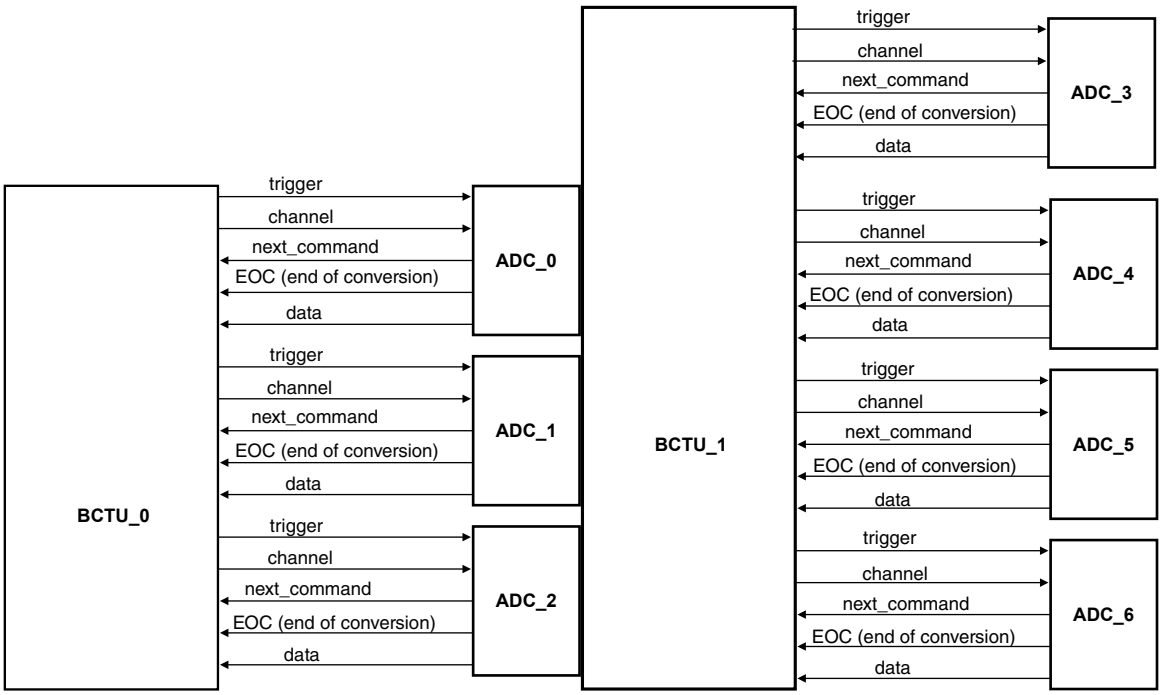


Figure 276. BCTU interface

57.1.5 Registers storing conversion data

The following ADC registers store 15-bit conversion data:

- PCDR*n*[CDATA]
- ICDR*n*[CDATA]
- ECDR*n*[CDATA]

Within BCTU, the ADC*n*DR[ADC_DATA] fields store 15-bit conversion data.

57.1.6 DMA interface

Each ADC supports a single DMA request that can occur after the conversion of every channel. The conversion result is stored in the DMAR registers and is transferred via DMA or host access.

NOTE

The final ongoing conversion is aborted as soon as ADC receives a STOP request from you. ADC then moves to Stop mode.

57.1.7 Hardware triggers

In this chip, TRGMUX outputs can provide hardware trigger signals. The normal conversion synchronization pulse is used with the normal conversion trigger to synchronize the start timing of normal conversion between multiple ADC instances.

Table 272. Hardware triggers

TRGMUX output number	Hardware trigger functions
0	ADC_0 normal conversion

Table continues on the next page...

Table 272. Hardware triggers (continued)

TRGMUX output number	Hardware trigger functions
1	ADC_0 injected conversion
2	ADC_0 normal conversion synchronization pulse
4	ADC_1 normal conversion
5	ADC_1 injected conversion
6	ADC_1 normal conversion synchronization pulse
8	ADC_2 normal conversion
9	ADC_2 injected conversion
10	ADC_2 normal conversion synchronization pulse
12	ADC_3 normal conversion
13	ADC_3 injected conversion
14	ADC_3 normal conversion synchronization pulse
16	ADC_4 normal conversion
17	ADC_4 injected conversion
18	ADC_4 normal conversion synchronization pulse
20	ADC_5 normal conversion
21	ADC_5 injected conversion
22	ADC_5 normal conversion synchronization pulse
24	ADC_6 normal conversion
25	ADC_6 injected conversion
26	ADC_6 normal conversion synchronization pulse

57.1.8 Self-test feature

You must, at regular intervals, check whether ADC is operating correctly. For this purpose, the chip provides a self-test feature. After self-test is enabled, ADC runs an automatic check on its own components and flags any errors.

57.1.9 Mux_mode GPR

Multiple pads drive some ADC channels. For this, DCM_GPR fields define which pad is connected to a particular ADC channel.

The following table shows the DCM_GPR configuration that is used for this purpose.

Table 273. DCM_GPR configuration

ADC channel	DCM_GPR register and field	Connected pad
ADC_1 standard channel 15 (ADC_1 S15)	DCMRWF4[MUX_MODE_EN_ADC 1_S15]	0: GPIO PAD4 (default) 1: GPIO PAD33

57.2 Overview

ADC produces a digital value from an input analog voltage using the SAR algorithm. It features various methods to trigger a conversion and offers flexibility in the selection of input channels. ADC is useful for a wide range of applications.

A configurable self-test capability supports use cases with increased requirements for functional safety.

57.2.1 Block diagram

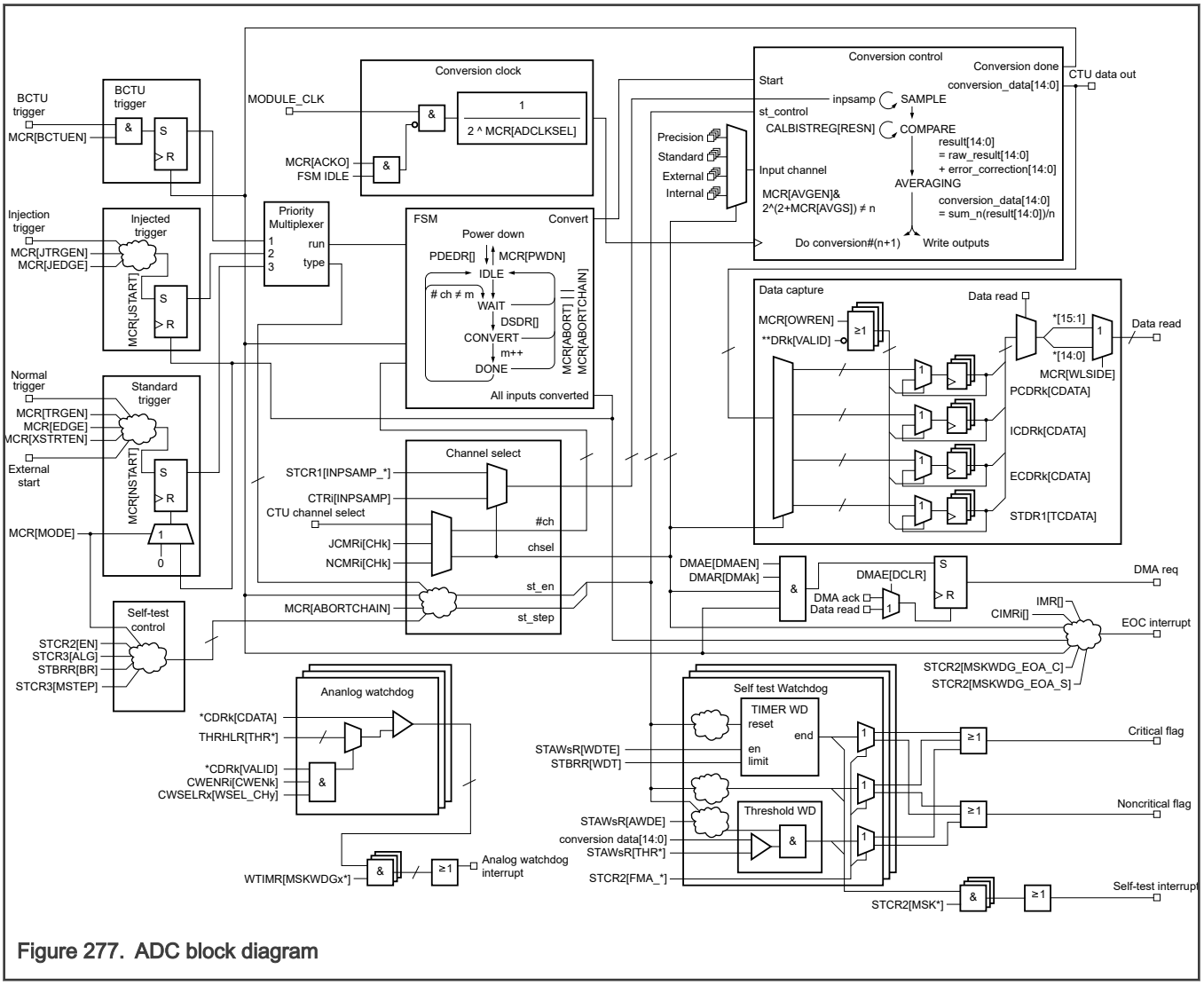


Figure 277. ADC block diagram

Guide to the diagram:

- The signal flow through the diagram is from left to right: inputs to blocks are on the left side, outputs are on the right.
- Block names have the first letters in uppercase and the other letters in lowercase—"Conversion Control," for example).
- Register names are in uppercase followed by a field name in brackets ("MCR[NSTART]," for example). Letters in lowercase are indexes. Asterisks are placeholders for letters (wildcards). Register names in the block diagram map to the names in ADC register descriptions.
- Signal names are in lowercase ("conversion done," for example).
- All digital signals shown are synchronous signals. Asynchronous inputs to the ADC are internally synchronized (synchronizers not shown).

The block diagram shows the signal flow through ADC from the left to the right and from the top to the bottom:

1. When ADC receives one of the three different types of triggers (BCTU, injected, or normal), the priority multiplexer initiates the conversion.
2. The input to be converted is selected in the Channel Select subblock, based on the type of trigger and on the self-test configuration.
3. The state machine (FSM) transitions from Idle state to Convert state. In case the channel to convert changed since the last conversion and this new channel is an external channel, the conversion starts after a delay configured by DSDR[DSD].
4. After a conversion begins, the Conversion Control block holds the internal capacitance network CDAC in the sample phase for a time defined by CTRi[INPSAMP].
5. During the compare phase, CALBISTREG[RESN] defines the number of steps used to execute the successive approximation algorithm. The error_correction values, determined during calibration, are added to the raw result. If averaging is enabled (MCR[AVGEN] = 1), up to 32 (specified via MCR[AVGS]) conversion results are averaged to obtain the result.
6. When the conversion completes and all averaging steps have completed:
    a. The conversion done signal indicates completion.
    b. Conversion_data[14:0] is written to the result registers in the Data Capture subblock.
    c. The FSM transitions into Done state.
7. The next input in the Channel Select block is selected and the next conversion is started by the transition of the FSM to Convert state. This continues until all selected inputs have been converted.
8. If an analog watchdog is enabled, the conversion result is compared to the configured threshold. If the limits are exceeded, an interrupt can be triggered.
9. Self-test can check the integrity of ADC, either interleaved with normal conversions or as a standalone check.
10. If an ongoing conversion is aborted (by writing 1 to MCR[ABORT]) or an ongoing conversion of a set of input channels is aborted (by writing 1 to MCR[ABORTCHAIN]), the FSM transitions into Idle state. The Conversion Control block stops the current conversion if MCR[ABORT] was written with 1, or finishes the current conversion if MCR[ABORTCHAIN] was written with 1. In both cases, the conversion done output signal of the Conversion Control block is set to 1.

Some details are not shown in the block diagram:

- Calibration must be performed to determine the error_correction values (see Calibration) before ADC can do meaningful conversions.
- An input can presample the internal low or high reference voltages to avoid a memory effect that may be present in the comparison due to a previous conversion (see Presampling).
- Monitor ADC status via status flags.
    - See Main Status (MSR) for the FSM state.
    - See Interrupt Status (ISR) to monitor interrupts.
    - See Channel End Of Conversion Flag For Precision Inputs (CEOCFR0) for conversion phase per input.
    - See the following registers to monitor analog watchdogs:
        - Analog Watchdog Out Of Range For Precision Inputs (AWORR0)
        - Analog Watchdog Out Of Range For Standard Inputs (AWORR1)
        - Analog Watchdog Out Of Range For External Inputs (AWORR2)

      See Analog Watchdog Threshold Interrupt Status (WTISR) to monitor analog watchdog interrupts.
    - See Self-Test Status 1 (STSR1) – Self-Test Status 4 (STSR4) to monitor self-test.

57.2.2 Features

- Selectable resolution (8-, 10-, 12-, 14-bit). Note that the conversion result is always 15 bits wide, even though the selected resolution is smaller (see CALBISTREG[RESN])
- Conversion data captured in a separate register for each input channel.
- Option to improve accuracy via averaging, which calculates conversion data by averaging the data of up to 32 conversions.
- Conversion triggers:
  - Normal conversion trigger converts a number of input channels, either once per trigger or continuously.
  - Injected conversion trigger interrupts an ongoing normal conversion and converts another set of input channels.
  - BCTU conversion trigger interrupts an ongoing conversion and converts an input channel, in which the input is selected and the conversion is started via the BCTU.
- An analog watchdog optionally monitors conversion data for each input channel and issues an interrupt if the converted data is below or above configurable limits.
- DMA functionality transfers conversion data to other modules.
- Programmable interrupts optionally issue an interrupt when conversion of one or of a set of input channels is finished.
- Self-test functions validate ADC structural integrity during functional operation and generate events with different severities on any finding.
- Conversion clock (AD_clk) control enables the use of ADC in systems with a higher clock frequency by using internal clock dividers.
- Auto turn-off of the conversion clock when ADC is idle.

57.3 Functional description

57.3.1 Clock

ADC is controlled by one clock signal, the module clock. Internally, the conversion circuit is controlled by the conversion clock, which is derived from the module clock.

The frequency of the conversion clock has to be within the limits defined in the data sheet. If the module clock frequency is higher than the maximum frequency of the conversion clock allowed during the functional conversion or during the calibration (see the chip data sheet), then you must configure the ADC conversion clock divider (MCR[ADCLKSEL]) so that the frequency of the conversion clock is within allowed limits. See Table 274.

Table 274. Clock configuration for highest conversion speeds

Module Clock Frequency f_mc[1]	Configuration during calibration	Configuration during functional conversion
40 MHz < f_mc ≤ 80 MHz	MCR[ADCLKSEL] = 1h AMSIO[HSEN] = 0h AMSIO[CMPCTRL0] = 0b	MCR[ADCLKSEL] = 0h AMSIO[HSEN] = 0h AMSIO[CMPCTRL0] = 0b
80 MHz < f_mc ≤ 120 MHz	MCR[ADCLKSEL] = 1h AMSIO[HSEN] = 1h AMSIO[CMPCTRL0] = 1b	MCR[ADCLKSEL] = 0h AMSIO[HSEN] = 1h AMSIO[CMPCTRL0] = 1b
120 MHz < f_mc ≤ 160 MHz	MCR[ADCLKSEL] = 2h	MCR[ADCLKSEL] = 1h

Table continues on the next page...

Table 274. Clock configuration for highest conversion speeds (continued)

Module Clock Frequency f_mc[1]	Configuration during calibration	Configuration during functional conversion
	AMSIO[HSEN] = 0h AMSIO[CMPCTRL0] = 0b	AMSIO[HSEN] = 0h AMSIO[CMPCTRL0] = 0b
160 MHz < f_mc ≤ 240 MHz	MCR[ADCLKSEL] = 2h AMSIO[HSEN] = 1h AMSIO[CMPCTRL0] = 1b	MCR[ADCLKSEL] = 1h AMSIO[HSEN] = 1h AMSIO[CMPCTRL0] = 1b
240 MHz < f_mc ≤ 320 MHz	MCR[ADCLKSEL] = 3h AMSIO[HSEN] = 0h AMSIO[CMPCTRL0] = 0b	MCR[ADCLKSEL] = 2h AMSIO[HSEN] = 0h AMSIO[CMPCTRL0] = 0b
320 MHz < f_mc ≤ 480 MHz	MCR[ADCLKSEL] = 3h AMSIO[HSEN] = 1h AMSIO[CMPCTRL0] = 1b	MCR[ADCLKSEL] = 2h AMSIO[HSEN] = 1h AMSIO[CMPCTRL0] = 1b

1. Lower resulting frequencies are allowed—see the chip data sheet.

When ADC is not converting (state machine is in Idle state), the conversion clock can be turned off (MCR[ACKO]).

57.3.2 Modes of operation

ADC is always in Functional mode. No other mode selection exists.

- Put ADC into Power Down state by writing 1 to MCR[PWDN] to reduce power consumption.
- Gate the clock signal by writing 1 to MCR[ACKO] when ADC is in Idle state.

57.3.3 Conversion

ADC measures the voltage of a signal—it converts an analog input value into a digital representation. When you read the conversion result, you must divide this conversion result by the number of codes (defined by selected conversion resolution in CALBISTREG[RESN]), and multiply it with the reference voltage value. This calculation provides the voltage value of the converted signal.

To convert an analog input voltage into its digital representation, ADC:

1. Receives a signal, referred to as a trigger, indicating it is to perform a conversion.
2. Captures the voltage of a signal via internal capacitances in a process referred to as sampling.
3. Compares the voltage to the reference voltage, using the SAR algorithm.

Before a conversion can be performed, you must select:

- The trigger source(s) to use (on the chip level)
- The input channel(s) to convert (NCMR0–2, JCMR0–2)

Additionally, you can tailor the conversion to meet your needs by changing the default configuration. For example, you can:

- Configure ADC to convert the selected input channel(s) only once or continuously in a loop (MCR[MODE]).
- Specify the duration that ADC samples the input signal (CTR0/1/2).
- Specify the resolution of the conversion result by selecting the number of bits (CALBISTREG[RESN]).

- Enable an analog watchdog to generate an interrupt when a conversion result falls outside a specified range (see Analog watchdog functions).
- Enable the DMA interface to send requests and receive acknowledgments (see DMA functionality).
- Check the operational integrity of ADC by running a self-test (see Self-test).

After power-up or a functional reset, ADC remains in Power Down state until enabled by writing 0 to MCR[PWDN]. After the system is powered on, you must run the calibration (see Calibration), before you can do a meaningful conversion with ADC.

Some configuration fields (listed below) are writeable only in Power Down state. If you intend to write to them, you must do so before exiting Power Down state.

- Select the conversion clock frequency to be within the allowed limits for a conversion.

57.3.4 Normal trigger

Select the input channels to convert by configuring the fields in NCMR0, NCMR1, and NCMR2.

These registers must be programmed before the start of conversion. You cannot reconfigure them until the conversion of all selected channels is complete. The sequence is always to convert the selected input channels in this order:

1. Start from the lowest input channel of the precision input channels.
2. Proceed through the standard input channels in ascending order.
3. End with the highest input channel of the external input channels.

57.3.4.1 Starting conversions in normal conversion mode

After programming the required fields of the following registers, you can start a conversion by writing 1 to MCR[NSTART]:

- Normal Conversion Enable For Precision Inputs (NCMR0)
- Normal Conversion Enable For Standard Inputs (NCMR1)
- Normal Conversion Enable For External Inputs (NCMR2)
- Main Configuration (MCR)

A hardware trigger can also start a normal conversion.

- If the external trigger is enabled (MCR[TRGEN] = 1), an external trigger enable is detected to start the conversion. The enable is checked only during start of conversion.
- Detection of an active edge defined by MCR[EDGE] (rising = 1, falling = 0) on an external trigger transitions MCR[NSTART] to 1 and starts the normal conversion.
- When MCR[TRGEN] = 1 (for example, when external trigger is enabled), conversion can be started by software.
- Any external trigger or software initiated conversion in normal conversion mode is ignored during any ongoing conversion chain.

NOTE

To have reliable operation there must be a gap of 3 clock cycles between configuration of NCMRx and the start of a conversion (by writing 1 to MCR[NSTART], or arrival of an external or internal hardware start trigger). ADC calculates the number of channels to be converted during this period.

57.3.4.2 Operation modes in normal conversions

Two operational modes are available during normal conversion:

- One-Shot mode
- Scan mode

For normal conversion, select the mode via MCR[MODE]. The first phase of the conversion process involves sampling the analog channel. The next phase is the conversion phase, curing which the sampled analog value is converted to digital as shown in the following figure.

Figure 278. Normal conversion flow

In One-Shot mode (MCR[MODE] = 0), a sequential conversion specified in the NCMR*n* mask registers is performed only once. At the end of each conversion, the digital result of the conversion is stored in the corresponding data register (CDR*n*).

For example: Channels A→B→C→D→E→F→G→H are present in a device where channels B→D→E are to be converted in One-Shot mode. Conversion begins with channel B, followed by conversion of channels D and E. At the end of conversion of channel E, the scanning of channels stops.

MSR[NSTART] automatically transitions to 1 when a normal conversion starts. At the same time, MCR[NSTART] is reset to zero by hardware, enabling software to program a new start of conversion in advance. In this case, the new requested conversion starts after completion of the running/current conversion. However, for correct functioning of the device, you should program MCR[NSTART] for the new conversion only after completion of the current conversion. The application can wait for an ECH interrupt prior to writing 1 to MCR[NSTART] again.

If an external trigger starts the conversion chain, ADC does not observe the trigger input until the conversion chain is finished. After the chain is finished, the next chain can be triggered by another hardware trigger edge.

In Scan mode operation (MCR[MODE]=1), a sequential conversion of N channels specified in the NCMR*n* registers is continuously performed. At the end of each conversion, the result is stored in the corresponding data register, as in One-Shot mode.

MSR[NSTART] automatically transitions to 1 when a normal conversion starts. Unlike One-Shot mode, MCR[NSTART] is not reset to 0 in Scan mode. It can be reset by software when you must exit Scan mode. In that case, ADC completes the current chain and after the last conversion, it resets MCR[NSTART] to 0.

For example: Channels A→B→C→D→E→F→G→H are present in the device where channels B→D→E are to be converted in Scan mode. MCR[MODE] = 1 selects Scan mode operation. Conversion starts from channel B followed by conversion of channels D→E. After conversion of channel E, the scanning of channel B starts followed by conversion of the channels D→E. This sequence repeats itself until MCR[NSTART] is reset to 0 by software.

If an external trigger starts a conversion, then MCR[NSTART] does not transition to 1. This scan chain can be stopped by writing 0 to MCR[NSTART]. The conversion stops when the ongoing chain is finished. Consequently, after it starts, the only way to stop Scan mode conversion is to write 0 to MCR[MODE].

End of conversion

In both modes, at the end of each conversion, an End of Conversion (EOC) interrupt is issued if enabled by the corresponding mask fields in CIMR*n* and IMR).

After conversion of all selected channels in NCMR*n* is complete, the conversion operation is considered finished. Then ISR[ECH] transitions to 1 and the End of Chain (ECH) interrupt is issued (if enabled in IMR[MSKECH]).

The corresponding channel field in the CEOCFR*n* register(s) is updated to indicate that data is available on data register CDR*n* of the respective channel.

If there is no channel selected in NCMR*n* and there is a start-of-conversion trigger, then ISR[ECH] is set to 1 and the End of Chain (ECH) interrupt is immediately issued (if enabled).

57.3.5 Injected trigger

An injected trigger enables you to convert a set of input channels although the standard trigger has already started conversion of another set of input channels. Each channel can be individually enabled by writing 1 to the corresponding field in JCMR0, JCMR1, or JCMR2.

The set of input channels of the injected trigger is converted only once. A continuous conversion of a set of input channels in a loop is only possible when started by a standard trigger. When an injected trigger is received, an ongoing conversion started by a standard trigger is interrupted. After the set of input channels of the injected trigger is converted once, the interrupted conversion of the set of input channels of the standard trigger resumes from the input channel that was interrupted, as shown in the following figure.

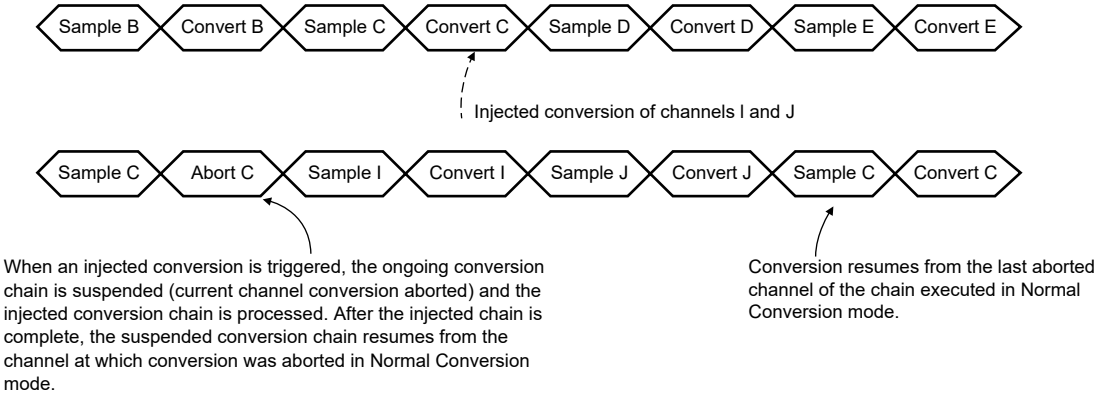


Figure 279. Injected trigger conversion sequence

57.3.5.1 Starting conversions in injected conversion mode

An injected conversion chain can be started:

- By software: When external triggering is disabled (MCR[JTRGEN] = 0), you can write 1 to MCR[JSTART], which causes the current conversion chain processed in Normal Conversion mode to be suspended and the injected chain to be processed.
- By external trigger: When external triggering is enabled (MCR[JTRGEN] = 1), a programmed event (rising/falling edge depending on the value of MCR[JEDGE]) on the injection external input starts the injected conversion.

MCR[JSTART] automatically transitions to 1 when the injected conversion chain starts. At the same time MCR[JSTART] is reset to 0, enabling software to program a new start of conversion in advance. In that case the new requested conversion starts after the running conversion completes.

At the end of each conversion, an End Of Injected Conversion (JEOC) interrupt is issued, if enabled by the corresponding mask field in Interrupt Mask (IMR). At the end of a chain, an End Of Injected Chain (JECH) interrupt is issued, if enabled by the corresponding mask field. Additionally, ADC writes 1 to ISR[JECH].

NOTE

If the content of all the Injected Conversion mask registers (JCMR*n*) is zero, that is, no channel is selected, the JECH interrupt is immediately issued after the start of conversion.

To have reliable ADC operation, there must be a gap of 3 cycles between configuration of JCMRx and starting of conversion (writing 1 to MCR[JSTART] or arrival of either an external or internal hardware start trigger). ADC calculates the total channel numbers to be converted during this period.

The corresponding channel bit in the CEOCFR*n* register is updated to indicate data is available in the channel's conversion data register, CDR*n*.

After starting, an injected chain conversion cannot be interrupted.

57.3.6 BCTU interface

The BCTU interface enhances ADC's injected conversion capability. It contains control inputs to select the channels to be converted from the appropriate event configuration register. Figure 280 shows the interface.

The BCTU generates a trigger (bctu_trigger) and a channel number (bctu_numchannel) to be converted. A single channel is converted for each request. After performing the conversion, ADC returns the result on the bctu_dataout bus together with two

output signals named bctu_nextcmd and bctu_push. The assertion of signal bctu_nextcmd means ADC is ready to accept the next trigger from BCTU. The bctu_push signal is asserted at the end of conversion, meaning that conversion is finished and the conversion result available at output bctu_dataout is valid.

The conversion result is also saved in the corresponding channel's data register and is compared with analog watchdog thresholds if requested.

The signals bctu_trigger, bctu_nextcmd and bctu_push are all of type single-cycle active-high-pulse in the ADC clock domain. The channel number provided from BCTU must be valid when bctu trigger is active-high. The result data from ADC is valid with bctu_push high.

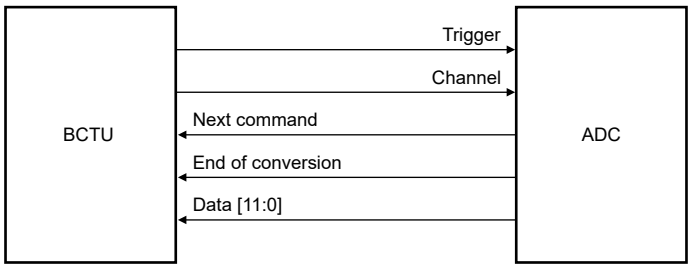


Figure 280. BCTU interface

The BCTU interface has two modes of operation:

- Trigger
- Control

To enable the BCTU interface, write 1 to MCR[BCTUEN]. The operating mode (Trigger or Control) can be fixed or programmable.

57.3.6.1 BCTU Trigger mode

In Trigger mode, normal and injected conversions can also be performed. All types of conversions can be initiated in this mode. The priorities among the three types of conversions are discussed below.

When a trigger is received, the channel number is taken as an injected channel value and the triggered injected conversion starts. MSR[BCTUSTART] transitions to 1 automatically at this point and it is also automatically reset to 0 when the triggered injected conversion is completed.

BCTU conversions must be requested only after successful ADC calibration. The application must prevent any BCTU trigger during calibration.

If a BCTU trigger is received during an ongoing injected conversion, the injected chain is aborted immediately and only the BCTU-triggered injected conversion proceeds. Additionally, MSR[JSTART] is reset to zero. The abort of an injected conversion is indicated by MSR[JABORT].

If a BCTU trigger is received during an ongoing normal conversion, the ongoing normal channel conversion is suspended and the BCTU-triggered injected conversion is processed. Normal conversion resumes from the suspended channel after completion of the BCTU-triggered conversion.

If a normal conversion is requested during BCTU conversion (MSR[BCTUSTART] = 1), the normal conversion starts after the BCTU conversion completes (MSR[BCTUSTART] is reset to zero).

Any injected conversion is discarded if requested during BCTU conversion and MCR[JSTART] is immediately reset to zero.

57.3.6.2 BCTU Control mode

In BCTU control mode (MCR[BCTU_MODE] = 0), only the BCTU can start a conversion. All other trigger sources are ignored.

Along with BCTU trigger, the information provided with signal bctu_numchannel is taken as the channel number for injected channel and BCTU triggered conversion starts. MSR[BCTUSTART] transitions to 1 automatically at the start of the conversion and it remains 1 unless BCTU is disabled by writing 0 to MCR[BCTUEN].

The conversion must be requested (generating bctu_trigger) when calibration has finished successfully. If a BCTU trigger is received during calibration execution, calibration is stopped immediately in order to satisfy the BCTU request. Calibration fails in this case.

57.3.7 Aborting a conversion

Two abort functions are provided:

- Abort of a single channel
- Abort of a chain

To abort an ongoing conversion, write 1 to MCR[ABORT]. The current conversion aborts and conversion of the next channel of the chain begins immediately.

Depending on the current state of a conversion, an Abort action may take 1 to 4 cycles of the bus clock. At the start of any conversion, and at the end of a particular conversion when internal state counters are changing, an abort action is delayed by a maximum of 3 cycles to put all states in a stable condition.

To ensure that the abort action completes, do not change MCR[ABORT] for the next 3 cycles.

Avoid writing 1 to MCR[ABORT] along with, and within 3 cycles of, writing 1 to MCR[NSTART] or MCR[JSTART].

During an abort:

- MCR[NSTART] and MCR[JSTART] remain 1, if not in the last channel of the chain.
- MCR[ABORT] is reset to 0 when the channel is aborted.
- The EOC interrupt corresponding to the aborted channel is not generated. This behavior applies to normal and injected conversions. If the last channel of a chain is aborted, the end of chain is reported by generating an ECH interrupt.

It is possible to abort the current chain of conversions by writing 1 to MCR[ABORTCHAIN]. In this case, the behavior of ADC depends on the value of MCR[MODE] (One-Shot/Scan operation modes). If Scan operation mode is disabled, MCR[NSTART] is automatically reset to 0 along with MCR[ABORTCHAIN]. Otherwise, in Scan Operation mode, a new chain is started. The EOC interrupt of the current aborted conversion is not generated but an ECH interrupt is generated to signal the end of the chain.

NOTE

For a single channel chain, an ECH interrupt is not generated for an abort or abort chain.

When an abort chain is requested while an injected chain is running over a suspended normal chain, both the injected and normal chains are aborted, and both MCR[NSTART] and MCR[JSTART] are reset to 0.

57.3.8 Configuring ADC clock divider and sample time settings

You can scale the AD_clk frequency via MCR[ADCLKSEL]. ADCLKSEL can only be written in Power Down state (MCR[PWDN] = 1). Depending on the frequency of the module clock, there might be different settings necessary for functional conversion and for calibration. See the chip data sheet for ADC electrical characteristics.

Three conversion timing registers are used (CTR*n*) to support different sampling times for the different types of channels. An exception exists for the temperature sensor channel, which always uses the Conversion Timing For Standard Inputs (CTR1) value. See the register description for details.

57.3.9 Presampling

The presampling feature enables pre-charge or discharge of the ADC internal sample capacitor node to a defined level before sampling of the selected analog input channel starts. This is useful for resetting information (history effect/offset) from the most recent conversion. During presampling, ADC samples the internally generated voltage. During the sampling phase, ADC samples analog input coming from pads.

Enable presampling on a per-channel basis by setting the corresponding fields in the PSR*n* registers to one.

After enabling presampling for a channel, the normal sequence of operation for the channel is:

1. Presampling
2. Sampling
3. Evaluation

You can bypass sampling of all channels by writing 1 to PSCR[PRECONV]. When sampling of a channel is bypassed, the sampled and stored internal voltage applied during the presampling phase is converted (Figure 281). See Conversion time for the timing equation for conversion.

Presampling does not apply for self-test channels.

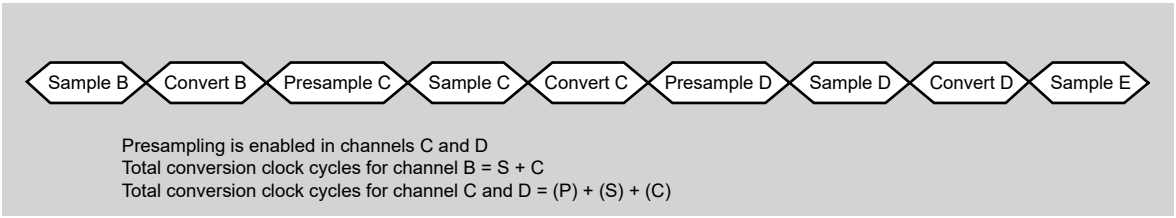


Figure 281. Presampling sequence

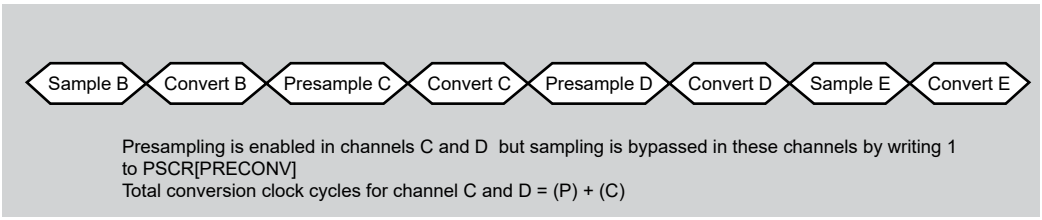


Figure 282. Presampling sequence with PRECONV=1

57.3.9.1 Enabling presampling per channel

Enable presampling for specific channels by programming Presampling Control (PSCR). You can select between two internally generated voltages by configuring the PREVAL*n* fields in Presampling Control (PSCR) to the appropriate values, as given in the following table.

Table 275. Presampling voltage selection via PREVAL*n*

PREVAL*n*	Presampling voltage
0	Presample voltage – 0: VREFL
1	Presample voltage – 1: VREFH

The presampling configuration field(s) (PSCR[PREVAL0], PSCR[PREVAL1], PSCR[PREVAL2]) are located in Presampling Control (PSCR). These fields enable selection of the presampling channel.

The temperature sensor channel has an exception. This channel is mapped with a fixed channel depending on device configuration, but it uses the presampling configuration defined for channel group 2. So, when the temperature sensor channel is selected, the presampling voltage defined by PSCR[PREVAL1] is selected. This voltage might be different from the one selected for channel group 1 via PSCR[PREVAL0].

57.3.10 Analog watchdog functions

When enabled, an analog watchdog monitors conversion results for an associated channel and reports an issue if it determines a result is outside customer-defined limits (as shown in Analog watchdog configuration (up to 16 watchdogs)). These limits are specified by an upper and a lower threshold value named THRH and THRL respectively.

After the conversion of the selected channel a comparison is performed between the converted value and the threshold values. If the converted value is outside that threshold value, then ADC generates a corresponding threshold violation interrupt.

The comparison result is stored as HAWIFx and LAWIFx fields in Analog Watchdog Threshold Interrupt Status (WTISR), as explained in the following table. Depending on the values of WTIMR[LAWIFENx] and WTIMR[HDWIFENx] mask fields, an interrupt is generated on a threshold violation.

Table 276. Values of HAWIFx and LAWIFx

HAWIFx	LAWIFx	Conversion result
1	0	Conversion result > THRH
0	1	Conversion result < THRL
0	0	THRH ≥ conversion result ≥ THRL

Depending on the chip's factory settings, up to 16 analog watchdogs are available. See the chip-specific configuration information for availability.

There are two types of mutually exclusive settings for analog watchdogs. Both types are described in the following sections. The availability depends on device configuration. See the chip-specific configuration information for availability.

Different capabilities are available with the two settings, as described below.

57.3.10.1 Channel analog watchdog select registers

ADC configuration includes selecting the analog watchdog threshold register (THRHLR*n*) that provides limits to monitor inputs of a given type. You select the THRHLR*n* using CWSELR*a*l*n* registers.

Table 277. CWSELR*a*l*n* register naming

Index	Description
a	ADC input type associated with a CWSELR*a*l*n* register. • P = Precision inputs • S = Standard inputs • E = External inputs
n	0-indexed register number.

57.3.10.2 Analog watchdog configuration (up to 16 watchdogs)

ADC can have up to 16 watchdogs in the factory configuration. (See the chip-specific configuration information for availability.) For each watchdog there is one threshold value register, THRHLR*n*, that contains the high and low thresholds.

You can independently enable the analog watchdog for each channel by programming the appropriate CWENR*n* register.

The threshold values for each channel can be selected independently from a maximum of 16 threshold registers (THRHLR*n*) using the corresponding WSEL_CH*n* field in the appropriate CWSELR*a*l*n*, where *a* indicates the input type:

- P = precision
- S = standard
- E = external

Each CWSELR*a*l*n* register is associated with 8 consecutive channels. CWSELR*a*l0 holds 8 WSEL_CH fields for channels 0 to 7. CWSELR*a*l1 is for channels 8 to 15 and so on. The availability of fields and registers depends on device configuration. See the chip-specific configuration information for availability.

If the conversion result of a selected channel is outside the range specified by threshold values, then the corresponding field in the Analog Watchdog Out of Range register (AWORR*n*) transitions to 1. For example, if channel 7 is to be monitored with the threshold values in THRHLR3, then CWSELR*a*l0[WSEL_CH7] must be programmed with 3. Enabling the watchdog is done by writing 1 to the corresponding field for channel 7 in CWENR0.

In this configuration, a set of threshold values (THRHLR*n*) can be linked to several ADC channels.

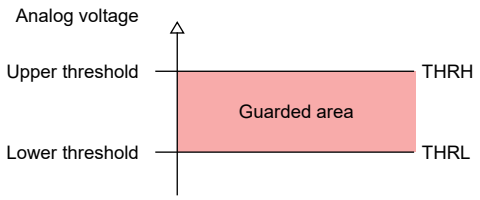


Figure 283. Guarded area

NOTE

If the higher threshold of the analog watchdog is programmed below the lower threshold and the conversion result is below the lower threshold, then the WDG*n*L interrupt for the low threshold violation transitions to 1. If the conversion result is greater than the lower threshold (and therefore also greater than the higher threshold), then the interrupt WDG*n*H for high threshold violation is generated. Thus you should take care to avoid that situation, as it could lead to misinterpretation of the watchdog interrupts.

57.3.11 DMA functionality

Conversion result data from any channel can be transferred from a register to system memory via Direct Memory Access (DMA). DMA transfers are enabled by writing 1 to DMAE[DMAEN]. After being enabled, the on-chip DMA controller can receive a DMA request after the conversion of each channel by writing 1 to the respective masking field in:

- DMA Request Enable For Precision Inputs (DMAR0)
- DMA Request Enable For Standard Inputs (DMAR1)
- DMA Request Enable For External Inputs (DMAR2)

DMA masking registers must be programmed before starting any conversion.

A DMA request to the DMA controller can be cleared at different times in two modes:

- Mode-1: Clearing of DMA request on acknowledgment from DMA controller (DMAE[DCLR] = 0)
- Mode-2: Clearing of DMA request on read to data registers (DMAE[DCLR] = 1)

The figures below show the operation of DMA in two modes (cycle counts are typical values).

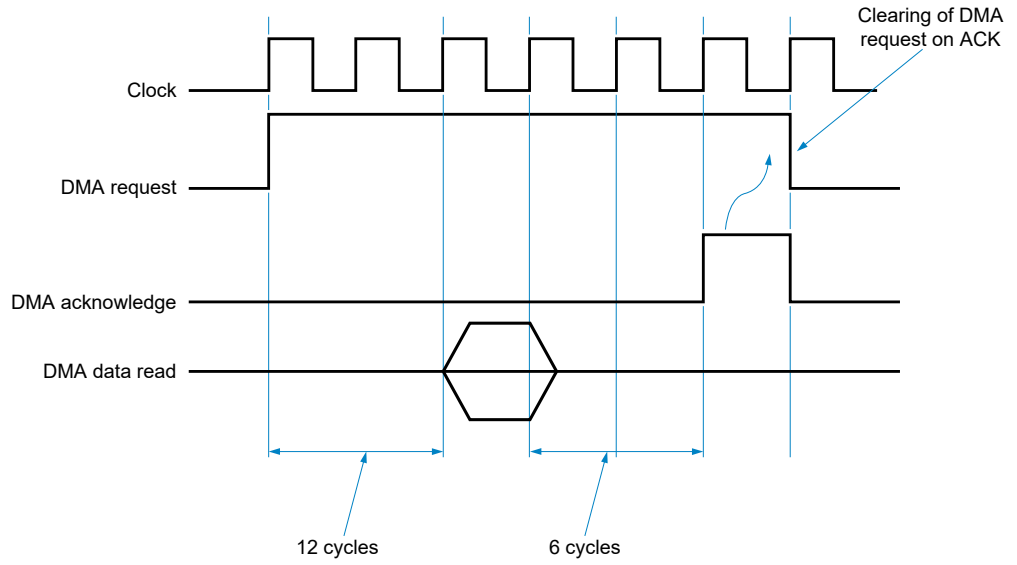


Figure 284. DMA operation Mode-1 (DMAE[DCLR] = 0)

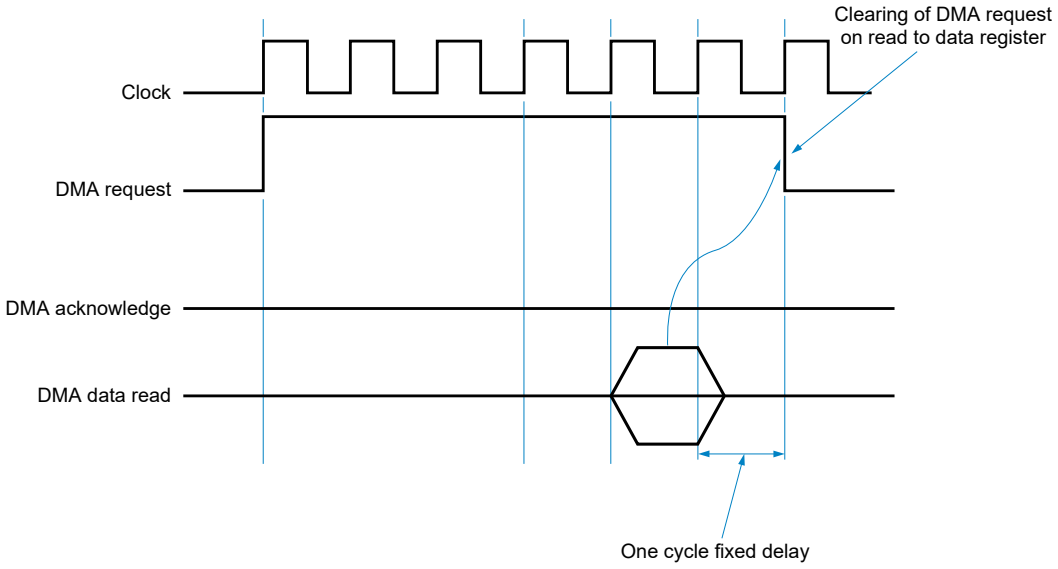


Figure 285. DMA operation Mode-2 (DMAE[DCLR] = 1)

57.3.12 Interrupts

ADC generates the following maskable interrupts:

- EOC (End of Conversion)
- ECH (End of Chain)
- JEOC (End of Injected Conversion)
- JECH (End of Injected Chain)
- EOBCTU (End of BCTU-triggered Conversion)
- LAWIFx and HDWIFx (Watchdog threshold)

- Self-testing interrupts

Interrupts are generated during the conversion process to signal events such as End Of Conversion (EOC), and so on, as described in Interrupt Status (ISR). ISR and another register, Interrupt Mask (IMR), are provided to check and enable the interrupt request to an external interrupt controller.

Interrupts can be individually enabled on a per-channel basis by programming EOC Interrupt Enable For Precision Inputs (CIMR0).

CEOCFR*n* are used for pending End of Conversion interrupts, with one field per channel to indicate completed conversions on a per-channel basis.

Interrupts generated due to the analog watchdogs are managed by two 32-bit registers, Analog Watchdog Threshold Interrupt Status (WTISR) and Analog Watchdog Threshold Interrupt Enable (WTIMR), to check and enable the interrupt request. A watchdog interrupt causes two corresponding fields to transition to 1 for each channel monitored. One field is in WTISR[WDG*n*H] and another in WTISR[WDG*n*L].

Generated events are logged into status registers and used to generate interrupts if enabled in corresponding Mask registers.

There are three different interrupt outputs. The interrupt structure is shown in Figure 286.

Each interrupt is generated by combining a group of events.

The following interrupts are combined (logic OR) into one interrupt output.

- EOC
- ECH
- EOBCTU
- JEOC
- JECH
- End of self-test algorithm (WDG_EOA_S and WDG_EOA_C)

Interrupts of all HDWIFx and LAWIFx are combined on the second interrupt output.

Interrupts of all self-test errors (watchdog threshold, sequence, and timer violations) in Self-Test Status 1 (STSR1) are combined on the third interrupt output. The errors are:

- WDSERR
- WDTERR
- ERR_S0
- ERR_S1
- ERR_S2
- ERR_C

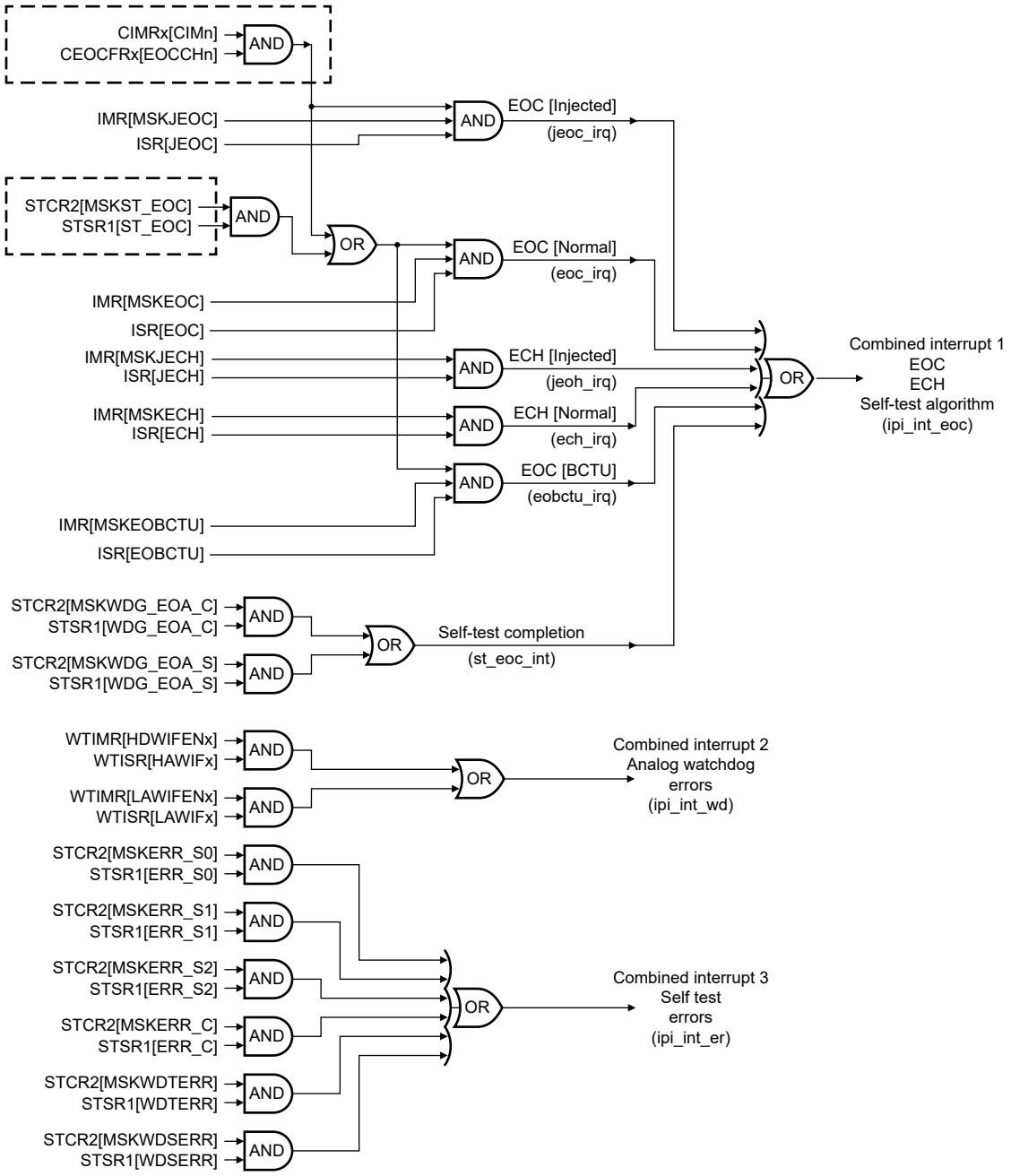


Figure 286. Interrupt structure of ADC

Interrupt Status (ISR) Indicates the interrupt pending request status. Write 1 to the corresponding status field to clear the pending interrupt flag (at this write operation all the other fields in Interrupt Status (ISR) must be maintained at 0).

ISR checks for three types of interrupts.

The first type, Interrupt 1, relates to the following:

- End of normal or injected conversion (EOC or JEOC)
- End of normal or injected conversion chain (ECH or JECH)
- End of algorithm C or algorithm S self-test (WD_EOA_C or WD_EOA_S)

Perform the following actions for this type of interrupt:

1. Read Interrupt Status (ISR) to determine whether the event is an EOC, JEOC, ECH, JECH, or EOBCTU event.
2. Read Self-Test Status 1 (STSR1) to identify the end of self-test algorithm events (WDG_EOA_S or WDG_EOA_C), if present.
3. If the interrupt is an EOC or JEOC event:
   - Clear the respective channel pending field in the appropriate CEOCFR*n* register for an EOC by writing a 1 to it.
   - Clear ISR[EOC] or ISRJEOC] by writing a 1 to it.
4. If the interrupt is an ECH or JECH, clear ISR[ECH] or ISR[JECH] by writing 1 to it.
5. If the interrupt is EOBCTU, clear ISR[EOBCTU] by writing 1 to it.
6. If the interrupt is for self-test end of algorithm, clear STSR1[WDG_EOA_S] or STSR1[WDG_EOA_C] by writing 1 to it.

The second type, Interrupt 2, relates to analog watchdog errors. Perform the following actions for this type of interrupt:

1. Read Analog Watchdog Threshold Interrupt Status (WTISR) to determine which watchdog triggered the interrupt.
2. Read the AWORRx register(s) to determine which channel's data caused the interrupt (if present).
3. Clear the respective field of the WTISR[WDG*n*H/WDG*n*L] register, where *n* = watchdog number, by writing 1 to it.
4. Clear the respective field of the AWORR*n*[AWOR_CH*n*] register, where x = register, n = channel, by writing 1 to it.

The third type, Interrupt 3, relates to self-test errors. Perform the following actions for this type of interrupt:

1. Read Self-Test Status 1 (STSR1) to determine the type of error encountered in self-test (WDSERR, WDTERR, ERR_S0, ERR_S1, ERR_S2, ERR_C, and so on) if present.
2. Clear the respective field in Self-Test Status 1 (STSR1) by writing 1 to it.

The connectivity of interrupt lines at the chip level (external to ADC) determines whether software must read all the registers for all three interrupts or any one or combination of any two.

57.3.13 External decode signals delay

The ADC provides three external decode signals which it uses to select one channel out of eight in the external analog multiplexers. There can be a maximum of four such multiplexers used to connect the 32 external channels. The ADC automatically sets the decode signals to control these external analog multiplexers, based on the current channel selected for conversion. Delay Start Of Data Conversion (DSDR) is provided to take the switching time of the external analog multiplexer into account. It enables you to program the delay between the decoding signal selection and the actual start of conversion.

If presampling is enabled, the DSD delay starts after the presample phase (presampling time is the same duration as sample time).

57.3.14 Power Down state

The analog part, along with the ADC controller, can be put in Power Down state by writing 1 to MCR[PWDN]. This shuts down ADC and stops the clock to the ADC controller. After release of reset, MCR[PWDN] remains 1, so the ADC analog module is kept in Power Down state by default. You must exit this state before starting any operation, by writing 0 to MCR[PWDN]. In Power Down state, no conversion can be started. If a BCTU trigger pulse is received during this state, it is discarded. You must ensure that a BCTU trigger is not initiated to ADC before writing 0 to MCR[PWDN], as it may cause the BCTU module to be stuck in a wait state.

You can set MCR[PWDN] by writing 1 to it at any time. If a conversion is ongoing, ADC does not move into Power Down state immediately. ADC enters Power Down state only after completion of the ongoing conversion. During scan operation, the ongoing operation should be aborted manually by writing 0 to MCR[NSTART] before or after writing 1 to MCR[PWDN].

ADC Power Down state status is indicated by MSR[ADCSTATUS] when ADC enters into Power Down state.

If the BCTU is enabled and MSR[BCTUSTART] = 1, then you cannot write 1 to PWDN. When BCTU Trigger mode is enabled, the application must wait for the end of conversion (MSR[BCTUSTART] is automatically reset to 0). When BCTU Control mode is enabled, before entering Power Down state the application must write 0 to BCTUEN also.

If Power Down state is entered by writing 1 to MCR[PWDN], the process running before entry into Power Down state must be restarted manually (by writing 1 to the appropriate START field in Main Configuration (MCR)) after exiting Power Down state.

NOTE

Writing 0 to MCR[PWDN] and writing 1 to MCR[NSTART] or MCR[JSTART] during the same cycle is not supported.

57.3.15 Low Power mode support

For low-power operation, ADC must be in Idle state and then put into Power Down state to ensure proper signal condition at the analog boundary.

From any of the states listed below, follow the sequence of steps shown to put ADC into Power Down state.

1. Idle condition
    a. Verify that ADC is in Idle state (MSR[ADCSTATUS] = 000b).
    b. Write 1 to MCR[PWDN], to shut off the clock to the hard macro with the proper state of signals required for Low Power mode.
    c. Verify that ADC is in Power Down state (MSR[ADCSTATUS] = 001b).
2. During calibration

    NOTE

    Writing 1 to MCR[PWDN] during calibration is prohibited. After calibration is started it should be allowed to finish normally. Alternatively, it can be terminated by starting a normal conversion before writing 1 to MCR[PWDN].

    a. Check the current ADC state either via MSR[ADCSTATUS] (000b = Idle, 011b = Calibration), or via CALBISTREG[C_T_BUSY] (1 = calibration is in progress).
    b. When ADC is in Idle state, write 1 to MCR[PWDN] to shut off the clock to the hard macro with the proper state of signals required for Low Power mode.
    c. Verify that ADC is in Power Down state (MSR[ADCSTATUS] = 001b).
3. During conversion (normal [one-shot]/Injected/BCTU):
    a. Write 1 to MCR[PWDN].
    b. ADC enters Power Down mode after completing the current conversion chain (for normal and injected conversions) or the conversion for conversion triggered by BCTU.
    c. Check the ADC state via MSR[ADCSTATUS] (000b = Idle state, 001b = Power Down state).
4. During Scan mode operation of normal conversion

    NOTE

    Writing 1 to MCR[PWDN] during scan mode operation has no effect other than to prevent software from starting a new normal or injected conversion. It does not stop a conversion in progress and cannot put ADC into Power Down state.

    a. Software must write 0 to MCR[NSTART] to stop the ongoing scan conversion before (or after) writing 1 to MCR[PWDN]. This stops conversion at the current chain boundary.
    b. ADC enters Power Down mode after coming to an Idle state after MCR[PWDN] is written with 1. This shuts the clock off to the hard macro and puts analog inputs in the proper state required for Low Power mode.
    c. Verify that ADC is in Power Down state (MSR[ADCSTATUS] = 001b).

57.3.16 Auto Clock Off mode

To reduce power consumption during Idle state (without going into Power Down state), an auto-clock-off feature can be enabled by writing 1 to MCR[ACKO]. When enabled, the internal ADC operating clock (AD_Clk) is automatically switched off during an idle period (for example, no conversion is programmed).

57.3.17 Calibration and self-test

57.3.17.1 Calibration

ADC must be calibrated before it can do meaningful conversions. The application must prevent any start of conversion before the ongoing calibration has finished successfully. No conversion trigger may be received during calibration.

During calibration, a known reference voltage is sampled and converted under controlled conditions to determine the correction values (calibration values) for offset, gain, and capacitor mismatch.

These calibration values (except gain calibration) are used in a post-processing step after conversion, reducing or eliminating the various error contribution effects. The gain calibration is used during sample phase to define the additional charge to be loaded to compensate for gain failure.

You must run calibration after every power-up reset (check device-specific reset connectivity for appropriate reset applied). You must also run calibration if it is indicated by the self-test (see Self-test).

Configuration and start of calibration is done by programming the Control And Calibration Status (CALBISTREG). During calibration, internal hardware averaging function should be enabled. Maximum averaging is recommended, and 16 should be the minimum.

Calibration status is captured by a status flag (CALBISTREG[TEST_FAIL]) to indicate any fault detected during calibration execution or if calibration was prematurely aborted. Calibration is aborted if any normal conversion is initiated during the calibration execution, which is called premature termination. (Flag TEST_FAIL = 1 indicates a calibration fail, for example when a calibration value is out of internally defined limits.)

To execute the calibration algorithm, perform the following steps:

1. Select the conversion clock frequency to be within the allowed limits for the calibration.
2. Bring ADC from Power Down state to active conversion (program MCR[PWDN] = 0b).
3. Configure the Control And Calibration Status (CALBISTREG). The default values are set for maximum accuracy (recommended).
4. Disable the error correction for the smaller capacitances in the CDAC of the ADC (write 0h to CAL2[ENX]).
5. Start calibration (program CALBISTREG[TEST_EN] = 1b), and calibration starts immediately.
6. Poll the status of CALBISTREG[C_T_BUSY] for 0 (wait until it transitions to 0).
7. Check CALBISTREG[TEST_FAIL] to determine the final status. If 1, then calibration failed.
8. Check the status of MSR[CALIBRTD]. If calibration was successful this field is 1.

57.3.17.2 Self-test

For safety applications, it is important to verify correct operation at regular intervals. ADC has a self-test feature for this purpose. When self-test is enabled, ADC automatically checks its components and flags errors, if any are found.

Tests can be enabled to check the reference (VrefH) and calibrated values.

The following test algorithms have been implemented:

- Supply self-test (algorithm S): It includes the conversion of the band gap and VREF voltages. It includes a sequence of num_supply_steps test conversions (steps). The supply test conversions must be an atomic operation (that is, all supply algorithm conversions must be performed one after another with no functional conversions in between).

- Capacitive self-test (algorithm C): It includes a sequence of test steps per definition of algorithm C (see Table 278) which executes the capacitive matrix of the CDAC used for sampling and conversion.

Individual steps can take up to 1 µs at 80 MHz ADC clock frequency.

Table 278. Self-test steps

STCR3[ALG]	STCR3 [step](per algorithm definition)	Description	Outcome	Comment
00 (algorithm S)	0	Supply self-test (band gap voltage)	Measures the internal band gap voltage	
	1	Supply self-test (reference voltage high)	Measures ADC high reference voltage	
	2	Supply self-test (reference voltage high)	Measures ADC high reference voltage	
01 (Reserved)	Reserved			
10 (algorithm C)	0 – 11	Capacitive self-test. One of the calibration steps is being run.	The difference/error of the individual offset value from the previously calibrated value is being returned as an ADC result that is compared with the programmed value in the self-test analog watchdog register(s) to detect any fault.	The ideal result value is expected to be 0. If the returned value is higher, it indicates a runtime fault or accuracy shift. The error is indicated in the status register and can be used to generate an interrupt also. It that indicates ADC should be recalibrated to check whether the reported error can be managed by calibration or that permanent damage occurred to ADC.
11 (algorithm S + C)	0 – 2 (S), 0 – 11 (C)	Supply for One-Shot mode and (supply + capacitive) for Scan mode only.	Same as above.	

ADC:

- Schedules self-testing algorithms using configuration registers.
- Monitors the converted data using analog watchdog registers.
- Flags any errors to a fault control unit (FCCU), if one exists.

Self-test steps can be activated from software (CPU) or BCTU.

ADC mode	TEST algorithm (CPU)	TEST algorithm/step (BCTU)
CPU mode (MCR[BCTUEN] = 0)	Yes	No

Table continues on the next page...

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ADC mode	TEST algorithm (CPU)	TEST algorithm/step (BCTU)
	• One-Shot operation mode • Scan operation mode	
BCTU mode	No	Yes

57.3.17.2.1 CPU mode

In this mode, self-test conversion is similar to normal conversion. You enable self-test by writing 1 to STCR2[EN].

Self-test conversions execute along with the functional conversions. The sequencing of steps of the selected algorithm depends on the operating mode of normal conversions (selected by MCR[MODE]).

In One-Shot operation mode, if self-test is enabled, only one step of the selected self-testing algorithm is executed at the end of the chain. The step number and algorithm to be executed are programmed in Self-Test Status 3 (STSR3). In One-Shot operation mode the sequence is:

1. Program NCMR*n* to select channels to be converted for normal conversion.
2. Write 0 to MCR[MODE] to select one-shot operation.
3. Configure the self-test algorithm threshold values (see Table 279).
4. Program sampling duration values in STCR1[INPSAMP*m*] (*m* = S, C).
5. Select the self-testing algorithm (in STCR3[ALG]), and step (in STCR3[MSTEP]). The default is algorithm S, step 0.
6. Enable self-testing by writing 1 to STCR2[EN].
7. Start the normal conversion by writing 1 to MCR[NSTART].
8. All normal conversions are executed as usual.
9. At the end of all normal conversions in the chain, the step number (programmed in STCR3[MSTEP]) of the self-testing algorithm (selected by STCR3[ALG]), is executed similar to a normal functional channel.
10. At the end of the conversion for the self-test channel:
    - The result is written to STDR1[TCDATA].
    - STDR1[VALID] transitions to 1.
    - ISR[EOC], ISR[ECH], and STSR1[ST_EOC] transition to 1.
11. ADC returns to Idle state.

For example: Channels A→B→C→D→E→F→G→H are present in the device where channels B→D→E are to be converted in One-Shot operation mode. At the end of conversion for channels B→D→E, self-test conversion is performed and ISR[ECH] and ISR[EOC] transition to 1. The sequence is B→D→E→self-test step.

MSR[NSTART] transitions to 1 when the normal conversion starts and transitions to 0 at the end of conversion for the test channel.

In Scan operation mode, consecutive steps of the selected self-test algorithm are converted continuously at the end of each chain of normal conversions. The number of channels converted at the end of each chain is 1 (except for algorithm S, in which all the steps are performed sequentially without any functional conversion interleaved). So, in Scan operation mode the sequence is:

1. Program NCMR*n* to select the channels to be converted for normal conversion.
2. Write 1 to MCR[MODE] to select Scan operation mode.
3. Configure the self-test algorithm threshold values (see Table 279).
4. Program sampling duration values in STCR1[INPSAMP*m*] field (*m* = S, C).

5. Select the self-testing algorithm in STCR3[ALG]. By default, all algorithms (supply and capacitive) are selected, that is, all algorithms are executed step-by-step, one after the other.
6. Enable self-testing by writing 1 to STCR2[EN].
7. Start the normal conversion by writing 1 to MCR[NSTART].
8. All normal conversions are executed as usual.
9. At the end of the chain of normal conversions (assuming the default value of STCR3[ALG]), all steps of algorithm S are performed (as algorithm S is always atomic). MSR[SELF_TEST_S] transitions to 1.
10. At the end of the conversion of the self-test channel for the last step of algorithm S, the result is written to STDR1[TCDATA] and STDR1[VALID] transitions to 1. At the same time, MSR[SELF_TEST_S] transitions to 0. The following registers also transition to 1:
    - ISR[EOC]
    - ISR[ECH]
    - STSR1[ST_EOC]
11. The next chain of normal conversions then starts.
12. At end of the chain of normal conversions, ADC executes step 0 of algorithm C.
13. At the end of the conversion of the test channel for step 0 of algorithm C, the result is stored in STDR1[TCDATA] and STDR1[VALID] transitions to 1 (if STSR1[OVERWR] is 1). Also, ISR[EOC] and ISR[ECH] transition to 1. STSR1[ST_EOC] also transitions to 1.
14. The next chain of normal conversion then starts.
15. At the end of the normal conversion chain, ADC executes step1 of algorithm C.

This process continues for all steps of all three algorithms. The state machine returns to Idle state when MCR[NSTART] transitions to 0.

For example: channels A→B→C→D→E→F→G→H are present in the device where channels B→D→E are to be converted in Scan operation mode. At the end of every conversion chain for channels B→D→E, one step of the self-test conversion is performed and ISR[ECH] and ISR[EOC] transition to 1.

The sequence is:

B→D→E→ST-S0→ST-S1→ST-S2→B→D→E→ST-C0→B→D→E→ST-C1→B→D→E→ST-C2→ . . . B→D→E→ST-C11→B→D→E→ST-S0 . . .

ST-Sx - Self-test supply step x (x = 0, 1, 2)

ST-Cx - Self-test capacitive step x (x = 0 to 11)

MSR[NSTART] transitions to 1 when normal conversion starts.

NOTE

- If instead of starting normal conversion by software (by writing 1 to MCR[NSTART]), it is started by an external trigger, the self-test behavior remains the same.
- Self-test channel conversion is not performed for injected conversions. It is performed only during normal conversions.
- If, during a test channel conversion, an injected conversion arrives, the test conversion is aborted (just as a normal functional channel) and the injected conversion is performed. After the injected conversion is complete, the test conversion resumes from the step at which it was aborted. In this case, MSR[SELF_TEST_S] remains 1 during the injected conversion.
- For self-test, MCR[MODE] should be programmed (at least one cycle) before writing 1 MCR[NSTART] and should not be changed until the conversion is finished or terminated.

Table 279. Recommended self-test threshold values

Register field	Hex value	Decimal value	Comment
STAW0R[THRH]	3669h	13929	The threshold values depend on the stability of the supply and the reference voltage. When you see voltage variations, widen the limits.
STAW0R[THRL]	5 V reference: 1A7Fh 3 V reference: 2B27h	5 V reference: 6784 3 V reference: 11047	
STAW1R[THRL]	3FF9h	16377	
STAW2R[THRL]	3FF9h	16377	
STAW4R[THRH]	20h	32	
STAW4R[THRL]	7FE0h	–32	
STAW5R[THRH]	20h	32	
STAW5R[THRL]	7FE0h	–32	

57.3.17.2.2 BCTU mode

BCTU mode is enabled by writing 1 to MCR[BCTUEN].

Self-test conversion behaves in the same way for all BCTU operating modes (Trigger mode and Control mode). In both cases, if MCR[BCTUEN] = 1, the self-test conversion can be started only by BCTU—software cannot start it. MCR[BCTUEN] must not be changed during normal conversion. The interface between BCTU and ADC (for self-test) is shown in the following figure.

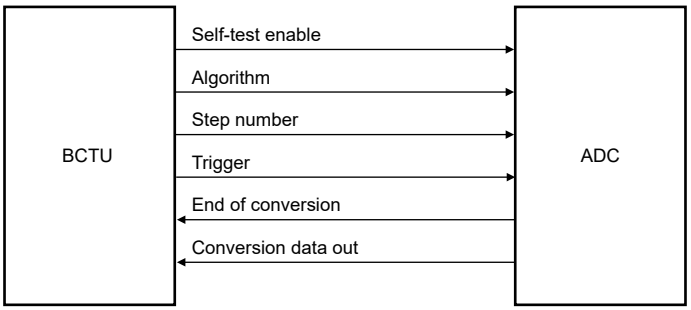

Figure 287. Self-test interface between ADC and BCTU

For self-test conversions in BCTU mode, BCTU asserts self-test enable along with the Trigger command. The algorithm and the step number to be executed is put on algorithm and step number, respectively. The other commands (Trigger, End Of Conversion, and Conversion Data Out) have the same meaning, like normal BCTU functional conversion.

As already mentioned for algorithm S, the three steps must be atomic. In BCTU mode, this is managed by BCTU, that is, BCTU sends three triggers (one for each step) asserting self-test enable and updating test_step for each step.

57.3.17.2.3 Abort and abort chain for self-testing channel

Writing 1 to MCR[ABORT] during self-test channel conversion has no effect.

In One-Shot operation mode, if you write 1 to MCR[ABORTCHAIN] during the self-test channel conversion, the self-test channel is aborted and ISR[ECH] transitions to 1. In this case, ISR[EOC] for the self-test channel is not generated.

In Scan operation mode, if MCR[ABORTCHAIN] = 1 when self-test channel step *n* is ongoing, self-test channel step *n* is aborted and the next chain conversion begins. At the end of the chain, the step *n* conversion is performed again. (For algorithm S, the full algorithm is executed again).

57.3.17.2.4 Self-test analog watchdog

ADC provides monitoring options for conversion data generated by self-test algorithms. Analog watchdogs determine whether the conversion results for self-test algorithms are in the range of a particular guard area. ADC provides separate self-test analog watchdog registers for each algorithm.

After the conversion of each step of a self-test algorithm, ADC compares the converted value and the threshold values if the analog watchdog feature has been enabled by writing 1 to STAW*n*R[AWDE] (for example, STAW0R[AWDE]). If the converted value is not between the upper and lower threshold values specified by the Self-Test Analog Watchdog Register for the particular algorithm, the corresponding error flag, STSR1[ERR_x], transitions to 1 and the step number in which error occurred is captured in STSR1[STEP_x] (for algorithm C). Erroneous data is written to STSR4[DATA*n*]. The STSR1[ERR_x] flags generate an interrupt if enabled by the corresponding mask bit in Self-Test Configuration 2 (STCR2). The fault indication is also forwarded to the fault control unit, if present, so that necessary action can be taken at the chip level. The fault type (critical or noncritical) is specified by the configuration in Self-Test Configuration 2 (STCR2).

The analog watchdog feature works differently for algorithm S. Algorithm S is always an atomic operation. Self-Test Status 1 (STSR1) has a separate error field for each step of algorithm S to avoid overwrite in case an error occurs in more than one step. Therefore, there are separate mask bits for each step in STCR1. For the same reason, the status registers (Self-Test Status 2 (STSR2) and Self-Test Status 3 (STSR3)) have separate fields for each step to store erroneous data.

In step 0 of the supply algorithm, ADC measures the band gap voltage (1.2 V), which is assumed to be stable. The conversion result of step 0 is compared against high (THRH) and low (THRL) thresholds as defined in Self-Test Analog Watchdog S0 (STAW0R), if enabled (STAW0R[AWDE] = 1). The STSR1[ERR_S0] flag transitions to 1 if any of the thresholds are violated. STSR1[ERR_S0] is cleared by writing 1 to it. The conversion result of ADC can be calculated with the following formula:

- ADC data (decimal) = (Vin × 2^{15} ÷ (Vrh - Vrl))

Where:

- Vin: input voltage (band gap voltage in this case)
- Vrh: ADC reference high voltage
- Vrl: ADC reference low voltage

The upper and lower threshold value can be calculated with the above formula using maximum and minimum values of Vin, Vrh, Vrl (Vin is the band gap supply voltage in this case):

- Upper threshold (THRH, decimal) = (Vin[max] × 2^{15}) ÷ (Vrh[min] - Vrl[max])
- Lower threshold (THRL, decimal) = (Vin[min] × 2^{15}) ÷ (Vrh[max] - Vrl[min])

The minimum and maximum voltages can be obtained from the chip data sheet. The band gap voltage tolerance, as well as the actual reference voltage used and its tolerances, must be considered when calculating high and low thresholds.

For algorithm S steps 1 and 2, (VREF/VREF) is measured in order to check the integrity of the sampling signal. For these particular conversions, no higher threshold value is required as the ideal value is FFFh. Only the lower threshold value is programmed in Self-Test Analog Watchdog S1 (STAW1R) and Self-Test Analog Watchdog S2 (STAW2R).

For algorithm C, a separate register is provided for step 0. In step 0 an offset for other steps is measured. The converted data is compared with the threshold values in Self-Test Analog Watchdog C (STAW5R) if STAW4R[AWDE] = 1. For other steps, this offset is subtracted from converted data before performing watchdog checks.

57.3.17.2.5 Watchdog timer

The watchdog timer is an additional check that monitors the sequence of the self-testing algorithm that has been implemented, and also checks whether the algorithm is completed within a safe time period. The watchdog timers are enabled for CPU as well as BCTU conversions. Each algorithm has an independent watchdog timer. The watchdog timer for a particular algorithm is enabled by writing 1 to STAWxR[WDTE]. The safe time value is programmed in STBRR[WDT] (the default value is 10 ms, assuming an 80 MHz clock).

The safe time is measured starting from step 0 of the algorithm (including all normal chain conversions in between) to the point where step 0 of the same algorithm starts again.

The programming sequence is:

1. Program NCMR*n* to select the channels for normal conversion in Scan operation mode (MCR[MODE] = 1).
2. Select the self-test algorithm in STCR3[ALG]. By default, all algorithms (supply and capacitive) are selected (all algorithms are executed step-by-step, one after the other).
3. Enable the self-test channel by writing 1 to STCR2[EN].
4. Program the safe period value in STBRR[WDT].
5. Enable the watchdog timer by writing 1 to STAWxR[WDTE]. Assume writing 1 to STAWxR[WDTE] occurs at time *t*0. It is important to do all configuration programming before writing 1 to STAWxR[WDTE], because the safe time check is also performed between writing 1 to STAWxR[WDTE] and the start of step 0. This is to verify that the algorithm has started within the safe time.
6. Start the normal conversion by writing 1 to MCR[NSTART].
7. At the end of the first conversion chain, three steps (steps 0, 1, and 2) of algorithm S are executed in sequence. Assume the start of Step 0 occurs at time *t*1.
8. After completion of algorithm S, ADC performs conversion of the next chain.
9. At the end of the conversion chain, the first step (step 0) of algorithm C is performed.
10. In this way, one step of algorithm C is performed after completion of one conversion chain until all steps are finished. Steps are executed in sequence (steps 0–11)
11. After the last step of algorithm C, another chain conversion is executed. At the end of this chain conversion, step 0 of algorithm S is started again, repeating the whole sequence. Assume this time (starting of step 0 of the supply algorithm) to be at time *t*2.
12. For algorithm S, if (*t*1 - *t*0) > safe period or (*t*2 - *t*1) > safe period, the watchdog timer flags an error and STSR1[WDTERR] transitions to 1. ADC asserts a fault signal per the criticality configuration (critical or noncritical) and an interrupt is generated, if enabled (STCR2[MSKWDTERR] = 1). Otherwise, the watchdog timer counter is reset and starts again to monitor the next sequence.
13. A similar sequence is followed for watchdog timers for algorithm C.

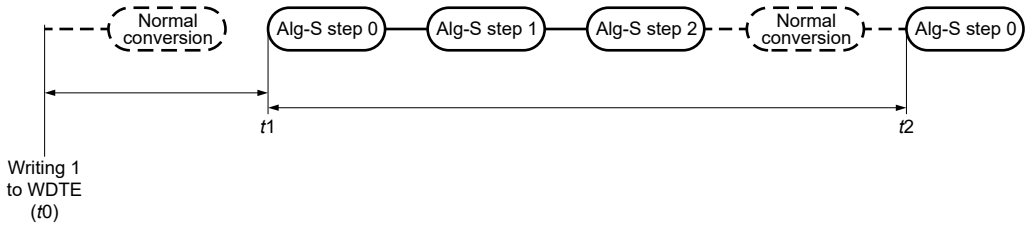

Figure 288. Watchdog timer monitor for algorithm S

NOTE

1. Because BCTU may not incorporate any safe period checking mechanism, the watchdog timers can also be enabled for BCTU conversions.
2. You must disable watchdog timers for self-test algorithms that are not executed.

57.3.17.2.5.1 Watchdog sequence checking

The self-test watchdog timer incorporates sequence checking features to verify that the steps of each algorithm are executed in the correct order. If the steps are not in the correct order, STSR1[WDSERR] transitions to 1 to indicate the error. A fault is indicated by an interrupt flag if STCR2[MSKWDSERR] = 1. A fault is also asserted as per criticality configuration (critical or noncritical) and an interrupt generated if STCR2[MSKWDSERR] = 1.

A watchdog sequence error is flagged in the following cases:

- The steps of any algorithm are not executed in proper order.
- The step numbers provided by BCTU for a BCTU conversion are not in order. Watchdog sequence checking is significant only for BCTU burst mode.
- When an abort chain occurs during a self-test channel conversion, that step must be repeated at the end of the next chain. This generates a sequence error as soon as the self-test channel conversion resumes. There is an exception, however. If an abort chain occurs during the last step of algorithm S, the sequence error is not flagged because the whole algorithm must be repeated.

If an injected conversion occurs during self-test channel conversion, a watchdog sequence error is not flagged, although the ongoing step number is aborted and is repeated.

NOTE

The watchdog timer feature is applicable for Scan operation mode but not for One-Shot operation mode.

57.3.17.2.6 Baud rate control for test channel

The baud rate control feature controls the scheduling of self-test channel conversions between normal conversion chains. The scheduling rate is specified by STBRR[BR].

By default, if the self-test channel is enabled, one step of the selected algorithm is executed after each normal conversion chain. The bandwidth consumed by the self-test channel depends on the number of channels in the normal chain. For example, if you have 50 normal conversions in a chain, then the self-test channel consumes only 2% of the total bandwidth, which is very small. If the number decreases to just 3 channels, the bandwidth consumed by the self-test channel is 25%, which is significant (and may not be desirable because it slows down the normal conversion rate).

STBRR[BR] provides flexibility by scheduling the self-test channel conversion to be performed not at the end of every chain, but at the end of BR + 1 chains. For example, if STBRR[BR] = 5, a single step of the selected algorithm for the test channel is performed after 6 chain conversions. The next step is performed at the end of the next six chain conversions, and so on. By default, STBRR[BR] = 0.

NOTE

This feature is applicable only for Scan operation mode and not for One-Shot operation mode. STBRR[BR] should be written with 0 for One-Shot operation mode.

To use the baud rate control feature in Scan operation mode, NCMR*n* should have a nonzero value.

57.3.17.2.6.1 Abort chain when baud rate is nonzero

As already described, for a nonzero value of STBRR[BR], the self-test channel conversion is performed at the end of BR + 1 chains. If an abort chain occurs during the chain in which a self-test channel conversion is scheduled to be performed, the self-test channel conversion is performed after the next BR + 1 chains.

For example, if STBRR[BR] = 2, the sequence is two normal chains (without any self-test channel conversion), followed by a chain with the self-test channel converted at the end. If an abort chain occurs during the first two chains, it is treated as a normal chain abort and the self-test channel is converted at the end of the third chain only (as in the case without any abort chain). However, if an abort chain occurs during the third chain in which the self-test channel is scheduled to be converted, the self-test channel is converted after the next three chains (for example, at the end of the sixth chain, counting from the beginning).

57.3.18 Conversion time

Total conversion time depends on the conversion clock frequency, which is configured by programming MCR[ADCLKSEL].

The components of conversion time and affecting configurations are:

- PST
- ST
- CT

- DP
- TPT

Presample phase time is equal to the sample time with a one AD_clk cycle delay for phase transition from presample phase to sample phase. CTR*n*[INPSAMP] controls sample time for different types of channels and is specified in terms of AD_clk cycles, so the presampling time is sample time plus one cycle of AD_clk. The minimum value of sample time is 8. If the value programmed is less than 8, it has no effect on sample time and the sample time is 8 AD_clk cycles.

Compare phase time is controlled by:

- The evaluation time of a single bit
- The number of bits converted

For *n*-bit conversions, the value of CT is *n* multiplied by the evaluation time of a single bit in terms of AD_clk cycles.

The evaluation time of a single bit is 4 AD_clk cycles if AMSIO[HSEN] = 0h and AMSIO[CMPCTRL0] = 0b. The evaluation time of a single bit is 6 AD_clk cycles if AMSIO[HSEN] = 1h and AMSIO[CMPCTRL0] = 1b.

The data processing time is 2 cycles of AD_clk. During these cycles raw converted data is corrected for offset, gain, capacitor mismatch, and so on.

Trigger processing time consists of:

- One module_clock cycle, which is required to prepare the channel and calculate the initial gain value used by ADC for the first conversion.
- BCTU triggering time:
  - Triggers from the synchronous BCTU interface require 1 cycle of the module clock for processing. One more cycle is required to register the BCTU trigger in synchronous mode.

The total conversion time, in terms of the module clock cycles, is calculated using the following equation for normal and injected conversions:

Total_conversion_time = ([(PST + ST + CT + DP) × chain_length] + TPT) × TAD_clk

Example:

The ADC controller clock is equal to the module clock (80 MHz, clock cycle = 12.5 ns)

- ADC resolution 12 bit + 1 bit for a special capacitor (CS)
- Three channels are programmed in NCMR*n*, so a chain of three is to be converted
- Default sample time (22 cycles) is specified
- No presampling
- Conversion time (4 cycles per bit)

The total time for the three conversions = [(0 + 22 + (4×13) + 2) × 3] + 1 = 229 cycles ~= 2.862 µs

Conversion timing in Calibration for full test:

- Single conversion time = [sample time (CALBISTREG[TSAMP]) + compare time (11 × 4) + data proc(2)]
- Inter-conversion gap = 1 cycle
- Total number of tests = 12
- Averaging = 32

One test duration = (single conversion time + inter-conversion gap) × averaging samples

Total test duration = ((one test duration) × total number of tests).

Example: sample time = 22

Total test time = ((((22 + (11×4) +2)+1) × 32) × 12) = 26496 cycles × 12.5 ns (80 MHz) = 331200 ns

Conversion time in self-test:

Self-test conversion time equals one test period multiplied by the number of consecutive (atomic) steps. For supply self-test, the atomic step is 3 and for other tests it is 1.

One test period for self-test is as below.

- For supply tests: ([sample_time + (13 × 4) + 2])
- For other algorithms: ([sample_time + (11 × 4) + 2])

NOTE

Algorithm S steps (conversions) always run in atomic operation, required for an algorithmic procedure. In Scan operation mode, when all algorithms are selected, three steps of algorithm S run together after the end of the conversion chain. algorithm C steps are not required to be run together, so after each conversion chain one step is executed serially. Conversion time with self-test must also be calculated accordingly.

Example.

- Channels in chain A→B→C.
- Scan operation mode.
- All self-test algorithms are selected.

So, the resulting conversion order is:

[A→B→C→AS_step0→AS_step1→AS_step2→A→B→C→AC_step0→A→B→C→AC_step1→A→B→C→AC_step2→.....→A→B→C→AC_step11]→[same sequence repeats]

NOTE

- AS = Algorithm S (supply self-test)
- AC = Algorithm C (capacitive self-test)

57.3.19 Conversion data processing

Raw converted data contains many types of errors, such as offset, gain, and so on. ADC processes raw conversion data before writing the result to a data register, to reduce or eliminate error contributions. The process of error correction happens in parallel with bit-by-bit evaluation, using the correction values generated during the offset determination and calibration process.

The error correction value is subtracted from the raw conversion result whenever the comparator output for one of the calibrated capacitors evaluates high during the conversion period.

To reduce data processing time, error correction is done in parallel during each bit evaluation of a conversion. Lower-weighted capacitors (smaller than C9) are not calibrated, so no error correction is performed for these capacitors. However, they are self-tested to guarantee that the error contribution is below specified accuracy limits.

The final result is checked for any overflow or underflow. When the processed data is above the maximum value that can be represented by ADC resolution, the output data is forced to all 1s (FFFh for 12-bit resolution). Similarly, if the processed data is negative then output data is forced to all 0s (000h for 12-bit resolution).

57.3.20 User-defined offset and gain values

In addition to the ADC-calculated offset value and gain value, ADC enables you to specify another set of offset and gain values in Offset And Gain User (OFSGNUSR). These values must be stored in two's complement format, where the leftmost bit (the most significant bit) is the sign bit.

ADC subtracts these values from the final processed conversion result. The values are used to removed fixed DC bias or any other known errors—for instance those caused by board design, sensors, and so on.

57.4 External signals

This module has no external signals.

57.5 Clock frequency

ADC's internal blocks are designed for an input clock frequency up to the Fin (Input Signal Bandwidth) maximum (see the ADC electrical specification section in the chip data sheet). The specified speed can be achieved with this clock frequency. If the input clock frequency exceeds the specified maximum frequency, ADC accuracy degrades and, in the worst case scenario, ADC malfunctions. ADC accuracy also degrades if the input clock frequency is below the specified minimum frequency. Sampling time has an absolute maximum value to guarantee the specified parameters and accuracy. For slower clocks, the sampling clock count must be programmed accordingly.

57.6 Memory map and register definition

ADC has a wide range of configurations to tailor its operation to application requirements. This comes with the drawback of possible corner cases. To avoid unintended behavior, configure ADC before starting a conversion and change any configuration only when ADC is idle, in other words when MSR[ADCSTATUS] = 0.

57.6.1 Transfer error description

The following register accesses cause a transfer error and do not change register content:

- Any access to an unused address.
- Any write access to a read-only register.

57.6.2 ADC register descriptions

57.6.2.1 ADC memory map

ADC_0 base address: 400A_0000h

ADC_1 base address: 400A_4000h

ADC_2 base address: 400A_8000h

ADC_3 base address: 400A_C000h

ADC_4 base address: 406D_0000h

ADC_5 base address: 406D_4000h

ADC_6 base address: 406D_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Main Configuration (MCR)	32	RW	0000_0001h
4h	Main Status (MSR)	32	R	0000_0001h
10h	Interrupt Status (ISR)	32	RW	0000_0000h
14h	Channel End Of Conversion Flag For Precision Inputs (CEOCFR0)	32	RW	0000_0000h
18h	Channel End Of Conversion Flag For Standard Inputs (CEOCFR1)	32	RW	0000_0000h
1Ch	Channel End Of Conversion Flag For External Inputs (CEOCFR2)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
20h	Interrupt Mask (IMR)	32	RW	0000_0000h
24h	EOC Interrupt Enable For Precision Inputs (CIMR0)	32	RW	0000_0000h
28h	EOC Interrupt Enable For Standard Inputs (CIMR1)	32	RW	0000_0000h
2Ch	EOC Interrupt Enable For External Inputs (CIMR2)	32	RW	0000_0000h
30h	Analog Watchdog Threshold Interrupt Status (WTISR)	32	RW	0000_0000h
34h	Analog Watchdog Threshold Interrupt Enable (WTIMR)	32	RW	0000_0000h
40h	Direct Memory Access Configuration (DMAE)	32	RW	0000_0000h
44h	DMA Request Enable For Precision Inputs (DMAR0)	32	RW	0000_0000h
48h	DMA Request Enable For Standard Inputs (DMAR1)	32	RW	0000_0000h
4Ch	DMA Request Enable For External Inputs (DMAR2)	32	RW	0000_0000h
60h - 6Ch	Analog Watchdog Threshold Values (THRHLR0 - THRHLR3)	32	RW	7FFF_0000h
80h	Presampling Control (PSCR)	32	RW	0000_0000h
84h	Presampling Enable For Precision Inputs (PSR0)	32	RW	0000_0000h
88h	Presampling Enable For Standard Inputs (PSR1)	32	RW	0000_0000h
8Ch	Presampling Enable For External Inputs (PSR2)	32	RW	0000_0000h
94h	Conversion Timing For Precision Inputs (CTR0)	32	RW	0000_0016h
98h	Conversion Timing For Standard Inputs (CTR1)	32	RW	0000_0016h
9Ch	Conversion Timing For External Inputs (CTR2)	32	RW	0000_0016h
A4h	Normal Conversion Enable For Precision Inputs (NCMR0)	32	RW	0000_0000h
A8h	Normal Conversion Enable For Standard Inputs (NCMR1)	32	RW	0000_0000h
ACh	Normal Conversion Enable For External Inputs (NCMR2)	32	RW	0000_0000h
B4h	Injected Conversion Enable For Precision Inputs (JCMR0)	32	RW	0000_0000h
B8h	Injected Conversion Enable For Standard Inputs (JCMR1)	32	RW	0000_0000h
BCh	Injected Conversion Enable For External Inputs (JCMR2)	32	RW	0000_0000h
C4h	Delay Start Of Data Conversion (DSDR)	32	RW	0000_0000h
C8h	Power Down Exit Delay (PDEDR)	32	RW	0000_0000h
100h - 11Ch	Precision Input n Conversion Data (PCDR0 - PCDR7)	32	R	0000_0000h
180h - 1E4h	Standard Input n Conversion Data (ICDR0 - ICDR25)	32	R	0000_0000h
200h - 27Ch	External Input n Conversion Data (ECDR0 - ECDR31)	32	R	0000_0000h
2B0h	Channel Analog Watchdog Select For Precision Inputs (CWSELRPI0)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
2C0h	Channel Analog Watchdog Select For Standard Inputs (CWSELRSI0)	32	RW	0000_0000h
2C4h	Channel Analog Watchdog Select For Standard Inputs (CWSELRSI1)	32	RW	0000_0000h
2C8h	Channel Analog Watchdog Select For Standard Inputs (CWSELRSI2)	32	RW	0000_0000h
2CCh	Channel Analog Watchdog Select For Standard Inputs (CWSELRSI3)	32	RW	0000_0000h
2D0h	Channel Analog Watchdog Select For External inputs (CWSELREI0)	32	RW	0000_0000h
2D4h	Channel Analog Watchdog Select For External inputs (CWSELREI1)	32	RW	0000_0000h
2D8h	Channel Analog Watchdog Select For External inputs (CWSELREI2)	32	RW	0000_0000h
2DCh	Channel Analog Watchdog Select For External inputs (CWSELREI3)	32	RW	0000_0000h
2E0h	Channel Watchdog Enable For Precision Inputs (CWENR0)	32	RW	0000_0000h
2E4h	Channel Watchdog Enable For Standard Inputs (CWENR1)	32	RW	0000_0000h
2E8h	Channel Watchdog Enable For External Inputs (CWENR2)	32	RW	0000_0000h
2F0h	Analog Watchdog Out Of Range For Precision Inputs (AWORR0)	32	RW	0000_0000h
2F4h	Analog Watchdog Out Of Range For Standard Inputs (AWORR1)	32	RW	0000_0000h
2F8h	Analog Watchdog Out Of Range For External Inputs (AWORR2)	32	RW	0000_0000h
340h	Self-Test Configuration 1 (STCR1)	32	RW	1818_2507h
344h	Self-Test Configuration 2 (STCR2)	32	RW	0000_0005h
348h	Self-Test Configuration 3 (STCR3)	32	RW	0000_0300h
34Ch	Self-Test Baud Rate (STBRR)	32	RW	0005_0000h
350h	Self-Test Status 1 (STSR1)	32	RW	0000_0000h
354h	Self-Test Status 2 (STSR2)	32	R	0000_0000h
358h	Self-Test Status 3 (STSR3)	32	R	0000_0000h
35Ch	Self-Test Status 4 (STSR4)	32	R	0000_0000h
370h	Self-Test Conversion Data 1 (STDR1)	32	R	0000_0000h
380h	Self-Test Analog Watchdog S0 (STAW0R)	32	RW	0727_04C5h
388h	Self-Test Analog Watchdog S1 (STAW1R)	32	RW	0000_3FF9h
38Ch	Self-Test Analog Watchdog S2 (STAW2R)	32	RW	0000_3FF9h
394h	Self-Test Analog Watchdog C0 (STAW4R)	32	RW	0010_3FF0h
398h	Self-Test Analog Watchdog C (STAW5R)	32	RW	0010_3FF0h

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Offset	Register	Width (In bits)	Access	Reset value
39Ch	Analog Miscellaneous In/Out register (AMSIO)	32	RW	0000_0811h
3A0h	Control And Calibration Status (CALBISTREG)	32	RW	See section
3A8h	Offset And Gain User (OFSGNUSR)	32	RW	0004_0000h
3B4h	Calibration Value 2 (CAL2)	32	RW	4300_8243h

57.6.2.2 Main Configuration (MCR)

Offset

Register	Offset
MCR	0h

Function

Configures most ADC features. You must change field values only when ADC is in Idle state, except for the ABORTCHAIN and ABORT fields.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	OWREN	WLSIDE	MODE	0	TRGEN	EDGE	XSTRTEN	NSTART	0	JTRGEN	JEDGE	JSTART	0		BCTUEN	BCTU_MO...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R		0			AVGEN	AVGS		Reserved	ABORTCH...	ABORT	ACKO	0	ADCLKSEL			PWDN
W	STCL								W1C	W1C						
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31 OWREN	Overwrite Enable Specifies whether a conversion data register accepts new data before the current conversion data has been read. When enabled, the new conversion result overwrites the older data, regardless of the validity of the older conversion data. When PCDR*n*[VALID] = 1, the conversion data has not been read. 0b - Disable

Table continues on the next page...

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Field	Function
	1b - Enable
30 WLSIDE	Write Left-Aligned Specifies whether conversion data is right-aligned or left-aligned when written to one of the conversion data registers: • PCDR*n* • ICDR0*n* • ECDR*n* Right-aligned data occupies *CDR[14:0]. Left-aligned data occupies *CDR[15:1], 0b - Right aligned 1b - Left-aligned
29 MODE	Normal Conversion Mode Specifies whether the set of input channels selected for a normal conversion are converted only once per start event or continuously after a start event. If a conversion is done only once, ADC enters an idle state after conversion is complete. For continuous conversion, all input channels selected for the normal conversion are converted continuously in a loop. Stop the loop by writing 0 to NSTART. 0b - Single conversion 1b - Continuous conversion
28 —	Reserved
27 TRGEN	External Trigger Enable Specifies whether the normal trigger input starts a conversion. 0b - Normal trigger input does not start a conversion 1b - Normal trigger input starts a conversion
26 EDGE	External Trigger Edge Selection Selects which edge of the normal trigger input starts a conversion. 0b - Falling edge 1b - Rising edge
25 XSTRTEN	Auxiliary External Start Enable Enables the auxiliary normal trigger source to start a conversion. You can use this field to synchronize the start of a conversion of two ADC instances. 0b - Disable 1b - Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
24 NSTART	Start Normal Conversion Starts a normal conversion. If the continuous mode is selected (MODE = 1), the value of this field remains 1. Write 0 to this field to stop the in-progress conversion loop after conversion of the last input channel of the selected set of input channels is complete. If continuous mode is not selected (MODE = 0), this field automatically resets to 0 after writing 1. 0b - No effect 1b - Starts conversion
23 —	Reserved
22 JTRGEN	Injection Trigger Enable Enables the injected trigger input as a source to start a conversion. 0b - Disable 1b - Enable
21 JEDGE	Injected Trigger Edge Selection Selects which edge of the injected trigger input starts an injected conversion. 0b - Falling edge 1b - Rising edge
20 JSTART	Injected Start Interrupts any ongoing normal conversion and starts an injected conversion. This field automatically resets to 0. If an injected conversion is already ongoing, the field value remains 1 until the next injected conversion starts. This field can only be written with 1. 0b - Injected conversion can be started 1b - Starts an injected conversion
19-18 —	Reserved
17 BCTUEN	Body Cross Trigger Unit Enable Enables BCTU as a trigger source. 0b - Disable 1b - Enable
16 BCTU_MODE	Body Cross Trigger Unit Mode Select Specifies whether sources other than BCTU can start a conversion when the BCTU is enabled as a trigger source (BCTUEN = 1). This field is writeable only when ADC is in Power Down state (PWDN = 1).

Table continues on the next page...

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Field	Function
	0b - Only BCTU can trigger conversion 1b - All trigger sources can trigger conversion
15 STCL	Self-Test Configuration Lock Protects the following registers from writing: • STCR1 • STCR2 • STCR3 • STBRR • STAW0R • STAW1R • STAW2R • STAW4R • STAW5R 0b - Registers are writeable 1b - Registers are read-only
14-12 —	Reserved
11 AVGEN	Averaging Enable Enables conversion averaging. 0b - Disable 1b - Enable
10-9 AVGS	Averaging Select Specifies the number of conversions ADC uses to calculate the conversion result. 00b - 4 conversions 01b - 8 conversions 10b - 16 conversions 11b - 32 conversions
8 —	Reserved
7 ABORTCHAIN	Abort Chain Aborts the conversion of the selected set of input channels (chain of input channels). The currently ongoing conversion completes.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field always reads 0. This field cannot be programmed during BCTU conversion. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Undefined When writing 0b - Conversion continues 1b - Conversion aborted
6 ABORT	Abort Conversion Aborts an ongoing conversion. This field always reads 0 and cannot be written during BCTU conversion. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Undefined When writing 0b - Conversion continues 1b - Conversion aborted
5 ACKO	Auto Clock Off Reduces power consumption by turning off the clock of the analog part of ADC when it is in Idle state. 0b - Clock always active 1b - Clock gated
4-3 —	Reserved
2-1 ADCLKSEL	Conversion Clock (AD_clk) Frequency Selection Selects the frequency for the clock signal of the conversion circuit (AD_clk = module clock ÷ ($2^{ADCLKSEL}$)). This field can be written only when ADC is in Power Down state (PWDN = 1). 00b - Module clock frequency 01b - Module clock frequency ÷ 2 10b - Module clock frequency ÷ 4 11b - Module clock frequency ÷ 8
0	Power Down

Table continues on the next page...

Table continued from the previous page...

Field	Function
PWDN	Reduces power consumption by turning off power to the analog portion of ADC. 0b - ADC enters a functional state 1b - ADC enters Power Down state

57.6.2.3 Main Status (MSR)

Offset

Register	Offset
MSR	4h

Function

Contains flags that indicate the current ADC state.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CALIBRTD	0						NSTART	JABORT	0		JSTART	0	SELF_TE...	Reserved	BCTUSTA...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CHADDR							0			ACKO	0		ADCSTATUS		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31 CALIBRTD	Calibration Status Indicates ADC calibration status. 0b - Uncalibrated or calibration unsuccessful 1b - Calibrated
30-25 —	Reserved
24	Normal Conversion Started

Table continues on the next page...

Table continued from the previous page...

Field	Function
NSTART	Shows whether a normal conversion is in progress. 0b - Not in progress 1b - In progress
23 JABORT	Injected Conversion Aborted Indicates whether the conversion of a set of inputs selected for injected conversion has been aborted. This field resets to 0 when a new injected conversion is started. 0b - Not aborted 1b - Aborted
22-21 —	Reserved
20 JSTART	Injected Conversion Started Indicates whether an ongoing conversion was started by the injection trigger. 0b - Not an injected conversion 1b - Injected conversion
19 —	Reserved
18 SELF_TEST_S	Indicates whether an ongoing conversion is for self-test. 0b - Not self-test 1b - Self-test
17 —	Reserved
16 BCTUSTART	BCTU Conversion Started Indicates whether a BCTU conversion is ongoing. This field is 1 when a BCTU trigger event is received and the BCTU conversion starts. When the BCTU trigger mode is selected, this field is automatically reset to 0 when conversion is completed. Otherwise, if BCTU control mode is selected, this field resets to 0 when the BCTU is disabled (BCTUEN = 0). 0b - Conversion was not triggered by BCTU 1b - Ongoing conversion was triggered by BCTU
15-9 CHADDR	Input Under Measure Contains the number of the input that is currently converted. 000_0000b-011_1111b - Input number
8-6	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
5 ACKO	Auto Clock-Off On Indicates whether the auto clock-off feature is active, and the conversion circuit is not receiving a clock signal. When auto clock-off is inactive, the conversion circuit is clocked. 0b - Inactive 1b - Active
4-3 —	Reserved
2-0 ADCSTATUS	ADC State Indicates the current state of the ADC Finite State Machine (FSM). 000b - Idle 001b - Power Down 010b - Wait 011b - Calibrate 100b - Convert 110b - Done

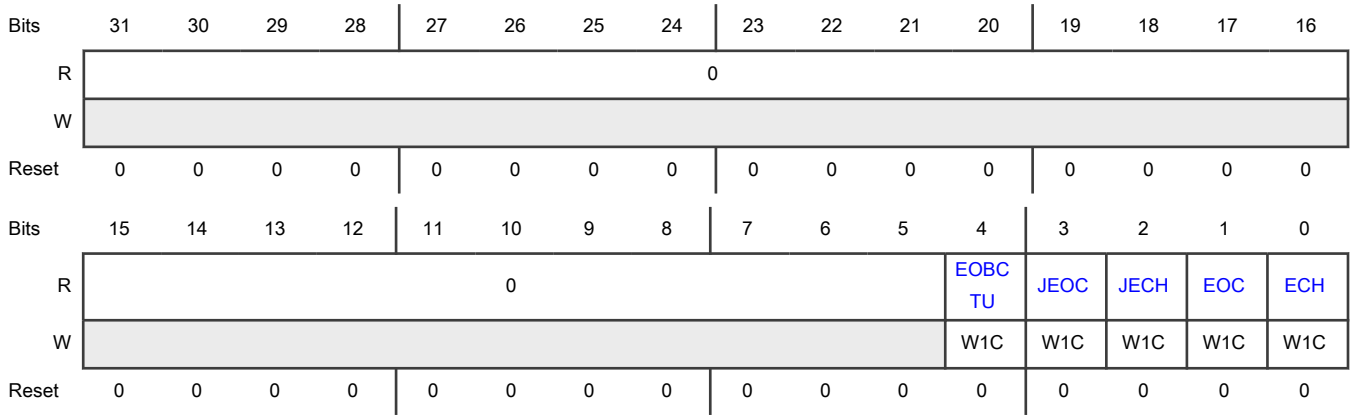
57.6.2.4 Interrupt Status (ISR)

Offset

Register	Offset
ISR	10h

Function
Contains flags that indicate whether an interrupt has been generated.

Diagram



Fields

Field	Function
31-5 —	Reserved
4 EOBCTU	End Of BCTU Conversion Indicates the status of the End of BCTU Conversion (EOBCTU) interrupt, which is generated after a BCTU conversion completes. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No EOBCTU interrupt generated 1b - EOBCTU interrupt generated When writing 0b - No effect 1b - Clears flag
3 JEOC	End Of Injected Conversion Indicates the status of the End of Injected Conversion (JEOC) interrupt, which is generated after an injected conversion completes. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No JEOC interrupt generated 1b - JEOC interrupt generated When writing

Table continues on the next page...

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Field	Function
	0b - No effect 1b - Clears flag
2 JECH	End Of Injected Chain Conversion Indicates the status of the End of Injected Chain (JECH) interrupt, which is generated after injected conversion of a set of inputs completes. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No JECH interrupt generated 1b - JECH interrupt generated When writing 0b - No effect 1b - Clears flag
1 EOC	End Of Conversion Indicates the status of the End of Conversion (EOC) interrupt, which is generated after a normal conversion completes. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No EOC interrupt generated 1b - Interrupt generated When writing 0b - No effect 1b - Clears flag
0 ECH	End Of Chain Conversion Indicates the status of the End of Chain (ECH) conversion interrupt, which is generated after a set of inputs has been converted normally. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Indicates no ECH interrupt generated 1b - Indicates an ECH interrupt has been generated When writing

Table continues on the next page...

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Field	Function
	0b - No effect 1b - Clears flag

57.6.2.5 Channel End Of Conversion Flag For Precision Inputs (CEOCFR0)

Offset

Register	Offset
CEOCFR0	14h

Function

Contains flags that indicate whether conversion is complete for a precision input.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved								PIEOCF7	PIEOCF6	PIEOCF5	PIEOCF4	PIEOCF3	PIEOCF2	PIEOCF1	PIEOCF0
W									W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7 PIEOCF7	Precision Input End Of Conversion Flag 7 Indicates whether conversion of a precision input 7 has completed. **NOTE** This field behaves differently for register reads and writes. When reading

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag
6 PIEOCF6	Precision Input End Of Conversion Flag 6 Indicates whether conversion of a precision input 6 has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag
5 PIEOCF5	Precision Input End Of Conversion Flag 5 Indicates whether conversion of a precision input 5 has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag
4 PIEOCF4	Precision Input End Of Conversion Flag 4 Indicates whether conversion of a precision input 4 has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Conversion complete When writing 0b - No effect 1b - Clears flag
3 PIEOCF3	Precision Input End Of Conversion Flag 3 Indicates whether conversion of a precision input 3 has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag
2 PIEOCF2	Precision Input End Of Conversion Flag 2 Indicates whether conversion of a precision input 2 has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag
1 PIEOCF1	Precision Input End Of Conversion Flag 1 Indicates whether conversion of a precision input 1 has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing

Table continues on the next page...

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Field	Function
	0b - No effect 1b - Clears flag
0 PIEOCF0	Precision Input End Of Conversion Flag 0 Indicates whether conversion of a precision input 0 has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag

57.6.2.6 Channel End Of Conversion Flag For Standard Inputs (CEOCFR1)

Offset

Register	Offset
CEOCFR1	18h

Function

Contains flags that indicate whether conversion is complete for a standard input.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved						SIEOCF25	SIEOCF24	SIEOCF23	SIEOCF22	SIEOCF21	SIEOCF20	SIEOCF19	SIEOCF18	SIEOCF17	SIEOCF16
W							W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SIEOCF15	SIEOCF14	SIEOCF13	SIEOCF12	SIEOCF11	SIEOCF10	SIEOCF9	SIEOCF8	SIEOCF7	SIEOCF6	SIEOCF5	SIEOCF4	SIEOCF3	SIEOCF2	SIEOCF1	SIEOCF0
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25-0 SIEOCFn	Standard Input End Of Conversion Flag Indicates whether conversion on standard input *n* is complete. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag

57.6.2.7 Channel End Of Conversion Flag For External Inputs (CEOCFR2)

Offset

Register	Offset
CEOCFR2	1Ch

Function
Contains flags that indicate whether conversion is complete for an external input.

NOTE
Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CEOCFR2	—
ADC_1	CEOCFR2	—
ADC_2	—	CEOCFR2
ADC_3	—	CEOCFR2
ADC_4	—	CEOCFR2
ADC_5	—	CEOCFR2

Table continues on the next page...

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Instance	Register supported	Register not supported
ADC_6	—	CEOCFR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EIEOCF31	EIEOCF30	EIEOCF29	EIEOCF28	EIEOCF27	EIEOCF26	EIEOCF25	EIEOCF24	EIEOCF23	EIEOCF22	EIEOCF21	EIEOCF20	EIEOCF19	EIEOCF18	EIEOCF17	EIEOCF16
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	EIEOCF15	EIEOCF14	EIEOCF13	EIEOCF12	EIEOCF11	EIEOCF10	EIEOCF9	EIEOCF8	EIEOCF7	EIEOCF6	EIEOCF5	EIEOCF4	EIEOCF3	EIEOCF2	EIEOCF1	EIEOCF0
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 EIEOCFn	External Input End Of Conversion Flag Indicates whether conversion on external input *n* is complete. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion not complete 1b - Conversion complete When writing 0b - No effect 1b - Clears flag

57.6.2.8 Interrupt Mask (IMR)

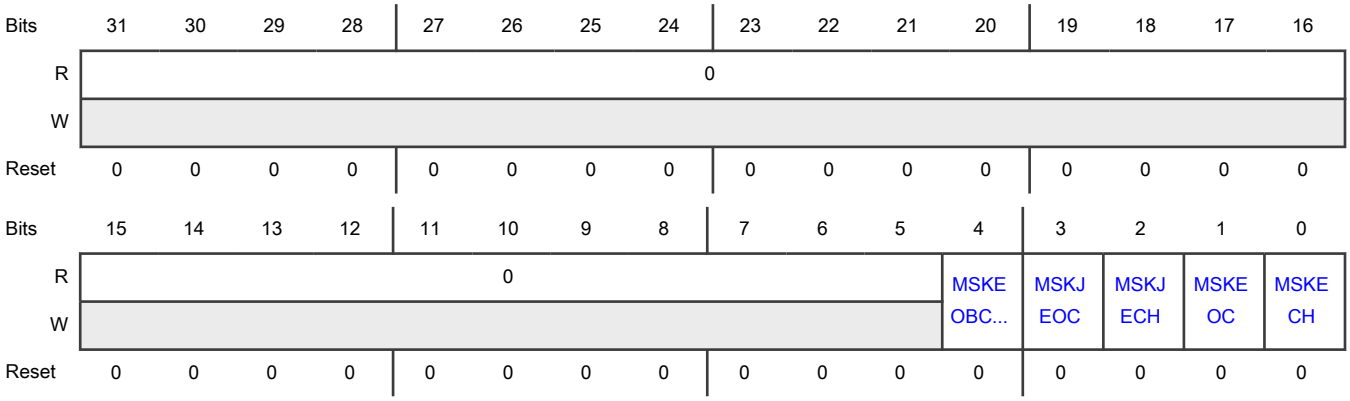
Offset

Register	Offset
IMR	20h

Function

Enables flagging of interrupts.

Diagram



Fields

Field	Function
31-5 —	Reserved
4 MSKEOBCTU	EOBCTU Interrupt Flag Enable Specifies whether a completed BCTU conversion flags the EOBCTU interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
3 MSKJEOC	JEOC Interrupt Flag Enable Specifies whether completion of an injected conversion flags the JEOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
2 MSKJECH	JECH Interrupt Flag Enable Specifies whether completion of an injected conversion of a set of inputs flags the JECH interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
1 MSKEOC	EOC Interrupt Flag Enable Specifies whether completion of a normal conversion flags the EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
0 MSKECH	ECH Interrupt Flag Enable Specifies whether completion of a normal conversion of a set of inputs flags the ECH interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged

57.6.2.9 EOC Interrupt Enable For Precision Inputs (CIMR0)

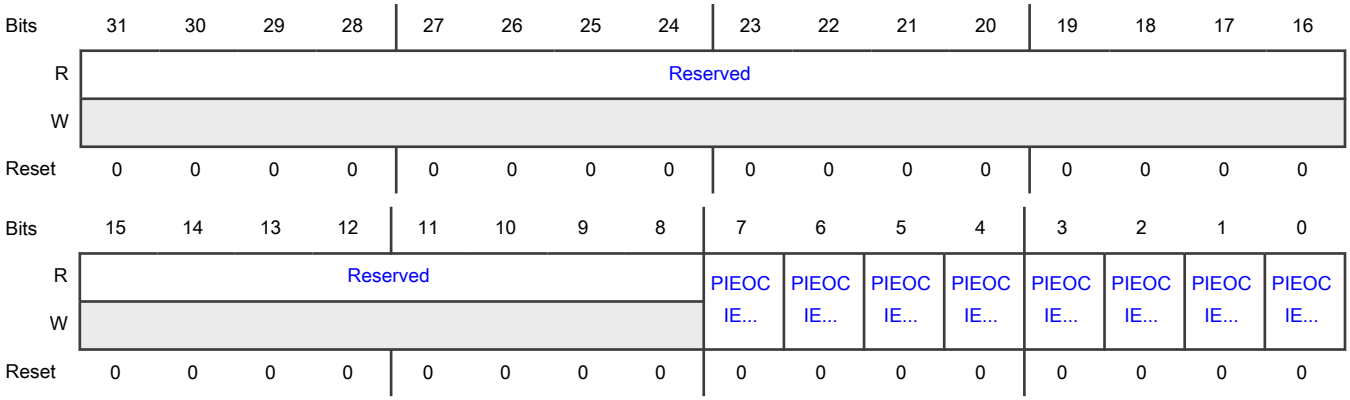
Offset

Register	Offset
CIMR0	24h

Function

Specifies whether a completed conversion of a precision input flags an EOC interrupt.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 PIEOCIEN7	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
6 PIEOCIEN6	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
5 PIEOCIEN5	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged

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Field	Function
4 PIEOCIEN4	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
3 PIEOCIEN3	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
2 PIEOCIEN2	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
1 PIEOCIEN1	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged
0 PIEOCIEN0	Precision Input EOC Interrupt Enable Specifies whether a completed conversion of precision input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged

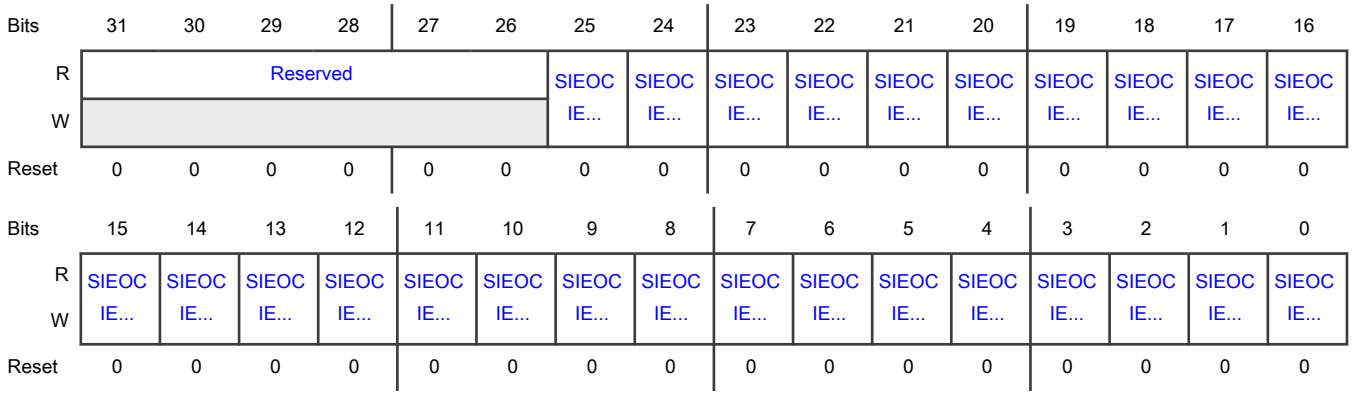
57.6.2.10 EOC Interrupt Enable For Standard Inputs (CIMR1)

Offset

Register	Offset
CIMR1	28h

Function
Specifies whether a completed conversion of a standard input flags an EOC interrupt.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-0 SIEOCIENn	Standard Input EOC Interrupt Enable Specifies whether a completed conversion of standard input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged

57.6.2.11 EOC Interrupt Enable For External Inputs (CIMR2)

Offset

Register	Offset
CIMR2	2Ch

Function

Specifies whether a completed conversion of an external input flags an EOC interrupt.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CIMR2	—
ADC_1	CIMR2	—
ADC_2	—	CIMR2

Table continues on the next page...

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Instance	Register supported	Register not supported
ADC_3	—	CIMR2
ADC_4	—	CIMR2
ADC_5	—	CIMR2
ADC_6	—	CIMR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...	EIEOCIE...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 EIEOCIENn	External Input EOC Interrupt Enable Specifies whether a completed conversion of external input *n* flags an EOC interrupt. 0b - Interrupt is not flagged 1b - Interrupt is flagged

57.6.2.12 Analog Watchdog Threshold Interrupt Status (WTISR)

Offset

Register	Offset
WTISR	30h

Function

Contains flags that indicate the result of a comparison between the conversion result and the threshold value defined in the analog watchdog.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	HAWIF16	LAWIF16	HAWIF15	LAWIF15	HAWIF14	LAWIF14	HAWIF13	LAWIF13	HAWIF12	LAWIF12	HAWIF11	LAWIF11	HAWIF10	LAWIF10	HAWIF9	LAWIF9
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	HAWIF8	LAWIF8	HAWIF7	LAWIF7	HAWIF6	LAWIF6	HAWIF5	LAWIF5	HAWIF4	LAWIF4	HAWIF3	LAWIF3	HAWIF2	LAWIF2	HAWIF1	LAWIF1
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 HAWIF16	High Analog Watchdog Interrupt Flag 16 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 16. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
30 LAWIF16	Low Analog Watchdog Interrupt Flag 16 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 16. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
29	High Analog Watchdog Interrupt Flag 15

Table continues on the next page...

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Field	Function
HAWIF15	Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 15. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
28 LAWIF15	Low Analog Watchdog Interrupt Flag 15 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 15. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
27 HAWIF14	High Analog Watchdog Interrupt Flag 14 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 14. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
26 LAWIF14	Low Analog Watchdog Interrupt Flag 14 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 14.

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Field	Function
	NOTE This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
25 HAWIF13	High Analog Watchdog Interrupt Flag 13 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 13. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
24 LAWIF13	Low Analog Watchdog Interrupt Flag 13 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 13. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
23 HAWIF12	High Analog Watchdog Interrupt Flag 12 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 12.

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Field	Function
	NOTE This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
22 LAWIF12	Low Analog Watchdog Interrupt Flag 12 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 12. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
21 HAWIF11	High Analog Watchdog Interrupt Flag 11 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 11. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
20 LAWIF11	Low Analog Watchdog Interrupt Flag 11 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 11.

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Field	Function
	NOTE This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
19 HAWIF10	High Analog Watchdog Interrupt Flag 10 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 10. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
18 LAWIF10	Low Analog Watchdog Interrupt Flag 10 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 10. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
17 HAWIF9	High Analog Watchdog Interrupt Flag 9 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 9.

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Field	Function
	NOTE This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
16 LAWIF9	Low Analog Watchdog Interrupt Flag 9 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 9. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
15 HAWIF8	High Analog Watchdog Interrupt Flag 8 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 8. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
14 LAWIF8	Low Analog Watchdog Interrupt Flag 8 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 8. **NOTE** This field behaves differently for register reads and writes.

Table continues on the next page...

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Field	Function
	When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
13 HAWIF7	High Analog Watchdog Interrupt Flag 7 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 7. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
12 LAWIF7	Low Analog Watchdog Interrupt Flag 7 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 7. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
11 HAWIF6	High Analog Watchdog Interrupt Flag 6 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 6. **NOTE** This field behaves differently for register reads and writes. When reading

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Field	Function
	0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
10 LAWIF6	Low Analog Watchdog Interrupt Flag 6 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 6. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
9 HAWIF5	High Analog Watchdog Interrupt Flag 5 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 5. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
8 LAWIF5	Low Analog Watchdog Interrupt Flag 5 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 5. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold

Table continues on the next page...

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Field	Function
	1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
7 HAWIF4	High Analog Watchdog Interrupt Flag 4 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 4. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
6 LAWIF4	Low Analog Watchdog Interrupt Flag 4 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 4. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
5 HAWIF3	High Analog Watchdog Interrupt Flag 3 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 3. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing

Table continues on the next page...

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Field	Function
	0b - No effect 1b - Clears flag
4 LAWIF3	Low Analog Watchdog Interrupt Flag 3 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 3. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag
3 HAWIF2	High Analog Watchdog Interrupt Flag 2 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 2. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
2 LAWIF2	Low Analog Watchdog Interrupt Flag 2 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 2. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag

Table continues on the next page...

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Field	Function
1 HAWIF1	High Analog Watchdog Interrupt Flag 1 Indicates whether the conversion result is higher than the high threshold value of the analog watchdog 1. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is lower than the specified high threshold 1b - Conversion result is higher than the specified high threshold When writing 0b - No effect 1b - Clears flag
0 LAWIF1	Low Analog Watchdog Interrupt Flag 1 Indicates whether the conversion result is lower than the low threshold value of the analog watchdog 1. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion result is greater than the specified low threshold 1b - Conversion result is lower than the specified low threshold When writing 0b - No effect 1b - Clears flag

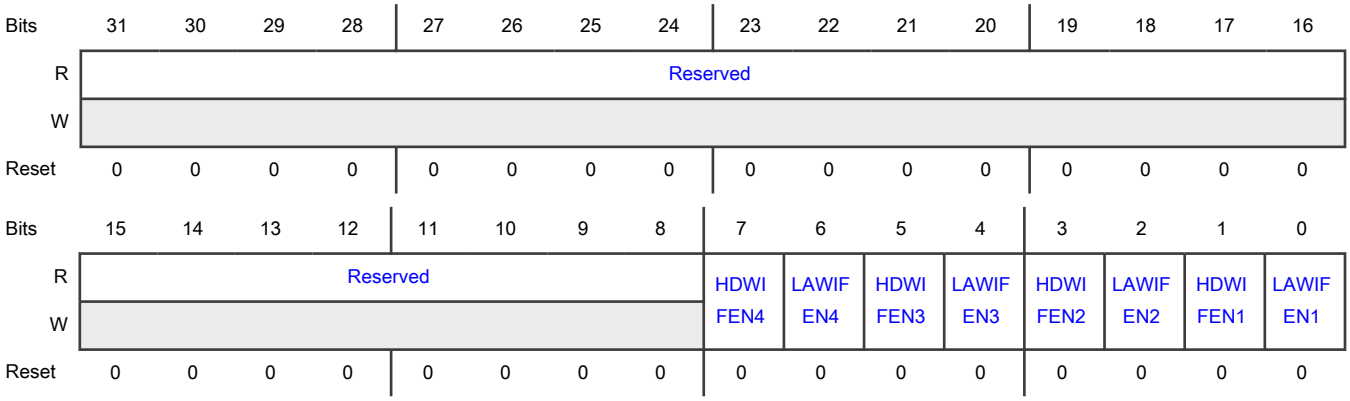
57.6.2.13 Analog Watchdog Threshold Interrupt Enable (WTIMR)

Offset

Register	Offset
WTIMR	34h

Function
Enables the interrupt for each analog watchdog threshold value.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 HDWIFEN4	High Data Watchdog Interrupt Flag Enable n Enables flagging of an interrupt when a conversion result is higher than the high threshold value of the analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged
6 LAWIFEN4	Low Analog Watchdog Interrupt Flag Enable n Enables flagging of an interrupt when a conversion result is lower than the low threshold value of analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged
5 HDWIFEN3	High Data Watchdog Interrupt Flag Enable n Enables flagging of an interrupt when a conversion result is higher than the high threshold value of the analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged
4 LAWIFEN3	Low Analog Watchdog Interrupt Flag Enable n Enables flagging of an interrupt when a conversion result is lower than the low threshold value of analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged
3	High Data Watchdog Interrupt Flag Enable n

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Field	Function
HDWIFEN2	Enables flagging of an interrupt when a conversion result is higher than the high threshold value of the analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged
2 LAWIFEN2	Low Analog Watchdog Interrupt Flag Enable n Enables flagging of an interrupt when a conversion result is lower than the low threshold value of analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged
1 HDWIFEN1	High Data Watchdog Interrupt Flag Enable n Enables flagging of an interrupt when a conversion result is higher than the high threshold value of the analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged
0 LAWIFEN1	Low Analog Watchdog Interrupt Flag Enable n Enables flagging of an interrupt when a conversion result is lower than the low threshold value of analog watchdog *n*. 0b - Interrupt is not flagged 1b - Interrupt is flagged

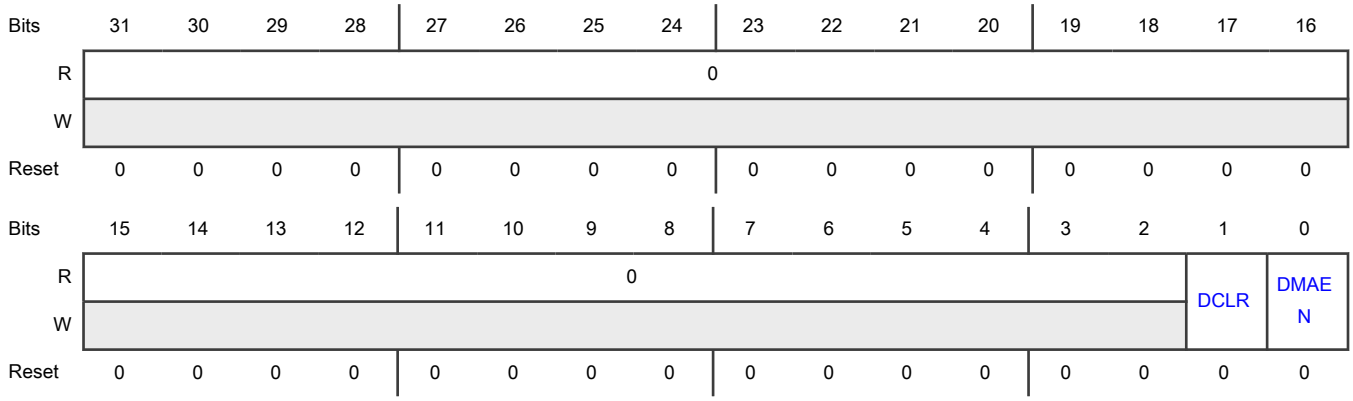
57.6.2.14 Direct Memory Access Configuration (DMAE)

Offset

Register	Offset
DMAE	40h

Function
Configures the DMA feature.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 DCLR	DMA Clear Request Selects one of the following events to clear a DMA request: • DMA controller acknowledges the request. • Application reads the conversion data register. 0b - DMA controller acknowledges the request 1b - Conversion data register is read
0 DMAEN	DMA Enable Enables DMA. 0b - Disable 1b - Enable

57.6.2.15 DMA Request Enable For Precision Inputs (DMAR0)

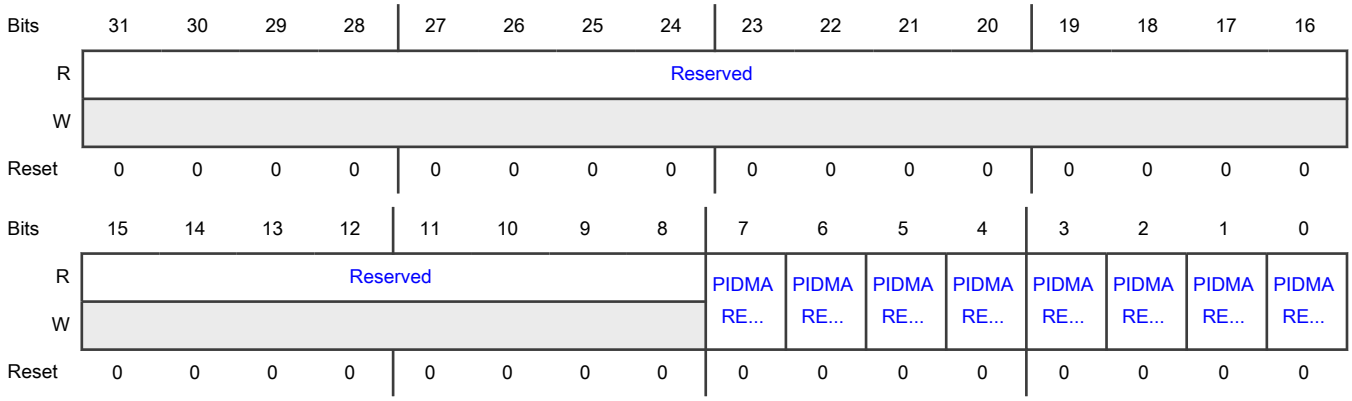
Offset

Register	Offset
DMAR0	44h

Function

Selects the precision inputs that trigger a DMA request after conversion is complete.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 PIDMAREN7	Precision Input DMA Request Enable 7 Specifies whether a DMA request is triggered after conversion is complete for precision input 7. 0b - Not triggered 1b - Triggered
6 PIDMAREN6	Precision Input DMA Request Enable 6 Specifies whether a DMA request is triggered after conversion is complete for precision input 6. 0b - Not triggered 1b - Triggered
5 PIDMAREN5	Precision Input DMA Request Enable 5 Specifies whether a DMA request is triggered after conversion is complete for precision input 5. 0b - Not triggered 1b - Triggered
4 PIDMAREN4	Precision Input DMA Request Enable 4 Specifies whether a DMA request is triggered after conversion is complete for precision input 4. 0b - Not triggered 1b - Triggered
3 PIDMAREN3	Precision Input DMA Request Enable 3 Specifies whether a DMA request is triggered after conversion is complete for precision input 3. 0b - Not triggered 1b - Triggered

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Field	Function
2 PIDMAREN2	Precision Input DMA Request Enable 2 Specifies whether a DMA request is triggered after conversion is complete for precision input 2. 0b - Not triggered 1b - Triggered
1 PIDMAREN1	Precision Input DMA Request Enable 1 Specifies whether a DMA request is triggered after conversion is complete for precision input 1. 0b - Not triggered 1b - Triggered
0 PIDMAREN0	Precision Input DMA Request Enable 0 Specifies whether a DMA request is triggered after conversion is complete for precision input 0. 0b - Not triggered 1b - Triggered

57.6.2.16 DMA Request Enable For Standard Inputs (DMAR1)

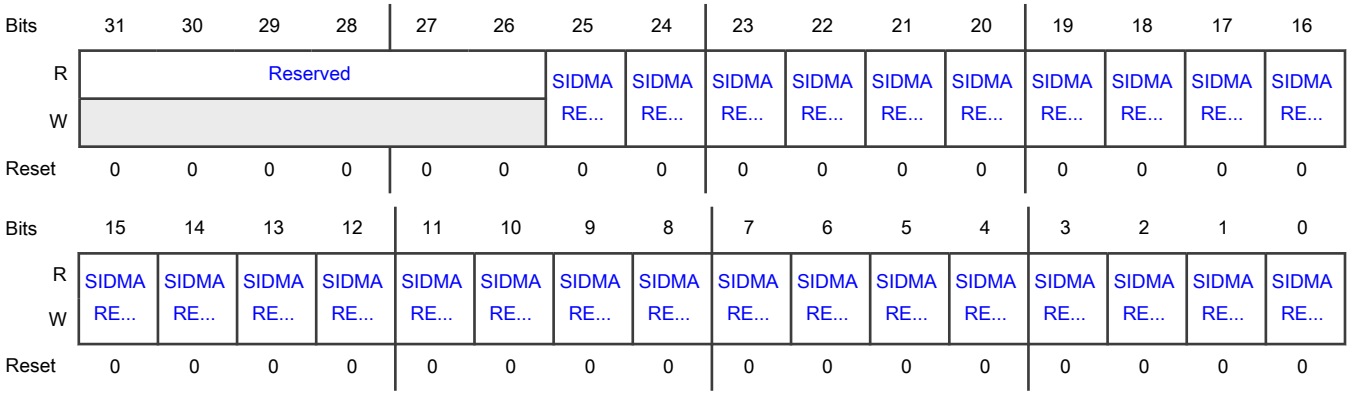
Offset

Register	Offset
DMAR1	48h

Function

Selects the standard inputs that trigger a DMA request after conversion is complete.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-0 SIDMARENn	Standard Input DMA Request Enable n Specifies whether a DMA request is triggered after conversion is complete for standard input *n*. 0b - DMA request is not triggered 1b - DMA is request triggered

57.6.2.17 DMA Request Enable For External Inputs (DMAR2)

Offset

Register	Offset
DMAR2	4Ch

Function
Selects the external inputs that trigger a DMA request after conversion is complete.

NOTE
Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	DMAR2	—
ADC_1	DMAR2	—
ADC_2	—	DMAR2
ADC_3	—	DMAR2
ADC_4	—	DMAR2
ADC_5	—	DMAR2
ADC_6	—	DMAR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...	EIDMARE...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 EIDMARENn	External Input DMA Request Enable n Specifies whether a DMA request is triggered after external input *n* is converted. 0b - DMA request is not triggered 1b - DMA request is triggered

57.6.2.18 Analog Watchdog Threshold Values (THRHLR0 - THRHLR3)

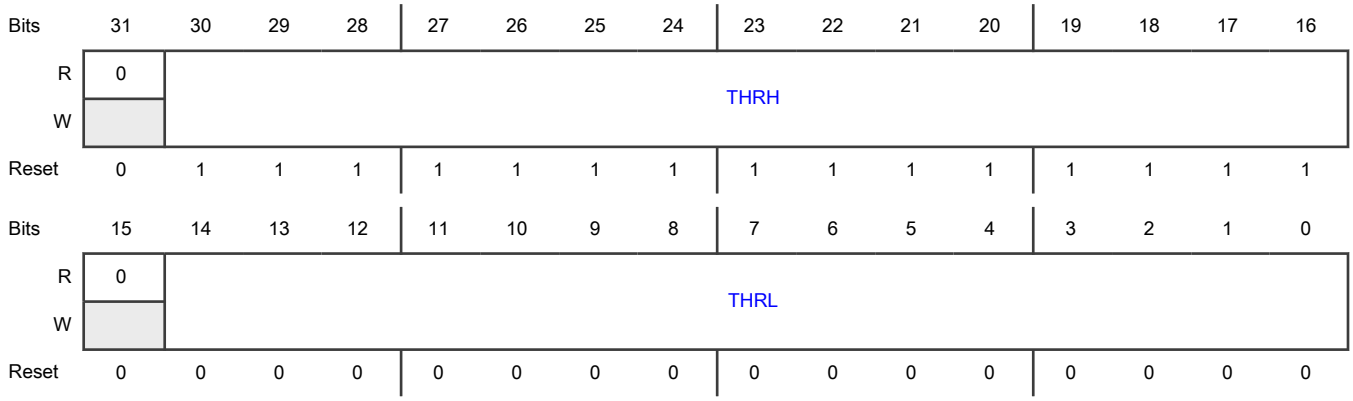
Offset

Register	Offset
THRHLR0	60h
THRHLR1	64h
THRHLR2	68h
THRHLR3	6Ch

Function

Specifies limits for the valid operating range of a monitored input.

Diagram



Fields

Field	Function
31 —	Reserved
30-16 THRH	High Threshold Value If enabled, flags an interrupt when the converted data of the input is higher than this value.
15 —	Reserved
14-0 THRL	Low Threshold Value If enabled, flags an interrupt when the converted data of the input is lower than this value.

57.6.2.19 Presampling Control (PSCR)

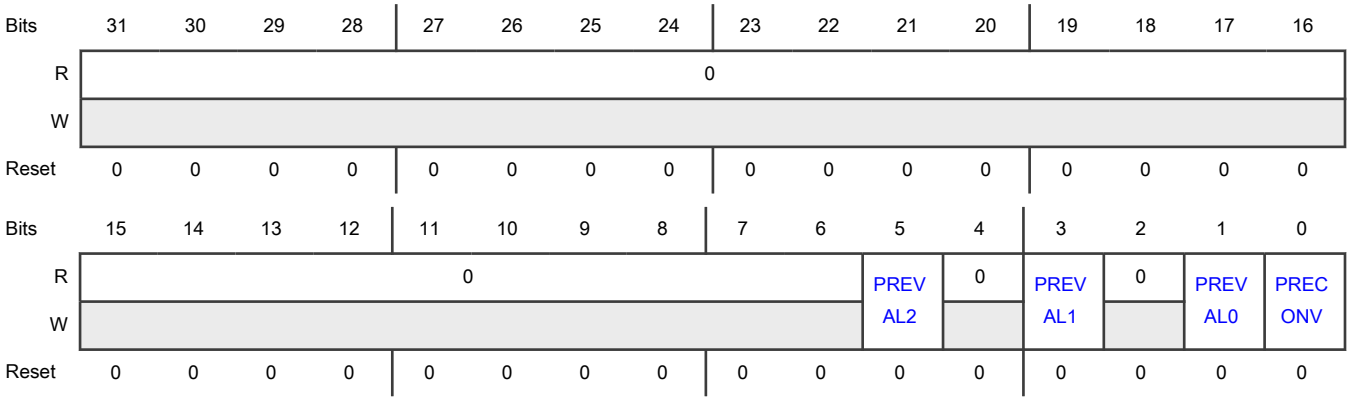
Offset

Register	Offset
PSCR	80h

Function

Configures ADC to presample an internal voltage before the actual input is converted.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 PREVAL2	Presampling Voltage Select For External Inputs Selects the internal voltage that is presampled for external inputs. **NOTE** This field is not supported in every instance. The following table includes only supported registers. 0b - VREFL 1b - VREFH
4 —	Reserved

Instance	Field supported in	Field not supported in
ADC_0	PSCR	—
ADC_1	PSCR	—
ADC_2	—	PSCR
ADC_3	—	PSCR
ADC_4	—	PSCR
ADC_5	—	PSCR
ADC_6	—	PSCR

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 PREVAL1	Presampling Voltage Select For Standard Inputs Selects the internal voltage that is presampled for standard inputs and for the temperature sensor. 0b - VREFL 1b - VREFH
2 —	Reserved
1 PREVAL0	Presampling Voltage Select For Precision Inputs Selects the internal voltage that is presampled for precision inputs. 0b - VREFL 1b - VREFH
0 PRECONV	Convert Presampled Value Specifies whether presampling is followed by the comparison. If enabled, presampling is followed by conversion and the result is written to the conversion data register of the selected input. 0b - No conversion after presampling 1b - Presampling is followed by conversion

57.6.2.20 Presampling Enable For Precision Inputs (PSR0)

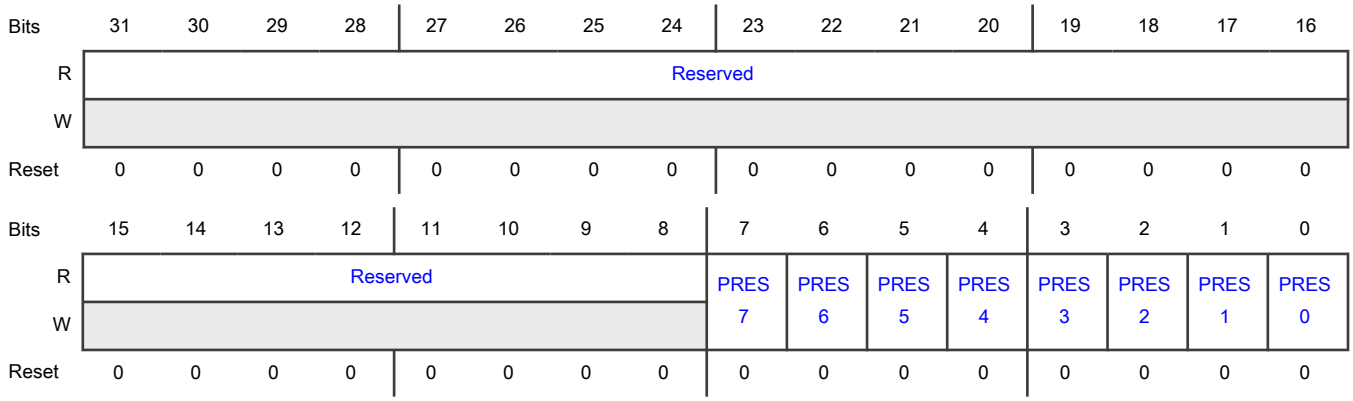
Offset

Register	Offset
PSR0	84h

Function

Enables presampling for each precision input.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 PRES7	Presampling Enable n Enables presampling for precision input *n*. 0b - Disable 1b - Enable
6 PRES6	Presampling Enable n Enables presampling for precision input *n*. 0b - Disable 1b - Enable
5 PRES5	Presampling Enable n Enables presampling for precision input *n*. 0b - Disable 1b - Enable
4 PRES4	Presampling Enable n Enables presampling for precision input *n*. 0b - Disable 1b - Enable
3 PRES3	Presampling Enable n Enables presampling for precision input *n*. 0b - Disable 1b - Enable
2 PRES2	Presampling Enable n Enables presampling for precision input *n*. 0b - Disable 1b - Enable
1 PRES1	Presampling Enable n Enables presampling for precision input *n*. 0b - Disable 1b - Enable
0	Presampling Enable n

Table continues on the next page...

Table continued from the previous page...

Field	Function
PRES0	Enables presampling for precision input *n*. 0b - Disable 1b - Enable

57.6.2.21 Presampling Enable For Standard Inputs (PSR1)

Offset

Register	Offset
PSR1	88h

Function

Enables presampling for each standard input.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved						PRES 25	PRES 24	PRES 23	PRES 22	PRES 21	PRES 20	PRES 19	PRES 18	PRES 17	PRES 16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PRES 15	PRES 14	PRES 13	PRES 12	PRES 11	PRES 10	PRES 9	PRES 8	PRES 7	PRES 6	PRES 5	PRES 4	PRES 3	PRES 2	PRES 1	PRES 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25-0 PRESn	Presampling Enable n Enables presampling for standard input *n*. 0b - Disable 1b - Enable

57.6.2.22 Presampling Enable For External Inputs (PSR2)

Offset

Register	Offset
PSR2	8Ch

Function

Enables presampling for each external input.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	PSR2	—
ADC_1	PSR2	—
ADC_2	—	PSR2
ADC_3	—	PSR2
ADC_4	—	PSR2
ADC_5	—	PSR2
ADC_6	—	PSR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PRES 31	PRES 30	PRES 29	PRES 28	PRES 27	PRES 26	PRES 25	PRES 24	PRES 23	PRES 22	PRES 21	PRES 20	PRES 19	PRES 18	PRES 17	PRES 16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PRES 15	PRES 14	PRES 13	PRES 12	PRES 11	PRES 10	PRES 9	PRES 8	PRES 7	PRES 6	PRES 5	PRES 4	PRES 3	PRES 2	PRES 1	PRES 0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0	Presampling Enable n

Table continues on the next page...

Field	Function
PRESn	Enables presampling for external input *n*. 0b - Disable 1b - Enable

57.6.2.23 Conversion Timing For Precision Inputs (CTR0)

Offset

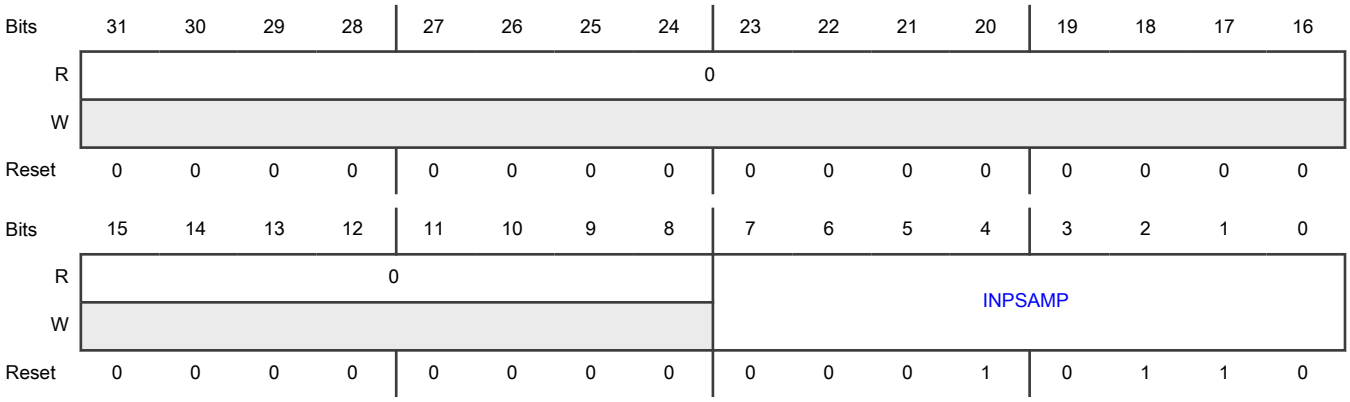
Register	Offset
CTR0	94h

Function

Specifies duration, in terms of the number of conversion clock cycles, of the sampling of precision inputs.

The conversion clock frequency depends on the configuration of MCR[ADCLKSEL].

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 INPSAMP	Input Sample Cycles Specifies the sample duration in terms of conversion clock cycles. The minimum value is 8. Specifying a lower value automatically forces a value of 8.

57.6.2.24 Conversion Timing For Standard Inputs (CTR1)

Offset

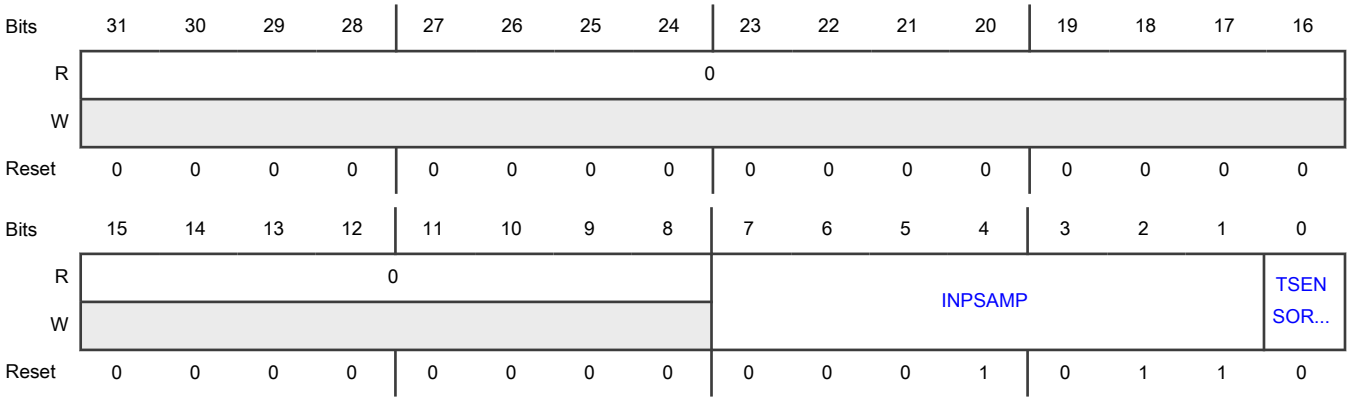
Register	Offset
CTR1	98h

Function

Specifies the duration, in terms of the number of conversion clock cycles, of the sampling of standard inputs or the temperature sensor.

The conversion clock frequency depends on the configuration of MCR[ADCLKSEL].

Diagram



Fields

Field	Function
31-8 —	Reserved
7-1 INPSAMP	Specifies the sample duration in terms of conversion clock cycles. The minimum value is 8. Specifying a lower value automatically forces a value of 8. This field uses the TSENSOR_SEL bit as its low-order bit. In other words, INPSAMP is effectively an 8-bit field, but the low-order bit has a dual function.
0 TSENSOR_SEL	Temperature Sensor Voltage Select Selects the voltage for external temperature sensors (if available). If a temperature sensor is available, this field may be used as the selector for the mux between two temperature sensors. **NOTE** This field is applicable only when there is more than one temperature sensor. 0b - Selects temperature sensor source 0 1b - Selects temperature sensor source 1

57.6.2.25 Conversion Timing For External Inputs (CTR2)

Offset

Register	Offset
CTR2	9Ch

Function

Specifies the number of conversion clock cycles when the external inputs are sampled.

The conversion clock frequency depends on the configuration of MCR[ADCLKSEL].

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CTR2	—
ADC_1	CTR2	—
ADC_2	—	CTR2
ADC_3	—	CTR2
ADC_4	—	CTR2
ADC_5	—	CTR2
ADC_6	—	CTR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								INPSAMP							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0

Fields

Field	Function
31-8 —	Reserved
7-0 INPSAMP	Input Sample Cycles Specifies the sample duration in terms of conversion clock cycles. The minimum acceptable value is 8. Specifying a lower value automatically forces a value of 8.

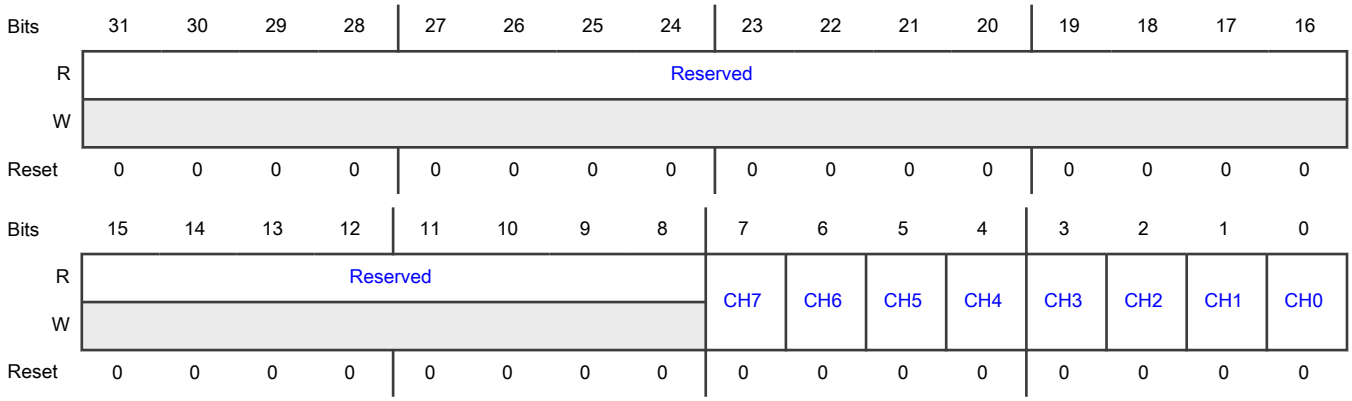
57.6.2.26 Normal Conversion Enable For Precision Inputs (NCMR0)

Offset

Register	Offset
NCMR0	A4h

Function
Selects the precision inputs to be converted during a normal conversion.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 CH7	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Input is selected
6 CH6	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected 1b - Input is selected
5 CH5	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected 1b - Input is selected
4 CH4	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected 1b - Input is selected
3 CH3	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected 1b - Input is selected
2 CH2	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected 1b - Input is selected
1 CH1	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected 1b - Input is selected
0 CH0	Precision Input To Be Converted Selects precision input *n* for conversion. 0b - Input is not selected 1b - Input is selected

57.6.2.27 Normal Conversion Enable For Standard Inputs (NCMR1)

Offset

Register	Offset
NCMR1	A8h

Function
Selects the standard inputs to be converted during a normal conversion.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved						CH57	CH56	CH55	CH54	CH53	CH52	CH51	CH50	CH49	CH48
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CH47	CH46	CH45	CH44	CH43	CH42	CH41	CH40	CH39	CH38	CH37	CH36	CH35	CH34	CH33	CH32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25-0 CHn	Standard Input To Be Converted Selects standard input *n* for conversion. 0b - Input *n* is not selected 1b - Input *n* is selected

57.6.2.28 Normal Conversion Enable For External Inputs (NCMR2)

Offset

Register	Offset
NCMR2	ACh

Function
Selects the external inputs to be converted during a normal conversion.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	NCMR2	—
ADC_1	NCMR2	—
ADC_2	—	NCMR2
ADC_3	—	NCMR2
ADC_4	—	NCMR2
ADC_5	—	NCMR2
ADC_6	—	NCMR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CH95	CH94	CH93	CH92	CH91	CH90	CH89	CH88	CH87	CH86	CH85	CH84	CH83	CH82	CH81	CH80
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CH79	CH78	CH77	CH76	CH75	CH74	CH73	CH72	CH71	CH70	CH69	CH68	CH67	CH66	CH65	CH64
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CHn	External Input To Be Converted Selects external input *n* for conversion. 0b - Input *n* is not selected 1b - Input *n* is selected

57.6.2.29 Injected Conversion Enable For Precision Inputs (JCMR0)

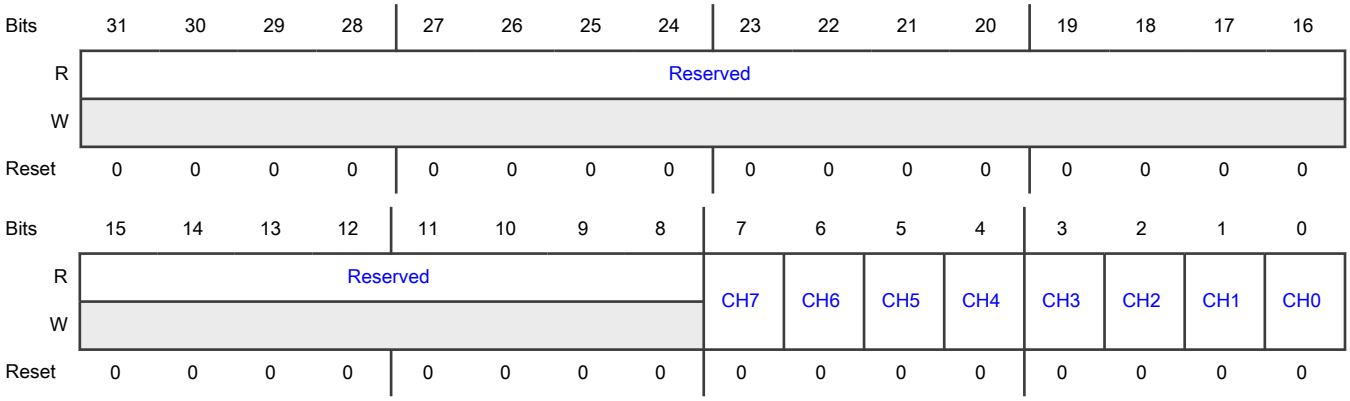
Offset

Register	Offset
JCMR0	B4h

Function

Selects the precision inputs to be converted during an injected conversion.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 CH7	Precision Input To Be Converted Selects precision input 7 for conversion. 0b - Input 7 is not selected 1b - Input 7 is selected
6 CH6	Precision Input To Be Converted Selects precision input 6 for conversion. 0b - Input 6 is not selected 1b - Input 6 is selected
5 CH5	Precision Input To Be Converted Selects precision input 5 for conversion. 0b - Input 5 is not selected 1b - Input 5 is selected
4 CH4	Precision Input To Be Converted Selects precision input 4 for conversion. 0b - Input 4 is not selected 1b - Input 4 is selected
3	Precision Input To Be Converted

Table continues on the next page...

Table continued from the previous page...

Field	Function
CH3	Selects precision input 3 for conversion. 0b - Input 3 is not selected 1b - Input 3 is selected
2 CH2	Precision Input To Be Converted Selects precision input 2 for conversion. 0b - Input 2 is not selected 1b - Input 2 is selected
1 CH1	Precision Input To Be Converted Selects precision input 1 for conversion. 0b - Input 1 is not selected 1b - Input 1 is selected
0 CH0	Precision Input To Be Converted Selects precision input 0 for conversion. 0b - Input 0 is not selected 1b - Input 0 is selected

57.6.2.30 Injected Conversion Enable For Standard Inputs (JCMR1)

Offset

Register	Offset
JCMR1	B8h

Function

Selects the standard inputs to be converted during an injected conversion.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved						CH57	CH56	CH55	CH54	CH53	CH52	CH51	CH50	CH49	CH48
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CH47	CH46	CH45	CH44	CH43	CH42	CH41	CH40	CH39	CH38	CH37	CH36	CH35	CH34	CH33	CH32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25-0 CHn	Standard Input To Be Converted Selects standard input *n* for conversion. 0b - Input *n* is not selected 1b - Input *n* is selected

57.6.2.31 Injected Conversion Enable For External Inputs (JCMR2)

Offset

Register	Offset
JCMR2	BCh

Function
Selects the external inputs to be converted during an injected conversion.

NOTE
Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	JCMR2	—
ADC_1	JCMR2	—
ADC_2	—	JCMR2
ADC_3	—	JCMR2
ADC_4	—	JCMR2
ADC_5	—	JCMR2
ADC_6	—	JCMR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CH95	CH94	CH93	CH92	CH91	CH90	CH89	CH88	CH87	CH86	CH85	CH84	CH83	CH82	CH81	CH80
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CH79	CH78	CH77	CH76	CH75	CH74	CH73	CH72	CH71	CH70	CH69	CH68	CH67	CH66	CH65	CH64
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CHn	External Input To Be Converted Selects external input *n* for conversion. 0b - Input *n* is not selected 1b - Input *n* is selected

57.6.2.32 Delay Start Of Data Conversion (DSDR)

Offset

Register	Offset
DSDR	C4h

Function

Delays the start of the conversion when another input channel is selected. The necessary delay depends on the device characteristics of, for example, the input channel multiplexer.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	DSDR	—
ADC_1	DSDR	—
ADC_2	—	DSDR
ADC_3	—	DSDR

Table continues on the next page...

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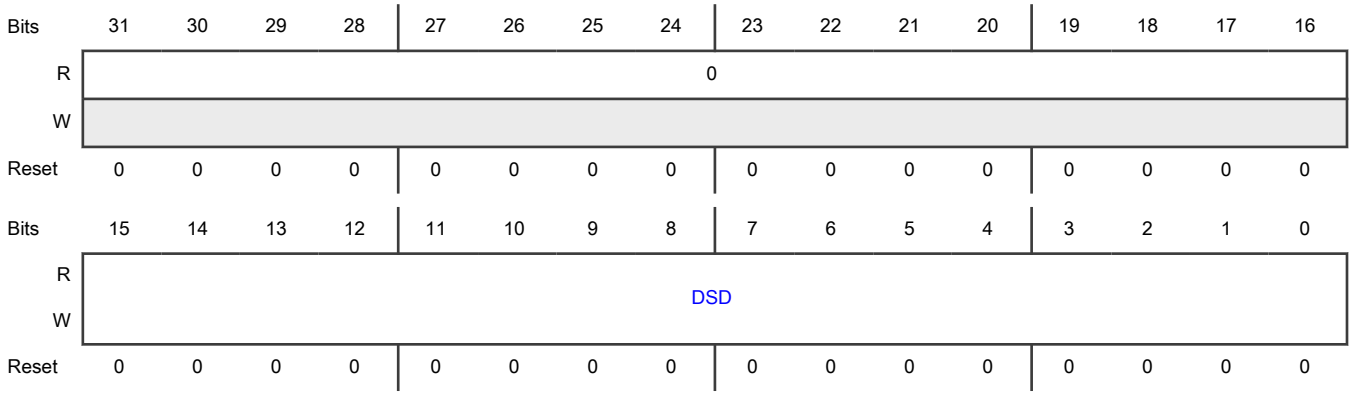
Instance	Register supported	Register not supported
ADC_4	—	DSDR
ADC_5	—	DSDR
ADC_6	—	DSDR

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 DSD	Delay Specifies the delay in terms of the number of module clock cycles.

57.6.2.33 Power Down Exit Delay (PDEDR)

Offset

Register	Offset
PDEDR	C8h

Function

Delays the transition out of Power Down into Idle state to wait for necessary settling times. See the device data sheet for the minimal time between the power-down exit request and when ADC can start a conversion.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								PDED							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0 PDED	Delay Specifies a delay in terms of the number of conversion clock cycles.

57.6.2.34 Precision Input n Conversion Data (PCDR0 - PCDR7)

Offset

For n = 0 to 7:

Register	Offset
PCDRn	100h + (n × 4h)

Function

Contains conversion data from precision input *n*.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0												VALID	OVERW	RESULT	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20 —	Reserved
19 VALID	Conversion Data Available Indicates whether new conversion data is available. This field is automatically reset to 0 when the data is read. 0b - No unread conversion data 1b - Unread conversion data is available
18 OVERW	Overwrite Status Flag Indicates whether the previous conversion data was overwritten without having been read, in which case the overwritten data is lost. The ability to overwrite conversion data is controlled by MCR[OWREN]. 0b - No unread data is overwritten 1b - Unread data is overwritten
17-16 RESULT	Conversion Data Type Indicates the type of trigger that started the conversion for this conversion data. 00b - Normal trigger 01b - Injected trigger 10b - BCTU trigger
15-0 CDATA	Conversion Data Contains conversion data from precision input *n*, determined by the successive approximation algorithm. The conversion data is always 15 bits wide, regardless of the conversion resolution selected (CALBISTREG[RESN]). Depending on the value of MCR[WLSIDE], the conversion data can be in bits [14:0] (MCR[WLSIDE] = 0), or in bits [15:1] (MCR[WLSIDE] = 1).

57.6.2.35 Standard Input n Conversion Data (ICDR0 - ICDR25)

Offset

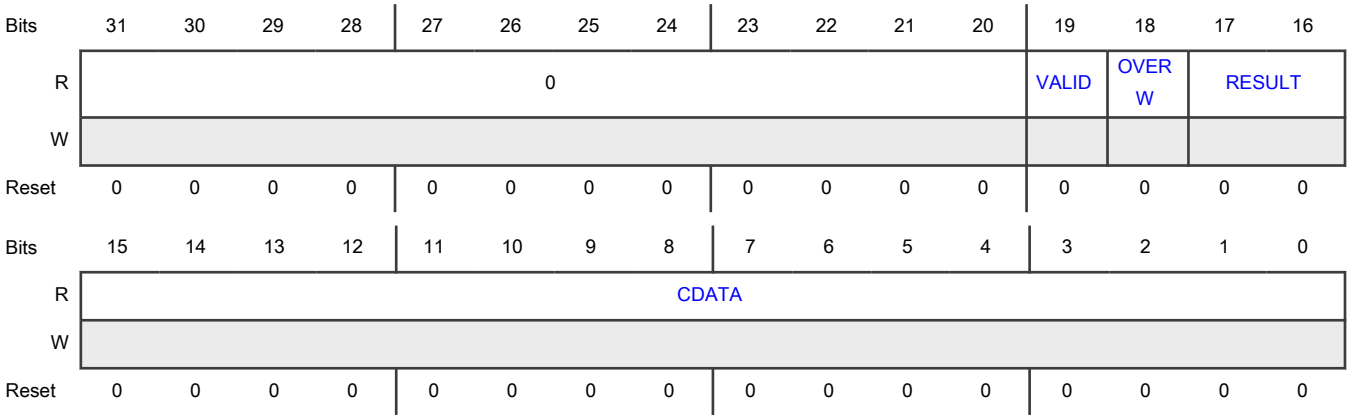
For a = 0 to 25:

Register	Offset
ICDRa	180h + (a × 4h)

Function

Contains conversion data from standard input *n*.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 VALID	Conversion Data Available Indicates whether new conversion data is available. This field is automatically reset to 0 when the data is read. 0b - No unread conversion data 1b - Unread conversion data is available
18 OVERW	Overwrite Status Flag Indicates whether the previous conversion data was overwritten without having been read, in which case the overwritten data is lost. The ability to overwrite conversion data is controlled by MCR[OWREN]. 0b - No unread data is overwritten 1b - Unread data is overwritten
17-16 RESULT	Conversion Data Type Indicates the type of trigger that started the conversion for this conversion data. 00b - Normal trigger 01b - Injected trigger 10b - BCTU trigger
15-0 CDATA	Conversion Data Contains conversion data from standard input *n*, determined by the SAR algorithm. The conversion data bit count is dependent on the conversion resolution selected (CALBISTREG[RESN]). Depending on the value of MCR[WLSIDE], the conversion data MSB bits start from 14 (MCR[WLSIDE] = 0), or 15 (MCR[WLSIDE] = 1).

57.6.2.36 External Input n Conversion Data (ECDR0 - ECDR31)

Offset

For a = 0 to 31:

Register	Offset
ECDRa	200h + (a × 4h)

Function

Contains conversion data from external input *n*.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	ECDR0–ECDR31	—
ADC_1	ECDR0–ECDR31	—
ADC_2	—	ECDR0–ECDR31
ADC_3	—	ECDR0–ECDR31
ADC_4	—	ECDR0–ECDR31
ADC_5	—	ECDR0–ECDR31
ADC_6	—	ECDR0–ECDR31

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0												VALID	OVERW	RESULT	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20 —	Reserved
19 VALID	Conversion Data Available Indicates whether new conversion data is available. This field is automatically reset to 0 when the data is read. 0b - No unread conversion data 1b - Unread conversion data is available
18 OVERW	Overwrite Status Flag Indicates whether the previous conversion data was overwritten without having been read, in which case the overwritten data is lost. The ability to overwrite conversion data is controlled by MCR[OWREN]. 0b - No unread data is overwritten 1b - Unread data is overwritten
17-16 RESULT	Conversion Data Type Indicates the type of trigger that started the conversion for this conversion data. 00b - Normal trigger 01b - Injected trigger 10b - BCTU trigger
15-0 CDATA	Conversion Data Contains conversion data from external input *n*, determined by the SAR algorithm. The conversion data is always 15 bits wide, regardless of the conversion resolution selected (CALBISTREG[RESN]). Depending on the value of MCR[WLSIDE], the conversion data can be in bits [14:0] (MCR[WLSIDE] = 0), or in bits [15:1] (MCR[WLSIDE] = MCR[WLSIDE]).

57.6.2.37 Channel Analog Watchdog Select For Precision Inputs (CWSELRPI0)

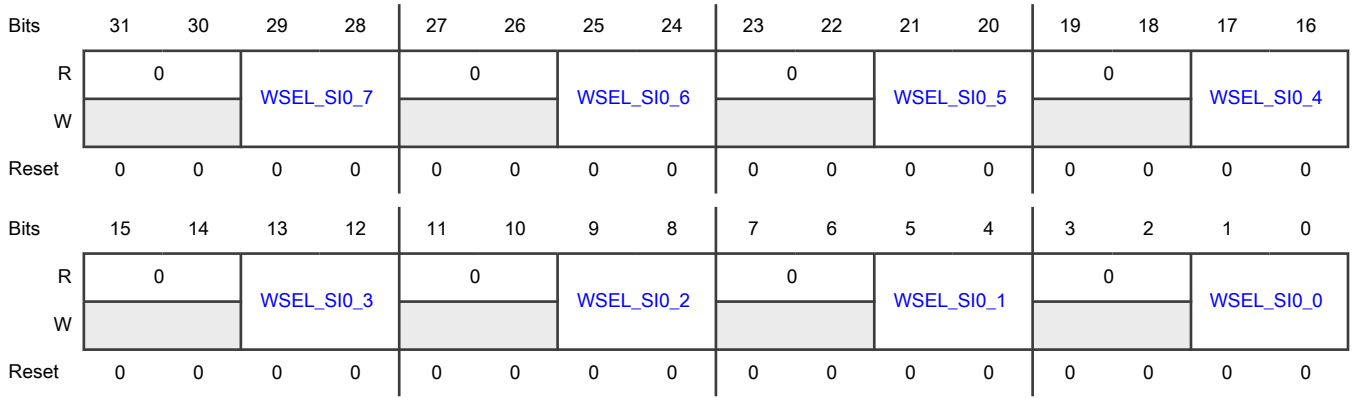
Offset

Register	Offset
CWSELRPI0	2B0h

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor precision inputs.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-28 WSEL_SI0_7	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI0_6	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22 —	Reserved
21-20 WSEL_SI0_5	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0

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Field	Function
	01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI0_4	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
15-14 —	Reserved
13-12 WSEL_SI0_3	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI0_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
7-6 —	Reserved
5-4 WSEL_SI0_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to.

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Field	Function
	00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI0_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

57.6.2.38 Channel Analog Watchdog Select For Standard Inputs (CWSELRSI0)

Offset

Register	Offset
CWSELRSI0	2C0h

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor the standard inputs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		WSEL_SI7_0		0		WSEL_SI6_0		0		WSEL_SI5_0		0		WSEL_SI4_0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		WSEL_SI3_0		0		WSEL_SI2_0		0		WSEL_SI1_0		0		WSEL_SI0_0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-28 WSEL_SI7_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI6_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22 —	Reserved
21-20 WSEL_SI5_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI4_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2

Table continues on the next page...

Table continued from the previous page...

Field	Function
	11b - Analog watchdog THRHLR3
15-14 —	Reserved
13-12 WSEL_SI3_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI2_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
7-6 —	Reserved
5-4 WSEL_SI1_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI0_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0

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Field	Function
	01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

57.6.2.39 Channel Analog Watchdog Select For Standard Inputs (CWSELRSI1)

Offset

Register	Offset
CWSELRSI1	2C4h

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor the standard inputs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		WSEL_SI7_1		0		WSEL_SI6_1		0		WSEL_SI5_1		0		WSEL_SI4_1	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		WSEL_SI3_1		0		WSEL_SI2_1		0		WSEL_SI1_1		0		WSEL_SI0_1	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-28 WSEL_SI7_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2

Table continues on the next page...

Table continued from the previous page...

Field	Function
	11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI6_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22 —	Reserved
21-20 WSEL_SI5_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI4_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
15-14 —	Reserved
13-12 WSEL_SI3_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0

Table continues on the next page...

Table continued from the previous page...

Field	Function
	01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI2_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
7-6 —	Reserved
5-4 WSEL_SI1_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI0_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

57.6.2.40 Channel Analog Watchdog Select For Standard Inputs (CWSELRSI2)

Offset

Register	Offset
CWSELRSI2	2C8h

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor the standard inputs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		WSEL_SI7_2		0		WSEL_SI6_2		0		WSEL_SI5_2		0		WSEL_SI4_2	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		WSEL_SI3_2		0		WSEL_SI2_2		0		WSEL_SI1_2		0		WSEL_SI0_2	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-28 WSEL_SI7_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI6_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0

Table continues on the next page...

Table continued from the previous page...

Field	Function
	01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22 —	Reserved
21-20 WSEL_SI5_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI4_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
15-14 —	Reserved
13-12 WSEL_SI3_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI2_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
7-6 —	Reserved
5-4 WSEL_SI1_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI0_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

57.6.2.41 Channel Analog Watchdog Select For Standard Inputs (CWSELRSI3)

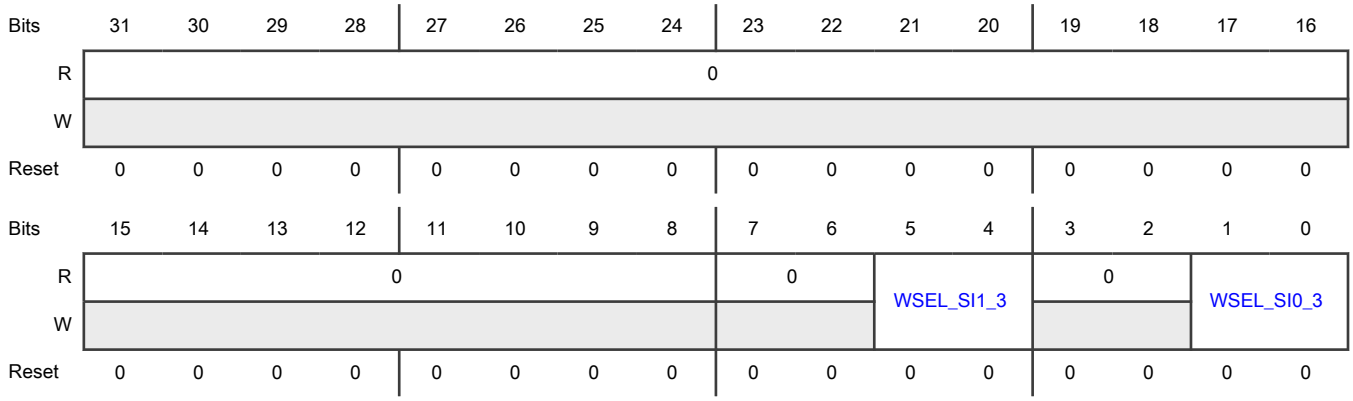
Offset

Register	Offset
CWSELRSI3	2CCh

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor the standard inputs.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-6 —	Reserved
5-4 WSEL_SI1_3	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI0_3	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

57.6.2.42 Channel Analog Watchdog Select For External inputs (CWSELREI0)

Offset

Register	Offset
CWSELREI0	2D0h

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor external inputs.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CWSELREI0	—
ADC_1	CWSELREI0	—
ADC_2	—	CWSELREI0
ADC_3	—	CWSELREI0
ADC_4	—	CWSELREI0
ADC_5	—	CWSELREI0
ADC_6	—	CWSELREI0

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		WSEL_SI0_7		0		WSEL_SI0_6		0		WSEL_SI0_5		0		WSEL_SI0_4	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		WSEL_SI0_3		0		WSEL_SI0_2		0		WSEL_SI0_1		0		WSEL_SI0_0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
29-28 WSEL_SI0_7	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI0_6	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22 —	Reserved
21-20 WSEL_SI0_5	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI0_4	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

Table continues on the next page...

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Field	Function
15-14 —	Reserved
13-12 WSEL_SI0_3	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI0_2	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
7-6 —	Reserved
5-4 WSEL_SI0_1	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI0_0	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2

Table continues on the next page...

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Field	Function
	11b - Analog watchdog THRHLR3

57.6.2.43 Channel Analog Watchdog Select For External inputs (CWSELREI1)

Offset

Register	Offset
CWSELREI1	2D4h

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor external inputs.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CWSELREI1	—
ADC_1	CWSELREI1	—
ADC_2	—	CWSELREI1
ADC_3	—	CWSELREI1
ADC_4	—	CWSELREI1
ADC_5	—	CWSELREI1
ADC_6	—	CWSELREI1

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		WSEL_SI1_15		0		WSEL_SI1_14		0		WSEL_SI1_13		0		WSEL_SI1_12	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		WSEL_SI1_11		0		WSEL_SI1_10		0		WSEL_SI1_9		0		WSEL_SI1_8	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-28 WSEL_SI1_15	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI1_14	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22 —	Reserved
21-20 WSEL_SI1_13	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI1_12	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2

Table continues on the next page...

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Field	Function
	11b - Analog watchdog THRHLR3
15-14 —	Reserved
13-12 WSEL_SI1_11	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI1_10	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
7-6 —	Reserved
5-4 WSEL_SI1_9	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI1_8	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0

Table continues on the next page...

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Field	Function
	01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

57.6.2.44 Channel Analog Watchdog Select For External inputs (CWSELREI2)

Offset

Register	Offset
CWSELREI2	2D8h

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor external inputs.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CWSELREI2	—
ADC_1	CWSELREI2	—
ADC_2	—	CWSELREI2
ADC_3	—	CWSELREI2
ADC_4	—	CWSELREI2
ADC_5	—	CWSELREI2
ADC_6	—	CWSELREI2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		WSEL_SI2_23		0		WSEL_SI2_22		0		WSEL_SI2_21		0		WSEL_SI2_20	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		WSEL_SI2_19		0		WSEL_SI2_18		0		WSEL_SI2_17		0		WSEL_SI2_16	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-28 WSEL_SI2_23	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI2_22	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22 —	Reserved
21-20 WSEL_SI2_21	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0

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Table continued from the previous page...

Field	Function
	01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI2_20	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
15-14 —	Reserved
13-12 WSEL_SI2_19	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI2_18	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
7-6 —	Reserved
5-4 WSEL_SI2_17	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to.

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Table continued from the previous page...

Field	Function
	00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI2_16	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

57.6.2.45 Channel Analog Watchdog Select For External inputs (CWSELREI3)

Offset

Register	Offset
CWSELREI3	2DCh

Function

Selects the analog watchdog threshold register (THRHLR) that provides limits to monitor external inputs.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CWSELREI3	—
ADC_1	CWSELREI3	—
ADC_2	—	CWSELREI3
ADC_3	—	CWSELREI3
ADC_4	—	CWSELREI3
ADC_5	—	CWSELREI3

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
ADC_6	—	CWSELREI3

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		WSEL_SI3_31		0		WSEL_SI3_30		0		WSEL_SI3_29		0		WSEL_SI3_28	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		WSEL_SI3_27		0		WSEL_SI3_26		0		WSEL_SI3_25		0		WSEL_SI3_24	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-28 WSEL_SI3_31	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
27-26 —	Reserved
25-24 WSEL_SI3_30	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
23-22	Reserved

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Field	Function
—	
21-20 WSEL_SI3_29	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
19-18 —	Reserved
17-16 WSEL_SI3_28	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
15-14 —	Reserved
13-12 WSEL_SI3_27	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
11-10 —	Reserved
9-8 WSEL_SI3_26	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

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Field	Function
7-6 —	Reserved
5-4 WSEL_SI3_25	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3
3-2 —	Reserved
1-0 WSEL_SI3_24	Analog Watchdog Selection Selects the analog watchdog thresholds that the input is to be compared to. 00b - Analog watchdog THRHLR0 01b - Analog watchdog THRHLR1 10b - Analog watchdog THRHLR2 11b - Analog watchdog THRHLR3

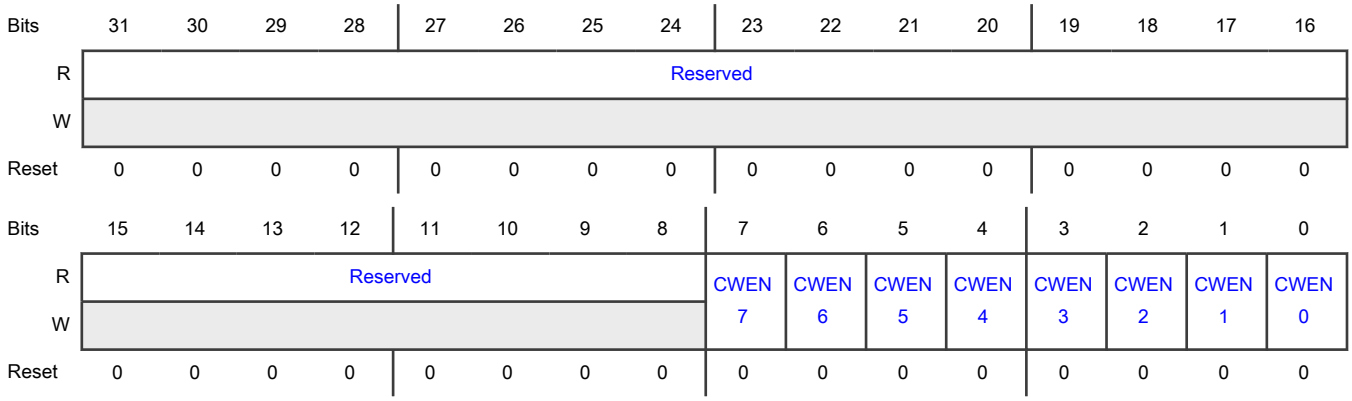
57.6.2.46 Channel Watchdog Enable For Precision Inputs (CWENR0)

Offset

Register	Offset
CWENR0	2E0h

Function
Enables the analog watchdog per precision input.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 CWEN7	Channel Analog Watchdog Enable 7 Enables the analog watchdog for precision input 7. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable
6 CWEN6	Channel Analog Watchdog Enable 6 Enables the analog watchdog for precision input 6. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable
5 CWEN5	Channel Analog Watchdog Enable 5 Enables the analog watchdog for precision input 5. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable
4 CWEN4	Channel Analog Watchdog Enable 4 Enables the analog watchdog for precision input 4. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable

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Field	Function
3 CWEN3	Channel Analog Watchdog Enable 3 Enables the analog watchdog for precision input 3. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable
2 CWEN2	Channel Analog Watchdog Enable 2 Enables the analog watchdog for precision input 2. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable
1 CWEN1	Channel Analog Watchdog Enable 1 Enables the analog watchdog for precision input 1. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable
0 CWEN0	Channel Analog Watchdog Enable 0 Enables the analog watchdog for precision input 0. When enabled, conversion data on the input is compared to the selected data watchdog threshold value. 0b - Disable 1b - Enable

57.6.2.47 Channel Watchdog Enable For Standard Inputs (CWENR1)

Offset

Register	Offset
CWENR1	2E4h

Function

Enables the analog watchdog for standard input *n*.

When enabled, conversion data on the input is compared to the selected data watchdog threshold value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved						CWEN 57	CWEN 56	CWEN 55	CWEN 54	CWEN 53	CWEN 52	CWEN 51	CWEN 50	CWEN 49	CWEN 48
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CWEN 47	CWEN 46	CWEN 45	CWEN 44	CWEN 43	CWEN 42	CWEN 41	CWEN 40	CWEN 39	CWEN 38	CWEN 37	CWEN 36	CWEN 35	CWEN 34	CWEN 33	CWEN 32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25-0 CWENn	Channel Analog Watchdog Enable For Standard Inputs Enables the analog watchdog for standard input *n*. 0b - Disable 1b - Enable

57.6.2.48 Channel Watchdog Enable For External Inputs (CWENR2)

Offset

Register	Offset
CWENR2	2E8h

Function

Enables the analog watchdog per external input.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	CWENR2	—
ADC_1	CWENR2	—
ADC_2	—	CWENR2

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
ADC_3	—	CWENR2
ADC_4	—	CWENR2
ADC_5	—	CWENR2
ADC_6	—	CWENR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CWEN 95	CWEN 94	CWEN 93	CWEN 92	CWEN 91	CWEN 90	CWEN 89	CWEN 88	CWEN 87	CWEN 86	CWEN 85	CWEN 84	CWEN 83	CWEN 82	CWEN 81	CWEN 80
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CWEN 79	CWEN 78	CWEN 77	CWEN 76	CWEN 75	CWEN 74	CWEN 73	CWEN 72	CWEN 71	CWEN 70	CWEN 69	CWEN 68	CWEN 67	CWEN 66	CWEN 65	CWEN 64
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CWENn	Channel Analog Watchdog Enable For External Inputs Enables the analog watchdog for external input *n*. 0b - Disable 1b - Enable

57.6.2.49 Analog Watchdog Out Of Range For Precision Inputs (AWORR0)

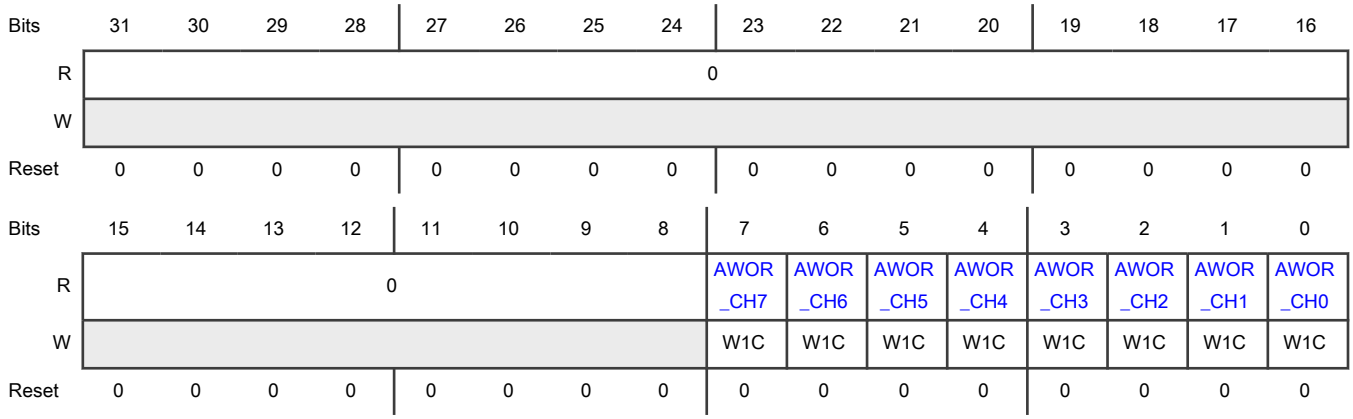
Offset

Register	Offset
AWORR0	2F0h

Function

Indicates the status of analog watchdog comparisons on precision inputs.

Diagram



Fields

Field	Function
31-8 —	Reserved
7 AWOR_CH7	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 7 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing 0b - No effect 1b - Clears flag
6 AWOR_CH6	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 6 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing

Table continues on the next page...

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Field	Function
	0b - No effect 1b - Clears flag
5 AWOR_CH5	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 5 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing 0b - No effect 1b - Clears flag
4 AWOR_CH4	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 4 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing 0b - No effect 1b - Clears flag
3 AWOR_CH3	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 3 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing

Table continues on the next page...

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Field	Function
	0b - No effect 1b - Clears flag
2 AWOR_CH2	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 2 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing 0b - No effect 1b - Clears flag
1 AWOR_CH1	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 1 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing 0b - No effect 1b - Clears flag
0 AWOR_CH0	Analog Watchdog Out Of Range For Precision Inputs Indicates whether a data conversion on precision input 0 is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No effect 1b - Clears flag

57.6.2.50 Analog Watchdog Out Of Range For Standard Inputs (AWORR1)

Offset

Register	Offset
AWORR1	2F4h

Function

Indicates the status of analog watchdog comparisons on standard inputs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved						AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...
W							W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH9	AWOR_CH8	AWOR_CH7	AWOR_CH6	AWOR_CH5	AWOR_CH4	AWOR_CH3	AWOR_CH2	AWOR_CH1	AWOR_CH0
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25-0 AWOR_CHn	Analog Watchdog Out Of Range For Standard Inputs Indicates whether a data conversion on a standard input *n* is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading

Table continues on the next page...

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Field	Function
	0b - Conversion is within limits 1b - Conversion is not within limits When writing 0b - No effect 1b - Clears flag

57.6.2.51 Analog Watchdog Out Of Range For External Inputs (AWORR2)

Offset

Register	Offset
AWORR2	2F8h

Function

Indicates the status of analog watchdog comparisons on external inputs.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
ADC_0	AWORR2	—
ADC_1	AWORR2	—
ADC_2	—	AWORR2
ADC_3	—	AWORR2
ADC_4	—	AWORR2
ADC_5	—	AWORR2
ADC_6	—	AWORR2

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH...	AWOR_CH9	AWOR_CH8	AWOR_CH7	AWOR_CH6	AWOR_CH5	AWOR_CH4	AWOR_CH3	AWOR_CH2	AWOR_CH1	AWOR_CH0
W	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 AWOR_CHn	Analog Watchdog Out Of Range For External Inputs Indicates whether a data conversion on external input *n* is out of the limits defined by the selected analog watchdog threshold value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Conversion is within limits 1b - Conversion is not within limits When writing 0b - No effect 1b - Clears flag

57.6.2.52 Self-Test Configuration 1 (STCR1)

Offset

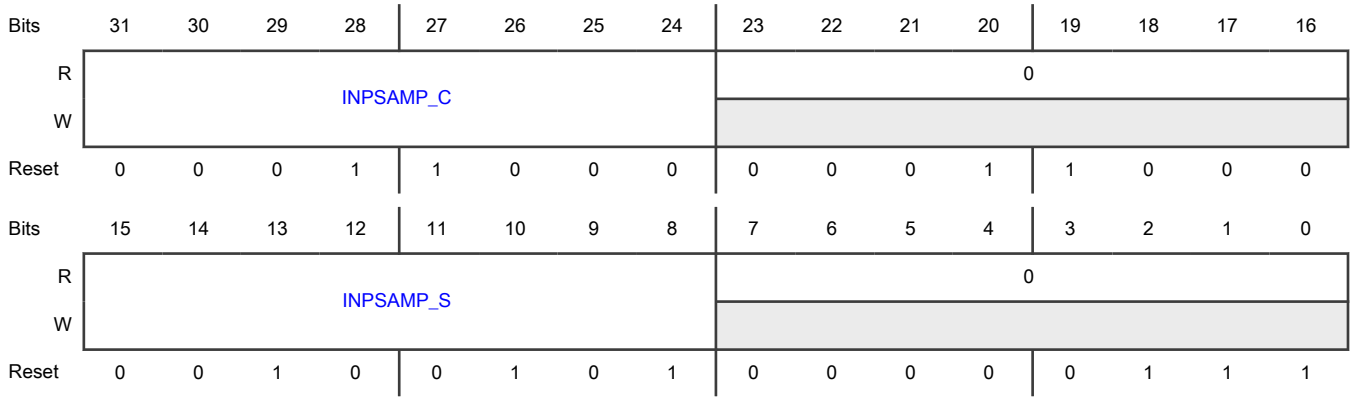
Register	Offset
STCR1	340h

Function

Specifies the input sampling duration in terms of conversion clock cycles.

Conversion clock frequency depends on the configuration of MCR[ADCLKSEL].

Diagram



Fields

Field	Function
31-24 INPSAMP_C	Input Sampling Time Algorithm C Specifies the sample duration for test conversions related to algorithm C. The minimum acceptable value is 8. Specifying a lower value automatically forces a value of 8.
23-16 —	Reserved
15-8 INPSAMP_S	Input Sampling Time Algorithm S Specifies sample duration for test conversions related to algorithm S. The minimum value is 8. Specifying a lower value automatically forces a value of 8.
7-0 —	Reserved

57.6.2.53 Self-Test Configuration 2 (STCR2)

Offset

Register	Offset
STCR2	344h

Function

Configures ADC self-test functions.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				MSKWDSE...	SERR	MSKWDTE...	0	MSKST_E...	0				MSKWDG_...	0	MSKWDG_...
W						W1C										
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MSKERR_C	0	MSKERR_...	MSKERR_...	MSKERR_...	0			EN	0		FMA_WDS...	FMA_WDT...	FMA_C	0	FMA_S
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

Fields

Field	Function
31-28 —	Reserved
27 MSKWDSERR	Mask Interrupt Self-Test Watchdog Sequence Error Generates an interrupt when the WDSERR flag transitions to 1. 0b - No interrupt is generated 1b - Interrupt is generated
26 SERR	Self-Test Error Injection Writes 1 to the STSR1[ERR_C], STSR1[ERR_S0], STSR1[ERR_S1], and STSR1[ERR_S2] status fields, causing an error. This field is reset to 0 immediately after writing. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Error can be injected 1b - Error is being injected When writing 0b - No effect 1b - Injects a self-test error
25 MSKWDTERR	Mask Interrupt Self-Test Watchdog Timer Error Generates an interrupt when the WDTERR flag is set. 0b - No interrupt is generated 1b - Interrupt is generated
24	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
23 MSKST_EOC	Mask Interrupt Self-Test End Of Conversion Generates an interrupt when the ST_EOC flag is set. 0b - No interrupt is generated 1b - Interrupt is generated
22-19 —	Reserved
18 MSKWDG_EOA_C	Mask Error Interrupt End Of Algorithm C Generates an interrupt when the WDG_EOA_C flag is set. 0b - No interrupt is generated 1b - Interrupt is generated
17 —	Reserved
16 MSKWDG_EOA_S	Mask Error Interrupt End Of Algorithm S Generates an interrupt when the WDG_EOA_S flag is set. 0b - No interrupt is generated 1b - Interrupt is generated
15 MSKERR_C	Mask Error Interrupt Algorithm C Generates an interrupt when the ERR_C flag is set. 0b - No interrupt is generated 1b - Interrupt is generated
14 —	Reserved
13 MSKERR_S2	Mask Error Interrupt Algorithm S2 Generates an interrupt when the ERR_S2 flag is set. 0b - No interrupt is generated 1b - Interrupt is generated
12 MSKERR_S1	Mask Error Interrupt Algorithm S1 Generates an interrupt when the ERR_S1 flag is set. 0b - No interrupt is generated

Table continues on the next page...

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Field	Function
	1b - Interrupt is generated
11 MSKERR_S0	Mask Error Interrupt Algorithm S0 Generates an interrupt when the ERR_S0 flag is set. 0b - No interrupt is generated 1b - Interrupt is generated
10-8 —	Reserved
7 EN	Self-Test Enable Enables ADC structural self-test. When BCTU is enabled, this field has no effect. This field must be 1 before starting normal conversion and must not be changed during conversion. This field must be reset to 0 only after end of conversion for the last self-test channel has been received. 0b - Disable 1b - Enable
6-5 —	Reserved
4 FMA_WDSERR	Fault Mapping Self-Test Watchdog Sequence Error Specifies whether a self-test watchdog sequence error sets the flag on the critical or noncritical fault line. 0b - Noncritical fault line 1b - Critical fault line
3 FMA_WDTERR	Fault Mapping Self-Test Watchdog Timer Error Specifies whether a self-test watchdog timer error sets the flag on the critical or noncritical fault line. 0b - Noncritical fault line 1b - Critical fault line
2 FMA_C	Fault Mapping Algorithm C Specifies whether a fault in algorithm C sets the flag on the critical or noncritical fault line. 0b - Noncritical fault line 1b - Critical fault line
1 —	Reserved
0 FMA_S	Fault Mapping Algorithm S Specifies whether a fault in algorithm S sets the flag on the critical or noncritical fault line.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Noncritical fault line 1b - Critical fault line

57.6.2.54 Self-Test Configuration 3 (STCR3)

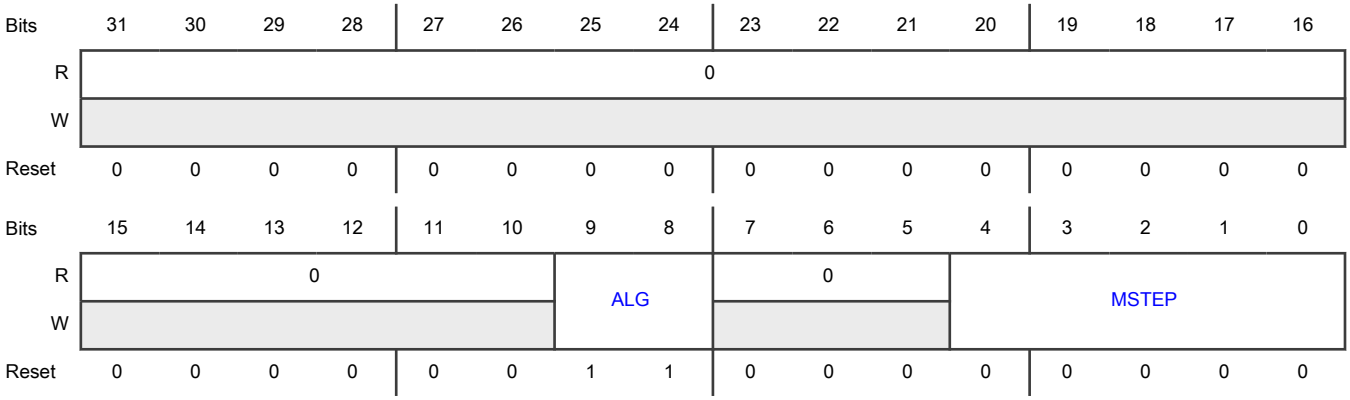
Offset

Register	Offset
STCR3	348h

Function

Configures ADC self-test functions. When BCTU is enabled, writes to the fields registers have no effect. This register must be programmed before starting a conversion and must not be changed when conversion is ongoing.

Diagram



Fields

Field	Function
31-10 —	Reserved
9-8 ALG	Algorithm Selection One-Shot operation mode: • 00 Algorithm S (single step = MSTEP) • 01 Reserved • 10 Algorithm C (single step = MSTEP)

Table continues on the next page...

Table continued from the previous page...

Field	Function
	• 11 Algorithm S (default) (use for test/debug purposes) Continuous conversion mode: • 00 Algorithm S • 01 Reserved • 10 Algorithm C • 11 Algorithm S + algorithm C (default)
7-5 —	Reserved
4-0 MSTEP	Algorithm Step For One-Shot operation mode: • MSTEP = 0 to 2 for algorithm S • MSTEP = 0 to 11 for algorithm C Unused codes are reserved and must not be used. For Scan operation mode: This field is not used in Scan operation mode because single-step execution (interleaved mode) is always performed. This field must be programmed to zero in Scan operation mode.

57.6.2.55 Self-Test Baud Rate (STBRR)

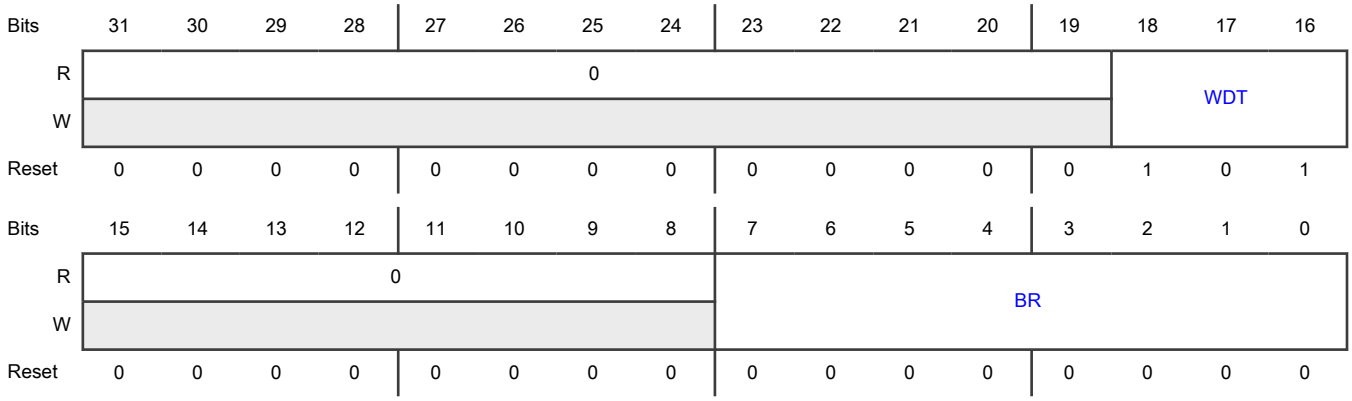
Offset

Register	Offset
STBRR	34Ch

Function

Specifies when the self-test algorithm steps are executed and the maximum time allowed for self-test to finish.

Diagram



Fields

Field	Function
31-19 —	Reserved
18-16 WDT	Self-Test Watchdog Timer Specifies the safe time period in terms of conversion clock cycles. The safe time period is the maximum duration until the running self-test is expected to finish. 000b - 8192 conversion clock cycles (~0.1 ms at 80 MHz) 001b - 39,936 conversion clock cycles (~0.5 ms at 80 MHz) 010b - 79,872 conversion clock cycles (~1 ms at 80 MHz) 011b - 159,744 conversion clock cycles (~2 ms at 80 MHz) 100b - 400,384 conversion clock cycles (~5 ms at 80 MHz) 101b - 799,744 conversion clock cycles (~10 ms at 80 MHz) 110b - 1,599,488 conversion clock cycles (~20 ms at 80 MHz) 111b - 3,999,744 conversion clock cycles (~50 ms at 80 MHz)
15-8 —	Reserved
7-0 BR	Baud Rate Selects the number of conversions of the selected inputs, after which the next self-test algorithm step executes. This field must be programmed when STCR2[EN] is zero, that is, before enabling self-test. 0000_0000b - A step of the selected self-test algorithm is executed every time after the set of selected inputs has been converted. 1111_1111b - A step of the selected self-test algorithm is executed after the set of selected inputs has been converted 256 times.

57.6.2.56 Self-Test Status 1 (STSR1)

Offset

Register	Offset
STSR1	350h

Function
Indicates self-test status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				WDSERR	0	WDTERR	OVERWR	ST_EOC	0				WDG_EOA...	0	WDG_EOA...
W					W1C		W1C	W1C	W1C					W1C		W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ERR_C	0	ERR_S2	ERR_S1	ERR_S0	0	STEP_C						0			
W	W1C		W1C	W1C	W1C											
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 WDSERR	Self-Test Watchdog Sequence Error Indicates whether the selected self-test algorithm has executed in the correct sequence. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Algorithm executed in correct sequence 1b - Algorithm did not execute in correct sequence When writing 0b - No effect 1b - Clears flag
26	Reserved

Table continues on the next page...

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Field	Function
—	
25 WDTERR	Self-Test Watchdog Timer Error Indicates whether the self-test algorithm has finished within the defined safe time period. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Algorithm finished within the safe time period (or safe time period not yet elapsed). 1b - Algorithm did not finish within safe time period. When writing 0b - No effect 1b - Clears flag
24 OVERWR	Self-Test Error Status Overwrite Indicates whether an error occurred when the respective error status flag (ERR_S0, ERR_S1, ERR_S2, or ERR_C) was set. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No self-test error status flag overwritten 1b - Self-test error status flag overwritten When writing 0b - No effect 1b - Clears flag
23 ST_EOC	Self-Test End Of Conversion Indicates whether a self-test conversion has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not complete 1b - Complete When writing 0b - No effect 1b - Clears flag

Table continues on the next page...

Table continued from the previous page...

Field	Function
22-19 —	Reserved
18 WDG_EOA_C	Self-Test Watchdog End Of Algorithm C Indicates whether self-test algorithm C has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not complete 1b - Complete When writing 0b - No effect 1b - Clears flag
17 —	Reserved
16 WDG_EOA_S	Self-Test Watchdog End Of Algorithm S Indicates whether self-test algorithm S has completed. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not complete 1b - Complete When writing 0b - No effect 1b - Clears flag
15 ERR_C	Error Algorithm C Indicates whether an error occurred during execution of algorithm C. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No error 1b - Error When writing

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No effect 1b - Clears flag
14 —	Reserved
13 ERR_S2	Error Algorithm S Step 2 Indicates whether an error occurred during execution of step 2 of algorithm S. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No error 1b - Error When writing 0b - No effect 1b - Clears flag
12 ERR_S1	Error Algorithm S Step 1 Indicates whether an error occurred during execution of step 1 of algorithm S. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No error 1b - Error When writing 0b - No effect 1b - Clears flag
11 ERR_S0	Error Algorithm S Step 0 Indicates whether an error occurred during execution of step 0 of algorithm S. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No error 1b - Error When writing

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No effect 1b - Clears flag
10 —	Reserved
9-5 STEP_C	Step Of Algorithm C Indicates the step of self-test algorithm C in which an error occurred. Although this register field is read-only, no transfer error is generated when writing to it.
4-0 —	Reserved

57.6.2.57 Self-Test Status 2 (STSR2)

Offset

Register	Offset
STSR2	354h

Function

Contains the conversion result when an error in step 1 of algorithm S has occurred.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	DATA0														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
15 —	Reserved
14-0 DATA0	Conversion Data ERR_S1 Contains conversion data from the moment when the error in step 1 of algorithm S has occurred.

57.6.2.58 Self-Test Status 3 (STSR3)

Offset

Register	Offset
STSR3	358h

Function

Contains the conversion result when an error has occurred in step 2 or step 0 of algorithm S.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	DATA1														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	DATA0														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30-16 DATA1	Conversion Data ERR_S2 Contains conversion data from the moment when the error in step 2 of algorithm S has occurred.
15	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
14-0 DATA0	Conversion Data ERR_S0 Contains the conversion data from the moment when the error in step 0 of algorithm S has occurred.

57.6.2.59 Self-Test Status 4 (STSR4)

Offset

Register	Offset
STSR4	35Ch

Function

Contains the conversion result when an error has occurred in algorithm C.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	DATA1														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30-16 DATA1	Conversion Data ERR_C Conversion data from the moment when the error in algorithm C has occurred.
15-0 —	Reserved

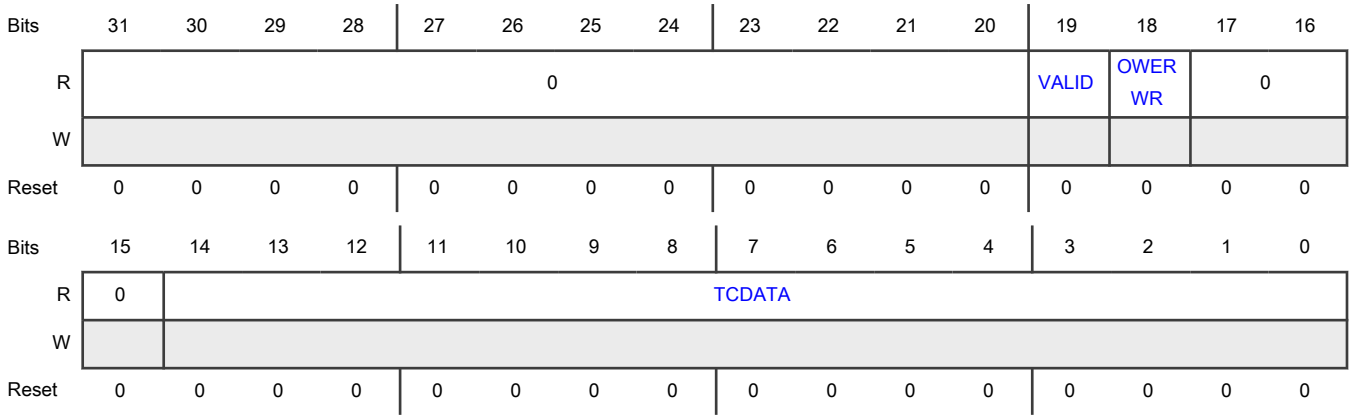
57.6.2.60 Self-Test Conversion Data 1 (STDR1)

Offset

Register	Offset
STDR1	370h

Function
Contains the result of the self-test conversion.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 VALID	Valid Conversion Data Indicates that conversion data is available in TCDATA. This field is automatically reset to 0 when the conversion data is read. 0b - No unread conversion data 1b - Unread conversion data is available
18 OWERWR	Conversion Data Overwrite Status Indicates whether the conversion data in TCDATA has been overwritten over previous data that had not been read. 0b - Current conversion data not overwritten 1b - Current conversion data was overwritten
17-16 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
15 —	Reserved
14-0 TCDATA	Test Channel Conversion Data Contains the conversion data from self-test. If overwrite is enabled (MCR[OWREN]=1), the conversion data is from the last-executed self-test conversion. When overwrite is not enabled, conversion data is available (not overwritten) until it is read by software. The conversion data in this register is in two's complement format.

57.6.2.61 Self-Test Analog Watchdog S0 (STAW0R)

Offset

Register	Offset
STAW0R	380h

Function

Configures self-test for step 0 of algorithm S.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	AWDE	WDTE	THRH													
W																
Reset	0	0	0	0	0	1	1	1	0	0	1	0	0	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	THRL														
W																
Reset	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	1

Fields

Field	Function
31 AWDE	Self-Test Watchdog Enable Enables the self-test watchdog for step 0 of algorithm S. 0b - Disable 1b - Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
30 WDTE	Self-Test Watchdog Timer Enable Enables the self-test watchdog timer for algorithm S. The self-test watchdog timer verifies: • Correct sequence of execution of the steps of the algorithm • Execution of the algorithm within the safe time period as defined by STBRR[WDT] This field must be 1 only in continuous conversion mode (MCR[MODE]=1). The safe time period starts when this field is written with 1. If the safe time period has elapsed before algorithm S starts, the WDTERR flag is set. The safe time period is restarted each time algorithm S starts. 0b - Disable 1b - Enable
29-16 THRH	Higher Threshold Value Sets the ERR_S0 flag when a self-test conversion value is greater than this value.
15 —	Reserved
14-0 THRL	Lower Threshold Value Sets the ERR_S0 flag when a self-test conversion value is less than this value.

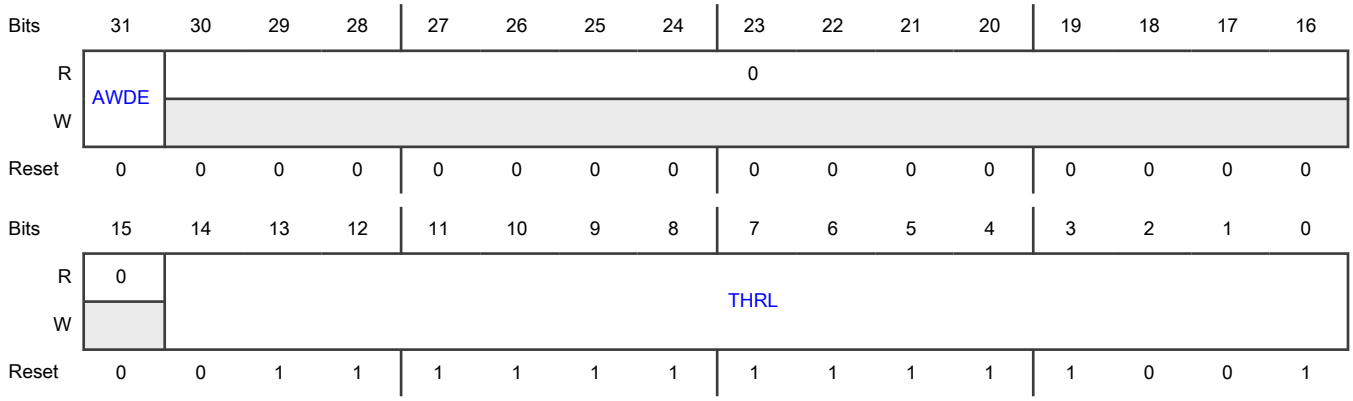
57.6.2.62 Self-Test Analog Watchdog S1 (STAW1R)

Offset

Register	Offset
STAW1R	388h

Function
Configures self-test for step 1 of algorithm S.

Diagram



Fields

Field	Function
31 AWDE	Self-Test Watchdog Enable Enables the self-test watchdog for step 1 of algorithm S. 0b - Disable 1b - Enable
30-16 —	Reserved
15 —	Reserved
14-0 THRL	Lower Threshold Value Sets the ERR_S1 flag when a self-test conversion value is less than this value.

57.6.2.63 Self-Test Analog Watchdog S2 (STAW2R)

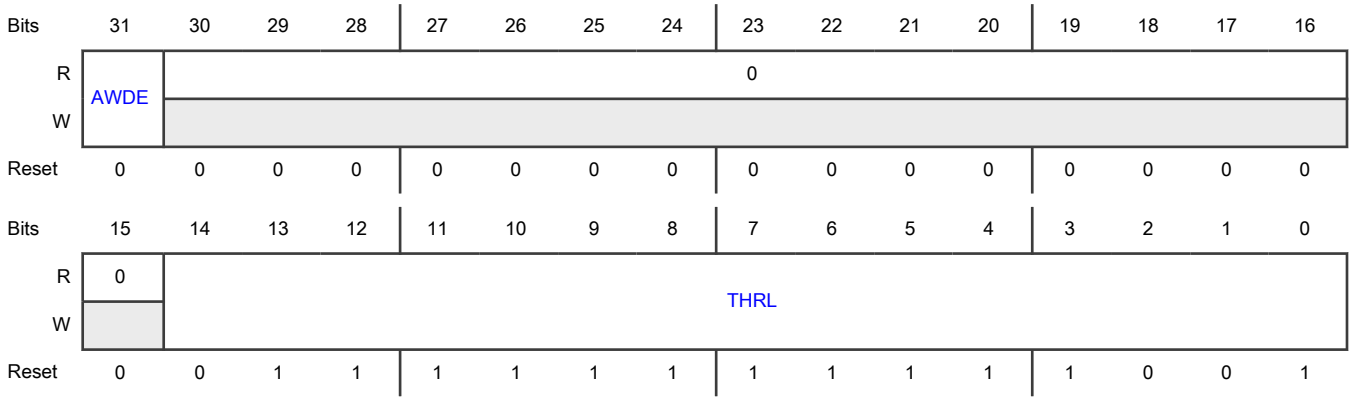
Offset

Register	Offset
STAW2R	38Ch

Function

Configures self-test for step 2 of algorithm S.

Diagram



Fields

Field	Function
31 AWDE	Self-Test Watchdog Enable Enables the self-test watchdog for step 2 of algorithm S. 0b - Disable 1b - Enable
30-16 —	Reserved
15 —	Reserved
14-0 THRL	Lower Threshold Value Sets the ERR_S2 flag when a self-test conversion value is less than this value.

57.6.2.64 Self-Test Analog Watchdog C0 (STAW4R)

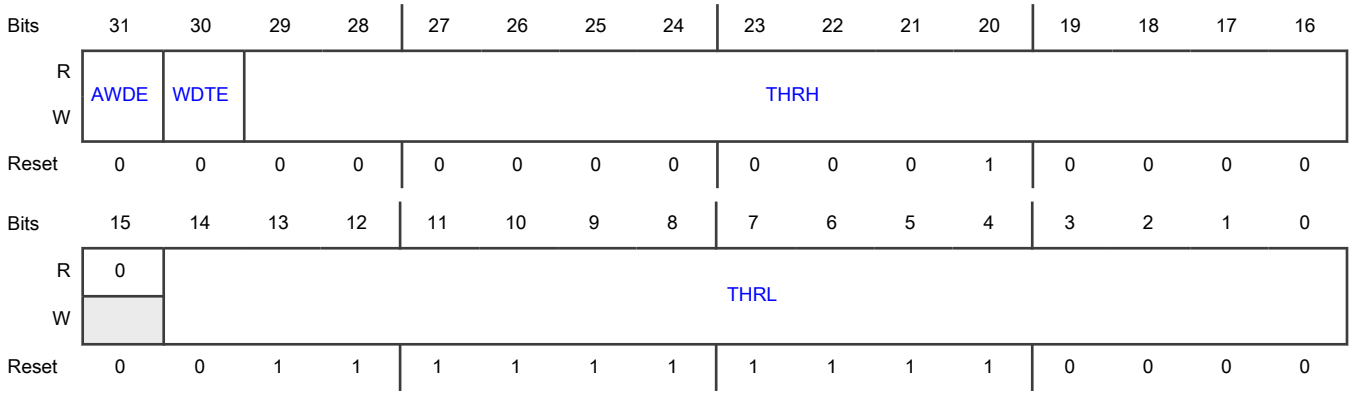
Offset

Register	Offset
STAW4R	394h

Function

Configures self-test for step 0 of algorithm C.

Diagram



Fields

Field	Function
31 AWDE	Self-Test Watchdog Enable Enables the self-test watchdog for algorithm C. 0b - Disable 1b - Enable
30 WDTE	Self-Test Watchdog Timer Enable Enables the self-test watchdog timer for algorithm C. The self-test watchdog timer verifies: • Correct sequence of execution of algorithm steps • Execution of the algorithm within the safe time period as defined by STBRR[WDT] This field must be 1 only in continuous conversion mode (MODE 1). The safe time period starts when this field is written with 1. If the safe time period elapses before algorithm C starts, the WDTERR flag is set. The safe time period is restarted each time algorithm C starts. 0b - Disable 1b - Enable
29-16 THRH	Higher Threshold Value Sets the ERR_C flag when a self-test conversion value is greater than this value. This value must be in two's complement format and must be positive. This value is valid only for step 0 of algorithm C (see STAW5R for the values used for the other steps of algorithm C).
15 —	Reserved
14-0 THRL	Lower Threshold Value

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Sets the ERR_C flag when a self-test conversion value is less than this value. This value must be in two's complement format and must be negative. (With the reset value of this bit field, the test always fails. You must set at least STAW4R[14]=1, in order to have a negative value in this bit field.) This value is used only for step 0 of algorithm C (see STAW5R for the values used for the other steps of algorithm C).

57.6.2.65 Self-Test Analog Watchdog C (STAW5R)

Offset

Register	Offset
STAW5R	398h

Function

Configures self-test for steps 1–11 of algorithm C.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	THRH														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	THRL														
W																
Reset	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0

Fields

Field	Function
31 —	Reserved
30-16 THRH	Higher Threshold Value Sets the ERR_C flag when a self-test conversion value is greater than this value. This value must be entered in two's complement format and must be positive. This value is valid only for steps 1–11 of algorithm C (see STAW4R for the value used for step 0 of algorithm C).

Table continues on the next page...

Table continued from the previous page...

Field	Function
15 —	Reserved
14-0 THRL	Lower Threshold Value Sets the ERR_C flag when a self-test conversion value is less than this value. This value must be in two's complement format and must be negative. This value is used only for steps 1–11 of algorithm C (see STAW4R for the value used for step 0 of algorithm C).

57.6.2.66 Analog Miscellaneous In/Out register (AMSIO)

Offset

Register	Offset
AMSIO	39Ch

Function

Configures the SAR algorithm compare step. In case you want to do a high-speed calibration or a high-speed conversion see Table 274. All other values in this register must stay at their reset value and may not be written.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0									Reserved		0	Reserved	HSEN		CMPCTRL0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				Reserved											
W																
Reset	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1

Fields

Field	Function
31-23 —	Reserved
22-21	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
20 —	Reserved
19 —	Reserved
18-17 HSEN	High-Speed Enable This setting must be adapted to the ADC clock frequency. See Table 274.
16 CMPCTRL0	Compare Control 0 This setting must be adapted to the ADC clock frequency. See Table 274.
15-12 —	Reserved
11-0 —	Reserved

57.6.2.67 Control And Calibration Status (CALBISTREG)

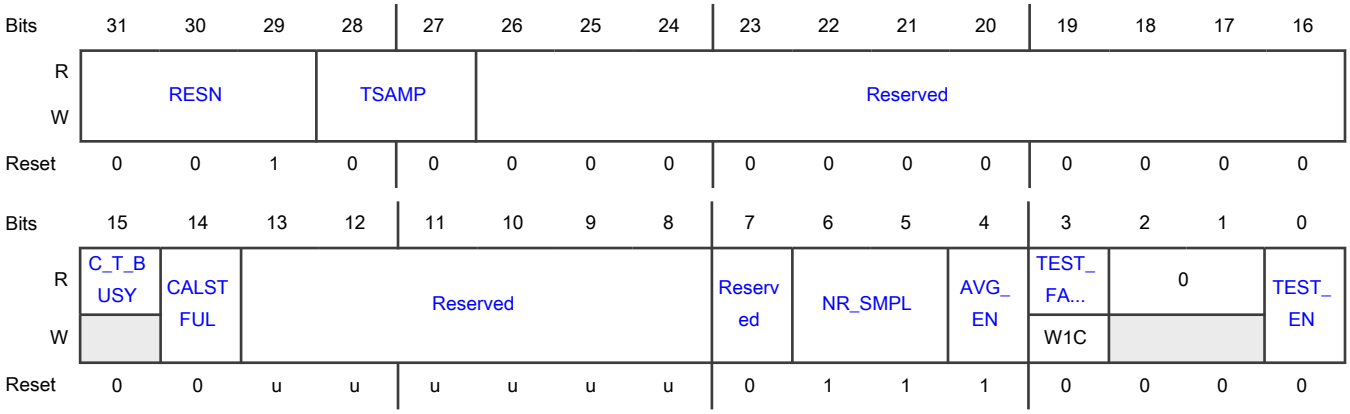
Offset

Register	Offset
CALBISTREG	3A0h

Function

Controls several ADC functions for data conversion, calibration, and calibration status.

Diagram



Fields

Field	Function
31-29 RESN	Conversion Resolution Specifies the number of significant bits per conversion data (functional conversion only, not for calibration or self-test). Reducing this number speeds up the conversion because the SAR algorithm executes fewer steps. This field must be modified only when ADC is idle. 000b - 14-bit resolution 001b - 12-bit resolution 010b - 10-bit resolution 011b - 8-bit resolution
28-27 TSAMP	Sample Period In Calibration Specifies the number of conversion clock cycles during which the reference voltage is sampled. 00b - 22 conversion clock cycles 01b - 8 conversion clock cycles 10b - 16 conversion clock cycles 11b - 32 conversion clock cycles
26-16 —	Reserved The value of this field must not be modified.
15 C_T_BUSY	Calibration Busy Indicates whether calibration is running. 0b - Calibration can be started 1b - Calibration is in progress
14 CALSTFUL	Calibration And Self-Test Full Range Comparison Specifies the range of conversion data bits compared when ADC is calibrated or running self-test. Because the results from calibration and self-test are so low that the significant bits are in the lower 11 bits only, the comparison cycles for the upper 4 bits can be skipped to reduce the execution duration of the calibration and of the self-test. 0b - Lowest 11 bits are compared. 1b - All 15 bits are compared.
13-8 —	Reserved **CAUTION** This field contains a value that ADC uses internally. Writing to this field can cause ADC to operate unreliably.
7 —	Reserved This field is reserved and always has the value 0. Only the reset value can be written to this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
6-5 NR_SMPL	Calibration Averaging Number Specifies the number of data conversions per result (averaging) during calibration. 00b - 4 samples 01b - 8 samples 10b - 16 samples 11b - 32 samples
4 AVG_EN	Calibration Averaging Enable Enables averaging of the calibration results over several conversion iterations to improve accuracy. This field only affects the calibration process. 0b - Disable 1b - Enable
3 TEST_FAIL	Calibration Status Indicates calibration status. This field reads 0 when calibration is in progress. This field is reset to 0 when calibration starts. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Calibration finished successfully or has not been run since the last reset 1b - Calibration did not finish successfully When writing 0b - No effect 1b - Clears flag
2-1 —	Reserved
0 TEST_EN	Calibration Enable Calibrates ADC. This field automatically resets to 0 after the calibration is complete or is interrupted. 0b - Wait to start a calibration 1b - Start calibration

57.6.2.68 Offset And Gain User (OFSGNUSR)

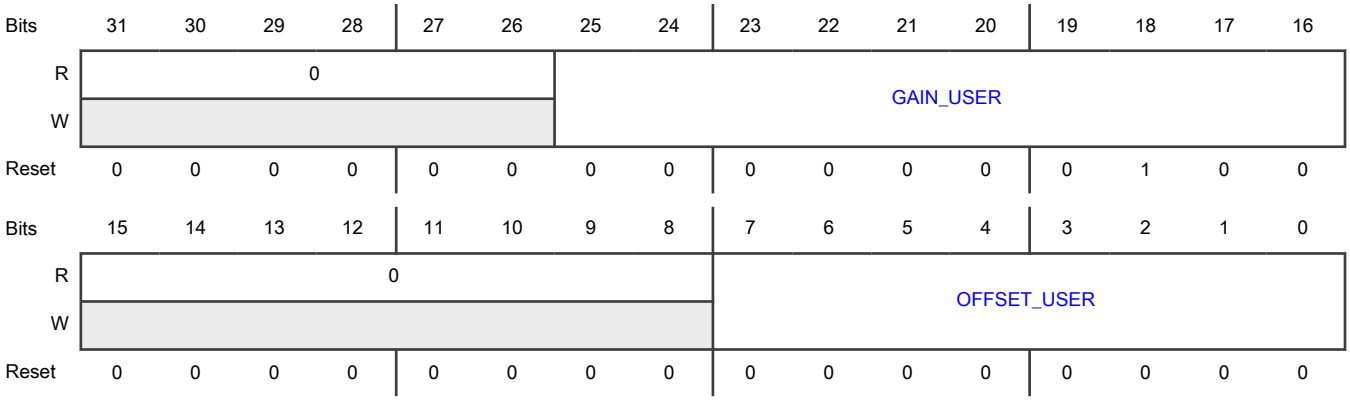
Offset

Register	Offset
OFSGNUSR	3A8h

Function

Specifies the user-configured offset and gain values used by the SAR algorithm. The values must be written in two's complement format and can be either positive or negative.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-16 GAIN_USER	Gain User Adds extra gain to the gain calculated during calibration. The value must be in two's complement format.
15-8 —	Reserved
7-0 OFFSET_USER	Offset User Adds extra offset to the offset calculated by calibration. The value is must be in two's complement format.

57.6.2.69 Calibration Value 2 (CAL2)

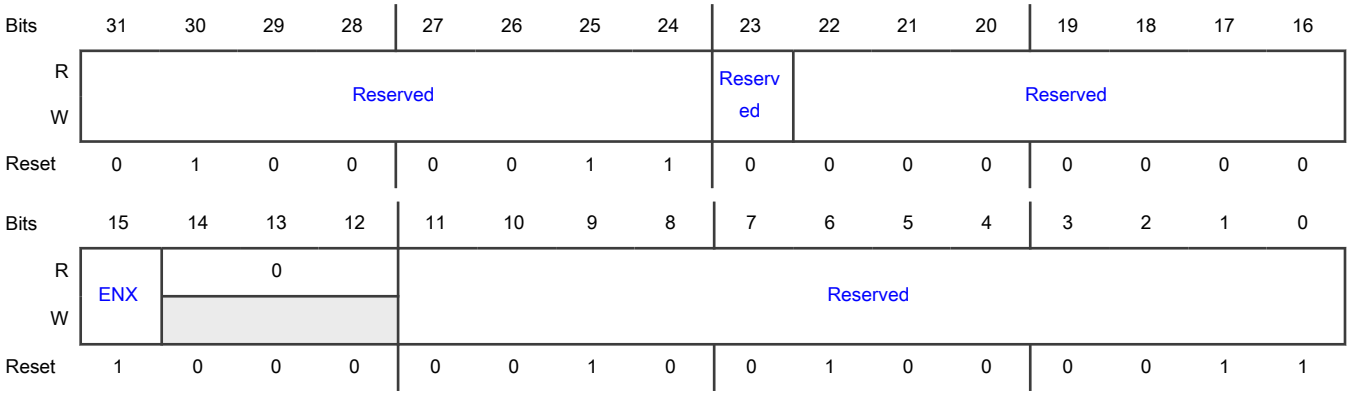
Offset

Register	Offset
CAL2	3B4h

Function

Contains fields used during calibration.

Diagram



Fields

Field	Function
31-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 ENX	Enable X Enables the inclusion of CLPX in error processing. 0b - Disable 1b - Enable
14-12 —	Reserved
11-0 —	Reserved

57.7 Glossary

CDAC	Capacitive digital to analog converter
CT	Compare phase time
DMA	Direct memory access
DP	Data processing time

PST	Presample phase time
ST	Sample phase time
SAR	Successive approximation
TPT	Trigger processing time
VrefH	Reference voltage high
VrefL	Reference voltage low

Chapter 58
SIGMA DELTA ANALOG TO DIGITAL CONVERTER (SDADC)

58.1 Chip-specific SDADC information

58.1.1 SDADC instances

This chip has 4 instances of SDADC:

- SDADC_0
- SDADC_1
- SDADC_2[5]
- SDADC_3[5]

NOTE

On die, vcom0_hv is shorted to VREFH and vcom1_hv to VREFL. Vcom2_hv is generated by BIASGEN as (VREFH+VREFL)/2.

58.1.2 Hardware Trigger interface

Table describes the mapping of trigger sources from different motor control IP instances to SDADC hardware trigger interface.

Table 280. Hardware Trigger interface of SDADC

To instance	From instance
SD_ADC0 .Hardware trigger [0]	Software Trigger port for SDADC 0
SD_ADC0. Hardware trigger [1]	Software Trigger port for SDADC 1
SD_ADC0. Hardware trigger [2]	Software Trigger port for SDADC 2
SD_ADC0. Hardware trigger [3]	Software Trigger port for SDADC 3
SD_ADC0. Hardware trigger [4]	TRGMUX output port index 28
SD_ADC0. Hardware trigger [5]	ETPU engine 1 [20]
SD_ADC0. Hardware trigger [6]	ETPU Engine 1[21]
SD_ADC0. Hardware trigger [7]	ETPU Engine 2[20]
SD_ADC0. Hardware trigger [8]	ETPU Engine 2[21]
SD_ADC1 .Hardware trigger [0]	Software Trigger port for SDADC 0
SD_ADC1. Hardware trigger [1]	Software Trigger port for SDADC 1
SD_ADC1. Hardware trigger [2]	Software Trigger port for SDADC 2
SD_ADC1. Hardware trigger [3]	Software Trigger port for SDADC 3
SD_ADC1. Hardware trigger [4]	TRGMUX output port 32

Table continues on the next page...

[5] SDADC_2/SDADC_3 are not available in S32K36x.

Table 280. Hardware Trigger interface of SDADC (continued)

To instance	From instance
SD_ADC1. Hardware trigger [5]	ETPU engine 1 [22]
SD_ADC1. Hardware trigger [6]	ETPU Engine 1[23]
SD_ADC1. Hardware trigger [7]	ETPU Engine 2[22]
SD_ADC1. Hardware trigger [8]	ETPU Engine 2[23]
SD_ADC2 .Hardware trigger [0]	Software Trigger port for SDADC 0
SD_ADC2. Hardware trigger [1]	Software Trigger port for SDADC 1
SD_ADC2. Hardware trigger [2]	Software Trigger port for SDADC 2
SD_ADC2. Hardware trigger [3]	Software Trigger port for SDADC 3
SD_ADC2. Hardware trigger [4]	TRGMUX output port 36
SD_ADC2. Hardware trigger [5]	ETPU engine 1 [24]
SD_ADC2. Hardware trigger [6]	ETPU Engine 1[25]
SD_ADC2. Hardware trigger [7]	ETPU Engine 2[24]
SD_ADC2. Hardware trigger [8]	ETPU Engine 2[25]
SD_ADC3 .Hardware trigger [0]	Software Trigger port for SDADC 0
SD_ADC3. Hardware trigger [1]	Software Trigger port for SDADC 1
SD_ADC3. Hardware trigger [2]	Software Trigger port for SDADC 2
SD_ADC3. Hardware trigger [3]	Software Trigger port for SDADC 3
SD_ADC3. Hardware trigger [4]	TRGMUX output port 40
SD_ADC3. Hardware trigger [5]	ETPU engine 1 [26]
SD_ADC3. Hardware trigger [6]	ETPU Engine 1[27]
SD_ADC3. Hardware trigger [7]	ETPU Engine 2[26]
SD_ADC3. Hardware trigger [8]	ETPU Engine 2[27]

58.2 Overview

SDADC digital interface block controls the on-chip SDADC and holds control and status registers accessible for application.

SDADC provides the output data at a rate of 4fs ÷ OSR and FIR compensation filter performs the decimation of 4 in DSP Core.

Figure 289 depicts the block diagram of SDADC and its digital control block. SDADC digital interface block provides all control information for operating mode selection (single-ended or differential), analog input gain, decimation rate, etc. It also generates the bias controls for common mode voltage selection, to bias the positive and negative terminals to different voltage levels (for example, half scale bias, reference ground, reference supply) for diagnostics. It generates the analog multiplexer control signals for the selected channels. It also provides external modulator support and keeps the internal modulator in low consumption mode. To assist synchronous operation across multiple ADC blocks, hardware trigger support is implemented to start data conversion.

58.2.1 Block diagram

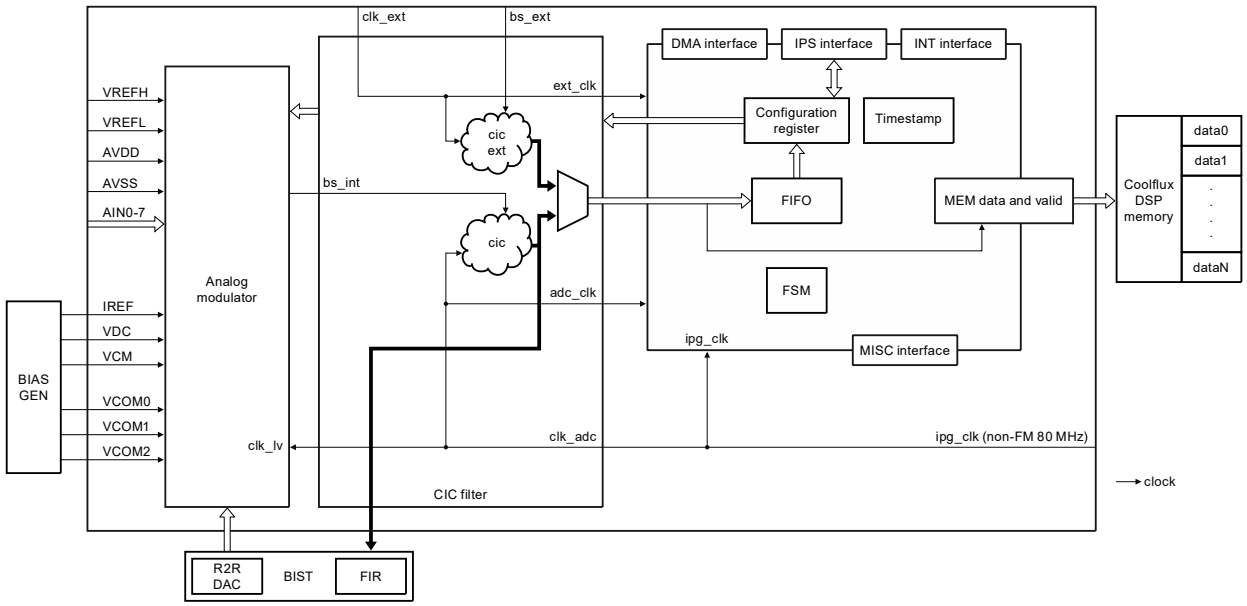


Figure 289. Block diagram

58.2.2 Features

- Sampling frequency (fs) is 40 MHz.
- 16-bit data resolution output.
- Single-ended input or differential input mode of operation.
- Programmable wraparound mechanism for both modes of operation:
  - Configurable trigger sources:hardware or software
  - Configurable initial entry and wraparound values for the loop
- Configurable biasing for negative input terminal in single ended mode.
- Gain and offset calibration support using fixed bias for input terminals.
- Programmable decimation rate.
- Programmable gain for analog inputs.
- External modulator support.
- Hardware trigger support for synchronous operation of multiple SDADC blocks.
- Trigger event output generation by software.
- Signed/Unsigned format of converted data output.
- Interrupt/DMA request generation based on various conditions:
  - Data buffer above the threshold
  - Data buffer overrun for interrupt only
  - WDG crossover event
- Programmable threshold range WDG support.
- Low power consumption mode.
- Optional conversion process halt mechanism on SoC debug request.

58.3 Functional description

58.3.1 Modes of operation

SDADC describes the different modes of operation. When exiting reset, the mode of operation is determined by Module Configuration Register (MCR).

- Low power consumption mode
- Differential input mode
- Single-ended input mode
- Input channel bias support mode (AC coupling mode)
- External modulator mode
- Wraparound mode
- 20 MHz sampling rate mode

58.3.2 Description of Modes

SDADC supports many modes. The description of each mode is given below.

58.3.2.1 Low power consumption mode

This is the default mode after exiting from reset. This mode is exited by asserting MCR[BIASGEN_EN] first then asserting MCR[EN] to enable SDADC block. The software should wait after enabling biasgen to stabilized bias supply to SDADC. When data conversion is not required, SDADC internal modulator can be put in low consumption mode by deasserting MCR[EN] to disable to reduce power consumption. Then deassert MCR[BIASGEN_EN] to disable. Since biasgen supports multiple SDADC, it is only disabled when MCR[BIASGEN_EN] is disabled in all SDADCs.

58.3.2.2 Differential input mode

After system reset exit, this is the default mode of operation if SDADC is enabled by asserting MCR[EN]. This mode is entered by negating MCR[MODE]. In differential input mode, a pair of analog inputs among AN[0:7] is connected to the input terminals of SDADC modulator block. The module supports four differential pairs: AN[0,1], AN[2,3], AN[4,5], and AN[6,7].

The modulator block has two input terminals, positive (INP) and negative (INM). The selection of input pair depends on CSR[ANCHSEL]. The connectivity of each analog input in a given differential pair, whether it is connected to positive or negative terminal, is determined according to Table 281.

The differential input mode can also be used to perform gain and offset calibration, where the input terminals are biased with fixed voltages coming from the bias block.

58.3.2.3 Single-ended input mode

Single-ended input mode is entered by asserting MCR[MODE]. In this mode, one of the analog inputs among AN[0:7] is selected by CSR[ANCHSEL], and is connected to the positive terminal. The negative input terminal is biased with a fixed internal voltage. There are three internal bias voltages available: vcom0, vcom1 and vcom2. The selection of this common mode voltage is controlled by MCR[VCOMSEL].

58.3.2.4 Input channel bias support mode (AC coupling mode)

The complete selection and connectivity of analog inputs AN[7:0] is based on CSR[ANCHSEL], MCR[MODE] and MCR[VCOMSEL], see Table 281. Each analog input can be biased to half scale (AVDD/2) via on-chip 100 kohm resistance. This allows simple AC coupling to the external analog inputs through a capacitor. This biasing is applicable irrespective of whether analog channel is selected through multiplexer or not. This mode should be enabled by asserting MCR.ENBIAS[7:0] corresponding to each channel. By default, the IP is in DC coupling mode (i.e. no biasing to the input channel).

58.3.2.5 External modulator mode

This mode is selected by asserting MCR[EMSEL]. In this mode, the data stream and clock outputs from the external modulator available on EMDATA/EMCLK input pins are multiplexed with internal modulator data output and input sampling clock. External modulator data must be synchronized with respect to the falling edge of EMCLK. In this mode, hardware trigger input is ignored even if it is enabled by asserting MCR[TRIGEN]. All other configuration settings (for example gain, decimation rate, filter, etc.) programmed in MCR have no effect on the conversion.

58.3.2.6 Wraparound mode

Incremented channel is converted upon receiving of trigger and it wraparounds to 0th channel after channel specified in CSR[ANCHSEL_WRAP]. Initial entry value for the first loop is selected by CSR[ANCHSEL]. Thereafter loop starts from '0'.

NOTE

Any conversion on non-existing/unconnected channel due to wraparound mode/any trigger may result into unknown data. Ignore data corresponding to non-existing/unconnected channel. See chip-specific SDADC chapter for the list of non-existing/unconnected channels.

In wraparound control mode, hardware and software triggers are equally valid. The hardware trigger source should be selected before enabling the wraparound mode.

Wraparound Control Mechanism: Wrap-around logic shall include all analog channels of the input multiplexer from 000") to CSR[ANCHSEL_WRAP] in both single ended and differential ended mode in wraparound sequence triggered by hardware or software source:

- MCR[WRMODE] would enable or disable the wraparound mechanism. Clearing MCR[WRMODE] automatically switches FSM back to software control mode.
- Every valid trigger advances the wraparound counter to next channel to be converted.
- Wraparound Counter: An internal wraparound counter which points to analog channel to be converted takes the initial entry value for the first loop of execution from CSR[ANCHSEL] while entering wraparound mode. From next loop onwards the counter wraparounds to default initial value '000'. Maximum value of the counter (wraparound value) should be programmed in CSR[ANCHSEL_WRAP] before entering wraparound mode, definition of CSR[ANCHSEL] and CSR[ANCHSEL_WRAP] is provided in Table 281, Analog input AN[0:7] selection.
- Upon entering or during wraparound mode user should take care to program CSR[ANCHSEL] value is less than CSR[ANCHSEL_WRAP] value.
- Possible trigger sources:
  - SOURCE1 (Software Bit): writing to RKR[RESET_KEY] at any time during the wraparound mode (irrespective of MCR[TRIGEN] or MCR[TRIGSEL] setting) generates a trigger pulse, each such trigger initiates a fresh conversion and advances the wraparound counter by one.

    NOTE

    Care should be taken while programming the TRIGEN/TRIGSEL of each SDADC instance that no unintended simultaneous SW triggering of multiple instances happen.

  - SOURCE2 (Hardware Trigger): Here external trigger output (for e.g., mux_advance of GTM) enabled by MCR[TRIGEN] or MCR[TRIGEDSEL] or MCR[TRIGSEL] before entering wraparound mode for selective or all SDADC instances provides trigger, each such valid trigger initiates a fresh conversion and advances the wraparound counter by one. One of the hw_trig_in ports can be used to connect the external trigger output.
- Next channel number to be converted can be updated by software even in the middle of wraparound sequence execution, this can be done by rewriting CSR[ANCHSEL]. After CSR[ANCHSEL] is rewritten, the next trigger takes updated value (wraparound counter would increment from the updated value).
- Current wraparound counter value can be read from SFR[ANCHSEL_CNT].

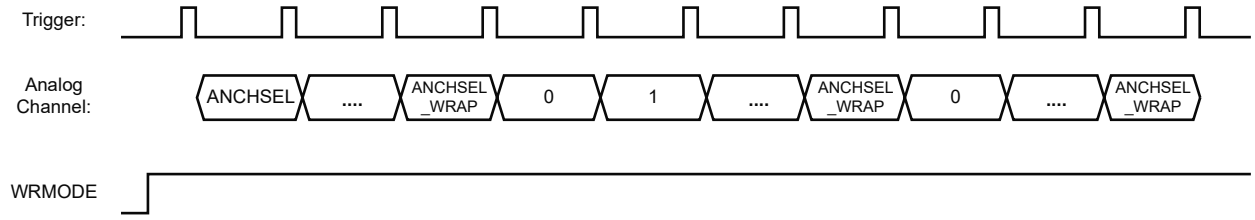


Figure 290. Wraparound Mode

58.3.2.7 20 MHz sampling rate mode

SDADC modulator can be run with 20 MHz sampling rate. For 20 MHz sampling rate mode, set CCR[CCR_B1_IPS_EN] = 1, then program CCR[OSR_HALF] = 1 and CCR[EN_CLK_RATE_HALF] = 1 in initialization sequence.

58.3.3 SDADC Channel Selection

This is analog channel selection table of SDADC.

Table 281. SDADC channel selection

MCR[MODE]	MCR[VCOMSEL]	CSR[ANCHSEL]	INP (positive terminal)	INM (negative terminal)
0	xx	000	AN[0]	AN[1]
		001	AN[2]	AN[3]
		010	AN[4]	AN[5]
		011	AN[6]	AN[7]
		100	vcom1_hv	vcom1_hv
		101	vcom2_hv	vcom2_hv
		110	vrefp	vrefn
		111	vrefn	vrefp
1	00	000	AN[0]	vcom0_hv
		001	AN[1]	vcom0_hv
		010	AN[2]	vcom0_hv
		011	AN[3]	vcom0_hv
		100	AN[4]	vcom0_hv
		101	AN[5]	vcom0_hv
		110	AN[6]	vcom0_hv

Table continues on the next page...

Table 281. SDADC channel selection (continued)

MCR[MODE]	MCR[VCOMSEL]	CSR[ANCHSEL]	INP (positive terminal)	INM (negative terminal)
		111	AN[7]	vcom0_hv
1	01	000	AN[0]	vcom1_hv
		001	AN[1]	vcom1_hv
		010	AN[2]	vcom1_hv
		011	AN[3]	vcom1_hv
		100	AN[4]	vcom1_hv
		101	AN[5]	vcom1_hv
		110	AN[6]	vcom1_hv
		111	AN[7]	vcom1_hv
1	10	000	AN[0]	vcom2_hv
		001	AN[1]	vcom2_hv
		010	AN[2]	vcom2_hv
		011	AN[3]	vcom2_hv
		100	AN[4]	vcom2_hv
		101	AN[5]	vcom2_hv
		110	AN[6]	vcom2_hv
		111	AN[7]	vcom2_hv
1	11	000	AN[0]	vcom0_hv
		001	AN[1]	vcom0_hv
		010	AN[2]	vcom0_hv
		011	AN[3]	vcom0_hv
		100	AN[4]	vcom0_hv
		101	AN[5]	vcom0_hv
		110	AN[6]	vcom0_hv
		111	AN[7]	vcom0_hv

58.3.4 Programmable decimation rate

SDADC is provided with a fixed input sampling clock of frequency fs. The input signal is grossly oversampled by the modulator in order to reduce quantization noise. To support different passbands with a fixed sampling clock, a programmable decimation rate is implemented. The process of decimation, to eliminate redundant data at the output while retaining the necessary information, is controlled by MCR[PDR].

58.3.5 Programmable gain

All analog inputs can be configured to have a selectable input gain as defined in MCR[PGAN]. This means that the input signal is sampled and the result is amplified by the factor determined by PGAN before providing the same to modulator.

58.3.6 Data conversion

Software Control Mechanism: SDADC block is in continuous conversion mode as soon as it is enabled. The conversion data is not accurate enough for some time, depending on the latency and output settling time specifications. This is true even when there is any change in the configuration settings provided by MCR, change in the analog channel selection due to mux switching time. To account for these delays, an internal timer is implemented which counts down from a start value determined by OSDR[OSD]. This timer is reloaded whenever RKR[RESET_KEY] is written with 5AF0h, which is required to start SDADC conversion from a fresh state with a changed configuration. The timer is stalled on reaching count '0' and asserts SFR[CDVF]. Once this flag is asserted, converted data is loaded into data FIFO at output data rate (fd).

Any write access to Module Configuration Register (MCR) and Channel Selection Register (CSR) deasserts SFR[CDVF] to indicate that the data coming from SDADC is not valid or corrupted. If SFR[CDVF] is reset, SFR[DFFF] and SFR[DFORF] are blocked from becoming asserted, i.e. transitioning from inactive state to active state. If SFR[DFFF] is already set, this means that the data FIFO is already full before SFR[CDVF] deassertion.

SFR[DFFF] (which not conditioned by the interrupt or DMA selection) is provided outside which can be routed to timer module at SoC level.

FIFO Flush Option: This option allows to clear FIFO content and re-initialize FIFO pointers before carrying out next set of conversion after reconfiguring the channel and conversion configuration parameters (Gain, Channel no. e.t.c). This can be done by providing a functional reset by setting FCR[FRST].

This allows to clear the stale unread data corresponding to previous conversion and starting afresh from new channel configuration.

58.3.7 Hardware triggering

Software Control Mechanism: SDADC conversion can be triggered by various hardware events coming from either external pins or internal timers. MCR[TRIGSEL] selects which hardware event is to be used for triggering conversions. This trigger event, which is synchronous to the peripheral clock, is enabled by asserting MCR[TRIGEN]. As soon as a trigger event is detected, reset input of SDADC block is asserted synchronously for four cycles. This ensures that SDADC starts from a fresh state when reacting to the input trigger event. SDADC internal modulator must be enabled before enabling the trigger event otherwise the trigger event is ignored. A hardware trigger event is also ignored when external modulator is selected (MCR[EMSEL] = 1).

If the same trigger event is provided to multiple SDADC digital interface modules and the respective enable controls (MCR[TRIGEN]) are asserted, synchronous operation of multiple SDADC blocks can be achieved with output results being updated at the same time. Once the reset input is deasserted, the first valid conversion output is stored in data FIFO after a configurable delay determined by OSDR[OSD].

It is also possible to generate a software trigger event output by a write access of Software Trigger Key Register (STKR) with a predefined key. This event output can be used as a trigger to achieve synchronous software start of multiple SDADC blocks.

In case of a hardware trigger, It should be synchronous to ADC clock. It is more than one ADC clock cycle due to synchronization. In case of a software trigger, all SDADCs start synchronous sampling.

58.3.8 Interrupt/DMA request support

SDADC has one condition that generates interrupts only and another that generates interrupts or DMA request.

SFR[DFFF] is asserted when the data FIFO full condition is detected, indicating that the number of converted datawords stored in data FIFO is greater than the value indicated by threshold determined by FCR[FTHLD]. The interrupt or DMA request is generated only when RSER[DFFDIRE] is asserted. RSER[DFFDIRS] selects whether a DMA request or an interrupt request is generated.

SFR[DFORF] indicates FIFO overflow condition. Further converted datawords cannot be received and data is lost. The interrupt request is generated only when RSER[DFORIE] is asserted.

Apart from above, a WDG threshold crossover event can also generate an interrupt or DMA request.

58.3.9 Gain and offset calibration

SoC/software should perform gain and offset calibration on final data using following methods:

NOTE

Offset and gain calibration needs to be performed at every power cycle.

58.3.9.1 Gain calculation

- Write 1 to MCR[BIASGEN_EN] to enable BIASGEN and 1 to MCR[VCOM2EN] to enable common mode output.
- Write 0 to MCR[MODE] to enable differential mode.
- Write 1 to MCR[ODF].
- Program channel ANCHSEL = b110.
- Configure OSDR[OSD] > 4.
- Write 1 to MCR[EN] to enable SDADC.
- Write 5AF0h to RKR[RESET_KEY] to generate a reset event.
- Read CDR. Take multiple readings and calculate the average output.
  - Average output is Dmax.
- Write 0 to MCR[EN] to disable SDADC.
- Program channel ANCHSEL = b111.
- Write 1 to MCR[EN] to enable SDADC.
- Write 5AF0h to RKR[RESET_KEY] to generate a trigger event.
- Read CDR. Take multiple readings and calculate the average output.
  - Average output is Dmin.
- Gain = (Dmax-Dmin)/65536.

NOTE

Data output from SDADC is in 2'complement form. So this calculation should take care of signed arithmetic.

58.3.9.2 Offset error calculation

- Write 1 to MCR[BIASGEN_EN] to enable BIASGEN and 1 to MCR[VCOM2EN] to enable common mode output.
- Write 0 to MCR[MODE] to enable differential mode.
- Write 1 to MCR[ODF].
- Program channel ANCHSEL = b100 or b101.
- Configure OSDR[OSD] > 4.
- Write 1 to MCR[EN] to enable SDADC.
- Write 5AF0h to RKR[RESET_KEY] to generate a trigger event.

- Read CDR. Take multiple readings and calculate the average output.
  - Average output is Doffset.
- Offset Error (OFS) is Doffset.

58.3.9.3 Data calculation after gain and offset calibration

Calculate the final data:

- Dadj = (Dout-OFS)/Gain

58.3.10 Clocking

SDADC has the following clock.

Clock	Description
MODULE_CLK	This clock is used for system bus, CIC filter, SD modulator. This should be kept at 80 MHz non-FM clock. This clock is also known as IPG_CLK.

58.3.11 Reset

SDADC has the following reset signal.

Reset Signal	Description
MODULE_RESETB (ipg_hard_async_reset_b)	This is active low reset with asynchronous assertion and synchronous de-assertion. It is used to reset all digital content in SDADC.

58.4 Initialization information

To initialize SDADC for data conversion, the following sequence is required.

1. Configure MCR to select the required mode, polarity, common mode voltage, input gain, and decimation rate.
   - Write 1 to MCR[BIASGEN_EN] to enable biasgen before SDADC enables MCR[EN].
2. Select the required analog channel for data conversion. It is possible to select the bias for each channel for AC coupling applications.
3. Configure OSD delay according to SDADC startup time or latency from reset exit.
4. Program FIFO threshold FCR[FTHLD] and enable FIFO FCR[FE].
5. Program Request Select and Enable Register (RSER) for DMA/Interrupt request.
6. Enable SDADC by asserting MCR[EN].
7. Write 5AF0h to RKR[RESET_KEY] to generate a trigger event. Otherwise, if data conversion need to be triggered by a hardware event, assert MCR[TRIGEN].
8. DFFF interrupt or DMA request is generated after the data FIFO has reached threshold to indicate that data can be transferred or Wait until SFR[DFFF] is clear.
9. Read data by CDR[CDATA].

Follow the sequence when external modulator mode of SDADC is selected for data conversions.

1. Configure and program MCR to select the external modulator mode.
2. Program FIFO threshold FCR[FTHLD] and enable FIFO FCR[FE].
3. Program Request Select and Enable Register (RSER) for DMA/Interrupt request.
4. Enable SDADC using MCR[EN].
5. Select the required external pins EMDATA/EMCLK in the system integration logic (SIUL) of the device.
   - Start EMCLK clock only after above steps are complete.
6. Configure OSD delay according to external modulator startup time or latency from reset exit.
7. External modulator clock should get enabled only when external modulator selection is done.
8. Write 5AF0h to RKR[RESET_KEY] to generate a reset event.
9. DFFF interrupt or DMA request is generated after the data FIFO has reached threshold to indicate that data can be transferred or wait until SFR[DFFF] is clear.
10. Read data by CDR[CDATA].

58.5 SDADC register descriptions

This section provides the descriptions of all registers used for configuring SDADC.

NOTE

Write to read-only register does not generate a transfer error.

58.5.1 SDADC memory map

Calculates register addresses by adding register offset plus SDADC base address. Use 8-bit, 16-bit, or 32-bit addressing to access registers.

SDADC_0 base address: 406F_4000h

SDADC_1 base address: 406F_8000h

SDADC_2 base address: 406F_C000h

SDADC_3 base address: 4070_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration Register (MCR)	32	RW	0000_0000h
4h	Channel Selection Register (CSR)	32	RW	0000_0000h
8h	Reset Key Register (RKR)	32	RW	0000_A50Fh
Ch	Status Flag Register (SFR)	32	RW	0000_0100h
10h	Request Select and Enable Register (RSER)	32	RW	0000_0000h
14h	Output Settling Delay Register (OSDR)	32	RW	0000_0000h
18h	FIFO Control Register (FCR)	32	RW	0000_0006h
1Ch	Software Trigger Key Register (STKR)	32	RW	0000_0000h
20h	Converted Data Register (CDR)	32	R	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
24h	WDG Threshold Register (WTHHLR)	32	RW	0000_0000h
28h	CIC Configuration Register (CCR)	32	RW	0400_0011h
30h	Test Configuration Register (TCR)	32	RW	0000_0008h

58.5.2 Module Configuration Register (MCR)

Offset

Register	Offset
MCR	0h

Function

Consists of different control bits to select the operating modes and various configuration settings which define the behavior of SDADC block.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BIASGEN...	0			PDR				0	0	PGAN		ODF	0	EMSEL	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	WDGEN	TRIGEDSEL		TRIGEN	TRIGSEL				FRZ	VCOM2EN	VCOMSEL		WRMODE	0	MODE	EN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 BIASGEN_EN	BIAS Generator Enable Enables/ disables the BIAS Generator 0b - Disable 1b - Enable
30-29 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
28-24 PDR	Programmable Decimation Rate Selects the over-sampling ratio to be applied to support different passbands with a fixed input sampling clock. The final output data rate (fd) of SDADC is equal to fs/(OSR), where fs is the input sampling clock frequency. The decimation of OSR/4 is done by CIC filter and the decimation of 4 is done by FIR compensation filter. When external modulator is selected, the output data rate is independent of this field and is fixed to fs_ext/128. 0_0000b - OSR = 120 0_0001b - OSR = 140 0_0010b - OSR = 160 0_0011b - OSR = 180 0_0100b - OSR = 200 0_0101b - OSR = 220 0_0110b - OSR = 240 0_0111b - OSR = 280 0_1000b - OSR = 320 0_1001b - OSR = 360 0_1010b - OSR = 376 0_1011b - OSR = 400 0_1100b - OSR = 440 0_1101b - OSR = 480 0_1110b - OSR = 560 0_1111b - OSR = 640 1_0000b - OSR = 720 1_0001b - OSR = 800 1_0010b - OSR = 880 1_0011b - OSR = 960 1_0100b - OSR = 1120 1_0101b - OSR = 1280 1_0110b - OSR = 125. This is special case. Here CIC decimation rate is 25 and FIR is suppose to do decimation by 5. 1_0111b - Reserved 1_1111b - Reserved
23 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
22 —	Reserved
21-20 PGAN	Programmable Gain Selects the gain to be applied to the analog input stage of SDADC. The effective analog input becomes the input voltage level multiplied by the gain factor. 00b - Gain = 1 01b - Gain = 2 10b - Gain = 4 11b - Gain = 8
19 ODF	Output Data Format Controls the output data in CDR. 0b - Output data is unsigned. Data in CDR represents magnitude only i.e. 16th bit (MSB) is always 0. 1b - Output data is signed and sign extended to 16 bits
18 —	Reserved
17 EMSEL	External Modulator Selection Selects data and clock from external modulator. 0b - External modulator data and clock inputs are ignored 1b - External modulator data stream and clock inputs are provided to SDADC
16 —	Reserved
15 WDGEN	Watchdog Enable Enables the WDG monitor. 0b - Disable 1b - Enable
14-13 TRIGEDSEL	Trigger Edge Selection Selects the edge of hardware trigger. 00b - Falling edge of trigger input is selected 01b - Rising edge of trigger input is selected 10b - Both edges of trigger input are selected 11b - Both edges of trigger input are selected

Table continues on the next page...

Table continued from the previous page...

Field	Function
12 TRIGEN	Trigger Enable Enables the hardware trigger input to initiate a fresh conversion. Upon receiving a trigger event, SDADC reset input is asserted and deasserted synchronously with respect to the peripheral clock. The reset pulse width is fixed to four peripheral clock cycles. The trigger event is ignored if SDADC internal modulator is not enabled (MCR[EN] = 0) or the external modulator is selected (MCR[EMSEL] = 1). 0b - Disable 1b - Enable
11-8 TRIGSEL	Trigger Input Selection Selects which input is used for hardware-triggered conversions. 0000b - Input trigger 0 is selected 0001b - Input trigger 1 is selected 0010b - Input trigger 2 is selected 0011b - Input trigger 3 is selected 0100b - Input trigger 4 is selected 0101b - Input trigger 5 is selected 0110b - Input trigger 6 is selected 0111b - Input trigger 7 is selected 1000b - Input trigger 8 is selected 1001b - Reserved 1010b - Reserved 1011b - Reserved 1100b - Reserved 1101b - Reserved 1110b - Reserved 1111b - Reserved
7 FRZ	Freeze Enables stopping SDADC conversions at the end of the current channel conversion when the SoC enters debug mode. When the SoC enters debug mode, further conversions by SDADC analog block is stopped, and converted data output from SDADC analog block are ignored. The ongoing channel conversion is completed and the converted data is stored. When the SoC exits debug mode, user must resume the conversion by writing in to RKR register. 0b - Conversions are not stopped. 1b - Conversions are stopped.
6 VCOM2EN	Common Mode Voltage Enable Enables/ disables common mode voltage output in BIASGEN.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
5-4 VCOMSEL	Common Voltage Bias Selection Selects the common voltage bias for the negative input terminal of SDADC during single-ended mode (MCR[MODE] = 1). 00b - Negative input terminal is biased with vcom0_hv 01b - Negative input terminal is biased with vcom1_hv 10b - Negative input terminal is biased with vcom2_hv 11b - Negative input terminal is biased with vcom0_hv
3 WRMODE	Wrap-Around Mode Selects the wraparound mechanism for conversion of programmed sequence of channels. 0b - Disable 1b - Enable
2 —	Reserved
1 MODE	Mode Selection Selects between differential input mode and single-ended input mode of SDADC. 0b - Differential input mode selected 1b - Single-ended input mode selected
0 EN	Enable for SDADC Block (PDR, PGAN, ODF, ODA, EMSEL, VCOMSEL, MODE, BIASEN and ANCHSEL) should be changed only when EN = 0. 0b - SDADC internal modulator placed in low consumption mode 1b - SDADC internal modulator enabled

58.5.3 Channel Selection Register (CSR)

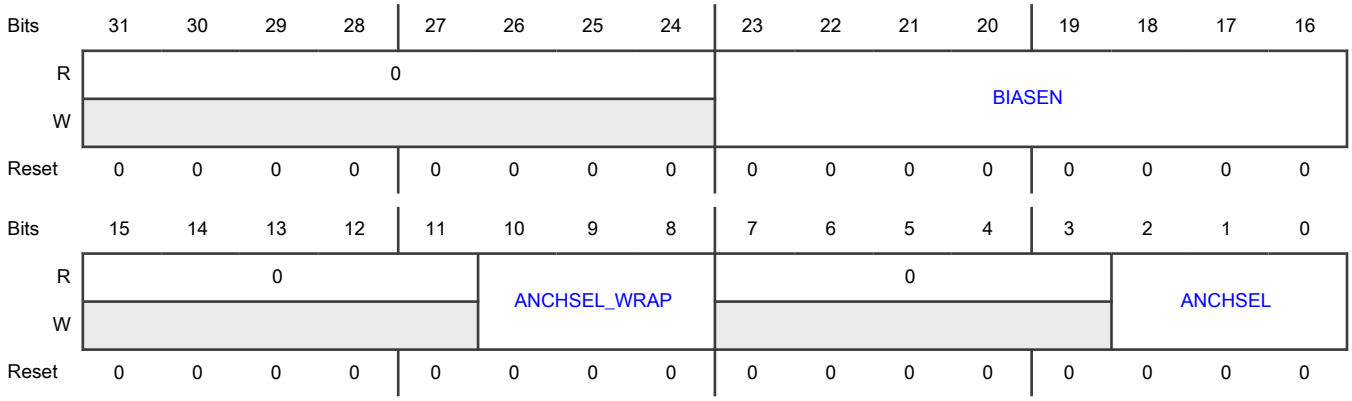
Offset

Register	Offset
CSR	4h

Function

Selects analog inputs AN[0:7] to be connected to positive and negative terminals of SDADC and controls the biasing of analog inputs to half-scale bias through 100 kohm resistance.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-16 BIASEN	Bias Enable If BIASEN[i] = 0, AN[i] channel is not biased. If BIASEN[i] = 1, analog input AN[i] (could be single-ended input or differential analog input) is connected to half-scale bias through a 100 Kohm resistor.
15-11 —	Reserved
10-8 ANCHSEL_WRAP	Analog Channel Selection Wraparound Value Indicates the maximum value of the wraparound counter when in wraparound mode, after which it is wrap around back to initial value 000. This value should be programmed before enabling wraparound mechanism (MCR[WRMODE] = 1)
7-3 —	Reserved
2-0 ANCHSEL	Analog Channel Selection Based on single-ended or differential mode of operation (MCR[MODE]), common mode voltage selection (MCR[VCOMSEL]), this field defines the connectivity of analog inputs to either positive or negative polarity terminals of SDADC. Wraparound Mode: 1. This field also indicates the initial entry value for the first loop of the wraparound sequence from where the wraparound counter starts incrementing when wraparound mode is entered (when wraparound mechanism enabled (MCR[MODE] = 1). 2. If this field is written any time during wraparound mode (when MCR[WRMODE]= 1), the present value of the wraparound counter is updated with the value of ANCHSEL - the next trigger acts on the updated channel, and the next increment is on the updated channel. Here, the value of ANCHSEL chosen should be less than CSR[ANCHSEL_WRAP]; otherwise it is ignored by hardware.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	3. Wraparound is always from initial counter value 000. **NOTE** For wraparound mode, see Wraparound mode.

58.5.4 Reset Key Register (RKR)

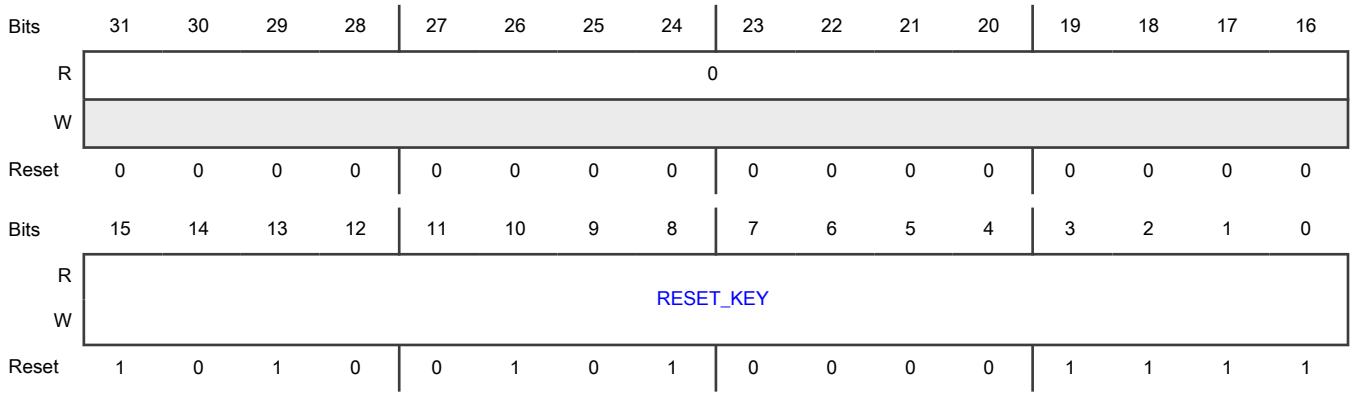
Offset

Register	Offset
RKR	8h

Function

Specifies a predefined key write operation to reset SDADC to start a fresh conversion.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 RESET_KEY	Reset Key Generates the reset for the SDADC block, when written with 5AF0h and reloads the internal counter with the start value programmed in OSDR. Any write access to this register which is different from the predefined key is ignored. Read access always returns the inverted key.

58.5.5 Status Flag Register (SFR)

Offset

Register	Offset
SFR	Ch

Function

Contains status and flag bits. These bits are set by hardware and reflect the status of SDADC and indicate the occurrence of events that may generate an interrupt or a DMA request. Software can clear some flags by writing '1' to those bits. Writing '0' to a flag has no effect.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0													ANCHSEL_CNT		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0							DFEF	0			WTHH	WTHL	CDVF	DFORF	DFFF
W												W1C	W1C		W1C	W1C
Reset	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18-16 ANCHSEL_CNT	Analog Channel Selection Counter Reflects the current value of the internal analog channel selection counter. It indicates the present number of the channel selected through the analog multiplexer.
15-9 —	Reserved
8 DFEF	Data FIFO Empty Flag Asserts when there is no dataword in FIFO. 0b - Not empty 1b - Empty
7-5	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
4 WTHH	Watchdog Upper Threshold Cross Over Event Sets when Converted Data crosses upper threshold of WDG. 0b - Did not occur 1b - Occurred
3 WTHL	Watchdog Lower Threshold Cross Over Event Sets when Converted Data crosses Lower Threshold of WDG. 0b - Did not occur 1b - Occurred
2 CDVF	Converted Data Valid Flag Specifies the actual status of data coming from SDADC block. The converted data is not valid or becomes corrupted whenever there is a change in configuration settings determined by Module Configuration Register (MCR), channel selection programmed in Channel Selection Register (CSR). Any write access to Module Configuration Register (MCR) and Channel Selection Register (CSR) resets this flag. This flag is set automatically after triggering SDADC and internal timer counts OSD cycles of output clock fd. **NOTE** If SDADC triggered in freeze mode, CDVF bit can get set automatically. Ignore CDVF bit in freeze mode. 0b - Data is not valid 1b - Data is valid
1 DFORF	Data FIFO Overrun Flag Indicates that software or DMA failed to prevent FIFO from overflowing with converted datawords. Software can clear this bit by writing '1' to it after reading FIFO contents through CDR. This flag remains set if software or DMA failed to clear the condition that caused this flag setting. If DFORF is set, further datawords are not received into FIFO even if sufficient room exists. 0b - No overrun has occurred since the last time the flag was cleared 1b - Overrun has occurred or DFORF has not been cleared since the last overrun occurred
0 DFFF	Data FIFO Full Flag Sets when the number of converted datawords in FIFO is more than the number indicated by FCR[FTHLD]. Software can clear this bit by writing '1' to it. This bit is also cleared by an acknowledgement from the DMA controller when DMA request generation is selected. This bit remains set if software or DMA failed to clear the condition that caused this flag setting. Even if DFFF is set, datawords continues to be received until an overrun condition occurs. Datawords are not received if the converted data is not valid (CDVF = 0). 0b -The number of datawords in FIFO is less than or equal to the number indicated by FCR[FTHLD]

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b -The number of datawords in FIFO is greater than the number indicated by FCR[FTHLD] at some point in time since this flag was last cleared **NOTE** Whenever (MCR[EN]) is cleared in order to stop SDADC or change the channel configuration, it is necessary to also clear RSER[DFFDIRE] alongwith. Similarly if DMA or software is too slow in not reading FIFO datawords resulting in DFFF condition it is advisable to stop SDADC by clearing (MCR[EN]) followed by clearing of RSER[DFFDIRE]. Both these actions ensure safe operation.

58.5.6 Request Select and Enable Register (RSER)

Offset

Register	Offset
RSER	10h

Function

Serves two purposes:

1. Enables the flag bits in SFR to generate DMA requests or interrupt requests.
2. Selects the type of request to generate.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								0						WTHDIRS	DFFDIRS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0											WTHDIRE	0	DFORIE	DFFDIRE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
23-18 —	Reserved
17 WTHDIRS	WDG Threshold Cross Over Event DMA/Interrupt Request Select When (SFR[WTHH])/ (SFR[WTHL]) and RSER[WTHDIRE] are set, this field selects between generating a DMA request or an interrupt request. 0b - Interrupt request is selected 1b - DMA request is selected
16 DFFDIRS	Data FIFO Full DMA/Interrupt Request Select When (SFR[DFFF]) and (RSER[DFFDIRE]) are set, this field selects between generating a DMA request or an interrupt request 0b - Interrupt request is selected 1b - DMA request is selected
15 —	Reserved
14-4 —	Reserved
3 WTHDIRE	WDG Threshold Cross Over Event DMA/Interrupt Request Enable Enables (SFR[WTHH]) or (SFR[WTHL]) to generate a request. (SFR[WTHDIRS]) determines which is selected, a DMA request or an interrupt request. 0b - Interrupt/DMA request is disabled on WDG threshold cross over event 1b - Interrupt/DMA request is enabled on WDG threshold cross over event
2 —	Reserved
1 DFORIE	Data FIFO Overrun Interrupt Enable Enables (SFR[DFORF]) to generate an interrupt request. 0b - Interrupt request is disabled when data FIFO overrun condition occurs 1b - Interrupt request is enabled when data FIFO overrun condition occurs
0 DFFDIRE	Data FIFO Full DMA/Interrupt Request Enable Enables (SFR[DFFF]) to generate a request. (RSER[DFFDIRS]) determines which is selected, a DMA request or an interrupt request. To have safe operation this bit should not be set when (MCR[EN] = 1) Whenever (MCR[EN]) is cleared this bit should also be cleared if already set and FCR[FRST] can be set to clear the previous FIFO content.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Interrupt/DMA request is disabled when data FIFO full condition occurs 1b - Interrupt/DMA request is enabled when data FIFO full condition occurs

58.5.7 Output Settling Delay Register (OSDR)

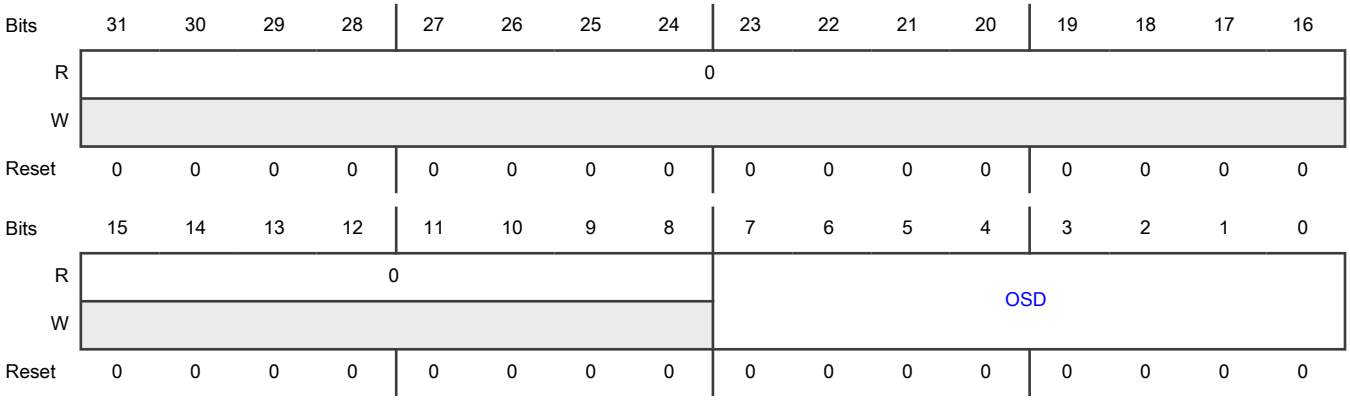
Offset

Register	Offset
OSDR	14h

Function

Provides a delay value to qualify the converted output data coming from SDADC.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 OSD	Output Settling Delay Defines the delay to qualify the conversion data stored in CDR. Whenever SDADC block is reset in order to start the conversion from a fresh state, an internal timer is loaded with this start value. The counter counts down with output data valid rate fd until it reaches zero, and then it generates a flag which qualifies the converted data. The output data valid rate fd is equal to fs/(OSR/4), where fs is the input sampling clock frequency. When external modulator is selected, the output valid data rate is fixed to fs/128.

58.5.8 FIFO Control Register (FCR)

Offset

Register	Offset
FCR	18h

Function

Provides the ability to turn on and off FIFO functionality, and to select the size of FIFO depth. This register also provides the ability to set the programmable threshold for notification of dataword removal from FIFO. This register may be read at any time, but should only be written when SDADC is disabled (MCR[EN] = 0).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															0
W																FRST
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				FTHLD				0				FOWEN	FSIZE		FE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

Fields

Field	Function
31-17 —	Reserved
16 FRST	FIFO Flush Reset This is functional soft reset to flush the current FIFO content and initialize the internal FIFO pointers. This is W1S (write one shot) bit which can be written as '1' but always read as '0'. Use this option only after disabling ADC i.e. (MCR[EN] = 0). 0b - No effect. 1b - Generate a single cycle reset event to flush FIFO.
15-12 —	Reserved
11-8 FTHLD	FIFO Threshold When the number of datawords in the data FIFO is greater than the value in FTHLD, FIFO full event is flagged. An interrupt or a DMA request is generated as determined by RSER[DFFDIRE] and

Table continues on the next page...

Table continued from the previous page...

Field	Function
	RSER[DFFDIRS]. For proper operation, the value in FTHLD must be set to be less than FIFO size as indicated by FCR[FSIZE].
7-4 —	Reserved
3 FOWEN	FIFO Over Write Enable When set the built-in FIFO structure allows the overwriting of new converted data over older converted data after FIFO has number of entries equal to FCR[FSIZE]. 0b - Disable 1b - Enable
2-1 FSIZE	FIFO Size Specifies the maximum number of converted datawords that can be stored in the data FIFO before an overrun occurs. This field is read-only. The reset value of this field depends on the implementation parameter to define FIFO size. 00b - FIFO depth = 1 dataword 01b - FIFO depth = 4 datawords 10b - FIFO depth = 8 datawords 11b - FIFO depth = 16 datawords
0 FE	FIFO Enable Enables the built-in FIFO structure after this field is set. The size of FIFO structure is indicated by FCR[FSIZE]. If this field is not set then FIFO depth is set to one dataword regardless of the value in FCR[FSIZE]. 0b - Data FIFO is not enabled for multiple datawords; FIFO depth is one dataword 1b - Data FIFO is enabled; FIFO depth is indicated by FSIZE

58.5.9 Software Trigger Key Register (STKR)

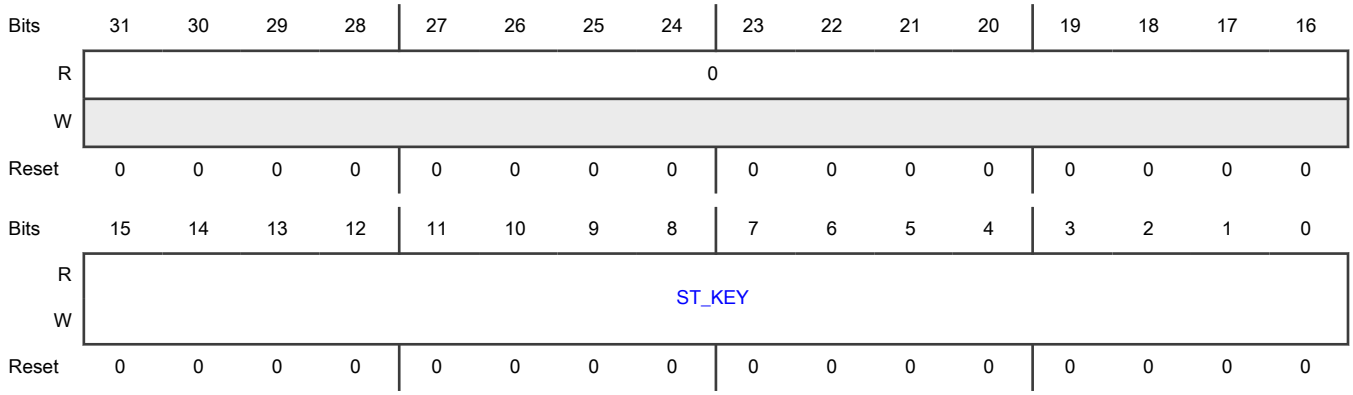
Offset

Register	Offset
STKR	1Ch

Function

Generates the trigger event output by a software write operation.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 ST_KEY	Software Trigger Key Generates the trigger event output, when written with FFFFh, which can be used to trigger conversions of multiple SDADC blocks synchronously depending on the SoC implementation. Any write access to this register which is different from the predefined key is ignored. Read access always returns 0000h.

58.5.10 Converted Data Register (CDR)

Offset

Register	Offset
CDR	20h

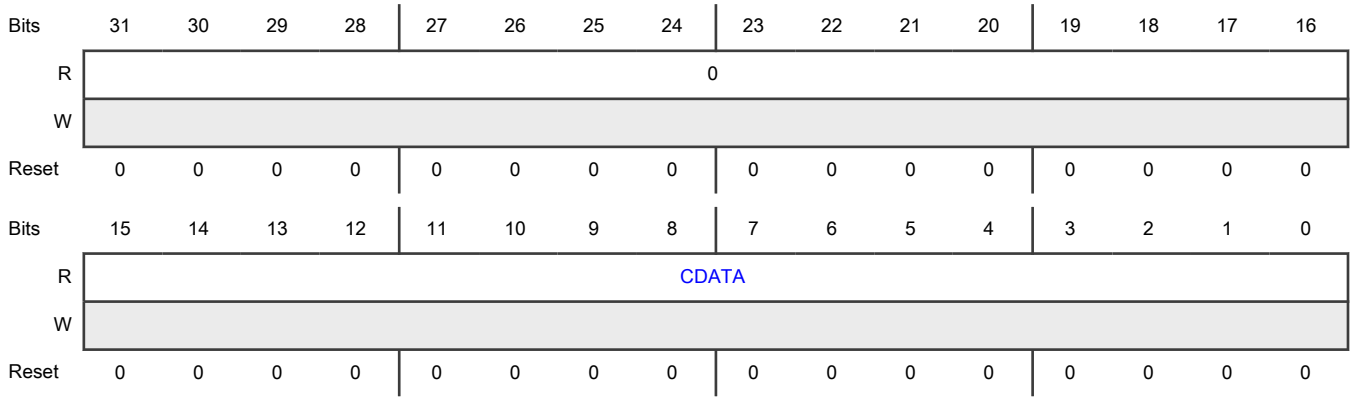
Function

Stores the converted data in the data FIFO.

NOTE

CDR read is not allowed in FIFO empty condition otherwise it may lead to invalid data read.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 CDATA	Converted Data The converted datawords can be read from FIFO by reading this register. The data width is 16 bits which has actual 16-bit data (bits 15 down to 0) coming from ADC.

58.5.11 WDG Threshold Register (WTHHLR)

Offset

Register	Offset
WTHHLR	24h

Function

This is the Converted Data Range WDG Threshold register.

NOTE

A single WDG monitor checks for lower and upper threshold crossover events.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	THRH															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	THRL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 THRH	WDG Upper Threshold Value Indicates the upper threshold for the converted data on any channel, above which threshold a crossover event would be flagged through SFR[WTHH].
15-0 THRL	WDG Lower Threshold Value Indicates the lower threshold for the converted data on any channel, below which threshold cross over event would be flagged through SFR[WTHL].

58.5.12 CIC Configuration Register (CCR)

Offset

Register	Offset
CCR	28h

Function

This is the CIC FILTER's control register. This register should be programmed when SDADC is disabled (i.e. MCR[EN] = 0).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CCR_B1_...	0			EN_CLK_...	0	OSR_HALF	0								
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Fields

Field	Function
31-16 —	Reserved
15 CCR_B1_IPS_EN	Enable or Disable CCR Byte 1 IPS programmability Enables or disables IPS programmability for CCR[OSR_HALF] and CCR[EN_CLK_RATE_HALF]. 0b - Disable IPS programmability 1b - Enable IPS programmability
14-11 —	Reserved
10 EN_CLK_RATE_HALF	Enable Sampling Clock Rate Half Reduces sampling frequency by half. 0b - Sampling frequency is 40 MHz 1b - Sampling frequency is 20 MHz
9 —	Reserved
8 OSR_HALF	Decimation Rate by Half Reduces the CIC's decimation rate by half. 0b - For actual OSR. See MCR[PDR] for OSR values. This bit should be asserted low when CCR[EN_CLK_RATE_HALF] = 0. 1b - For half OSR. See MCR[PDR] for OSR values. This bit should be asserted high when CCR[EN_CLK_RATE_HALF] = 1.
7-0 —	Reserved

58.5.13 Test Configuration Register (TCR)

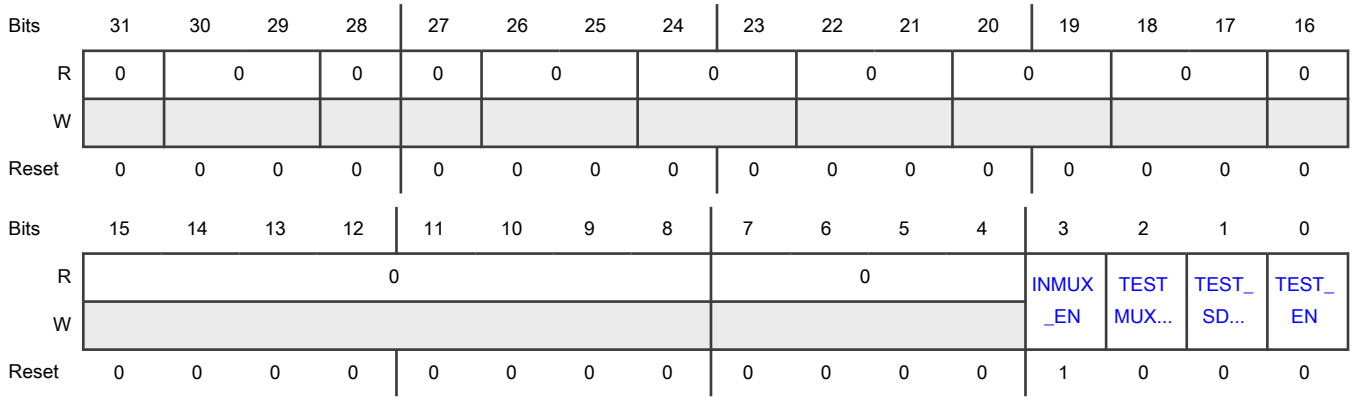
Offset

Register	Offset
TCR	30h

Function
Configures BIST control for SDADC.

NOTE
TESTMUX_EN and INMUX_EN must not be high at the same time.

Diagram



Fields

Field	Function
31 —	Reserved
30-29 —	Reserved
28 —	Reserved
27 —	Reserved
26-25 —	Reserved
24-23 —	Reserved
22-21 —	Reserved
20-19 —	Reserved
18-17 —	Reserved
16 —	Reserved

Table continues on the next page...

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Field	Function
15-8 —	Reserved
7-4 —	Reserved
3 INMUX_EN	Input Mux Enable Enables/ disables functional channels in analog modulator. 0b - Disable 1b - Enable
2 TESTMUX_EN	Test Mux Enable Enables/ disables BIST channel of SDADC. Enabling of test mux is gated with enable control from R2R DAC. 0b - Disable 1b - Enable
1 TEST_SDADC_EN	Test SDADC Enable Enables/ disables SDADC when TCR[TEST_EN] = 1. 0b - Disable 1b - Enable
0 TEST_EN	Test Enable Enables/ disables BIST mode of SDADC. This bit should not be programmed while SDADC in functional mode else it may lead to malfunctioning of SDADC. Program this bit when MCR[EN] = 0. 0b - Disable 1b - Enable

Chapter 59
ADCBIST

59.1 Introduction

ADCBIST creates a sine wave, which the SDADC being tested then measures. This measured data is sent from SDADC via DMA to the system.

59.1.1 Features

- A BIST to stimulate SDADC instances serially, where the conversion data of SDADC is filtered and sent on request via DMA to the system for further processing.
- R2RDAC to generate test stimuli for the ADC.

59.1.2 Block diagram

The following figure shows the general functional blocks of the module.

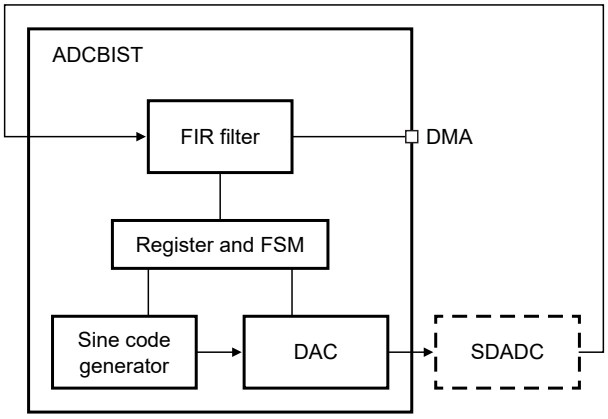

Figure 291. Block diagram

59.1.3 Detailed functioning

The following figure represents the detailed functioning of ADCBIST (for a top-level view, see Block diagram):

- Signals flow from left to right: inputs to blocks are shown on the left side, and outputs are shown on the right side of the figure.
- FIR filter, symbol rate counter, sine angle counter, and CORDIC algorithm are the names of functional blocks.
- Register and field mnemonics, for example, BISTCTL[TESTRUN], map to the mnemonics in ADCBIST register descriptions.
- Conversion control and conversion data are signal names.
- All shown digital signals are synchronous. Asynchronous inputs to ADCBIST are internally synchronized (synchronizers are not shown).

This figure also shows the data flow through ADCBIST and how you can use the registers provided in ADCBIST register descriptions to configure and control ADCBIST. The legend included with the figure explains the symbols used in the figure. You must:

- Configure SDCFG[SDSEL] to select SDADC under test.
- Configure BISTCFG[TESTSEL] to select the test to run.
- Write 1 to BISTCTL[TESTRUN] to run a test.

After you enable the SDADC test, the CORDIC algorithm is enabled, and that generates codes for the R-2R DAC to output a sine wave. You must configure SDCFG[DACSR] and SDSINECFG[SINESTEP] to set the frequency of the generated sine wave. SDADC measures the sine wave—you can observe the conversion data. You can read ADCBIST Status (BISTSTAT) to see the status of ADCBIST.

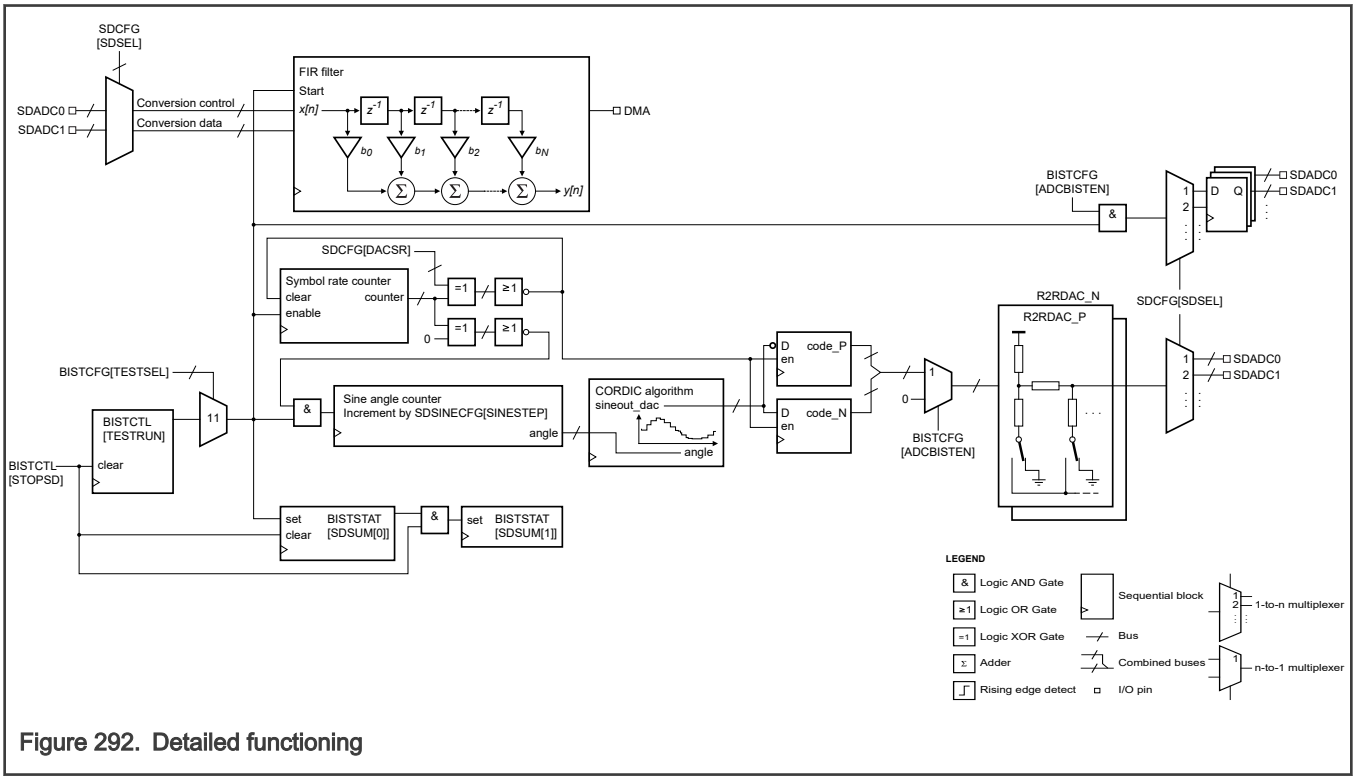

Figure 292. Detailed functioning

59.2 ADCBIST register descriptions

59.2.1 ADCBIST memory map

ADCBIST supports 32-bit write accesses and 32-bit, 16-bit, and 8-bit read accesses. ADCBIST generates a transfer error in these cases:

- Access to an address that does not map to a register
- Write access to a read-only register
- Non-32-bit write access

adc_bist base address: 4070_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VERID)	32	R	0200_0047h
4h	ADCBIST Configuration (BISTCFG)	32	RW	0000_0000h
8h	ADCBIST Control (BISTCTL)	32	RW	0000_0000h
Ch	ADCBIST Status (BISTSTAT)	32	R	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
200h	SDADC Test Configuration (SDCFG)	32	RW	0050_0080h
204h	SDADC Sine Wave Configuration (SDSINECFG)	32	RW	0054_0000h
800h	Finite Impulse Response Filter (FIRF)	32	RW	0000_0000h

59.2.2 Version ID (VERID)

Offset

Register	Offset
VERID	0h

Function

Reads the specific version of ADCBIST integrated on the chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MAJOR								MINOR							
W																
Reset	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								NUMSDADC				0			
W																
Reset	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1

Fields

Field	Function
31-24 MAJOR	Major Version Number Contains the major version number of the specification that was the basis for this version of ADCBIST.
23-16 MINOR	Minor Version Number Contains the minor version number of the specification that was the basis for this version of ADCBIST.
15-8 —	Reserved

Table continues on the next page...

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Field	Function
7-4 NUMSDADC	Number Of SDADC Instances Contains the number of SDADC instances that can be tested with this ADCBIST. Up to six instances of SDADC can be connected to ADCBIST for testing.
3-0 —	Reserved

59.2.3 ADCBIST Configuration (BISTCFG)

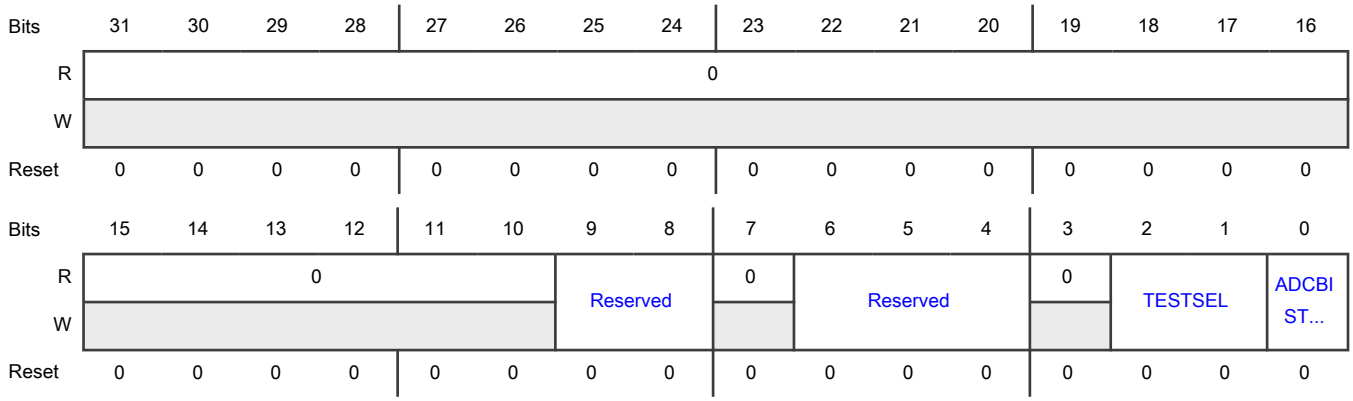
Offset

Register	Offset
BISTCFG	4h

Function

Configures ADCBIST before any test is started. You can write to this register only when no test is running, which means if BISTCTL[TESTRUN] = 0.

Diagram



Fields

Field	Function
31-10 —	Reserved
9-8 —	Reserved
7	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
6-4 —	Reserved
3 —	Reserved
2-1 TESTSEL	Test Selection Selects the test to be executed, by writing 1 to BISTCTL[TESTRUN]. 00b - No test selected 01b - Reserved 10b - Reserved 11b - Selects the SDADC test
0 ADCBISTEN	ADCBIST Enable Enables ADCBIST. 0b - Disables 1b - Enables

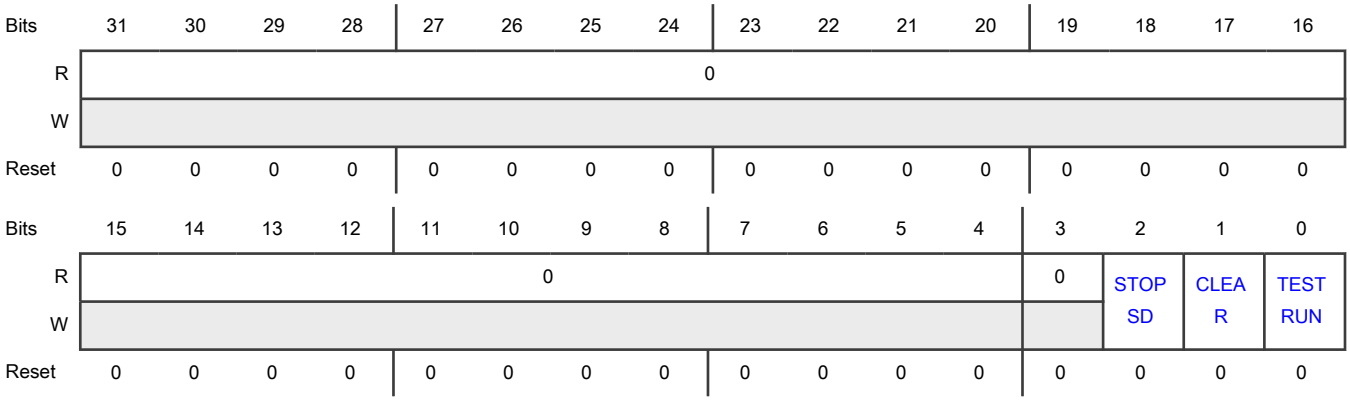
59.2.4 ADCBIST Control (BISTCTL)

Offset

Register	Offset
BISTCTL	8h

Function
Controls the test execution of ADCBIST.

Diagram



Fields

Field	Function
31-4 —	Reserved
3 —	Reserved
2 STOPSD	Stop SDADC Test Stops SDADC test from executing. Write 1 to this field to stop the test. The field becomes 0 automatically. 0b - Default state 1b - Stops the SDADC test
1 CLEAR	Clear BIST Resets ADCBIST, clears all status registers, flushes the FIR to FFT datapath, and resets all FSMs. You must write 1 to this field after a test is performed and the next one has not started. This field clears automatically after you write to it. You can write to it only when no test is running, that is, if BISTCTL[TESTRUN] = 0.
0 TESTRUN	Test Run Runs the test that BISTCFG[TESTSEL] selects. This field reads 1 while a test is running. You can start a test (by writing 1 to this field) only after selecting a test (BISTCFG[TESTSEL] must not be 0). Then, you must wait for the test to finish. You cannot write 0 to this field; it automatically becomes 0 after the test completes. To start a test, you must select a test and an ADC. You must select an SDADC by using SDCFG[SDSEL]. After a test completes and before starting another one, you must reset ADCBIST by writing 1 to BISTCTL[CLEAR]. 0b - No test running 1b - Starts a test

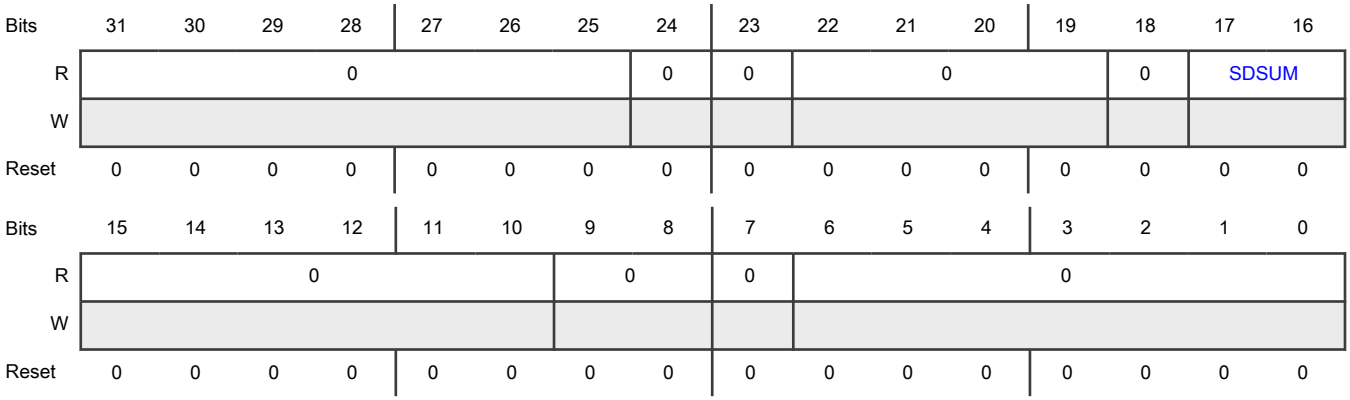
59.2.5 ADCBIST Status (BISTSTAT)

Offset

Register	Offset
BISTSTAT	Ch

Function
Reads the status of ADCBIST.

Diagram



Fields

Field	Function
31-25 —	Reserved
24 —	Reserved
23 —	Reserved
22-19 —	Reserved
18 —	Reserved
17-16 SDSUM	SDADC Test Summary Indicates the summary of the last test of SDADC.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	00b - Not started 01b - Currently running 10b - Completed 11b - Reserved
15-10 —	Reserved
9-8 —	Reserved
7 —	Reserved
6-0 —	Reserved

59.2.6 SDADC Test Configuration (SDCFG)

Offset

Register	Offset
SDCFG	200h

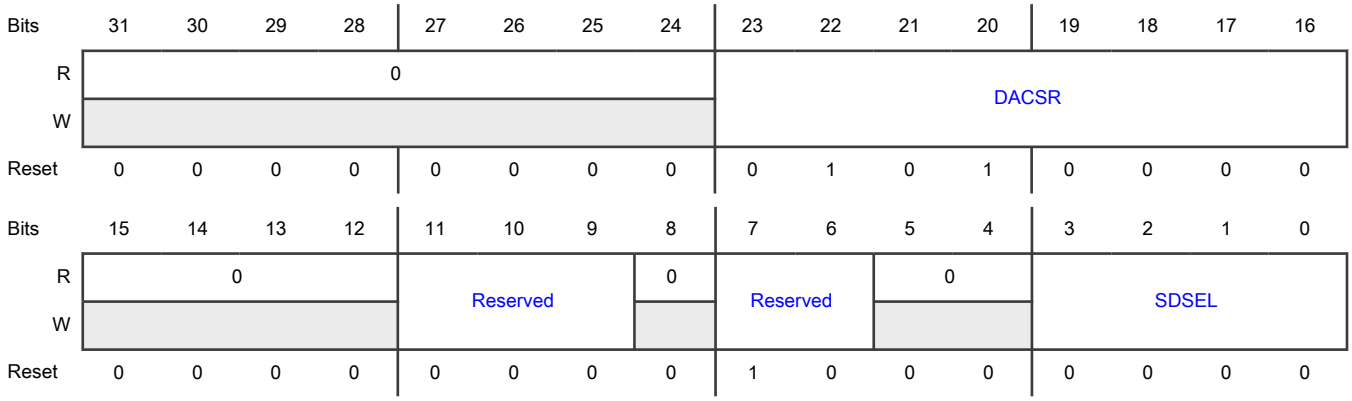
Function

Configures the tests where SDADC is used or tested.

You can:

- Write to this register only when no test is running, that is, when BISTCTL[TESTRUN] = 0.
- Use this register to define the number of module clock edges. After you do this, a new symbol (code) is given to R2RDAC. The resulting symbol rate is f_symbol = (module clock frequency) ÷ (DACSR + 1). The period to send a new code to R-2R DAC is constant only if the resulting symbol rate is an even value. Otherwise, the period differs by one clock cycle.
- Use this register to select the SDADC to be tested.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-16 DACSR	R2RDAC Symbol Rate Defines the number of module clock edges. Following are some of the values that represent this field's configurations. 0000_0000b - No division (f_symbol = module clock frequency) 0000_1001b - Division by 10 (f_symbol = 8 MHz at 80 MHz module clock frequency) 0010_0111b - Division by 40 (f_symbol = 2 MHz at 80 MHz module clock frequency) 0100_1111b - Division by 80 (f_symbol = 1 MHz at 80 MHz module clock frequency) 1111_1111b - Reserved (do not use)
15-12 —	Reserved
11-9 —	Reserved
8 —	Reserved
7-6 —	Reserved
5-4 —	Reserved
3-0	SDADC Selection

Table continues on the next page...

Table continued from the previous page...

Field	Function
SDSEL	Selects the SDADC to be tested. If you write the same or a higher value than you read in VERID[NUMSDADC], the contents of this field do not change.

59.2.7 SDADC Sine Wave Configuration (SDSINECFG)

Offset

Register	Offset
SDSINECFG	204h

Function

Configures the step size to generate the sine wave.

The value that you write to this register is $2^{32} \div N$, where N is the desired number of samples per period of the sine wave. This value must be equal to or larger than 2^{14}; smaller step sizes cannot be resolved.

You can write to this register only when no test is running, that is, if BISTCTL[TESTRUN] = 0.

NOTE

To program SDSINECFG[SINESTEP] with values mentioned against Configuration1 and Configuration2, refer to Table 282.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SINESTEP															
Reset	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SINESTEP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SINESTEP	Sine Wave Step Size Following are some of the values that represent this field's configurations. 0000_0000_0001_0000_0000_0000_0000_0000b - N = 4096 0000_0000_0100_0000_0000_0000_0000_0000b - N = 1024 0000_0000_1000_0000_0000_0000_0000_0000b - N = 512

59.2.8 Finite Impulse Response Filter (FIRF)

Offset

Register	Offset
FIRF	800h

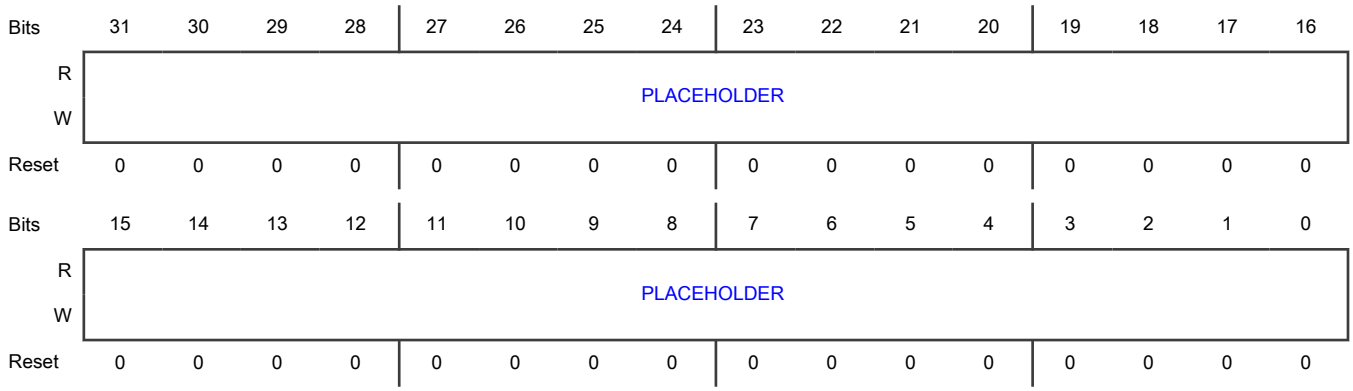
Function

Provides the address to access the FIRF.

You can write to this register only when no test is running, that is, if BISTCTL[TESTRUN] = 0.

See the "FIR Filter" chapter for details on accessible registers.

Diagram



Fields

Field	Function
31-0 PLACEHOLDER	Finite Impulse Response Filter

59.3 Functional description

59.3.1 Operating mode

ADCBIST includes only one operating mode. To enable this operating mode, you must write 1 to BISTCFG[ADCBISTEN].

59.3.2 SDADC test

You must test SDADC by stimulating the SDADC being tested with a sine wave and analyzing the conversion results outside ADCBIST.

Perform this procedure to run the SDADC test, configure ADCBIST, and start the SDADC test:

1. Select the SDADC being tested by configuring SDCFG[SDSEL].
2. Configure SDADC to achieve coherent sampling (see Table 282).

3. Ignore the conversion data received during test startup (write 14h to FIR Filter.OSDR[OSD]).
4. Select the SDADC test (write 11b to BISTCFG[TESTSEL]).
5. Start the SDADC test (write 1 to BISTCTL[TESTRUN]).

Perform this procedure to configure SDADC:

1. Enable the bias generator (write 1 to SDADC.MCR[BIASGEN_EN]).
2. Enable the SDADC being tested (write 1 to SDADC.TCR[TEST_SDADC_EN]).
3. Disable the inmux override (write 0 to SDADC.TCR[INMUX_EN]).
4. Enable the R2RDAC mux override (write 1 to SDADC.TCR[TESTMUX_EN]).
5. Enable the SDADC test mode (write 1 to SDADC.TCR[TEST_EN]).
6. Wait until SDADC is ready to use (check in SDADC if a delay is needed here).

The SDADC test starts running.

Observe the conversion data via DMA and perform post-processing (through FFT) outside ADCBIST.

After enough conversion data is received, perform this procedure to disable SDADC:

1. Disable the SDADC test mode (write 0 to SDADC.TCR[TEST_EN]).
2. Disable the R2RDAC mux override (write 0 to SDADC.TCR[TESTMUX_EN]).
3. Enable the inmux override (write 1 to SDADC.TCR[INMUX_EN]).
4. Disable the SDADC under test (write 0 to SDADC.TCR[TEST_SDADC_EN]).

Perform this procedure to stop the SDADC test:

1. Write 1 to BISTCTL[STOPSD].
2. Read BISTSTAT[SDSUM] to ensure that the SDADC test is complete.

You must repeat the aforementioned steps for all SDADC instances. Write 1 to BISTCTL[CLEAR] to clear ADCBIST before each test.

You can control the sine wave, which is used to stimulate SDADC, by configuring SDCFG[DACSR] (sets the limit for the symbol_rate_counter) and SDSINECFG[SINESTEP] (sets the angle for the CORDIC algorithm).

Together with the settings in the SDADC under test, you must configure the SDADC test to achieve coherent sampling, which is needed for running an FFT analysis on the conversion data: f_s ÷ f_r = N ÷ M, where:

- f_s is the sampling frequency of the generated sine wave.
- f_r is the frequency of the sine wave that SDADC converts.
- N is the number of samples taken (must be a power of 2).
- M is the number of cycles of the sine wave (must be mutually prime to the number of samples).

NOTE

SDADC BIST runs at the startup phase. While ADCBIST is running, both SDADC and DSPSS are unavailable for use. Only after ADCBIST completes, DSPSS is enabled. Therefore, ADCBIST cannot use PMEM in any use case when operating in this mode.

Table 282. Example settings for coherent sampling

Configuration	SDSINECFG[SINESTEP]	SDCFG[DACSR] @ 80 MHz module clock frequency	f_s	f_r	N (read samples via DMA)	M
1	028C_0000h	4Fh	1 MHz	10 kHz	16384	163
2	0514_0000h	4Fh	1 MHz	20 kHz	16384	325
3	0148_0000h	27h	2 MHz	10 kHz	8192	41
4	00A8_0000h	09h	8 MHz	20 kHz	8192	21

59.4 Glossary

FFT	Fast Fourier transformation
FIR	Finite impulse response
R-2R DAC	Resistor-2 resistor digital-to-analog converter

Chapter 60
FIR filter

60.1 Overview

Finite Impulse Response filter (FIR) is compensation filter for the SDADC devices.

It is implemented inside ADCBIST.

The basic implementation of an FIR requires three basic building blocks

- Multiplication
- Addition
- Signal delay
- Memory to store filter coefficient

The FIR filters has equation of the form the output.

$$y[n] = \sum_{k=0}^{3} b_k x[n-k]$$

Figure 293. Equation

Using the building blocks described above, we can construct a block diagram as below:

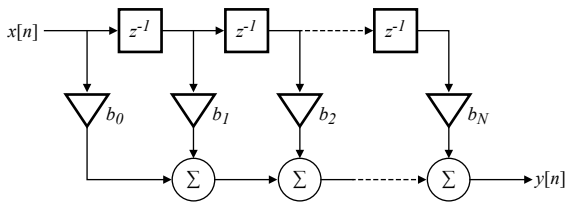


Figure 294. Functional block diagram

60.1.1 Block diagram

The following figure shows the block diagram of FIR filter.

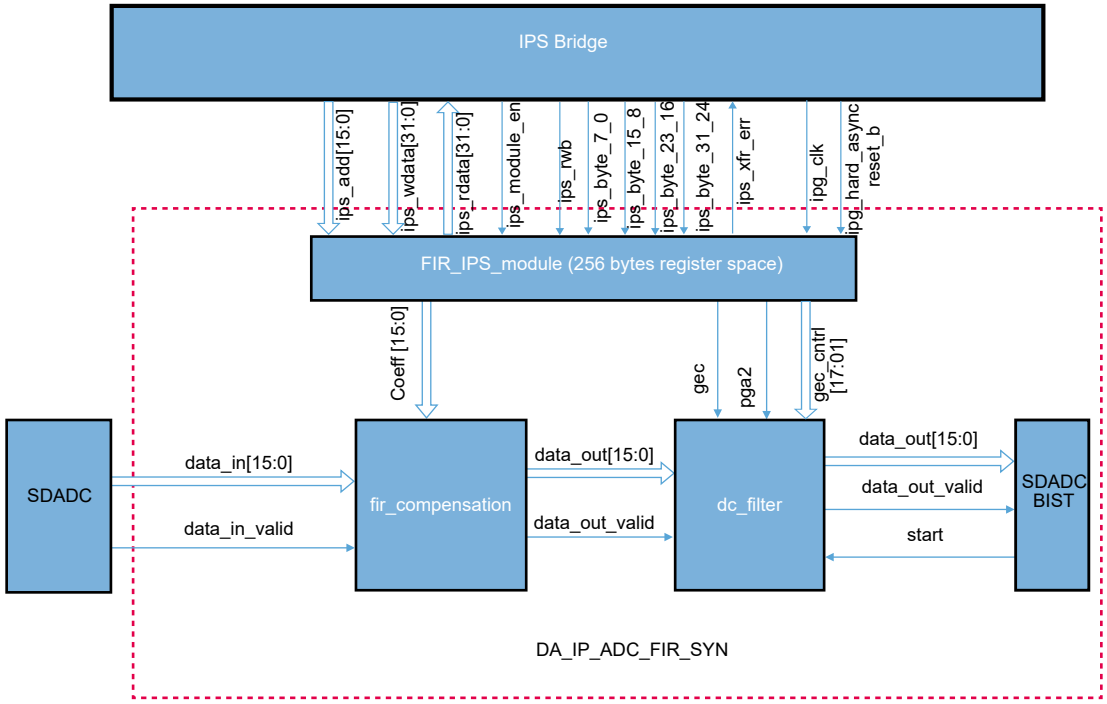


Figure 295. Block diagram

60.1.2 Features

FIR features include:

- 51 tap filter
- Support Gain Error Correction (GEC) enable/disable
- Support programmable gain by 2 enable/disable feature
- Support programmable gain error factor

60.2 Functional description

The HW FIR compensation filter for the SDADC is implemented in the ADCBIST IP. FIR compensation filter that uses down-sampling filter output (CIC filter) and provides an output at the final SDADC conversion rate. The output of the FIR filter is decimated by four before the final output.

The FIR compensation filter is a linear phase filter and have a symmetrical impulse response (symmetrical coefficients). FIR filter digital block has fir compensation and post processing blocks.

GEC (Gain Error Correction) and PGA2(programmable gain by 2) features are implemented in post processing block. The FIR compensation filter have 51 filter taps .

The FIR compensation filter shall receive a 16-bit sign extended input from the Sigma-Delta CIC filter and gives output SDADC BIST FFT.

60.2.1 FIR compensation

This is core FIR filter module. It takes coefficient and data as input and it gives filtered output. It is also do the decimation of data rate by 4.

60.2.2 Post processing module

This module does the post processing of data like gain error correction and programmable gain of 2.

60.2.3 Clocking

This clock is used for FIR compensation and postprocessing. This should be 80MHz non-FM clock.

60.2.4 Reset

The active low reset is [MODULE_RESETB/ipg_hard_async_reset_b] with asynchronous assertion and synchronous de-assertion. It is used to reset all digital content in FIR.

60.2.5 Interrupt/DMA request support

The following condition that generates interrupts or DMA request in FIR.

The DFFF field is asserted when the data FIFO full condition is detected, indicating that the number of converted datawords stored in data FIFO is equal to or greater than the value indicated by threshold determined by FCR[FTHLD]. The interrupt or DMA request is generated only when RSER[DFFDIRE] is asserted. RSER[DFFDIRS] selects whether a DMA request or an interrupt request is generated.

The data FIFO overrun flag (DFORF) indicates the FIFO overflow condition. Further converted datawords cannot be received and data is lost. The interrupt request is generated only when RSER[DFORIE] is asserted.

The following is an example of DMA transfer waveform.

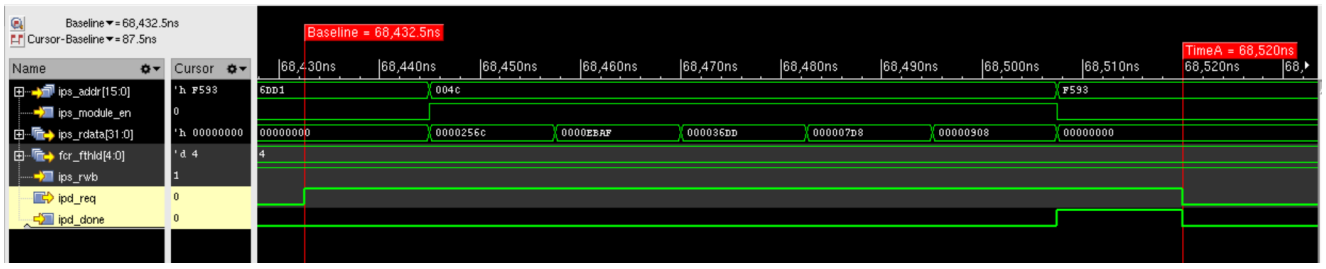


Figure 296. DMA waveform

60.3 External signals

This module has no external signals.

60.4 Initialization

1. Program FIR_CNTRL[PGA2] and FIR_CNTRL[GEC] (if required).
   - Program GEC_PRGRM_FACTOR accordingly.
2. Program FCR to enable fifo and fifo threshold.
3. Program RSER to select interrupt/DMA mode.
4. Generate a trigger event by writing 0x5AF0 to RESET_KEY of RKR.
5. Read CDR to read the FIR output data.

60.5 FIR_Filter register descriptions

60.5.1 FIR_Filter memory map

adc_bist_fir base address: 4070_4800h

Offset	Register	Width (In bits)	Access	Reset value
0h	Finite Impulse Response Filter Control (FIR_CNTRL)	32	RW	0000_0000h
4h	Gain Error Correction Programmable Factor (GEC_PRGRM_FACTOR)	32	RW	0000_0000h
3Ch	Status Flag Register (SFR)	32	RW	0000_0100h
40h	Request Select and Enable Register (RSER)	32	RW	0000_0000h
44h	Output Settling Delay Register (OSDR)	32	RW	0000_0000h
48h	FIFO Control Register (FCR)	32	RW	0000_0006h
4Ch	Converted Data Register (CDR)	32	R	0000_0000h

60.5.2 Finite Impulse Response Filter Control (FIR_CNTRL)

Offset

Register	Offset
FIR_CNTRL	0h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0				0		PGA2_EN	GEC_EN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-3	Reserved

Table continues on the next page...

Table continued from the previous page...

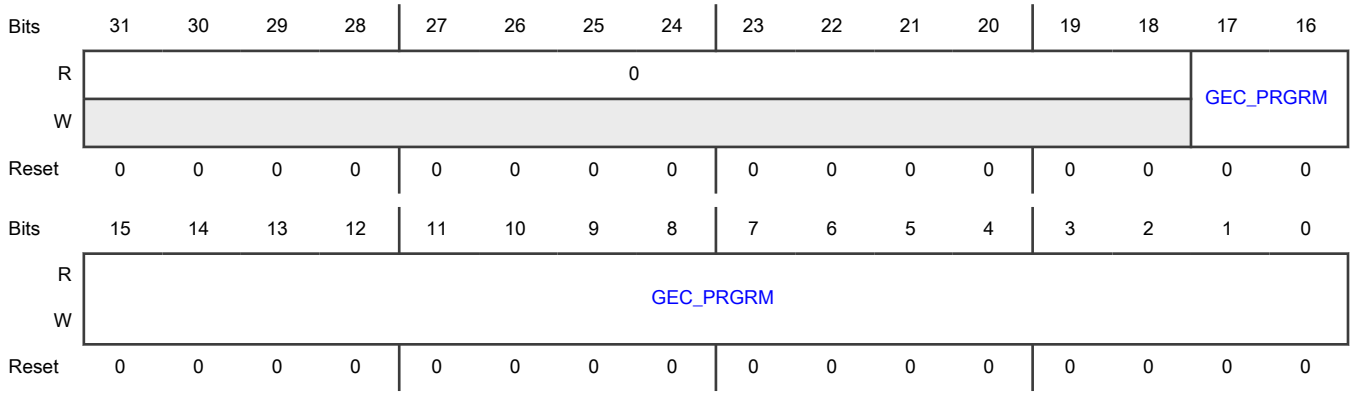
Field	Function
—	
2 —	Reserved
1 PGA2_EN	Programmable gain by 2 (PGA2) enable/disable 0b - PGA2 enable 1b - PGA2 disable
0 GEC_EN	Gain error correction enable 0b - GEC enable 1b - GEC disable

60.5.3 Gain Error Correction Programmable Factor (GEC_PRGRM_FACTOR)

Offset

Register	Offset	Description
GEC_PRGRM_FACTOR	4h	The output data as per following equation: 1. if FIR_CNTRL[GEC_EN] = 1 2. data_out = data_in * GEC_PRGRM / 65,536

Diagram



Fields

Field	Function
31-18	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
17-0 GEC_PRGRM	GEC programmable factor

60.5.4 Status Flag Register (SFR)

Offset

Register	Offset
SFR	3Ch

Function

The Status Flag Register (SFR) contains status and flag bits. These bits are set by hardware and reflect the status of the FIR and indicate the occurrence of events that may generate an interrupt or a DMA request. Software can clear some flags by writing '1' to those bits. Writing a '0' to a flag has no effect.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0													0		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0							DFEF	0					CDVF	DFORF	DFFF
W															W1C	W1C
Reset	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18-9 —	Reserved
8	Data FIFO Empty Flag

Table continues on the next page...

Table continued from the previous page...

Field	Function
DFEF	This field is asserted when there is no dataword in the FIFO. 0b - Data FIFO is not empty 1b - Data FIFO is empty
7-3 —	Reserved
2 CDVF	Converted Data Valid Flag This field gives the actual status of data coming from the FIR block. The converted data is not valid or becomes corrupted whenever there is a change in configuration settings determined by(FIR_CNTRL), FIR_COEFF0-13. Any write access to the registers(FIR_CNTRL) and FIR_COEFF0-13 will reset this flag. This flag is set automatically after generating FIR reset and internal timer counts OSD cycles of output clock fd. If OSD is 0 then, this flag will set at start itself. 0b - Data output from FIR is not valid 1b - Data output from FIR is valid
1 DFORF	Data FIFO Overrun Flag This field indicates that software or DMA failed to prevent FIFO from overflowing with converted datawords. Software can clear this bit by writing '1' to it after reading the FIFO contents through CDR. This flag remains set if software or DMA failed to clear the condition that caused this flag setting. If DFORF is set, further datawords will not be received into FIFO even if sufficient room exists. 0b - No overrun has occurred since the last time the flag was cleared 1b - Overrun has occurred or the DFORF has not been cleared since the last overrun occurred
0 DFFF	Data FIFO Full Flag This bit is set when the number of converted datawords in the FIFO is more than the number indicated by FCR[FTHLD]. Software can clear this bit by writing '1' to it. This bit is also cleared by an acknowledgement from the DMA controller when DMA request generation is selected. This bit remains set if software or DMA failed to clear the condition that caused this flag setting. Even if DFFF is set, datawords will continue to be received until an overrun condition occurs. Datawords will not be received if the converted data is not valid (CDVF = 0). 0b -The number of datawords in FIFO is equal to or less than the number indicated byFCR[FTHLD] 1b -The number of datawords in FIFO is greater than the number indicated by FCR[FTHLD] at some point in time since this flag was last cleared **NOTE** Whenever the FIR is stopped or change the configuration, it is necessary to also clear the RSER[DFFDIRE] bit along with. Similarly if DMA or software is too slow in not reading the FIFO datawords resulting in DFFF condition it is advisable to stop the FIR followed by clearing of RSER[DFFDIRE] bit. Both these action will ensure safe operation.

60.5.5 Request Select and Enable Register (RSER)

Offset

Register	Offset
RSER	40h

Function

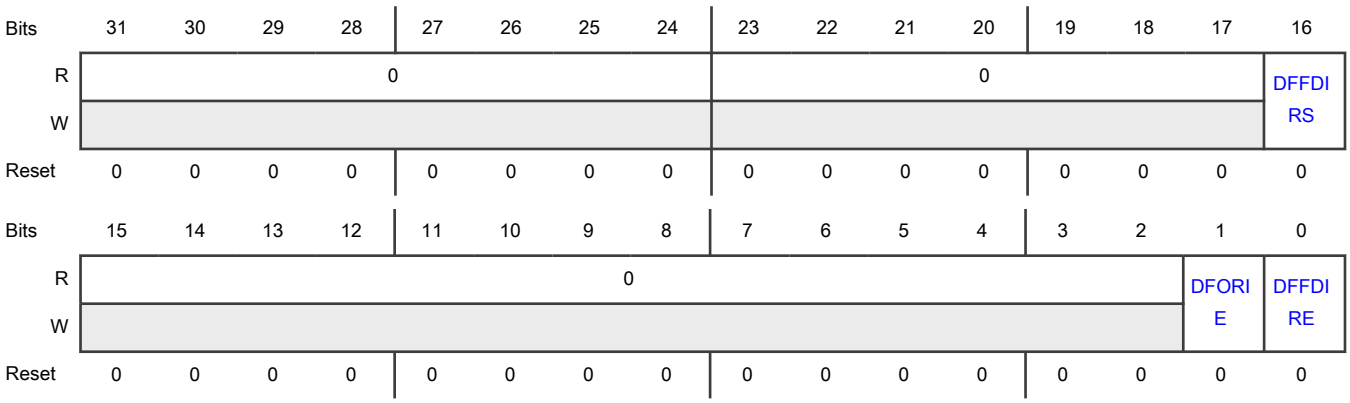
The Request Select and Enable Register (RSER) serves two purposes:

1. Enables the flag bits in SFR to generate DMA requests or interrupt requests.

2. Selects the type of request to generate.

Refer to the field descriptions for the type of requests that are supported

Diagram



Fields

Field	Function
31-24 —	Reserved
23-17 —	Reserved
16 DFFDIRS	Data FIFO Full DMA/Interrupt Request Select When the (SFR[DFFF])and (SFR[DFEF]) fields are set, this field selects between generating a DMA request or an interrupt request 0b - Interrupt request is selected 1b - DMA request is selected
15-2 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
1 DFORIE	Data FIFO Overrun Interrupt Enable This bit enables the (SFR[DFORF]) field to generate an interrupt request. The final interrupt request also depends on the gating signal if enabled by the GDIGE field. 0b - Interrupt request is disabled when data FIFO overrun condition occurs 1b - Interrupt request is enabled when data FIFO overrun condition occurs
0 DFFDIRE	Data FIFO Full DMA/Interrupt Request Enable This field enables the (SFR[DFFF]) field to generate a request. The DFFDIRS field determines which is selected, a DMA request or an interrupt request. The final DMA/interrupt request also depends on the gating signal if enabled by the GDIGE field. To have safe operation this bit should not be set when FIR is running. FCR[FRST] can be set to clear the previous FIFO content 0b - Interrupt/DMA request is disabled when data FIFO full condition occurs 1b - Interrupt/DMA request is enabled when data FIFO full condition occurs

60.5.6 Output Settling Delay Register (OSDR)

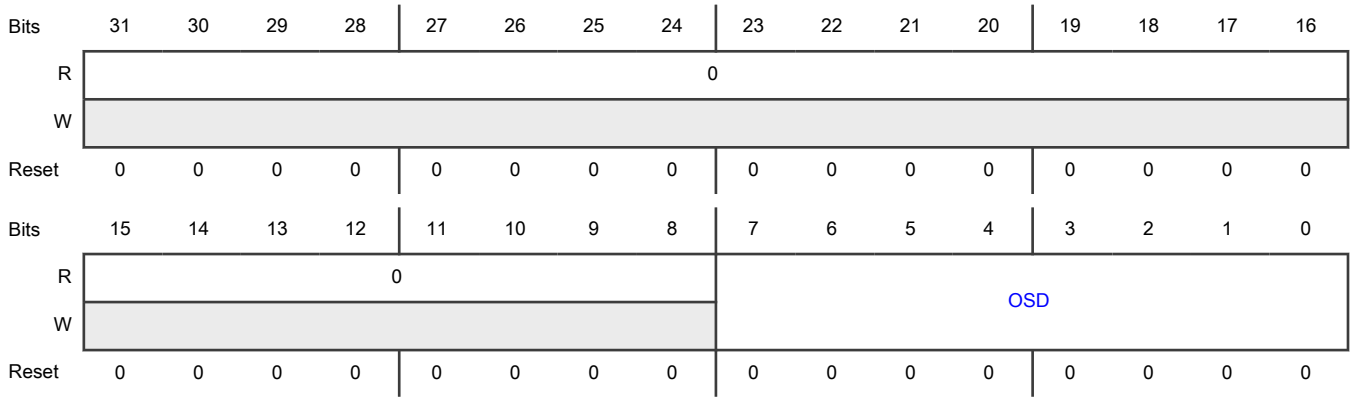
Offset

Register	Offset
OSDR	44h

Function

The Output Settling Delay Register (OSDR) provides a delay value to qualify the converted output data coming from the FIR.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 OSD	Output Settling Delay This field defines the delay to qualify the conversion data stored in CDR. Whenever the FIR block is reset in order to start the conversion from a fresh state, an internal timer is loaded with this start value.

60.5.7 FIFO Control Register (FCR)

Offset

Register	Offset
FCR	48h

Function

The FIFO Control Register (FCR) provides the ability to turn on and off the FIFO functionality, and to select the size of FIFO depth. This register also provides the ability to set the programmable threshold for notification of dataword removal from the FIFO. This register may be read at any time, but should only be written when FIR is disabled (FCR[FOWEN]=0).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															0
W																FRST
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				FTHLD				0				FOWEN	FSIZE		FE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

Fields

Field	Function
31-17 —	Reserved
16 FRST	FIFO Flush Reset

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This is functional soft reset to flush the current FIFO content and initialize the internal FIFO pointers. This is W1S(write one shot) bit which can be written as '1' but always read as '0'. Use this option only when FIR is not running. 0b - No effect. 1b - Generate a single cycle reset event to flush the FIFO.
15-12 —	Reserved
11-8 FTHLD	FIFO Threshold When the number of datawords in the data FIFO is greater than the value in FTHLD field, the FIFO full event is flagged. An interrupt or a DMA request will be generated as determined by DFFDIRE and DFFDIRS fields of RSER. For proper operation, the value in the FTHLD field must be set to be less than the FIFO size as indicated by FSIZE
7-4 —	Reserved
3 FOWEN	FIFO Over Write Enable When set the built-in FIFO structure allows the overwritting of new converted data over older converted data after the FIFO has number of entries equal to the FSIZE. 0b - Data FIFO OW option disabled. 1b - Data FIFO OW option enabled.
2-1 FSIZE	FIFO Size The maximum number of converted datawords that can be stored in the data FIFO before an overrun occurs. This field is read-only. The reset value of this field depends on the implementation parameter to define the FIFO size. 00b - FIFO depth = 1 dataword 01b - FIFO depth = 4 datawords 10b - FIFO depth = 8 datawords 11b - FIFO depth = 16 datawords
0 FE	FIFO Enable When this field is set the built-in FIFO structure is enabled. The size of the FIFO structure is indicated by the FSIZE field. If this field is not set then the FIFO depth is set to one dataword regardless of the value in the FSIZE field. 0b - Data FIFO is not enabled for multiple datawords; FIFO depth is one dataword 1b - Data FIFO is enabled; FIFO depth is indicated by FSIZE

60.5.8 Converted Data Register (CDR)

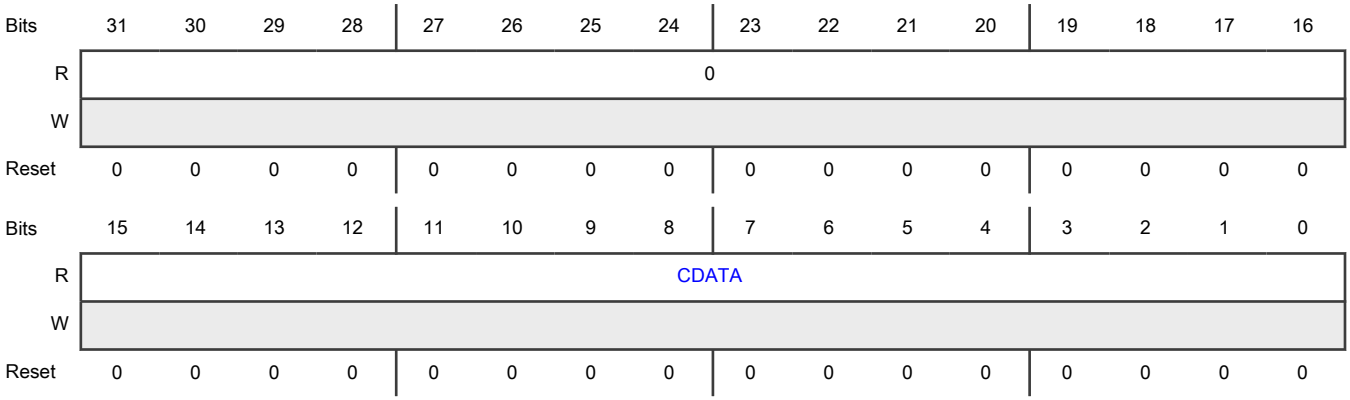
Offset

Register	Offset
CDR	4Ch

Function

The Converted Data Register (CDR) stores the converted data in the data FIFO.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 CDATA	Converted Data Register The converted datawords can be read from FIFO by reading this register. The data width is 16 bits which has actual 16-bit data (bits 15 down to 0) coming from ADC.

Chapter 61
Low Power Comparator (LPCMP)

61.1 Chip-specific LPCMP information

61.1.1 Instantiation information

Table 283. LPCMP instances

Chip	Instance	No. of external inputs
S32K396	LPCMP_0	8
	LPCMP_1[1]	4

1. LPCMP_1 is not available in S32K36x.

61.1.2 LPCMP input output connections

See the IOMUX file attached to this document for pin/pad assignments corresponding to CMP pins.

The LPCMP channels can be used as a wakeup source in trigger mode to wakeup the device from standby mode.

61.1.3 LPCMP-DAC "vrefh0" and "vrefh1" references

The 8-bit DAC sub-block supports selection of "vrefh0" and "vrefh1" by CMPx_DCR[VRSEL]. For this device, the references are connected as follows:

- vrefh0 (External Reference): VDD_HV_A
- vrefh1 (Internal Reference): 1.2 V PMC bandgap reference

NOTE

1.2 V internal reference voltage is not available in Standby mode.

61.1.4 LPCMP Window control

The window mode operation of all the comparator instances in the chip can be enabled/disabled by the TRGMUX. See the TRGMUX connectivity file attached to this document for details.

NOTE

Window/Sample signal must be of minimum 4 cycle pulse for Window mode/Sample mode to function.

61.1.5 Comparator Trigger Mode

The comparator modules in the device support trigger mode operation as described in 'Trigger Mode' section. Device can operate in trigger mode in both standby and run mode to continuously scan the input channels. The main features of the device trigger mode operation are:

- Round robin clock: RTC_CLK
- Round robin trigger source: RTC_API

NOTE

It must be ensured that the RTC_CLK period is greater than the comparison time corresponding to the value of C0[PMODE]. It is also required to **not** select the internal reserved channels, if available on the package, for trigger mode operation by INPSEL and INNSEL. See the IOMUX file attached to this document for the pins available in various packages supported for the device.

NOTE

Only SIRC is supported as RTC_CLK for trigger mode operation. The LPCMP initialization delay is not supported by RRCR0[RR_INITMOD] with FXOSC or FIRC as RTC_CLK.

NOTE

In run mode, the generated trigger is delayed by 3 RTC_CLK cycles before being given to comparator trigger input.

61.1.6 Interaction with RTC API to cause wakeup

LPCMP can be used for waking up the chip from standby. For this, RTC-API and LPCMP must be configured before entering into standby mode as per below shown figure.

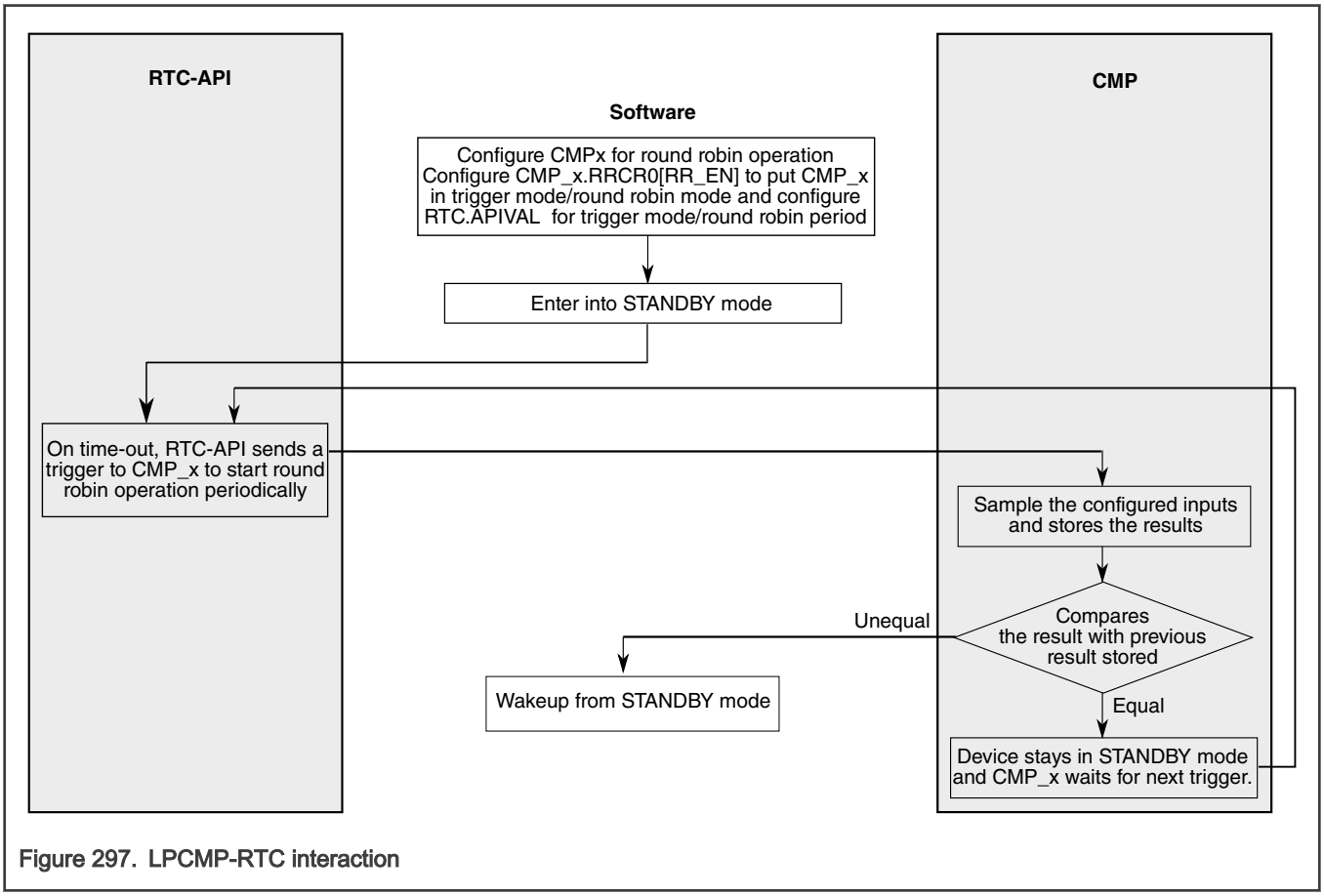


Figure 297. LPCMP-RTC interaction

In the trigger mode operation, only the continuous mode is supported. None of the window/filter/sample functions should be used. Refer to the "Functional Modes" section for details on comparator modes of operation.

Register configurations before entering Standby mode for LPCMP trigger mode operation:

1. Configure RTC.APIVAL to set the period of the round robin operation.
2. Execute standby mode entry.

61.2 Overview

The LPCMP module provides a circuit to compare two analog input voltages. It includes the following:

- A low power comparator (CMP)
- A DAC

- An analog mux (ANMUX)

See Block diagram for more information.

LPCMP can operate across the full range of the supply voltage, known as rail-to-rail operation.

DAC is a 256-tap resistor ladder network that provides a selectable voltage reference for applications requiring a voltage reference. DAC divides the supply reference V_{in} into 256 voltage levels. An 8-bit digital signal input selects the output voltage level, which varies from V_{in} to $V_{in}/256$.

You can select V_{in} from the following voltage sources:

- VREFH0
- VREFH1

See the Chip-specific LPCMP information for more information on source of VREFH0 and VREFH1.

NOTE

The LPCMP's internal DAC output is available as an on-chip internal signal only and is not available for an external chip pin.

ANMUX allows you to select an analog input signal from among eight channel options. One channel option is the DAC output. Other chip resources are connected to the other channels. See the Chip-specific LPCMP information section for more information. ANMUX can operate across the full range of the supply voltage.

61.2.1 Block diagram

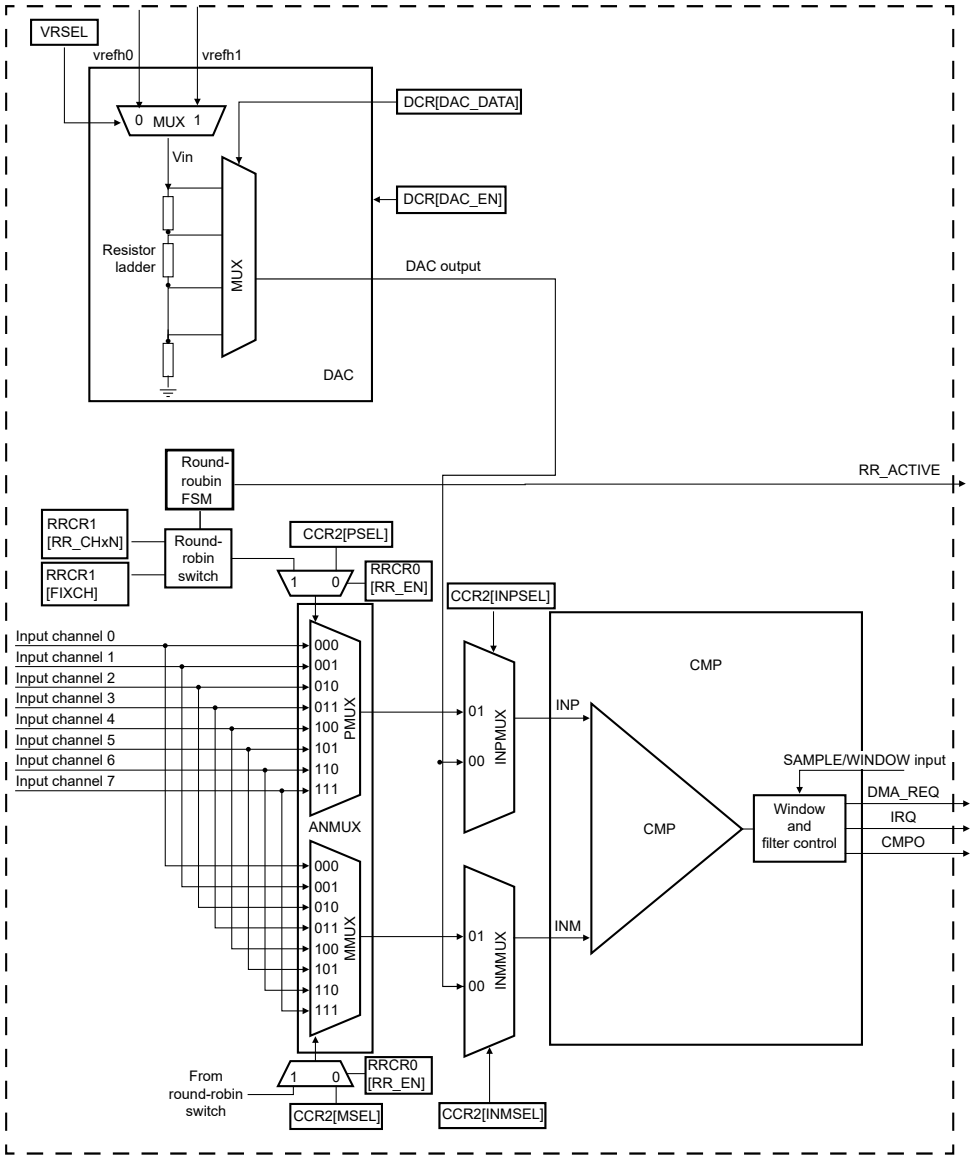


Figure 298. Block diagram

61.2.2 Features

The features of the LPCMP module include：

- Includes two 8-to-1 channel MUXes to select input signal from eight channels
- Supports multiple operation modes to produce a wide range of outputs such as:
  - Sampled
  - Windowed, which is ideal for certain PWM zero-crossing-detection applications
  - Digitally filtered
- Provides the following advance features for window and sample:

- Window and sample signals can be inverted.
- CMPO rising, falling or both edges closes the window.
- CMPO level can be defined when window is closed.

- Provides selectable performance levels:
  - Low-Power (speed) mode
  - High-Power (speed) mode
- Supports programmable hysteresis control
- Provides a selectable inversion on comparator output
- Uses an external hysteresis at the same time the output filter is used for internal functions
- Provides interrupt and DMA support
- Supports Round Robin Trigger mode
- Includes an 8-bit resolution DAC
- Provides a selectable supply reference source for DAC
- Provides a configurable Low-Power (speed) mode or High-Power (speed) mode for DAC

61.3 Functional description

61.3.1 Functional block diagram

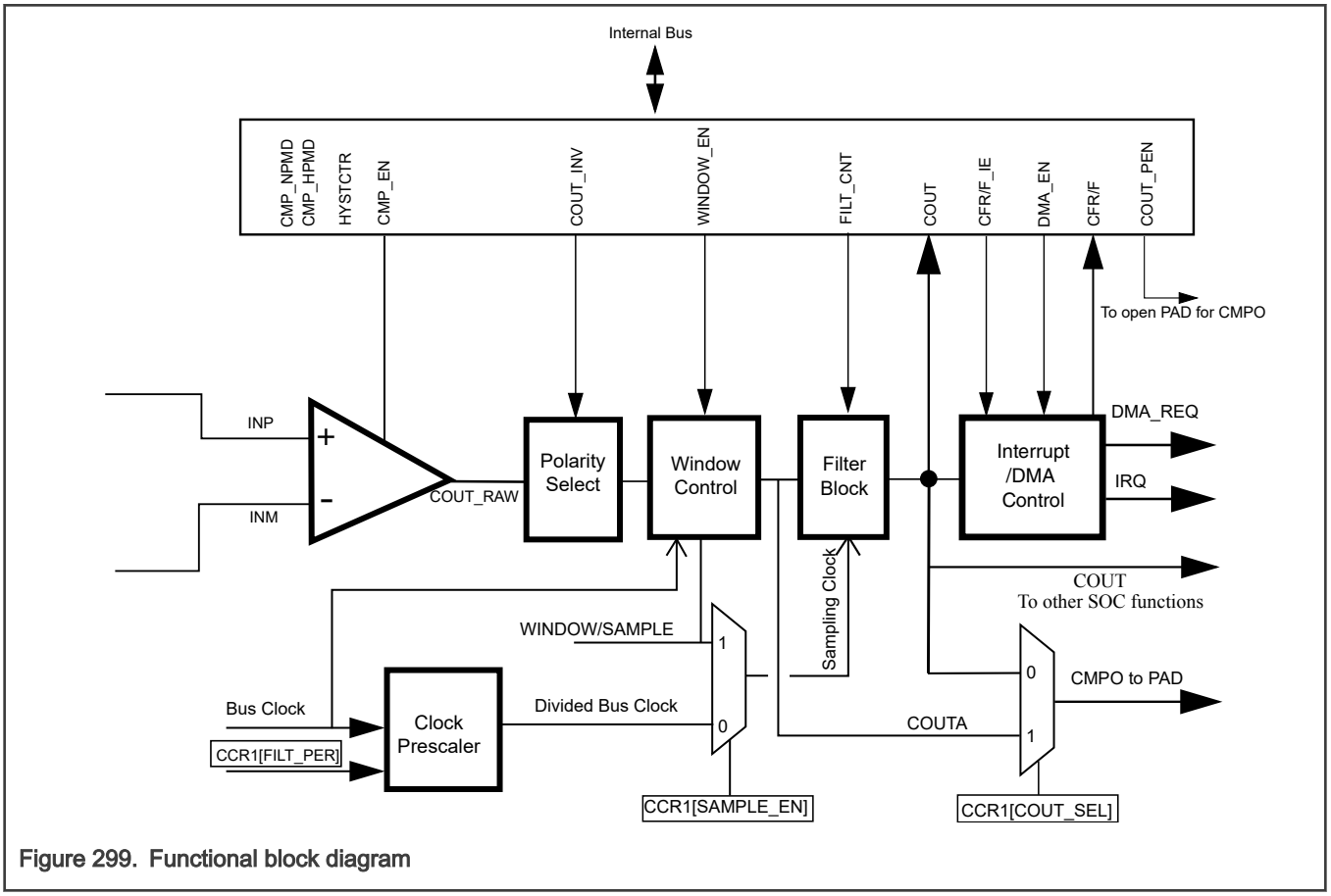


Figure 299. Functional block diagram

As shown in the block diagram, the functions are:

- Compared two analog input voltages applied to INP and INM, COUT_RAW is high when the INP input voltage is greater than the INM input voltage, and COUT_RAW is low when the INP input voltage is less than the INM input voltage.
- The COUT_RAW signal can be inverted by enabling CCR1[COUT_INV].
- The optionally inverted comparator output COUT_RAW is sampled on every bus clock when you enable the CCR1[WINDOW_EN] to generate COUTA. In this case, the comparator output is ignored during time periods when the input voltages are not valid. This is useful when you implement zero-crossing-detection for certain PWM applications.
- The window control block is bypassed when CCR1[WINDOW_EN] is disabled.
- The filter block acts as a simple sampler when CCR1[FILT_CNT] is set to 01h.
- The filter block acts as a filter based on multiple samples when CCR1[FILT_CNT] is set to be greater than 01h.
  - If CCR1[SAMPLE_EN] is set to 1, use the external SAMPLE input as the sampling clock.
  - If CCR1[SAMPLE_EN] is set to 0, use the divided bus clock as the sampling clock.
- Bypasses the filter block when it is not in use.

```
Bypass_Filter_Block = (FILT_CNT == 0x00) |  (~SAMPLE_EN & (FILT_PER == 0x00))
```

- Both COUTA and COUT can be configured as module output CMPO by configuring CCR1[COUT_SEL], and are used for different purposes within the system.
- The optionally filtered COUT can be read directly in CSR[COUT].
- The SAMPLE/WINDOW signal can be inverted by setting CCR1[WINDOW_INV].
- The SAMPLE/WINDOW signal can be closed by CMPO's falling edge and/or rising edge by setting CCR1[WINDOW_CLS] in Window mode.
- In Window mode, when window is closed, define the COUTA value as CCR1[COUTA_OW] by setting CCR1[COUTA_OWEN]. If CCR1[COUTA_OWEN] is not set, COUTA holds the last sampled value.

NOTE

See the chip configuration section for the source of SAMPLE/WINDOW input.

61.3.2 Round-robin trigger mode

You can enable Round-Robin Trigger mode by setting RRCR0[RR_EN] and CCR0[CMP_EN] to 1. A trigger event initiates a comparison sequence. The next trigger event should not occur before the current sequence completes.

RRCR1[FIXP] and RRCR1[FIXCH] select the reference channel for the plus side mux or the minus side mux. RRCR1[RR_CHnEN] selects active channels.

When a trigger comes, the analog comparator enables. After the comparison sequence completes, the analog comparator disables again. RRCR0[RR_INITMOD] controls the analog stabilization time.

NOTE

RR_INITMOD*round robin clock period must be longer than the initialization delay specified in the Comparator and 8-bit DAC electrical specifications section of LPCMP datasheet.

After the stabilization process completes, the round robin manner comparison sequence begins. Sample the comparison result for the selected active channel after RRCR0[RR_NSAM] defines the configurable number of operation clocks.

After all the active channels are sampled/compared, if the comparison result changes from its pre-programmed state, the corresponding flag in RRSR[RR_CHnF] is set. Write to RRCSR[RR_CHnOUT] to configure the pre-programmed state for each channel. Update RRCSR[RR_CHnOUT] to store the last comparison result for each channel. If any flag in RRSR[RR_CHnF] sets, CSR[RRF] also sets. If IER[RRF_IE] sets, an asynchronous interrupt asserts. Note that these flags do not support generating a DMA transfer event.

The following diagram shows the basic flow of this mode. In the diagram, RRCR1[RR_CH1EN], RRCR1[RR_CH3EN], and RRCR1[RR_CH4EN] are 1, so channels #1, #3, and #4 are selected for round-robin depending on their priority setting. RRCR0[RR_NSAM] sets to 2'b01, so you can sample one clock later the comparison result of the selected channel. After you compare the channel #4, the result is sampled, and round-robin ends. If any of the comparison results from channel #1, #3, or #4 changed from their programmed value (written to RRCSR[RR_CH1OUT], RRCSR[RR_CH3OUT], and RRCSR[RR_CH4OUT]), generates an interrupt. Software can then poll RRSR[RR_CHnF] to see which channel input(s) changed value.

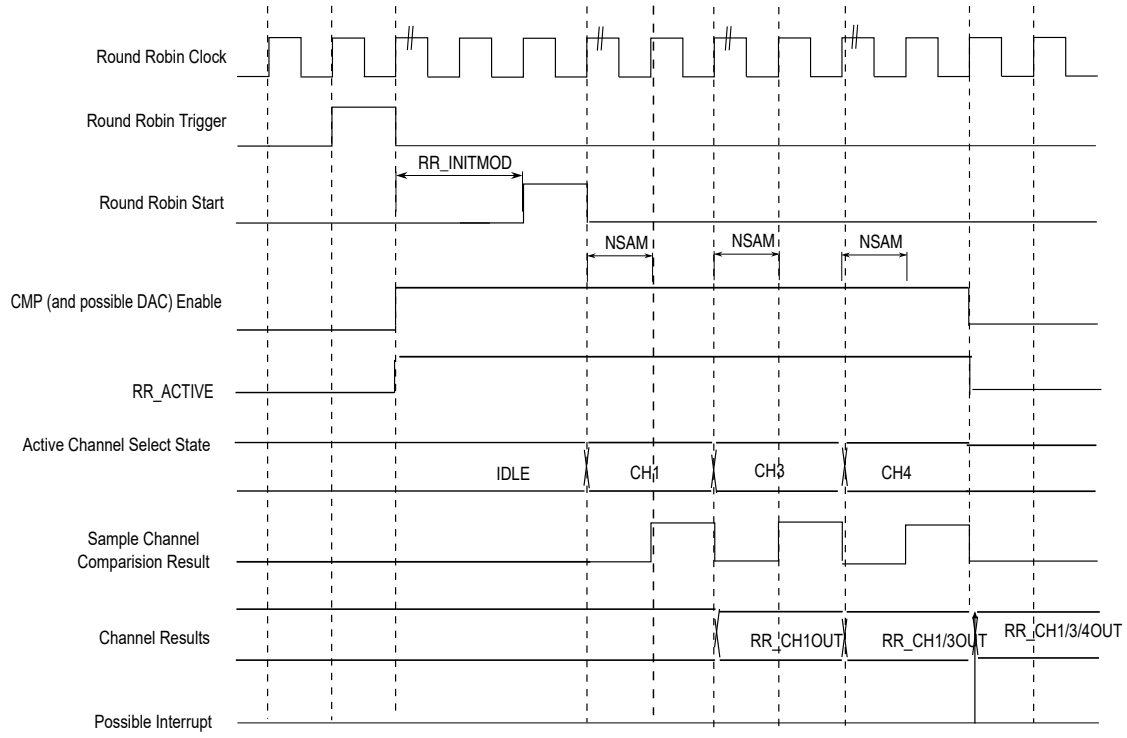


Figure 300. Trigger mode

The table below shows the channel decode in both Functional mode and Trigger mode. Other cases not in the table are illegal.

Table 284. CMP channel decode in functional mode and round-robin trigger mode

Mode	RR_EN	PSEL[2:0]	MSEL[2:0]	INPSEL[1:0]	INMSEL[1:0]	FIXP	FIXCH[2:0]	RR_CHxN	INP	INM	CMP Behavior
Functional mode	0	x[1]	0 to 7	0	1	x	x	x	DAC	Channel decoded from MSEL[2:0]	Channel 0 to 7 can be compared with DAC

Table continues on the next page...

Table 284. CMP channel decode in functional mode and round-robin trigger mode (continued)

Mode	RR_EN	PSEL[2:0]	MSEL[2:0]	INPSEL[1:0]	INMSEL[1:0]	FIXP	FIXCH[2:0]	RR_CHxN	INP	INM	CMP Behavior
		0 to 7	x	1	0	x	x	x	Channel decoded from PSEL[2:0]	DAC	Channel 0 to 7 can be compared with DAC
		0 to 7	0 to 7	1	1	x	x	x	Channel decoded from PSEL[2:0]	Channel decoded from MSEL[2:0]	Channel 0 to 7 can be compared with channel 0 to 7[2]
Trigger mode	1	x	x	0	1	0	x	0 to 7	DAC	Channel sweep (RR_CHxN)	Channel 0 to 7 can be swept with DAC
		x	x	1	0	1	x	0 to 7	Channel sweep (RR_CHxN)	DAC	Channel 0 to 7 can be swept with DAC
		x	x	1	1	0	0 to 7	0 to 7	Channel fixed by FIXCH[2:0]	Channel sweep (RR_CHxN)	Channel 0 to 7 can be swept with a fixed channel(0 to 7)[3]
		x	x	1	1	1	0 to 7	0 to 7	Channel sweep (RR_CHxN)	Channel fixed by FIXCH[2:0]	Channel 0 to 7 can be swept with a fixed channel(0 to 7)[3]

1. "x" means "don't care"
2. PSEL should not be same as MSEL.
3. Channel in the sweep side should not be same as the fixed side.

61.3.3 Low-pass filter mode

The low-pass filter mode operates on an unfiltered, optionally inverted comparator output COUTA, and generates the filtered and synchronized output COUT. You can configure both COUTA and COUT as module outputs and use for different purposes within the system.

Synchronization and edge detection determine the bit values of status register. They also apply to COUT for all sampling and windowed modes. You can perform filtering using an internal timebase defined by CCR1[FILT_PER], or use an external sample input to determine sample time.

The need for digital filtering and the amount of filtering depends on your requirements. Filtering can become more useful in the absence of an external hysteresis circuit. Without external hysteresis, generate a high-frequency oscillations at COUTA when the selected INM and INP input voltages differ by less than the offset voltage of the differential comparator.

61.3.3.1 Enabling low-pass filter mode

You can enable low-pass filter mode by setting the following:

- CCR1[FILT_CNT] > 01h
- CCR1[FILT_PER] to a nonzero value or writing 1 to CCR1[SAMPLE_EN].

If you use the divided bus clock to drive the low-pass filter, it samples COUTA every CCR1[FILT_PER] bus clock cycle.

If CCR1[SAMPLE_EN] is set to 1, the low-pass filter samples COUTA on each positive transition of the sample input. The output state of the filter changes when all the consecutive CCR1[FILT_CNT] samples agree that the output value has changed.

61.3.3.2 Latency issues

Program the value of CCR1[FILT_PER] or sample period such that the sampling period is longer than the period of the expected noise, ensuring that a given noise spike corrupts only one sample. You must choose the value of CCR1[FILT_CNT] to reduce the probability of noisy samples causing an incorrect transition to recognize. The probability of an incorrect transition is defined as the probability of an incorrect sample raised to the power of CCR1[FILT_CNT].

You must trade off the values of CCR1[FILT_PER] or sample period and CCR1[FILT_CNT] against the need for minimal latency in recognizing actual comparator output transitions. The probability of detecting an actual output change within the nominal latency is the probability of a correct sample raised to the power of CCR1[FILT_CNT].

Table 286 summarizes maximum latency values for the various modes of operation in the absence of noise. Filtering latency restarts each time the noise masks an actual output transition.

61.3.4 Low power mode operation

Below table introduces the mode of operation of lower power.

Table 285. Low power mode operation

Mode of operation	Description
STANDBY	LPCMP can operate only in Continuous mode or Round-robin trigger mode.

61.3.5 Functional modes

You can combine the comparator window and filter features as shown in the following table.

Table 286. Functional modes

Mode #	CMP_EN	WINDOW_EN	SAMPLE_EN	FILT_CNT	FILT_PER	Operation	Maximum latency[1]
1	0	X	X	X	X	See the Disabled mode (#1).	N/A
2A	1	0	X	0x00	X	See the Continuous mode (#2A and #2B).	T_{PD}
2B	1	0	0	X	0x00		
3A	1	0	1	0x01	X	See the Sampled, non-filtered mode (#3A and #3B).	$T_{PD} + T_{SAMPLE} + 3T_{per}$
3B	1	0	0	0x01	> 0x00		$T_{PD} + (FILT_PER * T_{per}) + 3T_{per}$

Table continues on the next page...

Table 286. Functional modes (continued)

Mode #	CMP_EN	WINDOW_EN	SAMPLE_EN	FILT_CNT	FILT_PER	Operation	Maximum latency[1]
4A	1	0	1	> 0x01	X	See the Sampled, filtered mode (#4A and #4B).	T_{PD} + (FILT_CNT * T_{SAMPLE}) + $3T_{per}$
4B	1	0	0	> 0x01	> 0x00		T_{PD} + (FILT_CNT * FILT_PER x T_{per}) + $3T_{per}$
5A	1	1	0	0x00	X	See the Windowed mode (#5A and #5B).	T_{PD} + $2T_{per}$
5B	1	1	0	X	0x00		
6	1	1	0	0x01	> 0x00	See the Windowed/ Resampled mode (#6).	T_{PD} + (FILT_PER * T_{per}) + $3T_{per}$
7	1	1	0	> 0x01	> 0x00	See the Windowed/ Filtered mode (#7).	T_{PD} + (FILT_CNT * FILT_PER x T_{per}) + $3T_{per}$
All other combinations of CMP_EN, WINDOW_EN, SAMPLE_EN, FILT_CNT, and FILT_PER are illegal.							

1. T_{PD} represents the intrinsic delay of the analog component plus the polarity select logic. T_{SAMPLE} is the clock period of the external sample clock. T_{per} is the period of the bus clock.

61.3.5.1 Disabled mode (#1)

In this mode:

- The analog comparator is non-functional and consumes no power.
- CSR[COUT] and CMPO are the same as CCR1[COUT_INV].

61.3.5.2 Continuous mode (#2A and #2B)

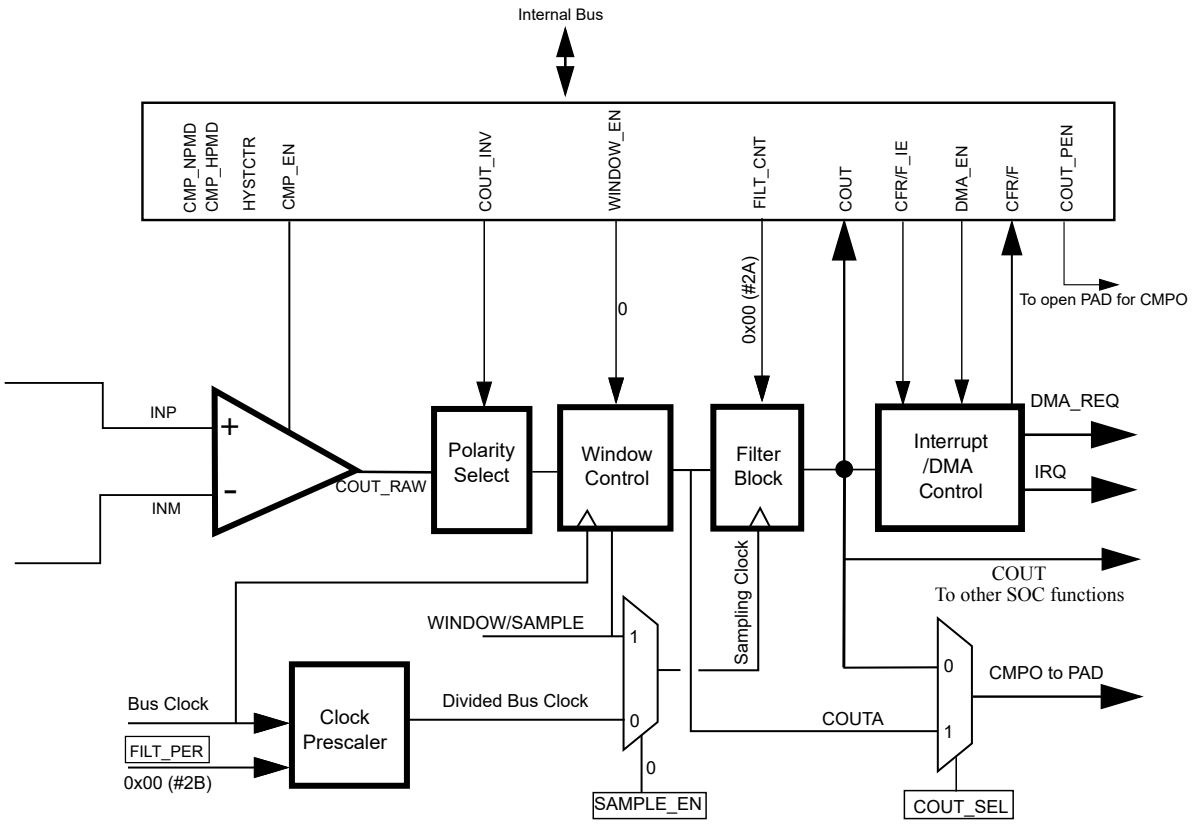


Figure 301. Comparator operation in continuous mode

COUT_RAW is optionally inverted in this mode but is not subject to external sampling or filtering. Both window control and filter blocks bypass completely, and CSR[COUT] updates continuously. The path from comparator input pins to output pins operates in a combinational (unclocked) mode. COUT and COUTA are identical in this mode.

For cases where a comparator drives a fault input, you must configure it to operate in Continuous mode so that an external fault can immediately pass to the target fault circuitry through the comparator.

61.3.5.3 Sampled, non-filtered mode (#3A and #3B)

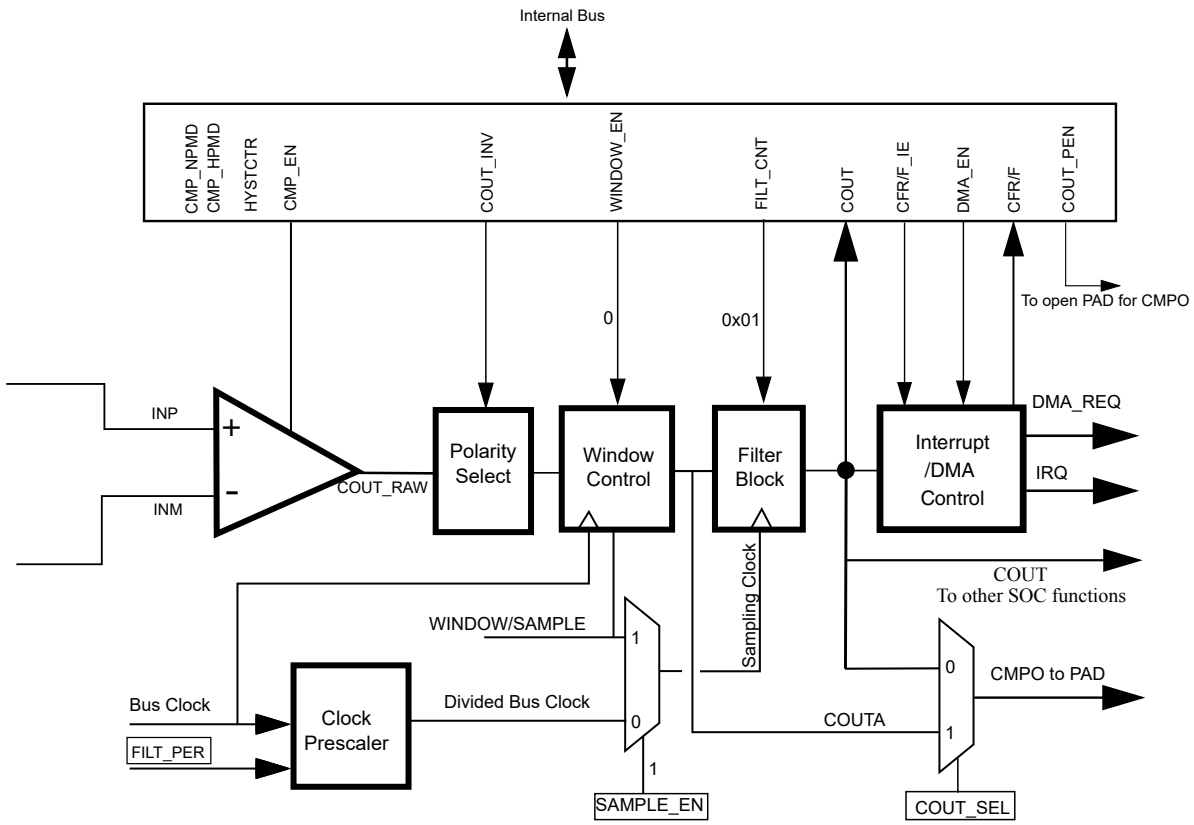


Figure 302. Sampled, non-filtered (#3A): sampling point externally driven

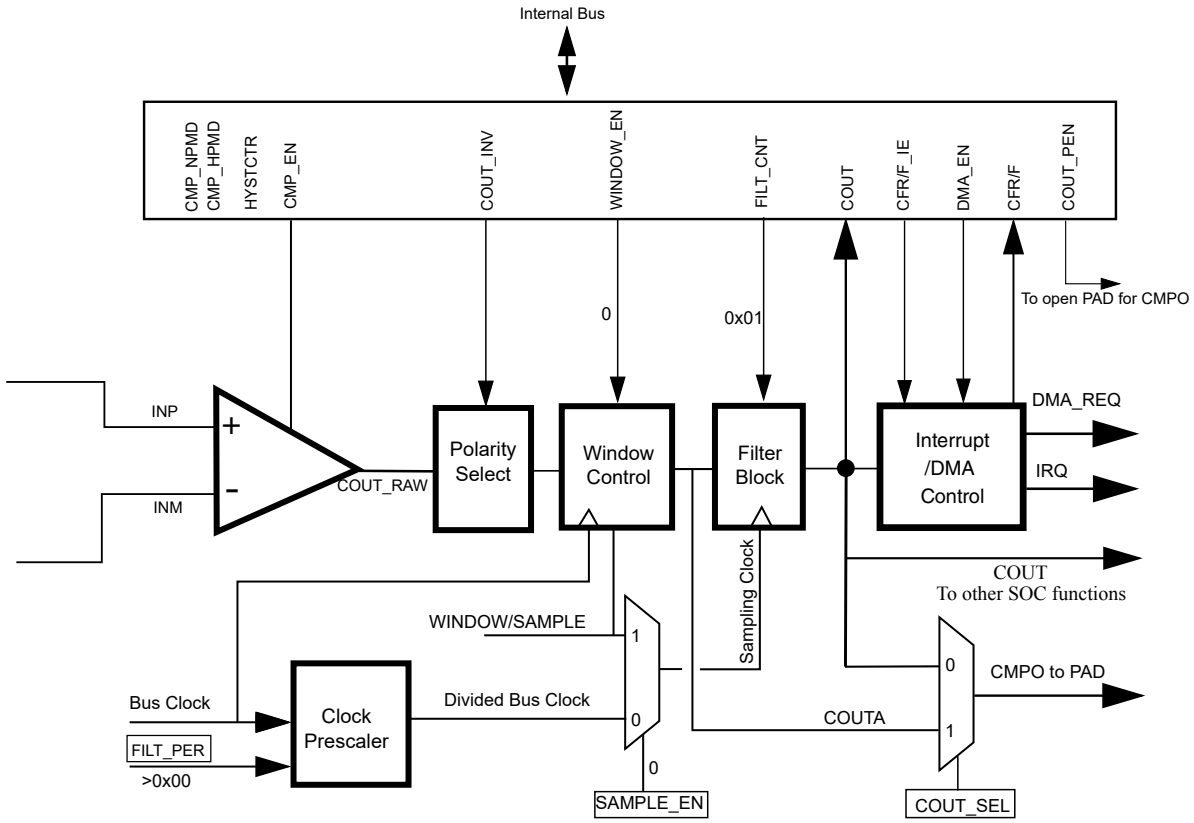


Figure 303. Sampled, Non-Filtered (#3B): sampling interval internally derived

In this mode, the path from analog inputs to COUTA is combinational (unclocked). Windowing control bypasses completely. You can sample COUTA whenever you detect a rising edge on the sampling clock.

The difference in two operation modes (#3A and #3B) of sampled, non-filtered mode is that how you drive the clock to the filter block. In #3A, the clock to filter block drives externally, and in #3B, the clock to filter block drives internally.

The filter block has no other function than sample or hold of the comparator output in this mode.

The following figure shows the comparator operation in this mode, assuming that the polarity select sets to a non-inverting state.

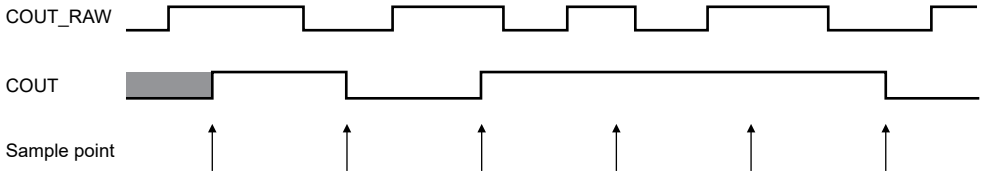


Figure 304. Sampled, Non-Filtered mode timing diagram

61.3.5.4 Sampled, filtered mode (#4A and #4B)

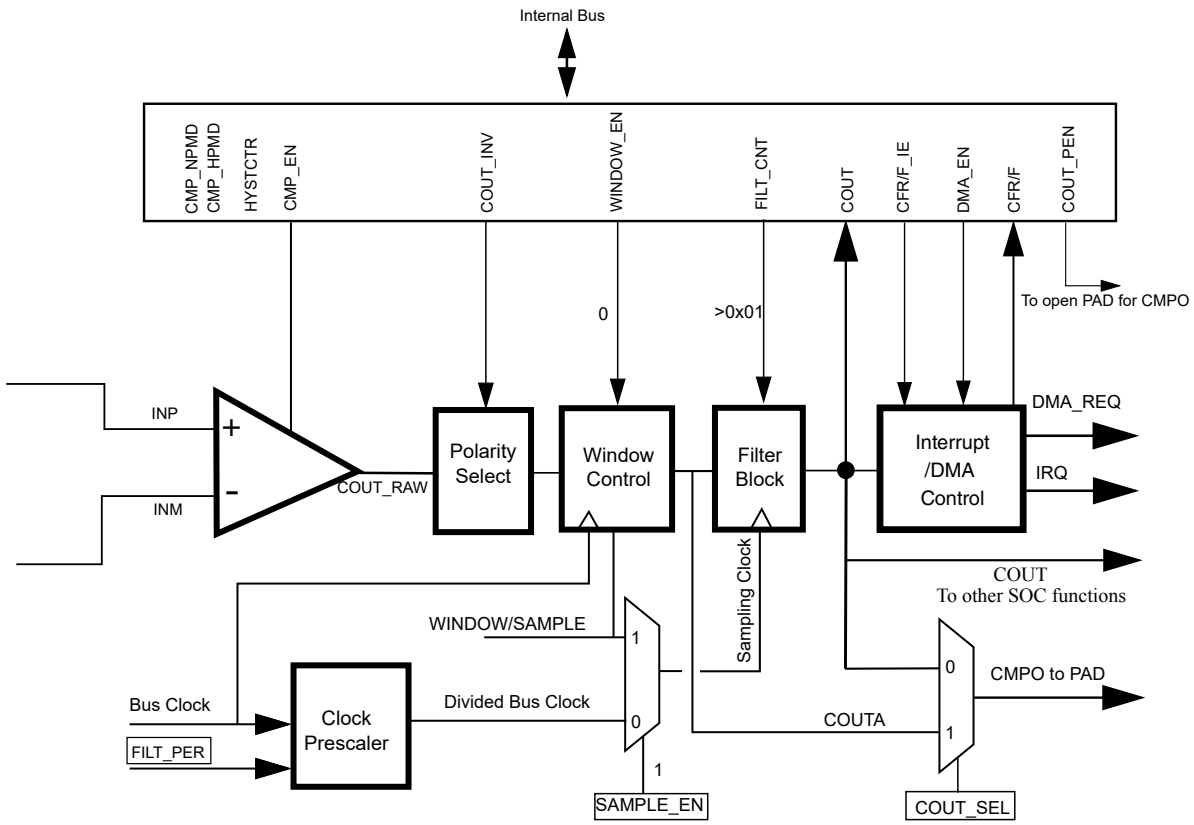


Figure 305. Sampled, filtered (#4A): sampling point externally driven

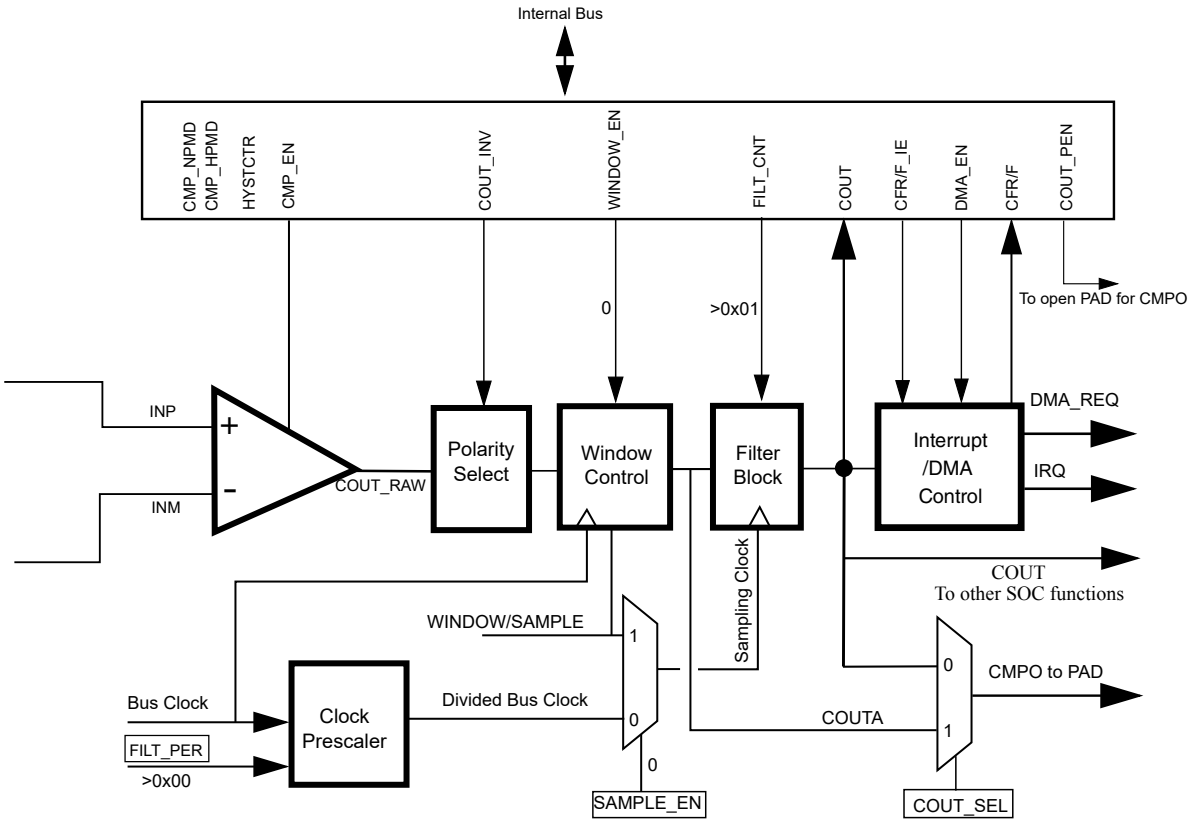


Figure 306. Sampled, filtered (#4B): sampling point internally derived

In this mode, the path from the analog inputs to COUTA is combinational(unclocked). Windowing control bypasses completely. You can sample COUTA whenever you detect a rising edge on the sampling clock.

The only difference in operation between sampled, non-filtered (#3A) mode and sampled, filtered (#4A) mode is that CCR1[FILT_CNT] is larger than 1, which activates filter operation.

The only difference in operation between sampled, non-filtered (#3B) mode and sampled, filtered (#4B) mode is that CCR1[FILT_CNT] is larger than 1, which activates filter operation.

61.3.5.5 Windowed mode (#5A and #5B)

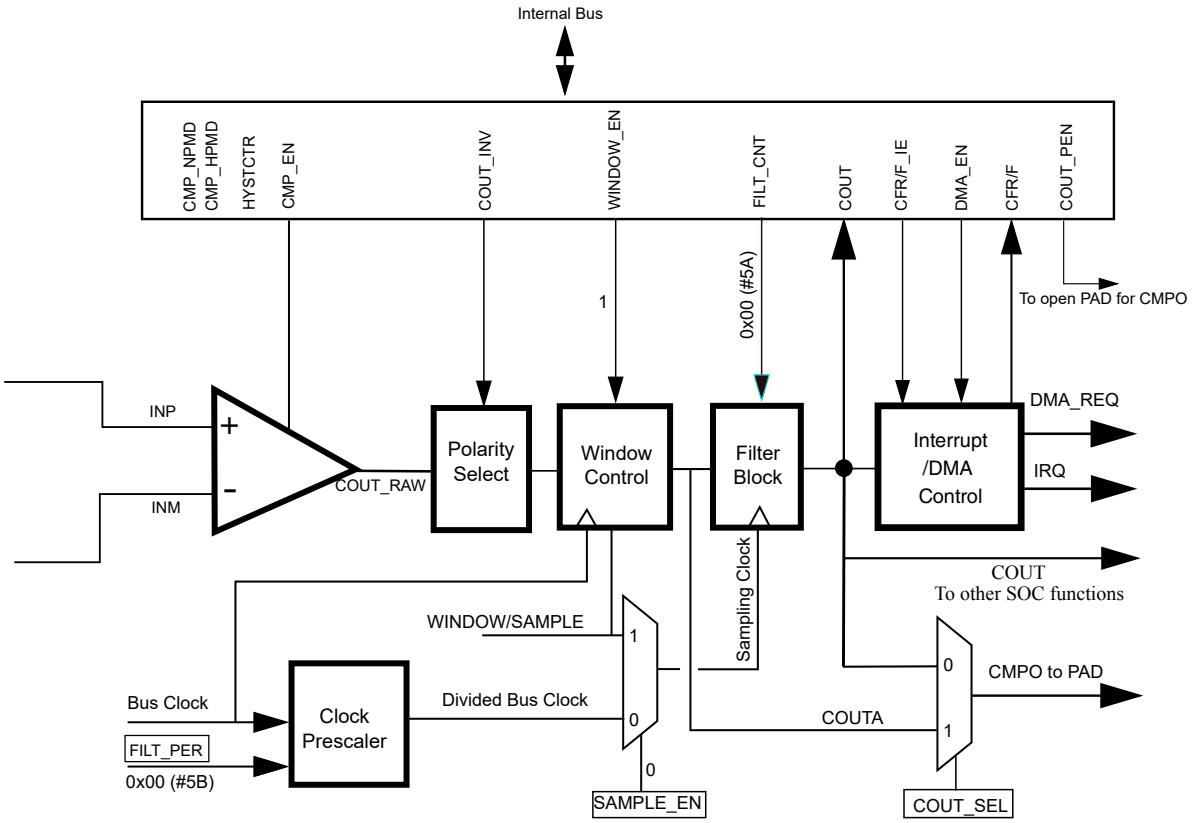


Figure 307. Windowed mode

The bus clock clocks COUTA whenever you enable the window in this mode. The last latched value holds after you disable the window and the filter block is bypassed.

The following figure shows the comparator operation in this mode, ignoring the latency of the analog comparator, polarity select, and window control block. The polarity select sets to a non-inverting state.

COUTA may lag the analog inputs by up to two functional clock cycles plus the combinational path delay through the comparator and polarity select logic in the actual operation.

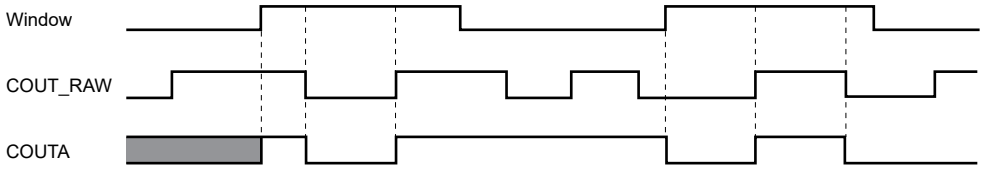


Figure 308. Windowed mode timing diagram

The following figure shows that if CCR1[COUTA_OWEN] becomes 1, you can define COUTA level as CCR1[COUTA_OW], after you closes the window.

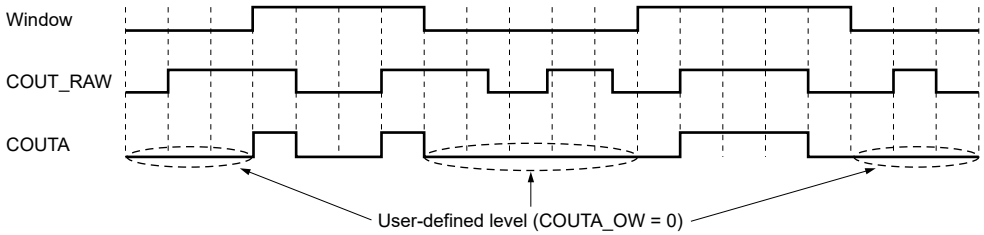


Figure 309. Windowed mode timing diagram with user defined value 0 outside window

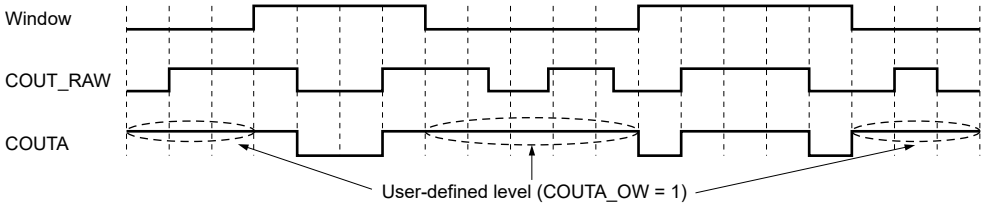


Figure 310. Windowed mode timing diagram with user defined value 1 outside window

NOTE

When the window is open, COUT_A will switch from COUTA_OW to COUT_RAW. When the window is closed, COUT_A will switch from COUT_RAW to COUTA_OW. This may generate unnecessary transition flags, for instance, CFR or CFF. User needs to choose COUTA_OW carefully according to the actual application, and select the appropriate flag CFR or CFF to generate interrupt.

If CCR1[WINDOW_CLS] becomes 1, you can define the CMPO event (rising edge, falling edge or both edges that CCR1[EVT_SEL] selects) to close the window. The external window signal has to go to zero and back to one to enable the internal window again. The following figure shows an example that CMPO rising edge closes the internal window.

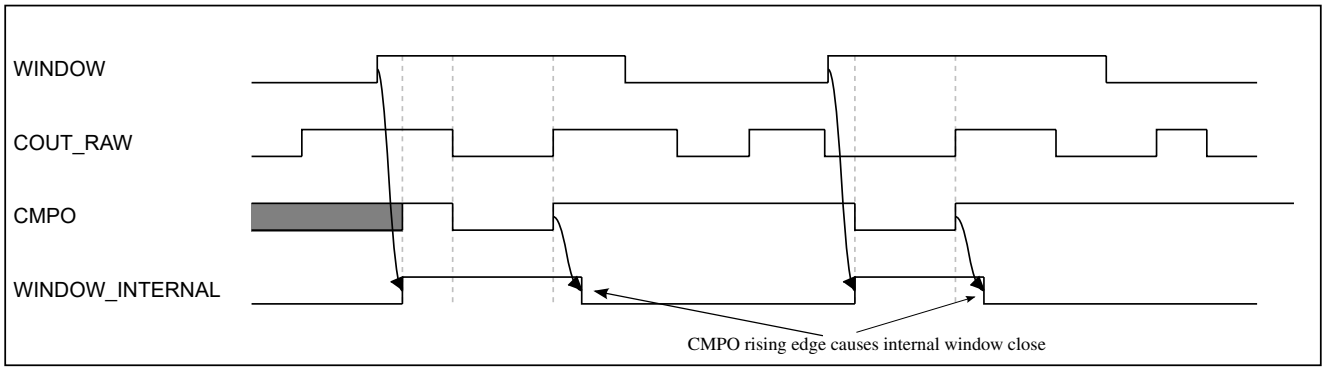


Figure 311. Windowed mode timing diagram with CMPO rising edge close window

The following figure shows that if CCR1[WINDOW_INV] becomes 1, you can invert the window signal before you use it.

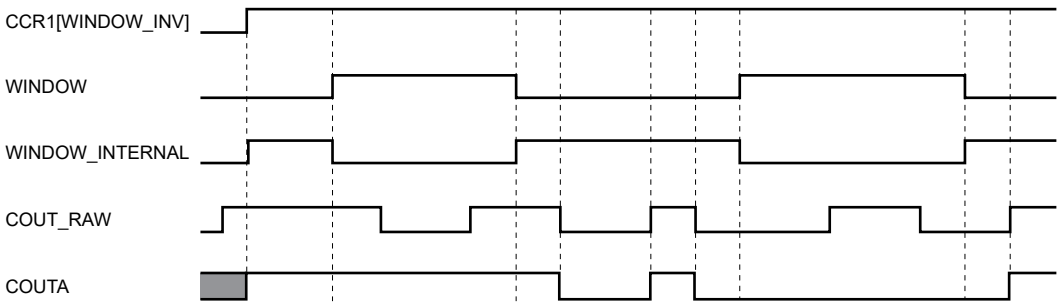


Figure 312. Windowed mode timing diagram with window signal inverted

61.3.5.6 Windowed/Resampled mode (#6)

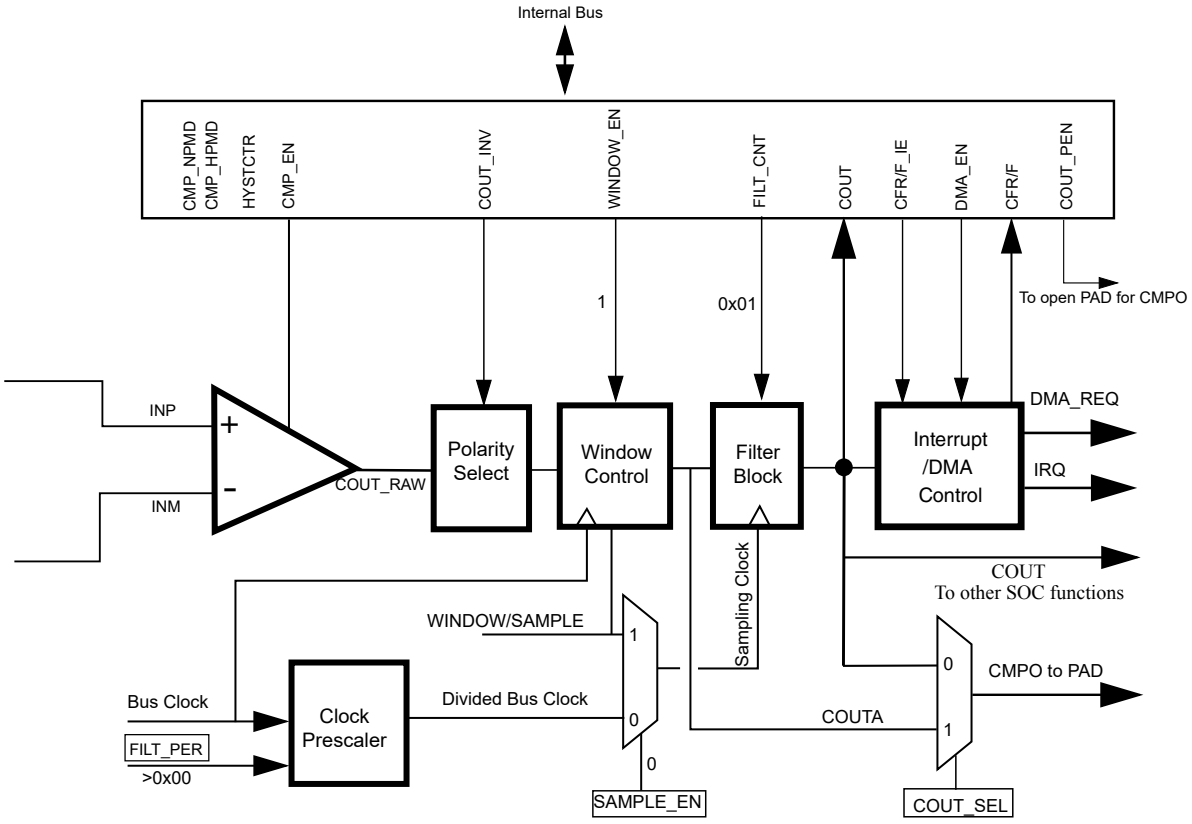


Figure 313. Windowed/Resampled mode

This mode of operation results in an unfiltered string of comparator samples where CCR1[FILT_PER] and the bus clock rate determines the interval between the samples. The following section shows that the configuration for this mode is virtually identical to that for the Windowed/Filtered mode. The only difference is that the value of CCR1[FILT_CNT] must be 1 in this mode.

The following figure uses the same input stimulus shown in Figure 308, and adds resampling of COUTA to generate COUT. The arrows in the figure indicate the time points at which the samples are taken. You can ignore prop delays and latency for clarity.

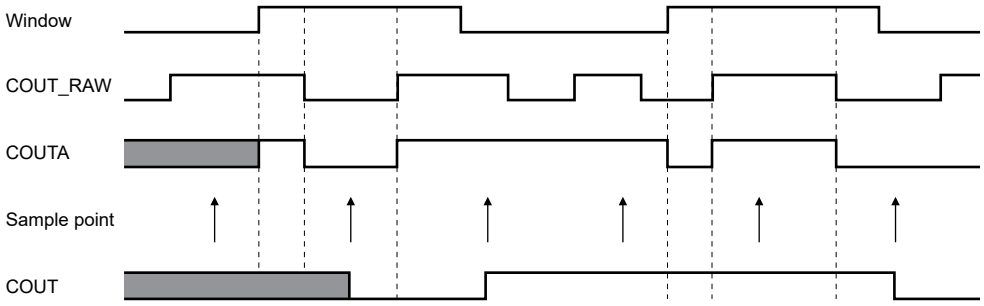


Figure 314. Windowed/Resampled mode operation

This example demonstrates the operation of the comparator in Windowed/Resampled mode, and does not reflect any specific application. Based on the sampling rate and window placement, COUT may not see zero-crossing events that the analog comparator detects. You must carefully consider the sampling period and/or window placement for a given application.

61.3.5.7 Windowed/Filtered mode (#7)

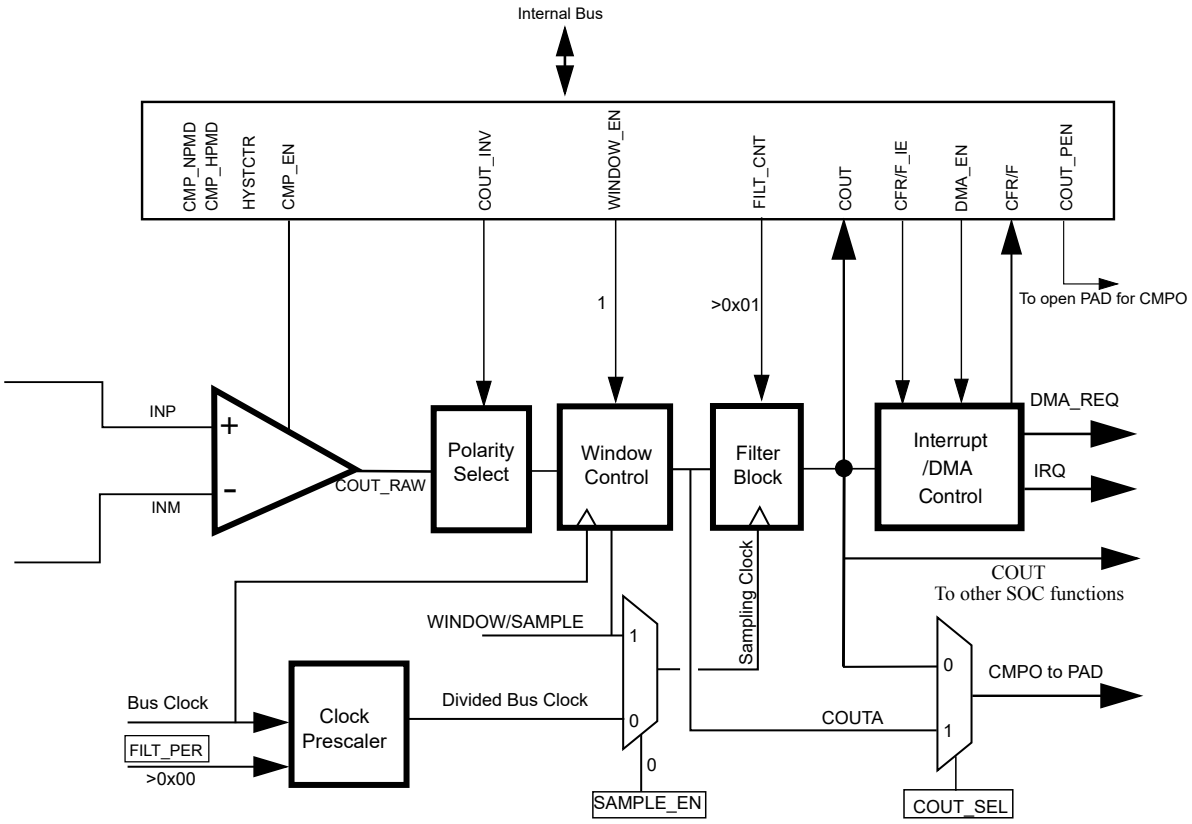


Figure 315. Windowed/Filtered mode

The only difference in operation between Windowed/Resampled mode (#6) and Windowed/Filtered mode (#7) is that CCR1[FILT_CNT] is >1, which activates filter operation.

This mode is the most complex mode of operation for the comparator block, as it utilizes both windowing and filtering features. It also has the highest latency of any of the modes. This is approximately: up to 2 peripheral clock synchronization in the window function + ((CCR1[FILT_CNT] x CCR1[FILT_PER]) + 1) x peripheral clock for the filter function.

61.3.6 DMA

After DMA is enabled by writing 1 to CCR1[DMA_EN] and interrupt is enabled by writing 1 to IER[CFR_IE], IER[CFF_IE], or both, the corresponding change on COUT forces a DMA transfer request rather than a CPU interrupt. After the DMA completes the transfer, it sends a transfer completing indicator signal that deasserts the DMA transfer request and clears the flags (both CSR[CFR] and CSR[CFF]) to allow a subsequent change on comparator output to occur and forces another DMA request.

61.3.7 Clocking

LPCMP requires the following clocks to operate:

Table 287. LPCMP clocks

Type of clock	Description
Bus	Controls the access to LPCMP registers and window/ filter function.
Round-robin clock (RCLK)	Controls Round-robin trigger mode.

61.3.8 Resets

The global chip reset signal resets LPCMP.

61.3.9 Interrupts

After the corresponding IER becomes 1, CSR[CFR], CSR[CFF], and CSR[RRF] can generate an interrupt, assuming that CCR1[DMA_EN] is not 1. You can clear either the flag or IER to deassert the interrupt.

61.4 External signal descriptions

Below table introduces external signals.

Table 288. External signal descriptions

Signal	Description	I/O
CMPO	Filtered or unfiltered comparator output	O
Input_Analog_Channels	Analog input channels (see the chip-specific information for more on the connections).	I
VREFH_EXT	External reference voltage for the CMP-DAC (see the chip-specific information for more on the connections).	I
RR_ACTIVE	Round-robin trigger mode enabled.	O

61.5 Initialization

You can enable LPCMP by writing 1 to CCR0[CMP_EN], and then configuring the control registers (CCR1, CCR2, DCR, and so on).

To disable LPCMP, write 0 to CCR0[CMP_EN]. Switching operation modes or changing control register fields on-the-fly (when CCR0[CMP_EN] is set to 1) may cause noise on the COUT or COUTA signals. To avoid unwanted signal noise, you must ensure to disable the module before switching modes or changing control fields.

The time required to stabilize COUT is the power-on delay of the comparators plus the largest propagation delay from a selected analog source through the analog comparator, windowing function, and filter (see the Comparator and 8-bit DAC electrical specifications section of LPCMP datasheet for more information on propagation delay and power-up delay). Table 286 specifies the delay that the windowing and filter function causes.

During operation, you must always consider the propagation delay of the selected data paths. It can take many bus clock cycles for COUT and CSR[CFR]/CSR[CFF] to reflect an input change or a configuration change to one of the components involved in the data path.

61.6 Application information

61.6.1 Round-robin trigger mode programing recommendation

Configure the Round-robin trigger mode as follows:

1. Configure the comparison cycles by RRCR0[RR_NSAM]. Note: It is a mandatory request that the round robin cycling period must set longer than the time that all the active channels complete the specified comparison cycles set by RRCR0[RR_NSAM].
2. Configure CMP initialization delay by RRCR0[RR_INITMOD]. Note: In programming RRCR0[RR_INITMOD], the RR_INITMOD x round robin clock period must be longer than the initialization delay, see the LPCMP datasheet for more information.
3. Configure RRCR1[FIXP] to select the fixed port of CMP and
    a. If you use one input channel to compare with other channels, configure RRCR1[FIXCH] to select the fixed channel.
    b. If you use DAC output to compare with input channels, configure CCR2[INPSEL] or CCR2[INMSEL] (according to RRCR1[FIXP]) to select the DAC output.
4. Configure channels for comparison by RRCR1[RR_CHnEN].
5. Write RRCSR[RR_CHnOUT] to define the pre-set state of channel n.
6. Clear channel flags RRSR[RR_CHnF].
7. Enable round robin interrupt by IER[RRF_IE] (disable IER[CFR_IE] and IER[CFF_IE]).
8. Enable round-robin trigger mode by setting RRCR0[RR_EN] to 1.
9. Enable comparator by setting CCR0[CMP_EN] to 1.

61.6.2 Round-robin clock (RCLK) frequency requirement

(1) RCLK high frequency limit

RCLK high frequency limit depends on two facts:

1. The analog CMP and DAC initialization time (see the chip data sheet for more information on the initialization time.)
    - RRCR0[RR_INITMOD] provides a maximum 63 RCLK cycles for the analog CMP and DAC initialization.
    - RCLK must be slow to assure: 63 * ($1/f_{RCLK}$) > $T_{initialization}$, where f_{RCLK} is in MHz, and $T_{initialization}$ is in microsecond.
    - so $f_{RCLK} < 63 / T_{initialization}$
    - Example: $T_{initialization}$ = 40 µs, then f_{RCLK} should be smaller than 1.575 MHz.
2. The analog CMP propagation delay (see the Comparator and 8-bit DAC electrical specifications section of LPCMP datasheet for more information on the CMP propagation delay.)
    - RRCR0[RR_NSAM] provides a maximum 4 RCLK cycles for the analog CMP propagation delay.
    - RCLK must be slow to assure: 4 * ($1/f_{RCLK}$) > $T_{propagation}$, where f_{RCLK} is in MHz, and $T_{propagation}$ is in microsecond.
    - $f_{RCLK} < 4 / T_{propagation}$
    - Example: $T_{propagation}$ = 0.1 µs, then f_{RCLK} must be smaller than 40 MHz.

(2) RCLK low frequency limit

In theory, RCLK frequency has no low limit. But the lower the RCLK frequency, the longer the scan time. Therefore, the lower limit of the RCLK frequency depends on the system application.

61.7 LPCMP register descriptions

The memory map comprises of 32-bit aligned registers, which you can access via 8-, 16- or 32-bit reads and 32-bit write. Attempted accesses using unsupported write data sizes, writes to read-only resources, or to reserved spaces terminate with an error. Read access to reserved address generates a transfer error and the read data bus shows all 0s.

61.7.1 LPCMP memory map

LPCMP_0 base address: 4037_0000h

LPCMP_1 base address: 4037_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VERID)	32	R	0100_0001h
4h	Parameter (PARAM)	32	R	0000_0002h
8h	Comparator Control Register 0 (CCR0)	32	RW	0000_0002h
Ch	Comparator Control Register 1 (CCR1)	32	RW	0000_0000h
10h	Comparator Control Register 2 (CCR2)	32	RW	0000_0000h
18h	DAC Control (DCR)	32	RW	0000_0000h
1Ch	Interrupt Enable (IER)	32	RW	0000_0000h
20h	Comparator Status (CSR)	32	RW	0000_0000h
24h	Round Robin Control Register 0 (RRCR0)	32	RW	0000_0000h
28h	Round Robin Control Register 1 (RRCR1)	32	RW	0000_0000h
2Ch	Round Robin Control and Status (RRCSR)	32	RW	0000_0000h
30h	Round Robin Status (RRSR)	32	RW	0000_0000h

61.7.2 Version ID (VERID)

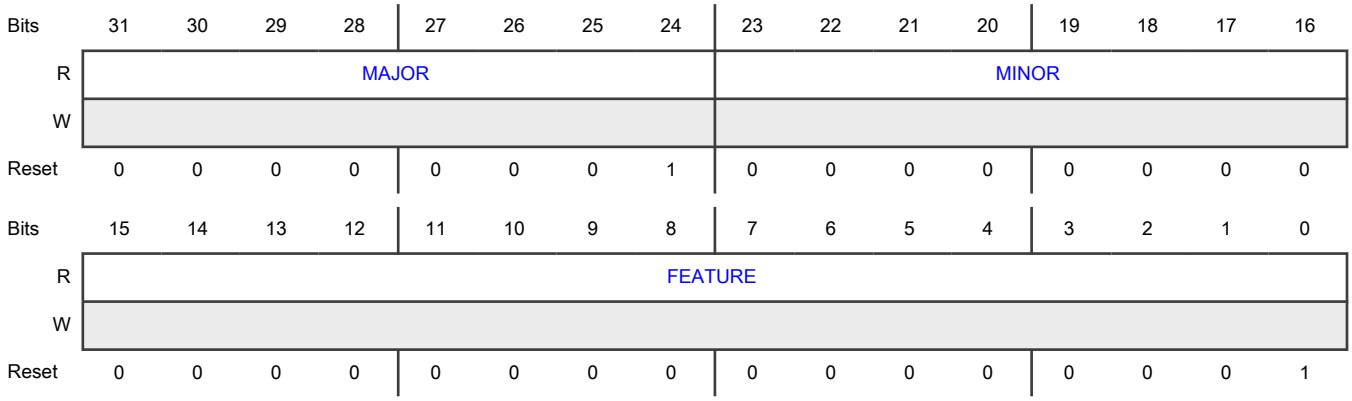
Offset

Register	Offset
VERID	0h

Function

Contains version numbers for the module design and feature set.

Diagram



Fields

Field	Function
31-24 MAJOR	Major Version Number Returns the major version number for the module design.
23-16 MINOR	Minor Version Number Returns the minor version number for the module design.
15-0 FEATURE	Feature Specification Number Returns the feature set number. 0000_0000_0000_0001b - Round robin feature

61.7.3 Parameter (PARAM)

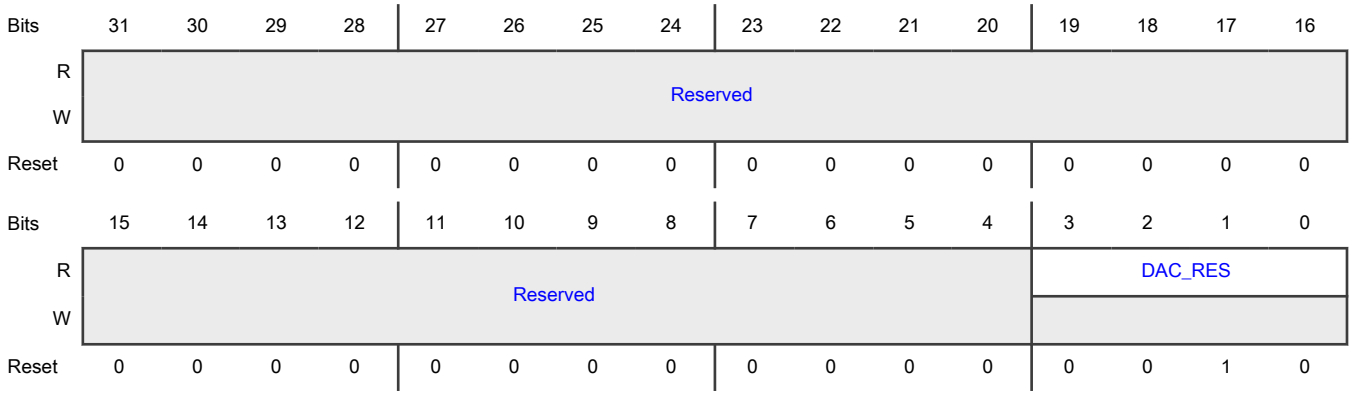
Offset

Register	Offset
PARAM	4h

Function

Contains parameter values that are implemented in the module.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 DAC_RES	DAC Resolution Indicates supported DAC resolutions. **NOTE** All other bit field values are reserved. 0000b - 4-bit DAC 0001b - 6-bit DAC 0010b - 8-bit DAC 0011b - 10-bit DAC 0100b - 12-bit DAC 0101b - 14-bit DAC 0110b - 16-bit DAC

61.7.4 Comparator Control Register 0 (CCR0)

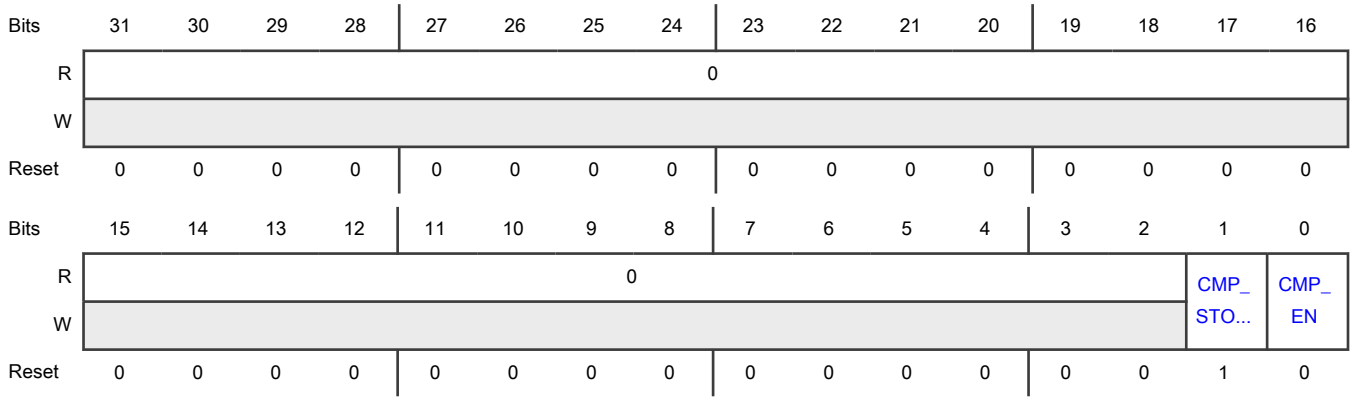
Offset

Register	Offset
CCR0	8h

Function

Contains configuration options for enabling the analog comparator.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 CMP_STOP_EN	Comparator STANDBY Mode Enable Enables the analog comparator or the DAC when the module is in STANDBY mode. **NOTE** This field has no effect in Round-robin Trigger mode. 0b - Disables the analog comparator regardless of CMP_EN. 1b - Allows CMP_EN to enable the analog comparator.
0 CMP_EN	Comparator Enable Enables the analog comparator. 0b - Disable (The analog logic remains off and consumes no power.) 1b - Enable

61.7.5 Comparator Control Register 1 (CCR1)

Offset

Register	Offset
CCR1	Ch

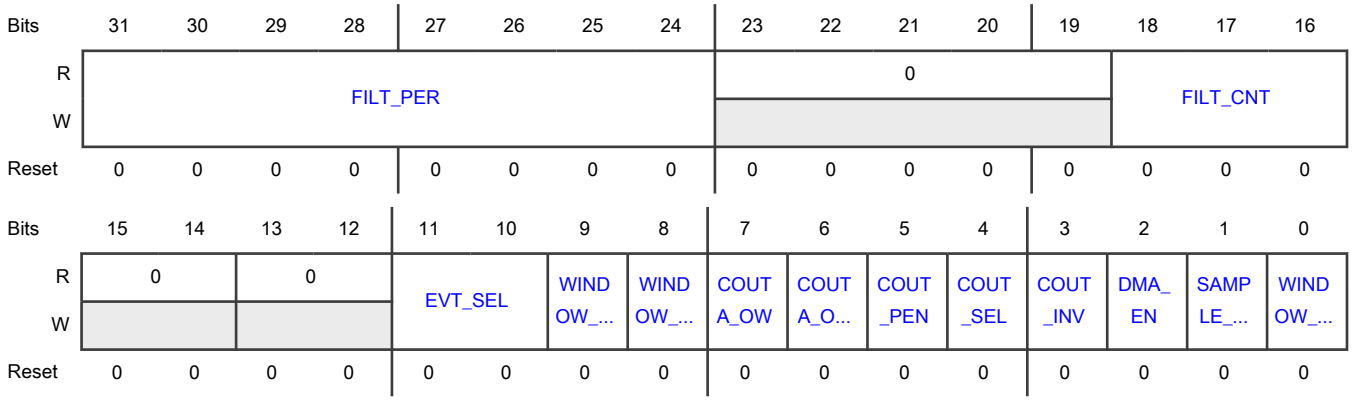
Function

Contains configuration options for the comparator operation, such as enabling Sampling or Windowing mode.

NOTE

You cannot enable Sampling and Windowing modes both at the same time. Sampling mode takes precedence over Windowing mode. If you write 1 to both SAMPLE_EN and WINDOW_EN, only SAMPLE_EN becomes 1.

Diagram



Fields

Field	Function
31-24 FILT_PER	Filter Sample Period Specifies the sampling period (in bus clock cycles) of the comparator output filter. Programming this field to 00h bypasses the filter. See Functional description for more information on filter programming and latency. **NOTE** FILT_PER has no effect in Sampling mode (CCR1[SAMPLE_EN] = 1).
23-19 —	Reserved
18-16 FILT_CNT	Filter Sample Count Specifies the number of consecutive samples that must agree before the comparator output filter accepts the sample as a new valid output state. See Functional description for more information on filter programming and latency. 000b - Filter is bypassed: COUT = COUTA 001b - 1 consecutive sample (Comparator output is simply sampled.) 010b - 2 consecutive samples 011b - 3 consecutive samples 100b - 4 consecutive samples 101b - 5 consecutive samples 110b - 6 consecutive samples 111b - 7 consecutive samples
15-14 —	Reserved
13-12 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
11-10 EVT_SEL	CMPO Event Select Selects which CMPO signal edge (rising, falling, or both) defines a CMPO event. **NOTE** Valid only in Windowing mode. 00b - Rising edge 01b - Falling edge 1xb - Both edges
9 WINDOW_CLS	CMPO Event Window Close Enables a CMPO event (defined as a CMPO rising edge, falling edge, or both) to close an active window. See EVT_SEL to configure the CMPO event. **NOTE** The WINDOW signal has to go to zero and back to one again to re-activate the window. Valid only in Windowing mode. 0b - CMPO event cannot close the window 1b - CMPO event can close the window
8 WINDOW_INV	WINDOW/SAMPLE Signal Invert Inverts the window/sample signal. 0b - Do not invert 1b - Invert
7 COUTA_OW	COUTA Output Level for Closed Window Defines the COUTA signal value when the window is closed. **NOTE** Valid only in Windowing mode and when COUTA_OWEN=1. 0b - COUTA is 0 1b - COUTA is 1
6 COUTA_OWEN	COUTA_OW Enable Enables the COUTA signal value to be defined by COUTA_OW when the window is closed. **NOTE** Valid only in Windowing mode. 0b - COUTA holds the last sampled value. 1b - Enables the COUTA signal value to be defined by COUTA_OW.
5	Comparator Output Pin Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
COUT_PEN	Enables the comparator output to become an available signal option for a selected package pin. 0b - Not available 1b - Available
4 COUT_SEL	Comparator Output Select Selects which comparator output option, COUT or COUTA, to use for CMPO. 0b - Use COUT (filtered) 1b - Use COUTA (unfiltered)
3 COUT_INV	Comparator Invert Selects the polarity of the analog comparator function, affecting the value driven to the COUT output (on both the chip pin and as CSR[COUT]) when CCR0[CMP_EN] is 0. **NOTE** COUT_INV has no effect in Trigger mode. 0b - Do not invert 1b - Invert
2 DMA_EN	DMA Enable Enables DMA transfers triggered from the LPCMP module. After this field and the corresponding interrupt enable field becomes 1, a DMA request is asserted when CFR or CFF becomes 1. 0b - Disable 1b - Enable
1 SAMPLE_EN	Sampling Enable Enables Sampling mode. 0b - Disable 1b - Enable
0 WINDOW_EN	Windowing Enable Enables Windowing mode. **NOTE** Valid only when SAMPLE_EN = 0. 0b - Disable 1b - Enable

61.7.6 Comparator Control Register 2 (CCR2)

Offset

Register	Offset
CCR2	10h

Function

Contains the configuration options for the comparator operation, such as selecting the plus and minus comparator inputs and the hysteresis levels.

NOTE

When an inappropriate operation selects the same signal for both the plus and minus comparator inputs, the analog comparator automatically shuts down (regardless of CMP_EN) to prevent itself from becoming a noise generator.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		INMSEL		0		INPSEL		0	MSEL			0	PSEL		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0										HYSTCTR		0	OFFSET	0	CMP_HPMD
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-28 INMSEL	Input Minus Select Selects the minus input of the comparator. **NOTE** These selections connect directly to the minus input of the comparator. 00b - IN0: from the 8-bit DAC output 01b - IN1: from the analog 8-1 mux 10b - Reserved 11b - Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
27-26 —	Reserved
25-24 INPSEL	Input Plus Select Selects the plus input of the comparator. **NOTE** These selections connect directly to the plus input of the comparator. 00b - IN0: from the 8-bit DAC output 01b - IN1: from the analog 8-1 mux 10b - Reserved 11b - Reserved
23 —	Reserved
22-20 MSEL	Minus Input MUX Select Selects the input used for the negative mux. See the chip-specific LPCMP information for more on connections. **NOTE** MSEL has no effect in Trigger mode. 000b - Input channel 0 001b - Input channel 1 010b - Input channel 2 011b - Input channel 3 100b - Input channel 4 101b - Input channel 5 110b - Input channel 6 111b - Input channel 7
19 —	Reserved
18-16 PSEL	Plus Input MUX Select Selects the input used for the positive mux. See the chip-specific LPCMP information for more on connections. **NOTE** PSEL has no effect in Trigger mode.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	000b - Input channel 0 001b - Input channel 1 010b - Input channel 2 011b - Input channel 3 100b - Input channel 4 101b - Input channel 5 110b - Input channel 6 111b - Input channel 7
15-6 —	Reserved
5-4 HYSTCTR	Comparator Hysteresis Control Selects the level of internally generated hysteresis for the comparator output. **NOTE** This applies to the comparator hard block. 00b - Level 0: Analog comparator hysteresis 0 mV. 01b - Level 1: Analog comparator hysteresis 10 mV. 10b - Level 2: Analog comparator hysteresis 20 mV. 11b - Level 3: Analog comparator hysteresis 30 mV.
3 —	Reserved
2 OFFSET	Comparator Offset Control Selects the level of internally generated voltage offset for the comparator output. See the chip data sheet to get the specific values for each offset level. 0b - Level 0: The hysteresis selected by HYSTCTR is valid for both directions (rising and falling). 1b - Level 1: Hysteresis does not apply when INP (input-plus) crosses INM (input-minus) in the rising direction or when INM crosses INP in the falling direction. Hysteresis still applies for INP crossing INM in the falling direction.
1 —	Reserved
0 CMP_HPMD	CMP High Power Mode Select Selects Low or High Power(Speed) mode for the comparator. 0b - Low power (speed) comparison mode

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - High power (speed) comparison mode

61.7.7 DAC Control (DCR)

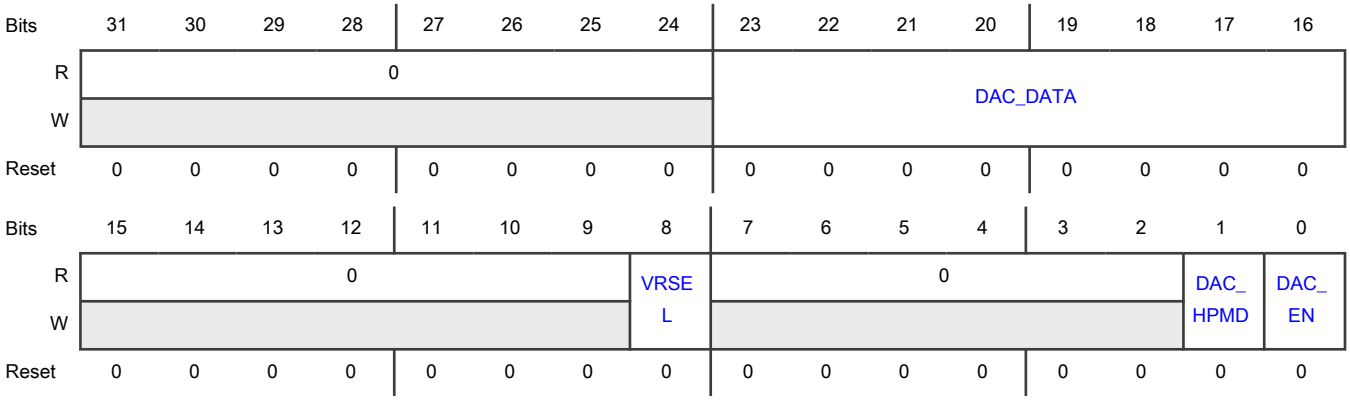
Offset

Register	Offset
DCR	18h

Function

Contains the configuration options to enable the DAC.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-16 DAC_DATA	DAC Output Voltage Select Selects the DAC output (DACO) voltage from one of 256 distinct levels by configuring the value of DAC_DATA. The DACO ranges from Vin/256 to Vin. **NOTE** DACO = (Vin/256) * (DAC_DATA + 1)
15-9 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
8 VRSEL	DAC Reference High Voltage Source Select Selects the high voltage reference source for the Vin supply of the DAC's resistor ladder network. See the chip-specific LPCMP information for the source of vrefh0 and vrefh1. 0b - VREFH0 1b - VREFH1
7-2 —	Reserved
1 DAC_HPMD	DAC High Power Mode Enables the DAC high power mode. 0b - Disable 1b - Enable
0 DAC_EN	DAC Enable Enables the DAC. When disabled, power-down the DAC to conserve power. 0b - Disable 1b - Enable

61.7.8 Interrupt Enable (IER)

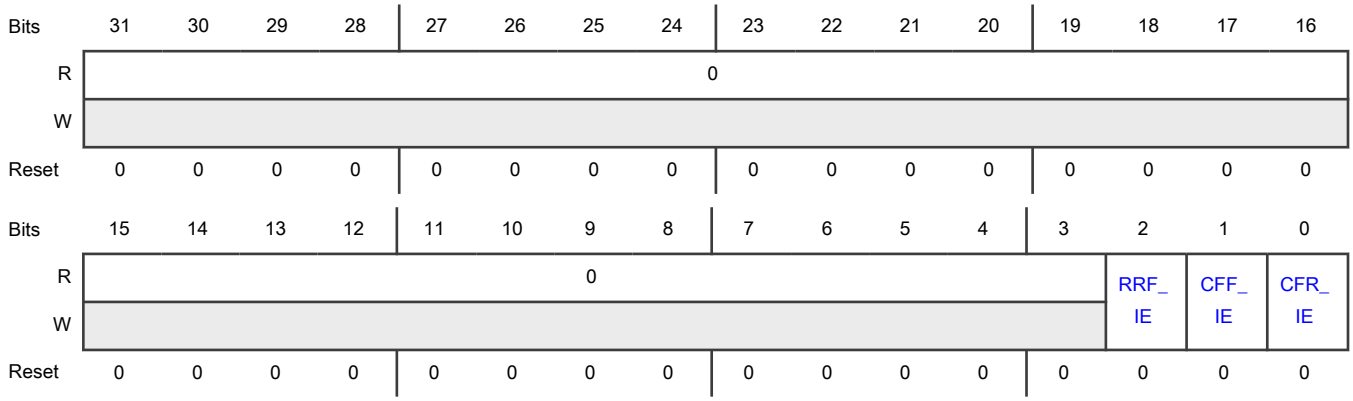
Offset

Register	Offset
IER	1Ch

Function

Provides enable fields for the comparator and round-robin flag interrupts.

Diagram



Fields

Field	Function
31-3 —	Reserved
2 RRF_IE	Round-Robin Flag Interrupt Enable Enables or disables the round-robin flag interrupt. 0b - Disables the round-robin flag interrupt. 1b - Enables the round-robin flag interrupt when the comparison result changes for a given channel.
1 CFF_IE	Comparator Flag Falling Interrupt Enable Enables or disables the comparator flag falling interrupt. 0b - Disables the comparator flag falling interrupt. 1b - Enables the comparator flag falling interrupt when CFF is set.
0 CFR_IE	Comparator Flag Rising Interrupt Enable Enables or disables the comparator flag rising interrupt. 0b - Disables the comparator flag rising interrupt. 1b - Enables the comparator flag rising interrupt when CFR is set.

61.7.9 Comparator Status (CSR)

Offset

Register	Offset
CSR	20h

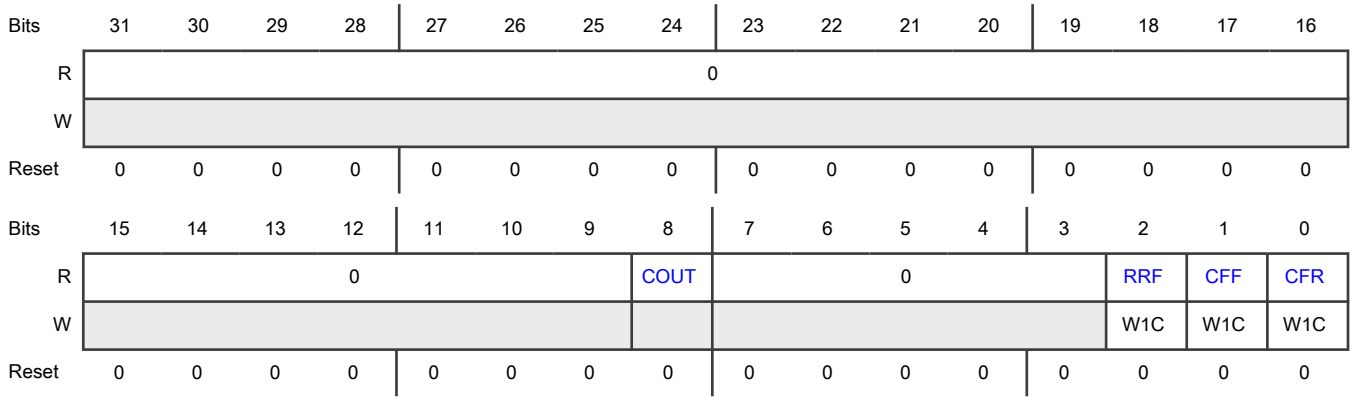
Function

Indicates comparator status, including COUT, CFF, CFR, and RRF.

NOTE

LPCMP may output a glitch and affect the value of CSR[CFF] and CSR[CFR] at the moment of enabling CMP. In order to ensure correctness, it is recommended to write one to clear (W1C) CSR[CFF] and CSR[CFR] before further configuring CMP.

Diagram



Fields

Field	Function
31-9 —	Reserved
8 COUT	Analog Comparator Output Returns the current value of the analog comparator output when read. This field resets to 0 and reads as CCR1[COUT_INV] after the analog comparator module disables when CCR0[CMP_EN] = 0. Writing to this field is ignored.
7-3 —	Reserved
2 RRF	Round-Robin Flag Detects when any channel's last comparison result is different from the pre-set value in Trigger mode. Write 1 to clear this field. This field clears when CCR0[CMP_EN] or RRCR0[RR_EN] is not 1. 0b - Not detected 1b - Detected
1 CFF	Analog Comparator Flag Falling Detects when a falling edge on COUT occurs. Write 1 to clear this field when CCR1[DMA_EN] is disabled. If CCR1[DMA_EN] is enabled, the flag automatically clears after DMA is done. This field clears when CCR0[CMP_EN] is not 1. 0b - Not detected 1b - Detected
0 CFR	Analog Comparator Flag Rising Detects when a rising edge on COUT occurs. Write 1 to clear this field when CCR1[DMA_EN] is disabled. If CCR1[DMA_EN] is enabled, the flag automatically clears after DMA is done. This field clears when CCR0[CMP_EN] is not 1. 0b - Not detected 1b - Detected

61.7.10 Round Robin Control Register 0 (RRCR0)

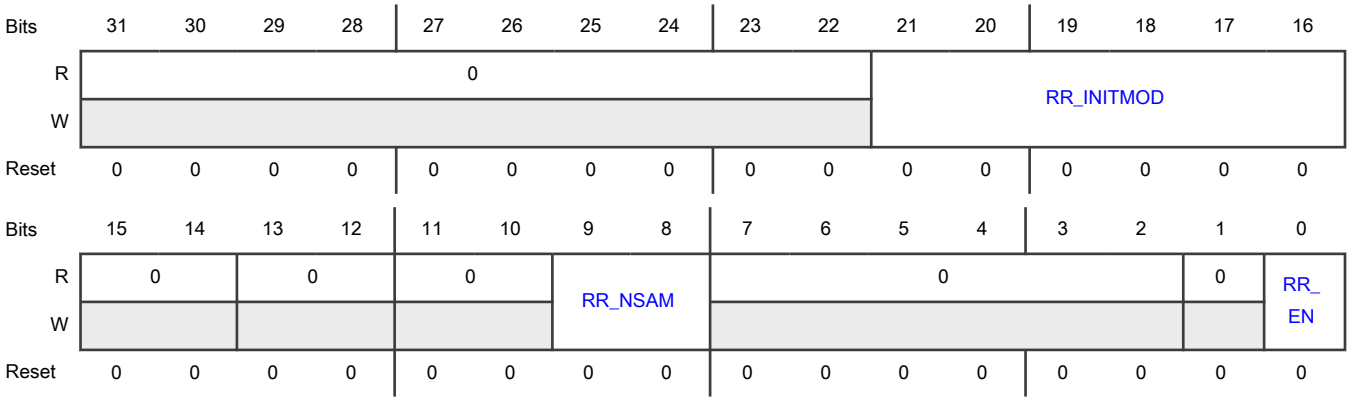
Offset

Register	Offset
RRCR0	24h

Function

Contains configuration options for the round-robin operation, such as enabling it and specifying the initialization delay.

Diagram



Fields

Field	Function
31-22 —	Reserved
21-16 RR_INITMOD	Initialization Delay Modulus Specifies the number of round-robin clock cycles that determines the comparator and DAC initialization delay specified in the chip datasheet. Calculate the initialization delay as RR_INITMOD * (round-robin clock period). For example, if the initialization delay is 80us and the round-robin clock is 100kHz, program RR_INITMOD to be 80us/10us = 8. 00_0000b - 63 cycles (same as 111111b) 00_0001b-11_1111b - 1 to 63 cycles
15-14 —	Reserved
13-12 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
11-10 —	Reserved
9-8 RR_NSAM	Number of Sample Clocks Specifies the number of the round-robin clock cycles to wait after scanning the active channel before sampling the channel's comparison result. After the next cycle of the round-robin clock, the sampling takes place RR_NSAM clocks later. 00b - 0 clock 01b - 1 clock 10b - 2 clocks 11b - 3 clocks
7-2 —	Reserved
1 —	Reserved
0 RR_EN	Round-Robin Enable Enables the round-robin operation. 0b - Disable 1b - Enable

61.7.11 Round Robin Control Register 1 (RRCR1)

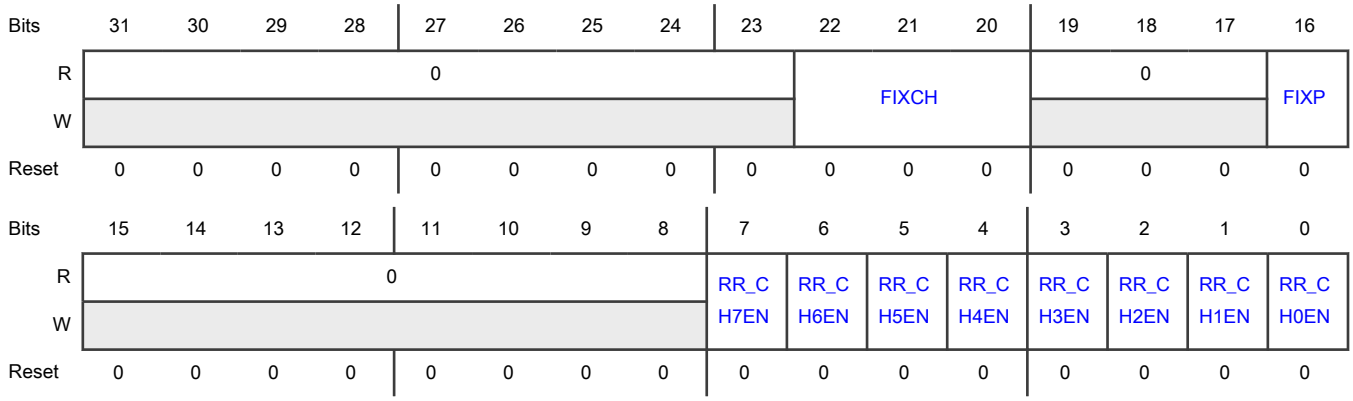
Offset

Register	Offset
RRCR1	28h

Function

Contains configuration options for the round-robin operation, such as enabling individual channels to participate.

Diagram



Fields

Field	Function
31-23 —	Reserved
22-20 FIXCH	Fixed Channel Select Selects which channel in the mux port to fix for a given round-robin trigger mode application. 000b - Channel 0 001b - Channel 1 010b - Channel 2 011b - Channel 3 100b - Channel 4 101b - Channel 5 110b - Channel 6 111b - Channel 7
19-17 —	Reserved
16 FIXP	Fixed Port Fixes an analog mux port (plus or minus) for round-robin trigger mode. The inputs to the non-fixed port sweep during each round. 0b - Fix the plus port. Sweep only the inputs to the minus port. 1b - Fix the minus port. Sweep only the inputs to the plus port.
15-8 —	Reserved
7-0	Channel n Input Enable in Trigger Mode

Table continues on the next page...

Table continued from the previous page...

Field	Function
RR_CHnEN	Enables channel n of the non-fixed mux port to check its voltage value when in Trigger mode. **NOTE** RR_CHnEN has no effect when the same channel is selected as the reference voltage. 0b - Disable 1b - Enable

61.7.12 Round Robin Control and Status (RRCSR)

Offset

Register	Offset
RRCSR	2Ch

Function

Contains the latest comparison results of the individual channels with the fixed mux port. It also allows you to define the pre-set state for each channel.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								RR_CH7O...	RR_CH6O...	RR_CH5O...	RR_CH4O...	RR_CH3O...	RR_CH2O...	RR_CH1O...	RR_CH0O...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0 RR_CHnOUT	Comparison Result for Channel n Returns the latest comparison result for channel n when read and defines the pre-set state for channel n when written to.

61.7.13 Round Robin Status (RRSR)

Offset

Register	Offset
RRSR	30h

Function

Contains individual channel flags that indicates when a channel's last comparison result is different from its pre-set value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								RR_CH7F	RR_CH6F	RR_CH5F	RR_CH4F	RR_CH3F	RR_CH2F	RR_CH1F	RR_CH0F
W									W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0 RR_CHnF	Channel n Input Changed Flag Indicates when the corresponding channel's last comparison result is different from its pre-set value. **NOTE** To clear a flag, write a 1 to it. 0b - No different 1b - Different

61.8 Glossary

CMP	Comparator
DAC	Digital-to-analog convertor
ANMUX	Analog multiplexer

Chapter 62
Logic Control Unit (LCU)

62.1 Chip-specific LCU information

62.1.1 LCU instances

This chip has 2 instances of LCU:

- LCU_0
- LCU_1

62.2 Overview

LCU selects multiple inputs from timers, Pulse Width Modulation (PWM) signals, and Input/Output (I/O) pads, and combines them using a programmable logic function to create output waveforms.

62.2.1 Block diagram

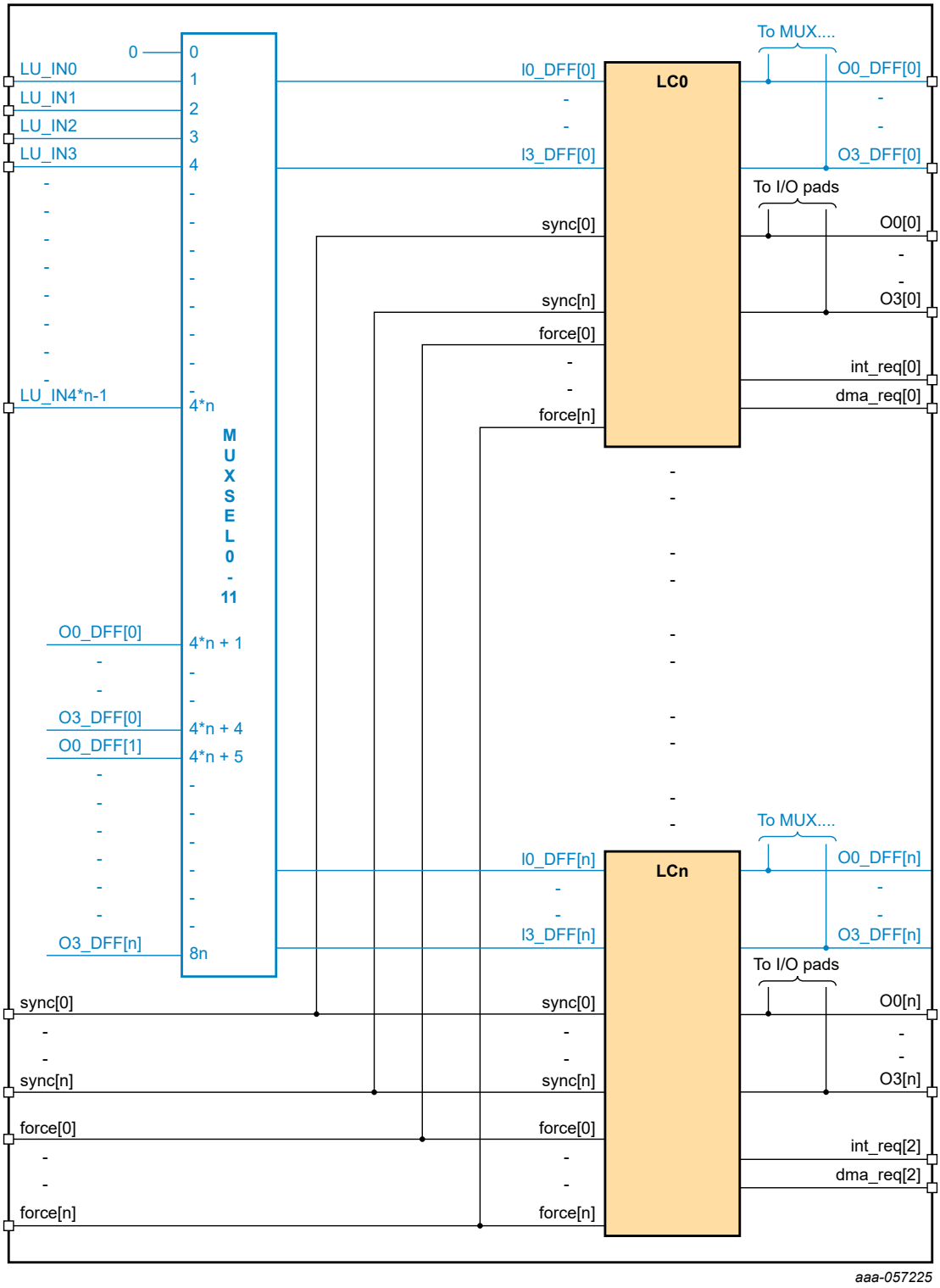


Figure 316. Block diagram

NOTE

3 LCs are shown in this block diagram.

62.2.2 Features

- 3 LCs with programmable logic function for generating output results
- 12 inputs to and 12 outputs from LCs
- Muxing to map any input to any LC
- Independent filters for the rising and falling output states of each LC
- Software override logic for inputs using multiple modes
- 4 force inputs with programmable edge filtering to force output states using multiple modes
- 2 sync inputs to control transition timing
- Lock bit to block writes to CFG[WP]
- Interrupt request generation based on output change or force event
- DMA transfer request generation based on output change or force event

62.3 Functional description

62.3.1 LC operation

62.3.1.1 Overview

An LC performs logic operations based on the LUT principle, as described in Logic operations.

Each LC supports the following features:

- Independent filter thresholds for the rising and falling output states support different transition delays.
- Bypass of the output state filter by setting the filter threshold to zero. Bypassing the filter causes the asynchronous signal to propagate to the output of the LC.
- Force logic that instantly switches an LC output to the inactive state upon external fault signal assertion. The return from the inactive state to the output state is either:
  - Instantaneous: when LCU deasserts the force signal.
  - Instantaneous synchronized: when LCU deasserts the force signal and then the sync input asserts.
  - Manual: when you write 1 to the force status bit and then the LCU deasserts the force input.
  - Manual synchronized: when you write 1 to the force status bit and LCU deasserts the force input, and then the sync input asserts.
- Input software override logic to override external inputs by writing to the following registers:
  - LC*n* Sync Control (LC*n*_SCTRL[SW_MODE])
  - Software Override Value (SWVALUE[SWVALUE])
  - Software Override Enable (SWEN[SWEN])
- Generation of interrupt requests or DMA transfer requests.

62.3.1.2 LC diagram

This figure illustrates an example LC implementation with:

- One LC
- Four force inputs
- Two sync inputs

For the number of each resource in this chip, see Features.

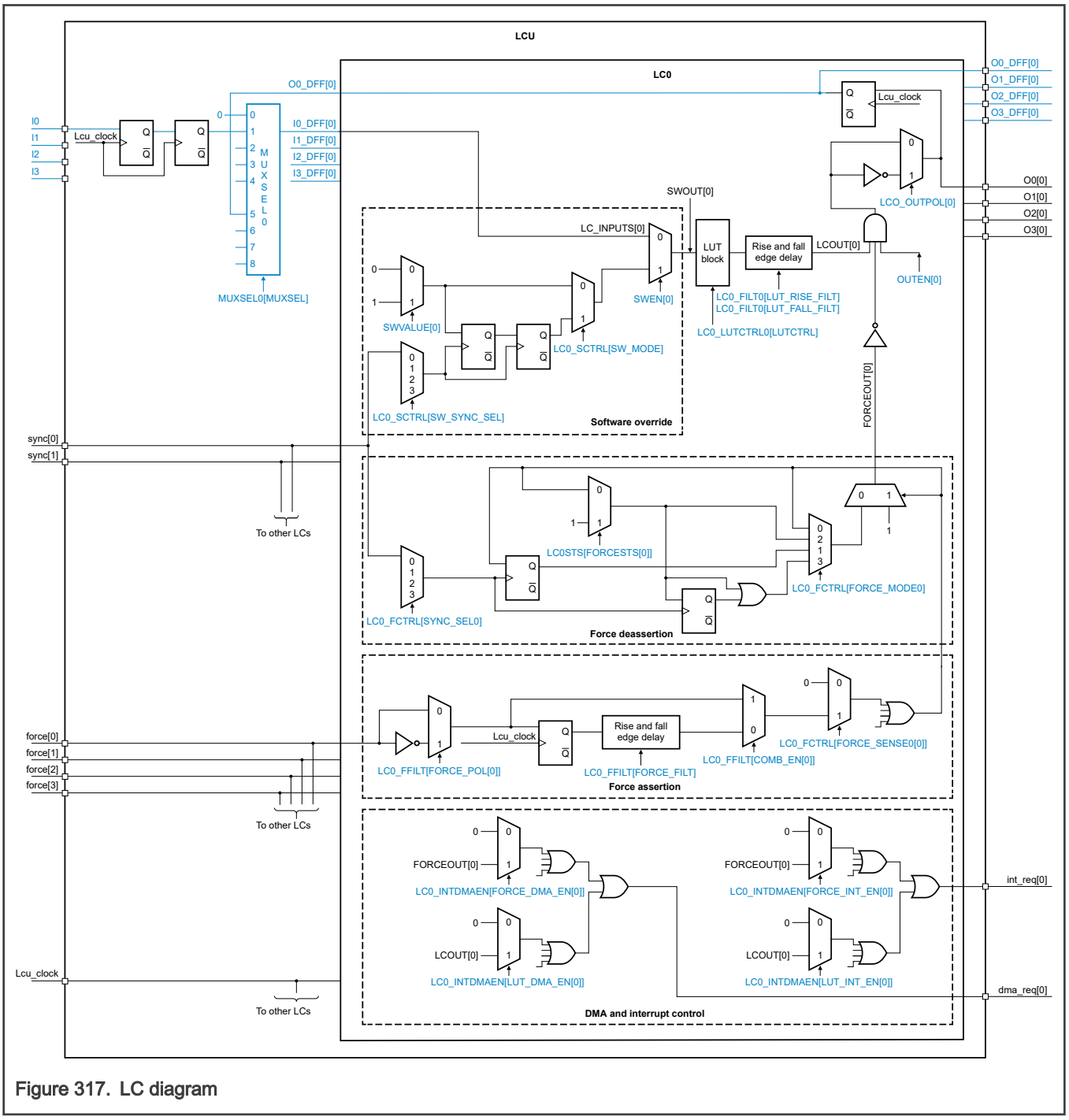


Figure 317. LC diagram

62.3.1.3 Logic operations

An LC reads its set of inputs (inputs 3, 2, 1, and 0) as a four-bit binary value, with Input 3 as the most-significant bit and Input 0 as the least-significant bit. For example, if:

Input 0 = 0

Input 1 = 1

Input 2 = 0

Input 3 = 1

then the combined input value is 1010b (10 decimal).

Each possible four-bit input value corresponds to a bit position in the LUT Control (LCn_LUTCTRLm[LUTCTRL]), as illustrated in LC LUT. For a given LC output, if the combined LC input value corresponds to a bit position in that output's LUTCTRL value that equals 1, then the LC asserts that output.

For example, if you write 35h to LUTCTRL (shown in the Example column of the LC LUT), then the combined input values 0 (0000b), 2 (0010b), 4 (0100b), and 5 (0101b) cause assertion of the output. All other input values cause deassertion of the output.

LCU processes each look-up table asynchronously.

62.3.1.4 LC LUT

The LUT maps the combined LC input value to a bit position in LC*n*_LUTCTRL*m*.

Table 289. LC LUT

Input 3	Input 2	Input 1	Input 0	LUTCTRL bit position	Example LUTCTRL value: 35h
0	0	0	0	0	1
0	0	0	1	1	0
0	0	1	0	2	1
0	0	1	1	3	0
0	1	0	0	4	1
0	1	0	1	5	1
0	1	1	0	6	0
0	1	1	1	7	0
1	0	0	0	8	0
1	0	0	1	9	0
1	0	1	0	10	0
1	0	1	1	11	0
1	1	0	0	12	0
1	1	0	1	13	0
1	1	1	0	14	0
1	1	1	1	15	0

62.3.1.5 LC output filters

Each LC supports two optional digital filters, a Rise Filter (LC*n*_FLIT*m*[LUT_RISE_FILT]) and a Fall Filter (LC*n*_FLIT*m*[LUT_FALL_FILT]), to post-process the LUT output and delay the output signal change.

Each filter starts accumulating clock cycles on the occurrence of the associated LUT event. The Rise Filter counts from an output assertion, and the Fall Filter counts from an output deassertion. When the number of clock cycles reaches the filter threshold (matches the specified filter value), the output flips to the new state. For example, if you specify a Rise Filter value of 100h, and the LUT event triggers an output assertion, the output signal does not assert until the 256th clock cycle after the event.

A filter value of 0 bypasses the filter.

NOTE

LCU usecase (intercell/feedback loop path along with TRGMUX Path) does not work with default RISE/FALL filter time. You must configure RISE/FALL Filter delay at least for 1 cycle to avoid such glitches/failures.

62.3.2 Behavior in different chip modes of operation

Table 290. Modes of operation

Operation mode	Status of outputs
Normal	• Controlled by LC*n*_LUTCTRL*m* and MUXSEL*n* • Toggled based on the states of the selected inputs
Debug	Inactive or normal operation controlled by Debug Mode Enable (DBGEN)

62.3.3 Clocking

This module has no clocking considerations.

62.3.4 Interrupts

Each LC has a single interrupt request output int_req[n]. Interrupt request enables bits for all the 4 outputs in each LC defined in LC*n*_INTDMAEN with LC*n*_INTDMAEN[FORCE_INT_EN] for interrupt request generation when a force event occurs and LC*n*_INTDMAEN[LUT_INT_EN] for interrupt request generation when a LUT event occurs.

When user enables interrupt for a force event on an output and the force event occurs on that output, LCU generates an interrupt request if LC*n*_STS[FORCESTS] and LC*n*_INTDMAEN[FORCE_INT_EN] for that output is 1. Similarly when user enables interrupt for a LUT event on an output and a LUT event occurs on that output, LCU generates an interrupt request if LC*n*_STS[LUT_STS] and LC*n*_INTDMAEN[LUT_INT_EN] for that output is 1.

62.3.5 DMA

Each LC has a single DMA request output dma_req[n]. DMA request enables bits for all the 4 outputs in each LC defined in LC*n*_INTDMAEN with LC*n*_INTDMAEN[FORCE_DMA_EN] for DMA request generation when a force event occurs and LC*n*_INTDMAEN[LUT_DMA_EN] for DMA request generation when a LUT event occurs.

When user enables DMA for a force event on an output and the force event occurs on that output, LCU generates a DMA request if LC*n*_STS[FORCESTS] and LC*n*_INTDMAEN[FORCE_DMA_EN] for that output is 1. Similarly when user enables DMA for a LUT event on an output and a LUT event occurs on that output, LCU generates a DMA request if LC*n*_STS[LUT_STS] and LC*n*_INTDMAEN[LUT_DMA_EN] for that output is 1.

62.4 External signals

This module has no external signals.

62.5 Initialization

This module does not require initialization.

62.6 Application information

62.6.1 Use-case examples

62.6.1.1 Two-channel multiplexer

62.6.1.1.1 Overview

A multiplexer (or mux) takes multiple inputs and, based on some control mechanism, passes only one of those inputs to the output. You can implement a two-channel multiplexer controlled by an external signal or a software override using three inputs and one output of a single LC, as illustrated in Logic diagram and Implementation.

This example implementation controls the multiplexer with the SEL input signal and a software override. The software override controls the multiplexer output regardless of the SEL signal state. To use software override, you must enable it for the corresponding output (SWEN[SWEN]). You assert software override by writing 1 to the corresponding bit of the Software Override Value (SWVALUE[SWVALUE]).

62.6.1.1.2 Logic diagram

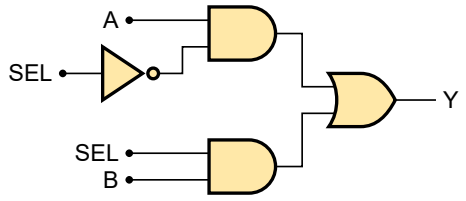


Figure 318. Logic diagram

62.6.1.1.3 Implementation

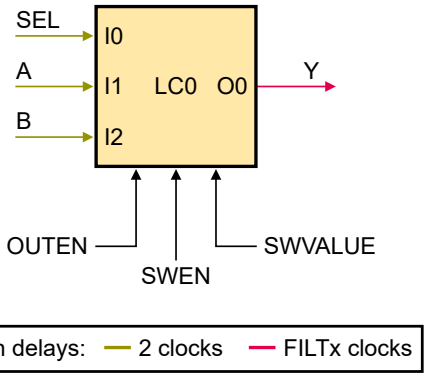


Figure 319. Implementation

62.6.1.1.4 Connections and controls

Table 291. Connections and controls

Name	Description
SEL	Input signal
A	
B	
OUTEN	Output enable
SWEN	Software override enable
SWVALUE	Software override
Y	Output signal

62.6.1.1.5 Truth table

Table 292. Truth table

Inputs			Output
A	B	SEL	Y
0	0	0	0
0	0	1	0
1	0	0	1
1	0	1	0
0	1	0	0
0	1	1	1
1	1	0	1
1	1	1	1

62.6.1.1.6 Register configuration

Table 293. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	E4E4h	—	—	—
LUTCTRL1	—	—	—	—	—	0h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	1h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	3h	—	—	—	—	—	—
MUXSEL3	0h	—	—	—	—	—	—	—
SWEN	—	—	—	—	Disable software override for LC0 input 0: 0h			

Table continues on the next page...

Table 293. Register configuration (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
					Enable software override for LC0 input 0: 1h			
SWVALUE	—	—	—	—	Deassert software override for LC0 input 0: 0h Assert software override for LC0 input 0: 1h			
OUTEN	—	—	—	—	1h			

62.6.1.1.7 Waveforms

In this figure, the SWEN and SWVALUE signals represent the states of the software override control registers. Writes to SWEN and SWVALUE have immediate impact on LC outputs, whereas LC inputs require input synchronization to prevent metastability.

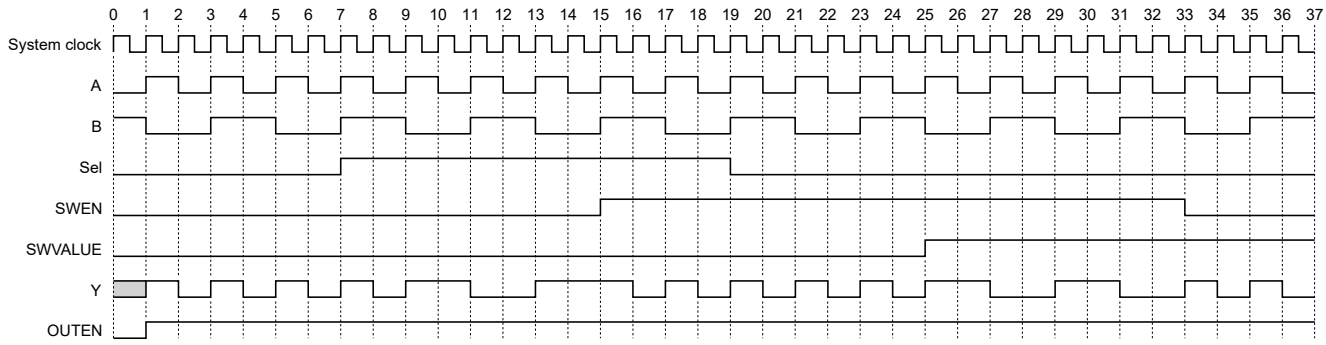


Figure 320. Waveforms

62.6.1.2 Binary to Gray code converter

62.6.1.2.1 Overview

Gray code, also known as reflected binary code (RBC), is a non-weighted, minimum change code. In this code, any two adjacent code numbers differ by only one bit. This code solves the problem of physical switch transitions by changing only one switch at a time, so there is never any ambiguity of position.

You can implement binary to Gray code conversion using a single LC, as illustrated in Logic diagram and Implementation.

In this example, the LC also generates a DMA request on each rising edge of output 3, which is bit 0 of the Gray code (G0).

62.6.1.2.2 Conversion table

Table 294. Conversion table

Decimal	Binary	Gray
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110

Table continues on the next page...

Table 294. Conversion table (continued)

Decimal	Binary	Gray
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

62.6.1.2.3 Logic diagram

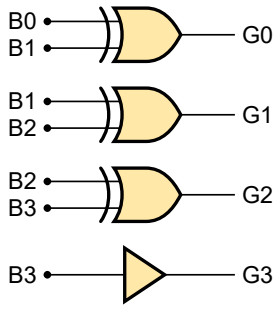


Figure 321. Logic diagram

62.6.1.2.4 Implementation

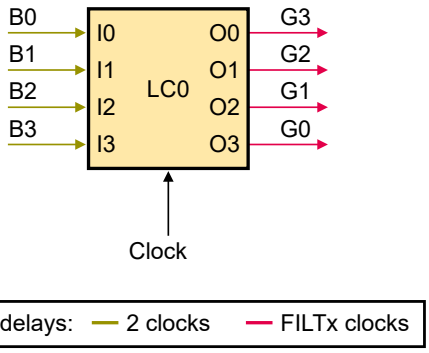


Figure 322. Implementation

62.6.1.2.5 Connections and controls

Table 295. Connections and controls

Name	Description
B0	Bit 0 of the input binary code
B1	Bit 1 of the input binary code
B2	Bit 2 of the input binary code
B3	Bit 3 of the input binary code
G0	Bit 0 of the output Gray code
G1	Bit 1 of the output Gray code
G2	Bit 2 of the output Gray code
G3	Bit 3 of the output Gray code
Clock	System clock input

62.6.1.2.6 Truth table

Table 296. Truth table

Inputs				Outputs			
B3	B2	B1	B0	G3	G2	G1	G0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	1
0	0	1	1	0	0	1	0
0	1	0	0	0	1	1	0
0	1	0	1	0	1	1	1
0	1	1	0	0	1	0	1
0	1	1	1	0	1	0	0
1	0	0	0	1	1	0	0
1	0	0	1	1	1	0	1
1	0	1	0	1	1	1	1
1	0	1	1	1	1	1	0
1	1	0	0	1	0	1	0
1	1	0	1	1	0	1	1
1	1	1	0	1	0	0	1
1	1	1	1	1	0	0	0

62.6.1.2.7 Register configuration

Table 297. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	FF00h	—	—	—
LUTCTRL1	—	—	—	—	—	FF0h	—	—
LUTCTRL2	—	—	—	—	—	—	3C3Ch	—
LUTCTRL3	—	—	—	—	—	—	—	6666h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	800h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0h	—	—	—	01h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	3h	—	—	—	—	—	—
MUXSEL3	4h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	Fh			

62.6.1.2.8 Waveforms

The LC outputs are delayed by two clock cycles because of the two-stage input synchronizers.

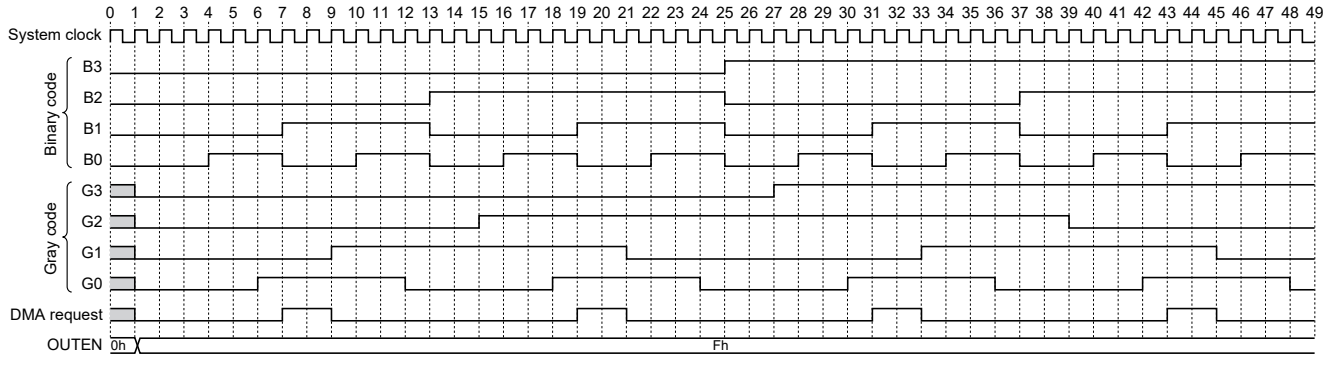


Figure 323. Waveforms

62.6.1.3 Manchester encoder and decoder

62.6.1.3.1 Overview

Manchester encoding (also known as phase encoding) is a data-modulation technique for binary data transfer based one of these signals:

- Analog
- RF
- Optical
- High-speed-digital
- Long-distance-digital

The fundamental idea behind Manchester encoding is to use voltage transitions, instead of voltage levels, to represent 1s and 0s. It performs an exclusive OR of data and clock signals to encode and decode data. A high-to-low transition on the falling clock edge indicates 0. A low-to-high transition on the rising clock edge indicates 1.

62.6.1.3.2 Logic diagram

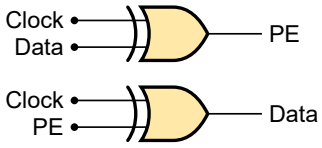


Figure 324. Logic diagram

62.6.1.3.3 Implementation

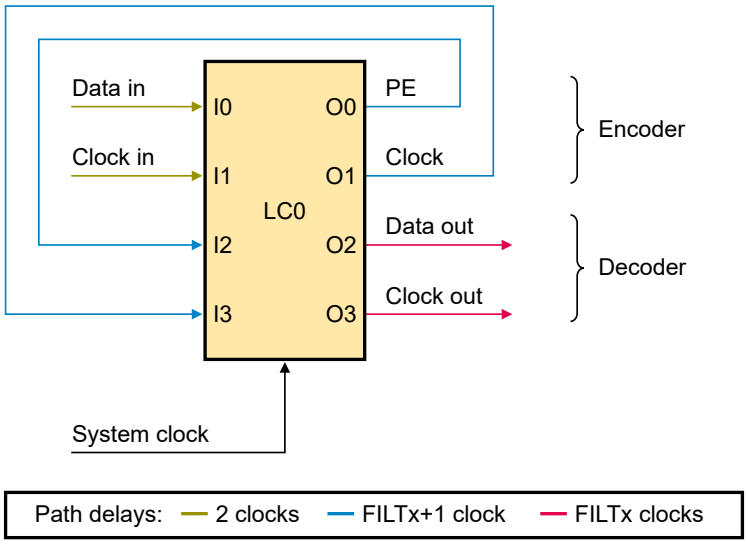


Figure 325. Implementation

62.6.1.3.4 Connections and controls

Table 298. Connections and controls

Name	Description
Data in	Input signal
Clock in	
PE	Manchester-encoded signal from LC
Clock	Auxiliary signal fed to the decoder to allow Manchester decoding
Data out	Output signal after Manchester decoding
System clock	Clock frequency supplied to LC
Clock out	Output signal

62.6.1.3.5 Truth table for encoder

Table 299. Truth table for encoder

Inputs		Output
Data in	Clock in	PE
0	0	0
0	1	1
1	0	1
1	1	0

62.6.1.3.6 Truth table for decoder

Table 300. Truth table for decoder

Inputs		Output
Clock	PE	Data out
0	0	0
0	1	1
1	0	1
1	1	0

62.6.1.3.7 Register configuration

Table 301. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	6666h	—	—	—
LUTCTRL1	—	—	—	—	—	AAAAh	—	—
LUTCTRL2	—	—	—	—	—	—	FF0h	—

Table continues on the next page...

Table 301. Register configuration (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL3	—	—	—	—	—	—	—	FF00h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	1h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	5h	—	—	—	—	—	—
MUXSEL3	6h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	Fh			

62.6.1.3.8 Waveforms for encoder

This figure includes the Manchester-encoded waveform (labeled PE) of the input waveform (labeled "Data in"). The PE waveform is delayed by two clock cycles because of two-stage input synchronization.

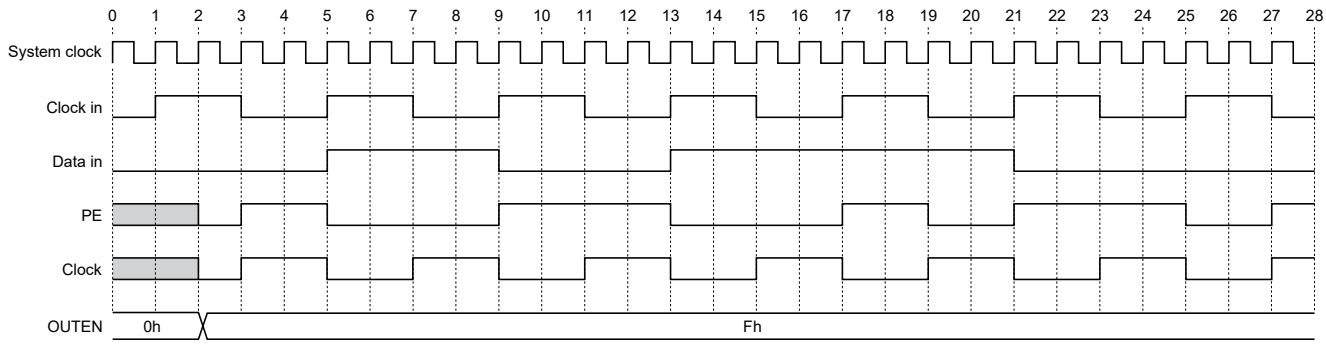


Figure 326. Waveforms for encoder

62.6.1.3.9 Waveforms for decoder

The output waveform (labeled "Data out") is delayed by four clock cycles from the input waveform (labeled "Data in") because of two-stage input synchronization. In this example, the Manchester encoder also propagates the Clock waveform that the decoder uses to reconstruct the "Data in" waveform from the Manchester-decoded waveform (labeled PE).

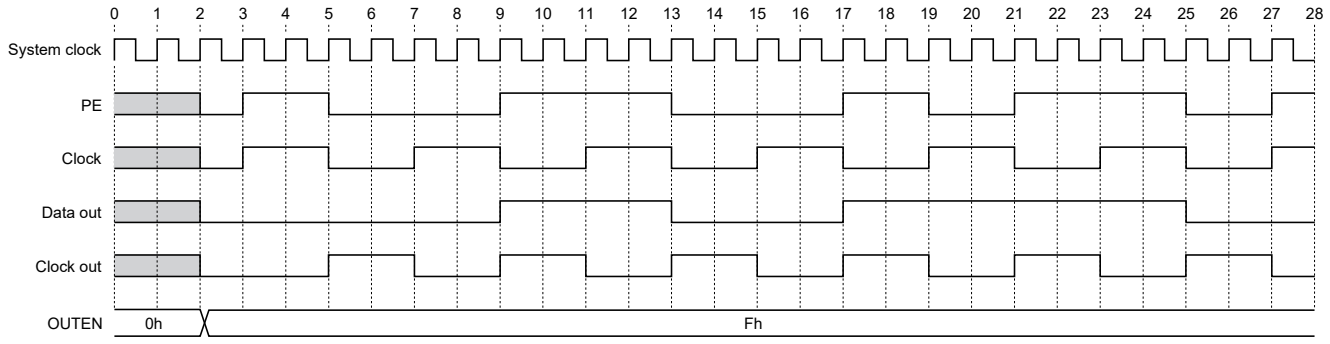


Figure 327. Waveforms for decoder

62.6.1.4 Adjustable PWM/FM generator

62.6.1.4.1 Overview

In many cases, it is useful to route an LC output back to one of its inputs, as illustrated in Implementation. In addition, you can delay outputs with a digital filter with different time constants for delaying rising and falling edges. Combining these capabilities, you can use an LC to generate output waveforms with adjustable pulse width and frequency.

In addition to waveform generation, the software-override feature forces the generator output low or high by software. You control the override via Software Override Enable (SWEN) and Software Override Value (SWVALUE).

62.6.1.4.2 Implementation

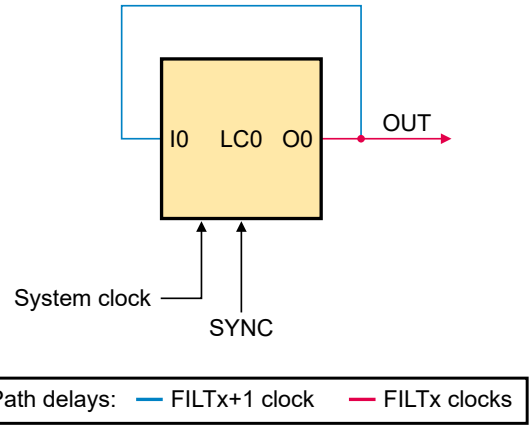


Figure 328. Implementation

62.6.1.4.3 Connections and controls

Table 302. Connections and controls

Name	Description
I0	Delayed output routed back to LC input
O0 and OUT	Delayed output
System clock	Clock frequency supplied to LC
SYNC	Software override synchronization signal

62.6.1.4.4 Truth table

This example generates an adjustable PWM/FM waveform according to the following table. In the table:

- OUT is the LC output signal that is also routed to the LC input using an internal multiplexer.
- TdH is the digital filter value to delay the rising edge of the output signal.
- TdL is the digital filter value to delay the falling edge of the output signal.

Table 303. Truth table

I0	OUT
0	1 delayed by TdH (see Output edge delays)
1	0 delayed by TdL (see Output edge delays)

62.6.1.4.5 Output edge delays

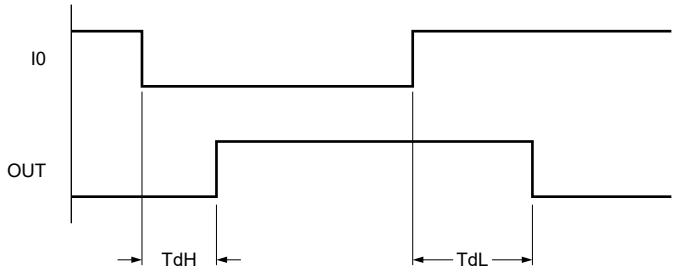


Figure 329. Output edge delays

62.6.1.4.6 Register configuration

Table 304. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	1h	—	—	—
LUTCTRL1	—	—	—	—	—	0h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	1_0001h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			

Table continues on the next page...

Table 304. Register configuration (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
SCTRL	—	—	—	—	SWVALUE for input 0 changes immediately: 0h SWVALUE for input 0 changes on rising edge of sync: 1h			
MUXSEL0	—	—	—	5h	—	—	—	—
MUXSEL1	—	—	0h	—	—	—	—	—
MUXSEL2	—	0h	—	—	—	—	—	—
MUXSEL3	0h	—	—	—	—	—	—	—
SWEN	—	—	—	—	Disable software override: 0h Enable software override: 1h			
SWVALUE	—	—	—	—	Deassert software override: 0h Assert software override: 1h			
OUTEN	—	—	—	—	1h			

62.6.1.4.7 Waveforms for immediate software override

In this figure, the SWEN and SWVALUE signals represent the states of the software override control registers. Writes to Software Override Enable (SWEN) and Software Override Value (SWVALUE) have immediate impact on LC outputs, whereas LC inputs require input synchronization to prevent metastability.

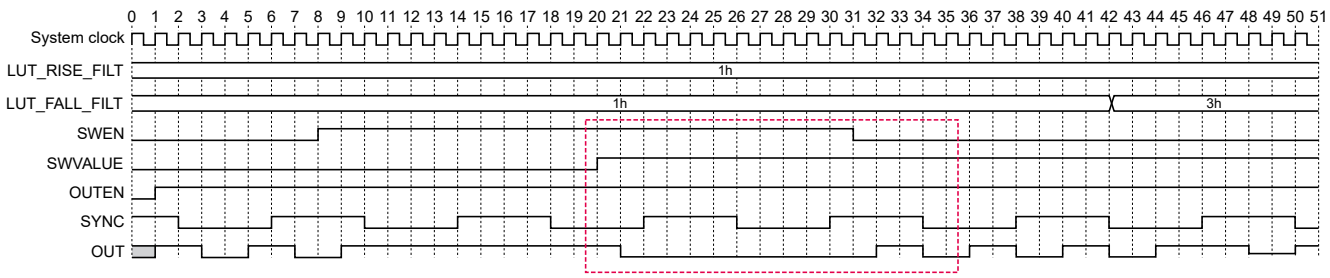


Figure 330. Waveforms for immediate software override

62.6.1.4.8 Waveforms for synced software override

In this example, software override control is synced with the rising edges of the SYNC waveform.

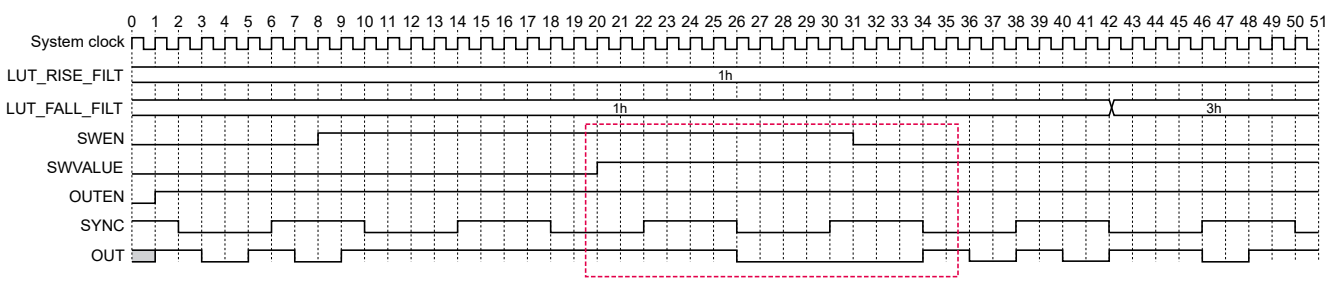


Figure 331. Waveforms for synced software override

62.6.1.5 SR latch

62.6.1.5.1 Overview

An SR latch is the simplest bistable device and a fundamental component of data storage.

This example implementation uses one LC that includes an internal feedback path configured by the internal multiplexer, as illustrated in Implementation. Output Q responds to inputs S (set) and R (reset). It changes with a delay of two clock cycles—the time required for the S and R signal inputs to pass through the internal two-stage synchronizers. This example implementation bypasses the Q digital filter; therefore, the loop of Q back to the input experiences a delay of one clock cycle." See Waveforms.

62.6.1.5.2 Implementation

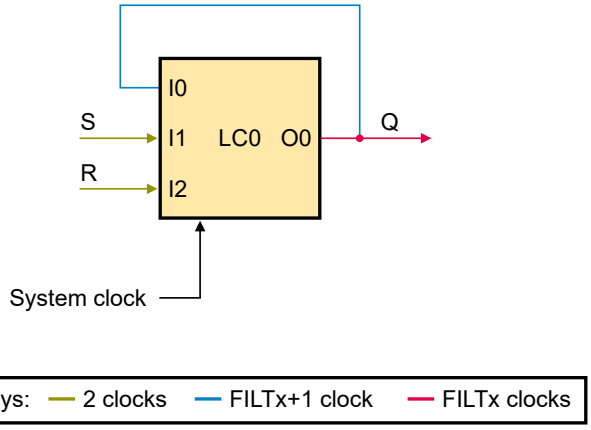


Figure 332. Implementation

62.6.1.5.3 Connections and controls

Table 305. Connections and controls

Name	Description
S	Set input
R	Reset input
Q	Both an output signal and an input that feeds back to LC0
System clock	Clock frequency supplied to LC

62.6.1.5.4 Truth table

Table 306. Truth table

Inputs			Output	State
R	S	Q	Q	
0	0	0	0	Latch
0	0	1	1	Latch
0	1	0	1	Set

Table continues on the next page...

Table 306. Truth table (continued)

Inputs			Output	State
R	S	Q	Q	
0	1	1	1	Set
1	0	0	0	Reset
1	0	1	0	Reset
1	1	0	0	Not allowed
1	1	1	0	

62.6.1.5.5 Register configuration

Table 307. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	Eh	—	—	—
LUTCTRL1	—	—	—	—	—	0h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	5h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	3h	—	—	—	—	—	—
MUXSEL3	0h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	1h			

62.6.1.5.6 Waveforms

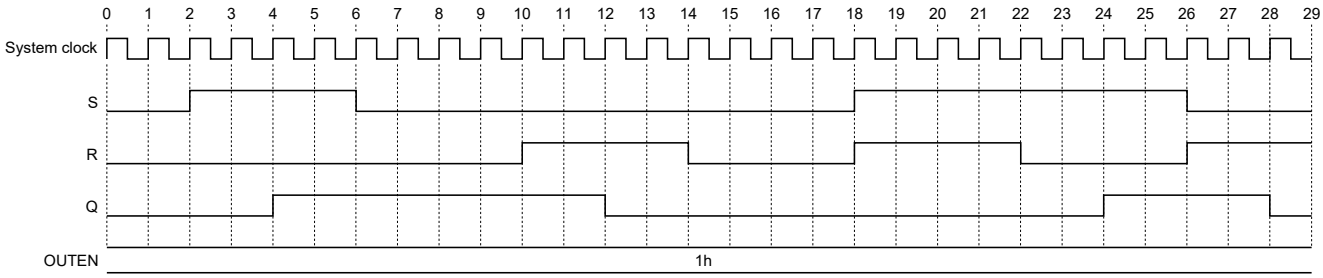


Figure 333. Waveforms

62.6.1.6 D flip-flop

62.6.1.6.1 Overview

A D flip-flop stores and outputs whatever logic level is applied to its data terminal at the time its clock input goes high.

You can implement a D flip-flop element using an LC as illustrated in Implementation. On a clock rising edge, the LC either asserts or deasserts the Q output based on the D input.

The Q output and CLKO digital filters are bypassed. Therefore, the states of these variables are fed to inputs with a delay of one clock cycle. See Waveforms.

62.6.1.6.2 Implementation

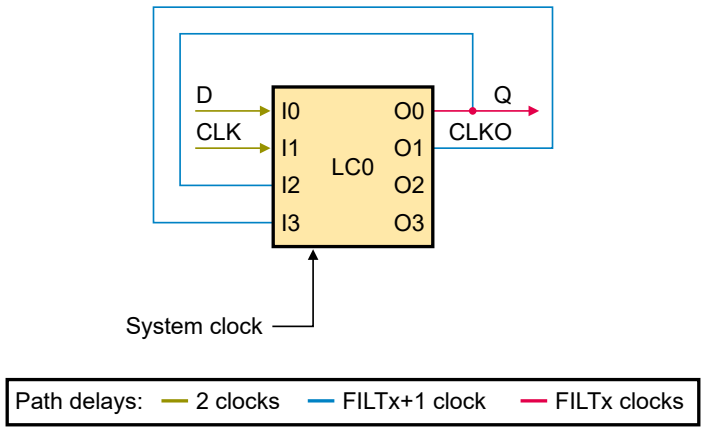


Figure 334. Implementation

62.6.1.6.3 Connections and controls

Table 308. Connections and controls

Name	Description
D	Input signal
CLK	Input clock
Q	Output signal; holds the logic state of the last Q output
CLKO	Holds the logic state of the last CLK input

62.6.1.6.4 Truth table

Table 309. Truth table

Inputs				Outputs		State
CLKO	Q	CLK	D	Q	CLKO	
0	0	0	0	0	0	Hold
0	0	0	1	0	0	Hold
0	0	1	0	0	1	Reset
0	0	1	1	1	1	Set
0	1	0	0	1	0	Hold
0	1	0	1	1	0	Hold
0	1	1	0	0	1	Reset
0	1	1	1	1	1	Set
1	0	0	0	0	0	Hold
1	0	0	1	0	0	Hold
1	0	1	0	0	1	Hold
1	0	1	1	0	1	Hold
1	1	0	0	1	0	Hold
1	1	0	1	1	0	Hold
1	1	1	0	1	1	Hold
1	1	1	1	1	1	Hold

62.6.1.6.5 Register configuration

Table 310. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	F0B8h	—	—	—
LUTCTRL1	—	—	—	—	—	CCCCh	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			

Table continues on the next page...

Table 310. Register configuration (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	1h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	5h	—	—	—	—	—	—
MUXSEL3	6h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	3h			

62.6.1.6.6 Waveforms

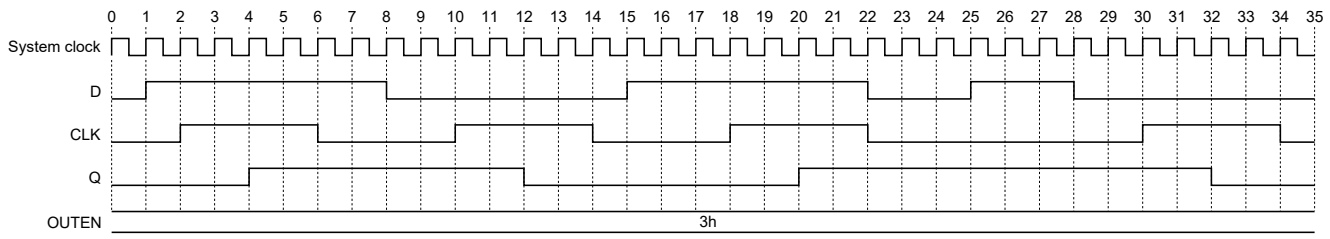


Figure 335. Waveforms

62.6.1.7 JK flip-flop

62.6.1.7.1 Overview

A JK flip-flop is a gated SR latch (see SR latch) with an added clock input circuit that prevents the illegal or invalid output condition that can occur when both SR-latch inputs (S and R) are asserted.

Truth table for JK flip-flop presents the four possible input combinations for a JK flip-flop. All output changes occur at the clock rising edge.

You can create a JK flip-flop using two LCs, as illustrated in Implementation. The first LC detects rising edges of the CLK clock input (see Truth table for LC0). The second LC processes J and K inputs at every rising clock edge (see Truth table for LC1).

Output Q and CLKO digital filters are bypassed. Therefore, the states of these variables are fed to inputs with a delay of one clock cycle (see Waveforms).

62.6.1.7.2 Implementation

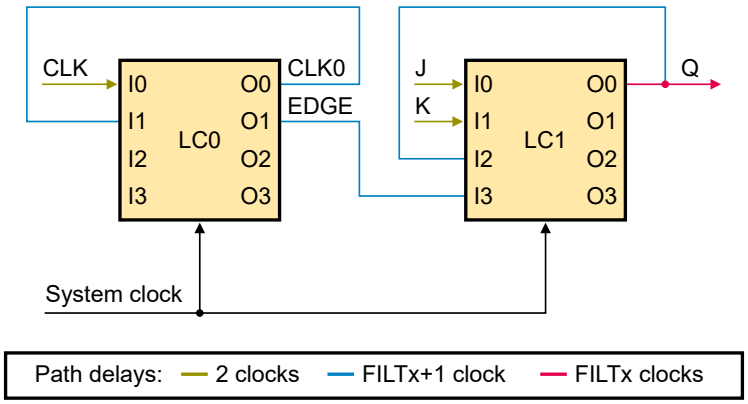


Figure 336. Implementation

62.6.1.7.3 Truth table for JK flip-flop

Table 311. Truth table for JK flip-flop

J	K	State
0	0	Hold
1	0	Set
0	1	Clear
1	1	Toggle

62.6.1.7.4 Truth table for LC0

Table 312. Truth table for LC0

Inputs		Outputs		State
CLKO	CLK	CLKO	EDGE	
0	0	0	0	No edge
0	1	1	1	Edge detected
1	0	0	0	No edge
1	1	1	0	No edge

62.6.1.7.5 Truth table for LC1

Table 313. Truth table for LC1

Inputs				Output	State
EDGE	Q	J	K	Q	
0	0	X	X	0	Hold
0	1	X	X	1	Hold

Table continues on the next page...

Table 313. Truth table for LC1 (continued)

Inputs				Output	State
EDGE	Q	J	K	Q	
1	0	0	0	0	Hold
1	1	0	0	1	Hold
1	X	1	0	1	Set
1	X	0	1	0	Clear
1	0	1	1	1	Toggle
1	1	1	1	0	Toggle

62.6.1.7.6 Register configuration for LC0

Table 314. Register configuration for LC0

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	Ah	—	—	—
LUTCTRL1	—	—	—	—	—	2h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	1h	—	—	—	—
MUXSEL1	—	—	9h	—	—	—	—	—
MUXSEL2	—	0h	—	—	—	—	—	—
MUXSEL3	0h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	3h			

62.6.1.7.7 Register configuration for LC1

Table 315. Register configuration for LC1

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	3AF0h	—	—	—
LUTCTRL1	—	—	—	—	—	0h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL4	—	—	—	5h	—	—	—	—
MUXSEL5	—	—	6h	—	—	—	—	—
MUXSEL6	—	Dh	—	—	—	—	—	—
MUXSEL7	Ah	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	10h			

62.6.1.7.8 Waveforms

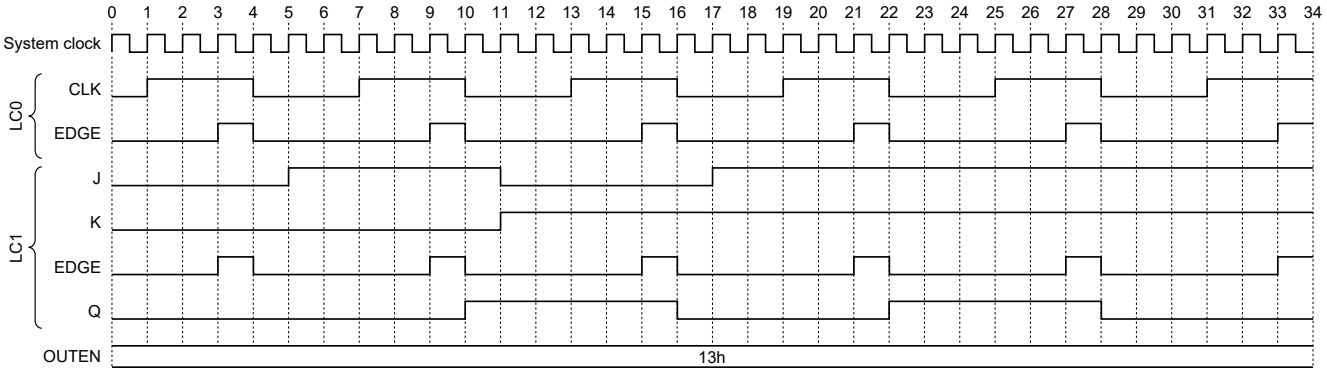


Figure 337. Waveforms

62.6.1.8 Incremental encoder

62.6.1.8.1 Overview

An incremental encoder provides A and B pulse outputs in the form of 90-degree shifted waveforms (see Outputs). The decoding circuit processes these waveforms to detect the rotor position and the direction of rotation.

This example implementation requires two LCs (see Implementation):

- LC0 provides pulse streams on CW or CCW output at every A and B signal edge. If the encoder rotation is CW (A signal leading), then pulses appear at the CW output. If the encoder rotation is CCW (B signal leading), then pulses appear at the CCW output. Two pulse counters accumulate these pulse streams to provide the actual absolute encoder position in the respective direction of rotation.
- LC1 then uses the LC0 outputs to detect the direction of the rotation.

62.6.1.8.2 Outputs

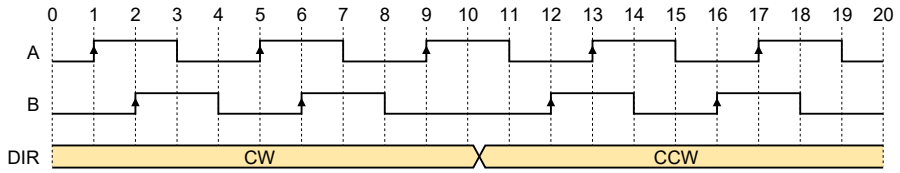


Figure 338. Outputs

62.6.1.8.3 Implementation

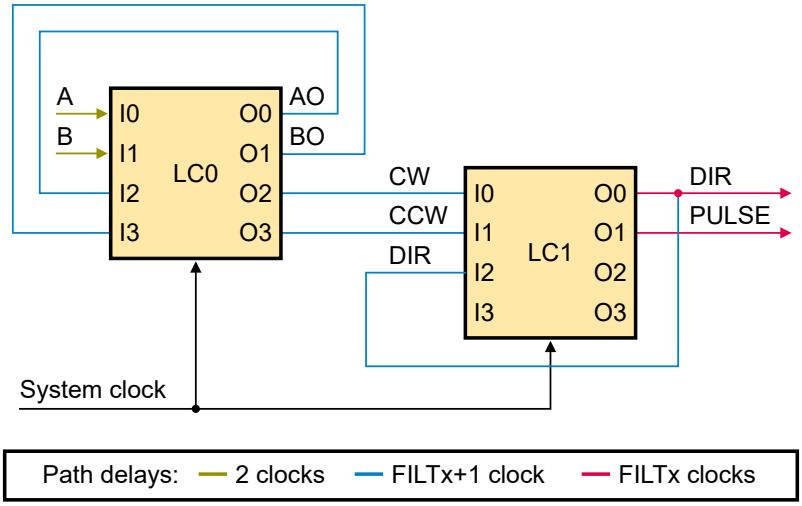


Figure 339. Implementation

62.6.1.8.4 Truth table for pulse generation

Table 316. Truth table for pulse generation

Inputs				Outputs			
BO	AO	B	A	AO	BO	CW	CCW
0	0	0	0	0	0	—	—
0	0	0	1	1	0	1	—
0	0	1	0	0	1	—	1
0	0	1	1	1	1		
0	1	0	0	0	0	—	1
0	1	0	1	1	0		
0	1	1	0	0	1	—	—
0	1	1	1	1	1	1	—
1	0	0	0	0	0	1	
1	0	0	1	1	0	—	—
1	0	1	0	0	1	—	—
1	0	1	1	1	1	—	1
1	1	0	0	0	0		
1	1	0	1	1	0	—	1
1	1	1	0	0	1	1	—
1	1	1	1	1	1	—	—

62.6.1.8.5 Truth table for decoding direction of rotation

In this table:

- DIR = 0 represents a CCW direction.
- DIR = 1 represents a CW direction.

Table 317. Truth table for decoding direction of rotation

Inputs			Output
DIR	CCW	CW	DIR
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

62.6.1.8.6 Register configuration for LC0

Table 318. Register configuration for LC0

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	AAAAh	—	—	—
LUTCTRL1	—	—	—	—	—	CCCCh	—	—
LUTCTRL2	—	—	—	—	—	—	4182h	—
LUTCTRL3	—	—	—	—	—	—	—	2814h
FILT0	—	—	—	—	1_0001h	—	—	—
FILT1	—	—	—	—	—	1_0001h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	1h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	9h	—	—	—	—	—	—
MUXSEL3	Ah	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	Fh			

62.6.1.8.7 Register configuration for LC1

Table 319. Register configuration for LC1

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	BAh	—	—	—
LUTCTRL1	—	—	—	—	—	0h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h

Table continues on the next page...

Table 319. Register configuration for LC1 (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL4	—	—	—	Bh	—	—	—	—
MUXSEL5	—	—	Ch	—	—	—	—	—
MUXSEL6	—	Dh	—	—	—	—	—	—
MUXSEL7	0h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	10h			

62.6.1.8.8 Waveforms

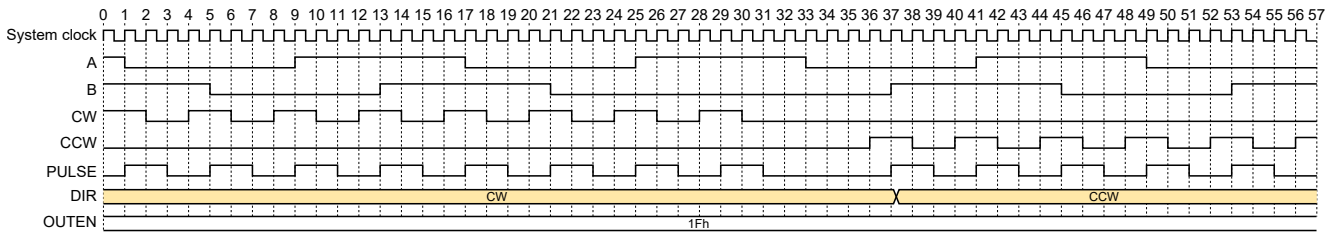


Figure 340. Waveforms

62.6.1.9 AC motor PWM controller

62.6.1.9.1 Overview

Driving a three-phase AC motor requires dedicated PWMs to perform:

- Complementary signal generation
- Dead time insertion
- Fault-state assertion
- Manual or automatic fault recovery

LCU enhances basic timer functionality with the necessary complementary features available only on dedicated motor control PWMs.

Implementation for AC motor controller shows all input and output signals of LCU in a typical three-phase motor control application.

TdH is the time delay preceding each rising edge of the complementary PWM output signals. See Truth table for details.

Fault signals are routed from analog comparators or external protection circuits to protect power switches against damage caused by overcurrent. Any active fault must immediately change all PWM outputs to the inactive state. Force logic causes PWM outputs to transition to the inactive state upon an external fault event. See Truth table for details.

The dead time is one clock cycle. On a fault event, both PWM outputs transition to the inactive state (logic 0). When the fault event deasserts, both PWM signals start operating according to FORCE_MODE = 00 (cleared on force deassertion). See Waveforms for force cleared on force deassertion for details.

62.6.1.9.2 Implementation for AC motor controller

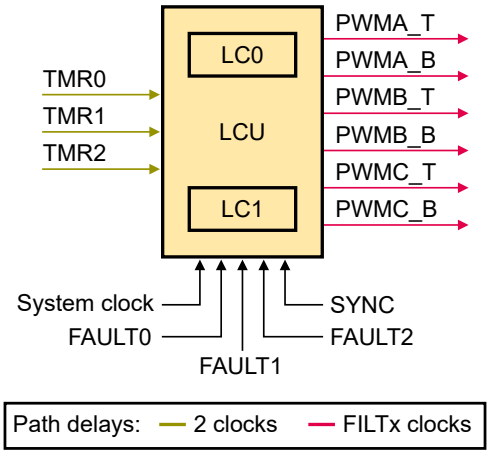


Figure 341. Implementation for AC motor controller

62.6.1.9.3 Implementation for controlling one phase of AC motor controller

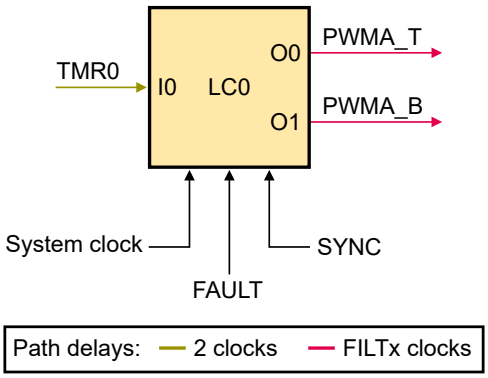


Figure 342. Implementation for controlling one phase of AC motor controller

62.6.1.9.4 Connections and controls

Table 320. Connections and controls

Name	Description
TMR*n*	Synchronized timer input signals
System clock	Clock supplied to the LC
FAULT*n*	Fault signal (see Overview)

Table continues on the next page...

Table 320. Connections and controls (continued)

Name	Description
SYNC	Sync signal for optional automatic fault recovery
PWM*x*_T	PWM output signal for controlling top power switch
PWM*x*_B	PWM output signal for controlling bottom power switch

62.6.1.9.5 Truth table

Table 321. Truth table

Input	Outputs	
TMR0	PWMA_T	PWMB_B
0	0	1 delayed by TdH (see Output edge delays)
1	1 delayed by TdH (see Output edge delays)	0

62.6.1.9.6 Register configuration

Table 322. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	2h	—	—	—
LUTCTRL1	—	—	—	—	—	1h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	1_0000h	—	—	—
FILT1	—	—	—	—	—	1_0000h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	100_0000h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	Software sync on rising edge for inputs 2 and 0, immediate for 3 and 1: 101h Software sync on rising edge for all four inputs: 1111h			
MUXSEL0	—	—	—	01h	—	—	—	—
MUXSEL1	—	—	0h	—	—	—	—	—
MUXSEL2	—	0h	—	—	—	—	—	—
MUXSEL3	0h	—	—	—	—	—	—	—

Table continues on the next page...

Table 322. Register configuration (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	3h			

62.6.1.9.7 Waveforms for force cleared on force deassertion

This example shows two behaviors, depending on the Force Clearing mode (LC0_FCTRL[FORCE_MODE0]).

00b - Both PWM signals start normal operation when the fault event deasserts. See Waveforms for force cleared on force deassertion for details.

01b - Both PWM signals start normal operation on rising sync after the fault event deasserts. See Waveforms for force cleared on rising sync after force deassertion for details.

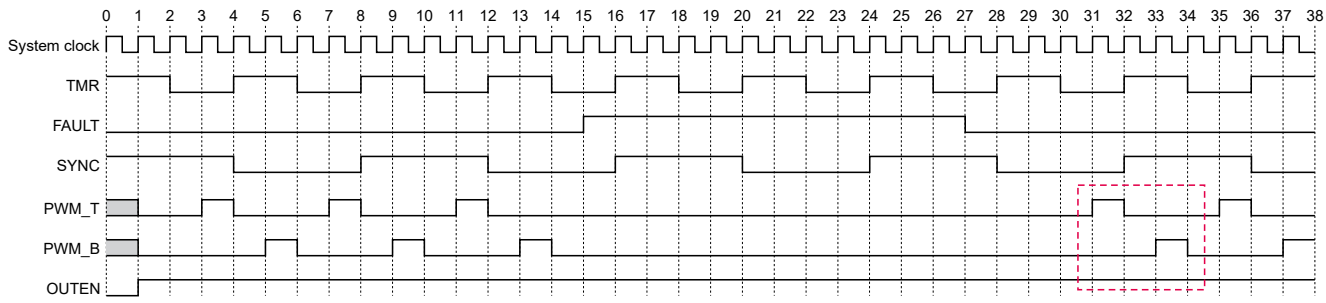


Figure 343. Waveforms for force cleared on force deassertion

62.6.1.9.8 Waveforms for force cleared on rising sync after force deassertion

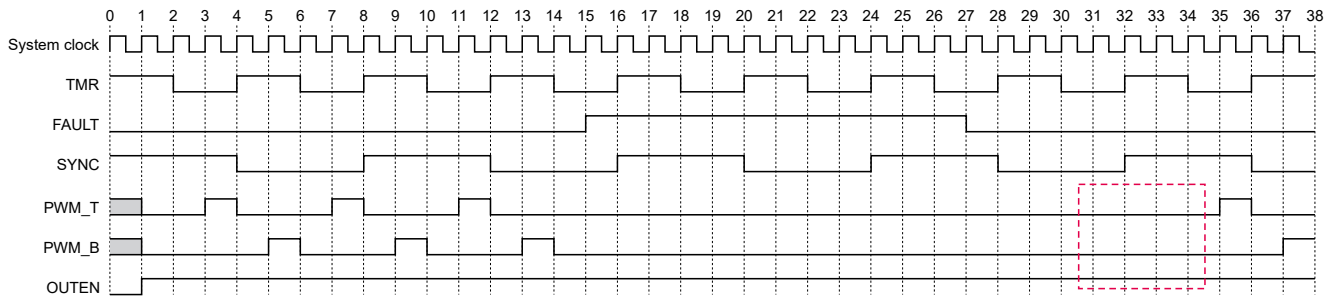


Figure 344. Waveforms for force cleared on rising sync after force deassertion

62.6.1.10 AC motor double-switching controller

62.6.1.10.1 Overview

The simplest method of obtaining motor winding currents is to measure the current in each phase by placing a shunt resistor in two or three inverter legs (phases).

This example implementation of an AC motor drive for low-cost and high-volume applications uses a single shunt on the DC bus return path, as illustrated in AC motor power stage schematic. LCU supports double-switching by XORing two timer channel outputs. The implementation uses two LCs arranged to perform double switching, dead time generation, and the processing of three external fault signals.

62.6.1.10.2 Double-switching

The double-switching technique requires:

- Six synchronized timer pulses
- Three fault signals
- Six PWM outputs for controlling top and bottom power switches
- A sync signal for automatic fault recovery

Waveforms for double-switching technique example applies the PWM switching cycle to an AC motor to reconstruct currents in three phases using a single DC bus shunt resistor (RSH). It applies the non-zero switching vectors 100, 110, and 101 to the power switches, which sample currents IA[0], -IC[0], -IC[1], and IA[1]. Because the durations (T1) of active vectors 110 and 101 are the same, it also applies the zero switching vector (000) with durations T2 and T3 in the middle of the switching cycle to allow phase current reconstruction. This technique can only be used by PWM modules targeted at motor control and power conversion applications.

62.6.1.10.3 Fault inputs and deadtime insertion

Fault signals are routed from analog comparators or external protection circuits to protect power switches against damage caused by overcurrent. You must program the Combinational Force Path (LCn_FFILT[COMB_EN]) to enable an active fault input to immediately force all PWM outputs to the inactive state.

62.6.1.10.4 Deadtime insertion

In Waveforms for generation of PWM complementary signals using an LC, the PWMA_T output is generated by XORing timer outputs TMR0 and TMR1. The PWMA_B output is complementary to PWMA_T. Digital filters insert a dead time of one system clock cycle to delay the rising edges of both PWM signals.

62.6.1.10.5 Fault events

Waveforms for force cleared on force deassertion shows the reaction to the fault event. On a fault event, both the PWM outputs transition to the inactive state (logic 0). When fault event deasserts, both the PWM signals start operating according to FORCE_MODE = 00 (cleared on force deassertion).

Alternatively, after the fault event deasserts, fault clearing can be performed according to FORCE_MODE = 01 (cleared on rising sync force deassertion). See Waveforms for force cleared on rising sync after force deassertion for details.

62.6.1.10.6 AC motor power stage schematic

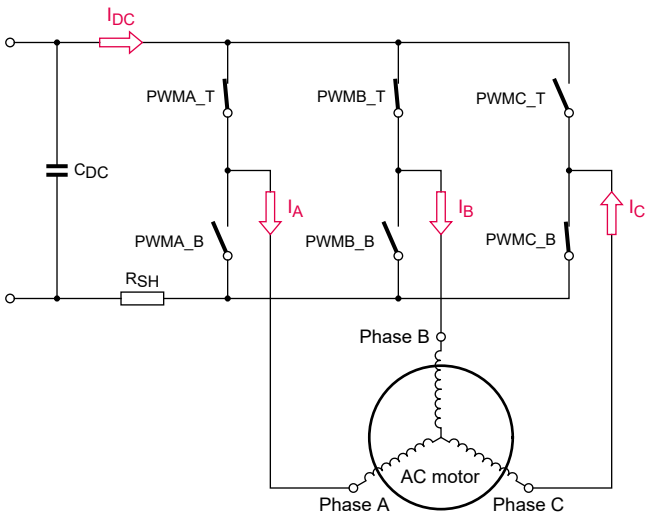


Figure 345. AC motor power stage schematic

62.6.1.10.7 Waveforms for double-switching technique example

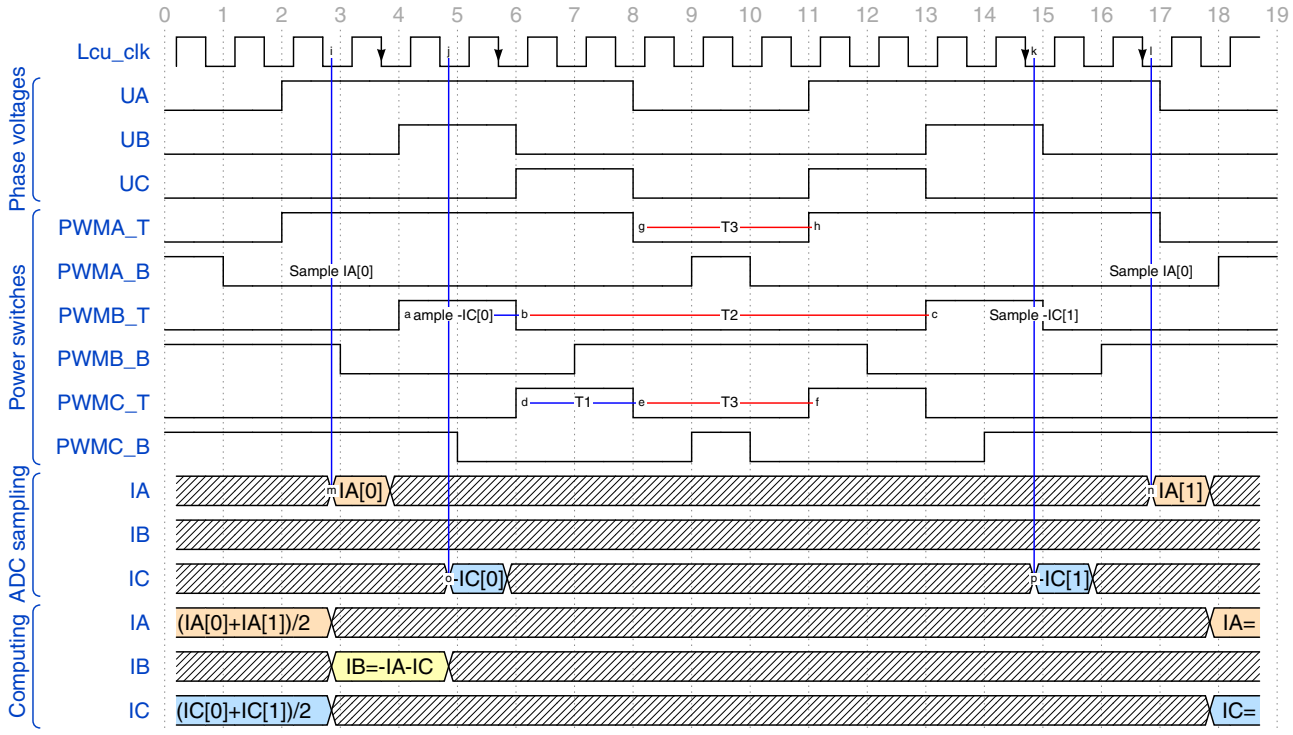


Figure 346. Waveforms for double-switching technique example

62.6.1.10.8 Implementation for AC motor double-switching controller

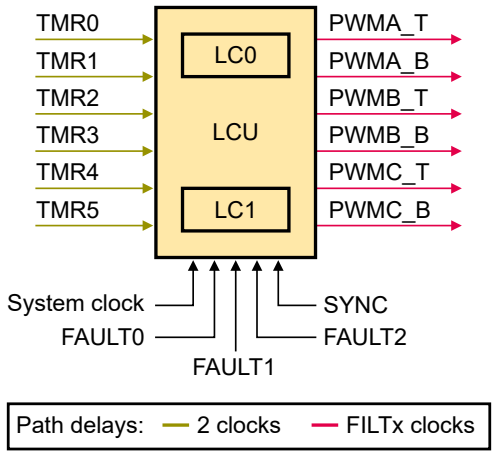


Figure 347. Implementation for AC motor double-switching controller

62.6.1.10.9 Implementation for controlling one phase

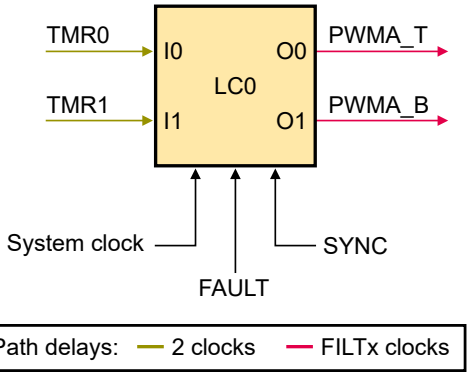


Figure 348. Implementation for controlling one phase

62.6.1.10.10 Connections and controls

Table 323. Connections and controls

Name	Description
TMR*n*	Synchronized timer input signals
System clock	Clock supplied to the LC
FAULT*n*	Fault signal (see Implementation for AC motor double-switching controller for more details)
SYNC	Sync signal for optional automatic fault recovery
PWM*x*_T	PWM output signal for controlling top power switch
PWM*x*_B	PWM output signal for controlling bottom power switch

62.6.1.10.11 Truth table

Table 324. Truth table

Inputs		Outputs	
TMR1	TMR0	PWMA_T	PWMB_B
0	0	0	1 delayed by TdH (see Output edge delays)
0	1	1 delayed by TdH (see Output edge delays)	0
1	0	1 delayed by TdH (see Output edge delays)	0
1	1	0	1 delayed by TdH (see Output edge delays)
0	0	0	0
0	1	0	0
1	0	0	0
1	1	0	0

62.6.1.10.12 Register configuration

Table 325. Register configuration

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	6h	—	—	—
LUTCTRL1	—	—	—	—	—	9h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	1_0000h	—	—	—
FILT1	—	—	—	—	—	1_0000h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	100_0000h			
FCTRL	—	—	—	—	Force inputs 2 and 0 affect output 0, but force inputs 3 and 1 do not affect output 0: 101h All four inputs affect output 0: 1111h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	1h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	0h	—	—	—	—	—	—
MUXSEL3	0h	—	—	—	—	—	—	—

Table continues on the next page...

Table 325. Register configuration (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	3h			

62.6.1.10.13 Waveforms for generation of PWM complementary signals using an LC

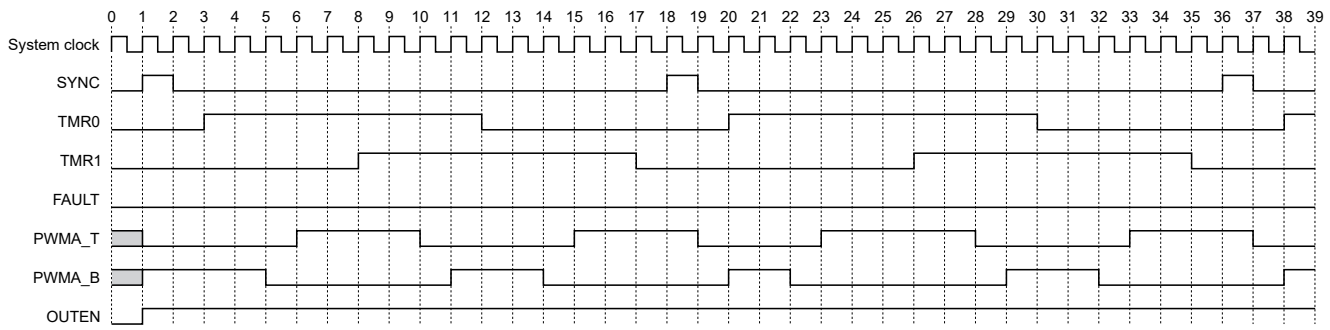


Figure 349. Waveforms for generation of PWM complementary signals using an LC

62.6.1.10.14 Waveforms for force cleared on force deassertion

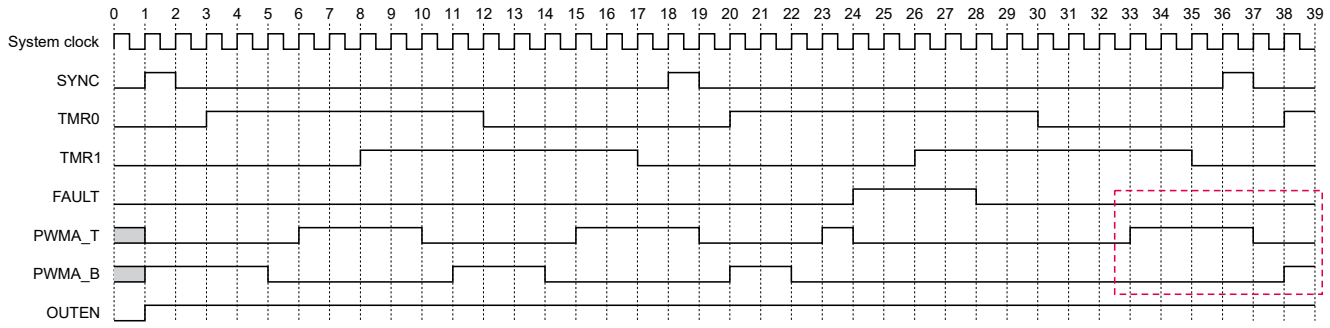


Figure 350. Waveforms for force cleared on force deassertion

62.6.1.10.15 Waveforms for force cleared on rising sync after force deassertion

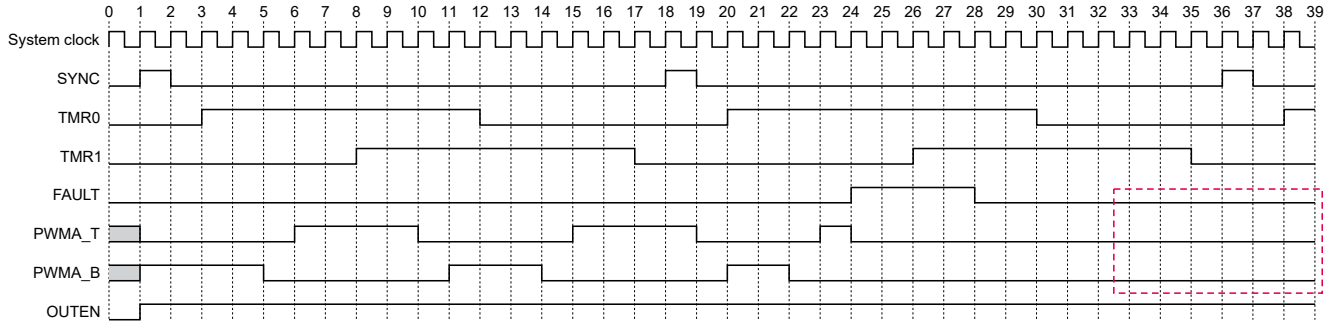


Figure 351. Waveforms for force cleared on rising sync after force deassertion

62.6.1.11 Brushless DC (BLDC) motor PWM controller

62.6.1.11.1 Overview

You can use LCU to replace the mechanical commutator in the BLDC motor control application with Hall-sensor position measurement.

In this example implementation, LC0 receives the direction (DIR) and Hall A, Hall B, and Hall C sensor output states, and from those inputs generates the switching states S1, S2, and S3. LC1 and LC2 convert the switching states to PWM or on-off signals for controlling power switches, as illustrated in Waveforms for BLDC motor control technique.

BLDC motor power stage schematic and BLDC motor electrical arrangement illustrate a three-phase BLDC motor power stage with switching pulses and phase currents controlling motor rotation in the CCW direction. The state of the Hall sensors is 010. As the rotor shaft rotates, Hall sensors track the motor position. You accelerate or decelerate the motor by controlling the width of the PWM signal. You can include one or more faults (force inputs) to force power switches instantaneously into the inactive state if there is an overcurrent.

62.6.1.11.2 Implementation

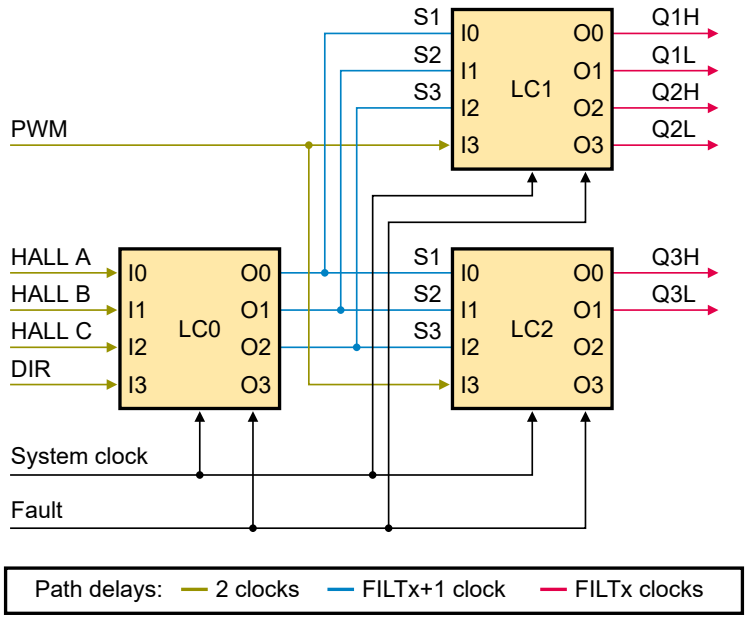


Figure 352. Implementation

62.6.1.11.3 BLDC motor power stage schematic

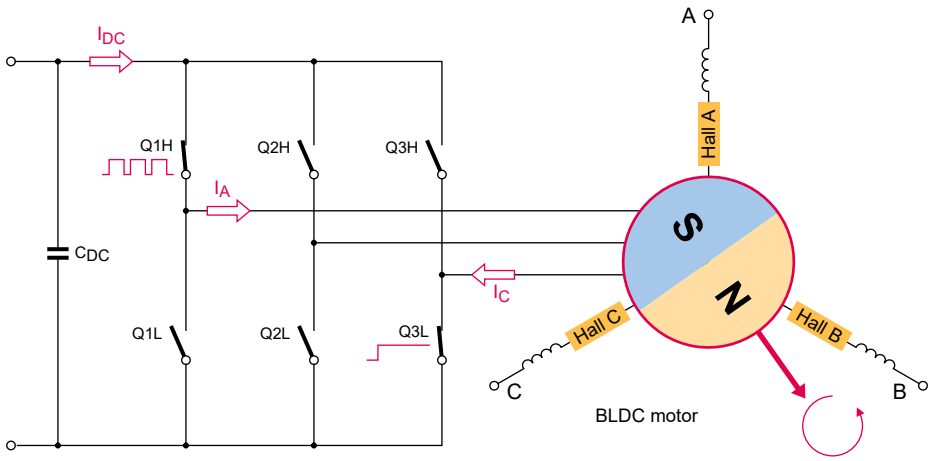


Figure 353. BLDC motor power stage schematic

62.6.1.11.4 BLDC motor electrical arrangement

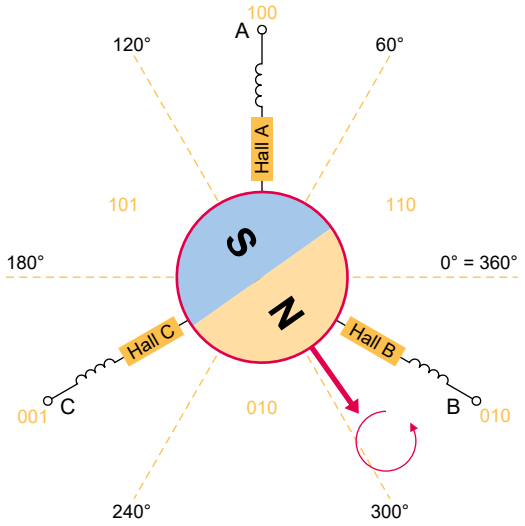


Figure 354. BLDC motor electrical arrangement

62.6.1.11.5 Waveforms for BLDC motor control technique

This figure illustrates the basic waveforms for controlling a BLDC motor with stator windings and Hall sensors arranged according to BLDC motor electrical arrangement. Configure the external hardware (motor or sensor) so that it can produce these waveforms; then you can configure LCU.

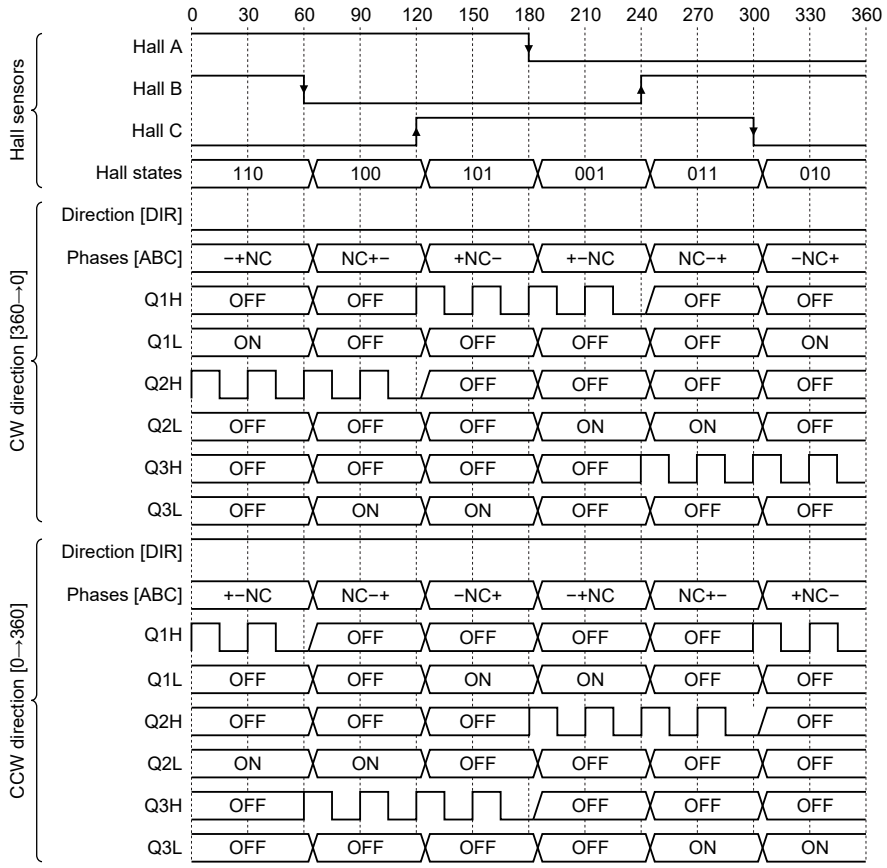


Figure 355. Waveforms for BLDC motor control technique

62.6.1.11.6 Connections and controls

Table 326. Connections and controls

Input-output group	Name	Description
LC0 inputs	HALL A	Hall sensor A output state
	HALL B	Hall sensor B output state
	HALL C	Hall sensor C output state
	DIR	Direction of shaft rotation, as illustrated in Waveforms for reversing BLDC motor.
LC1 and LC2 inputs	S1	Switching state 1 (output 0 from LC0)
	S2	Switching state 2 (output 1 from LC0)
	S2	Switching state 3 (output 2 from LC0)
	PWM	Output from PWM
LC0, LC1, and LC2 inputs	Clock	LCU clock input
	Fault	Optional fault input

Table continues on the next page...

Table 326. Connections and controls (continued)

Input-output group	Name	Description
LC1 outputs	Q1H	Motor control switch outputs, as illustrated in BLDC motor electrical arrangement
	Q1L	
	Q2H	
	Q2L	
LC2 outputs	Q3H	
	Q3L	

62.6.1.11.7 Truth table for generating switching states

This table includes all Hall sensor states, even those that never occur because of sensor displacement by 120°.

Table 327. Truth table for generating switching states

Inputs				Outputs			Comments
DIR	Hall C	Hall B	Hall A	S1	S2	S3	
0	0	0	0	0	0	0	Not used
0	0	0	1	1	0	0	Hall states
0	0	1	0	0	1	0	Hall states
0	0	1	1	1	1	0	Hall states
0	1	0	0	0	0	1	Hall states
0	1	0	1	1	0	1	Hall states
0	1	1	0	0	1	1	Hall states
0	1	1	1	0	0	0	Not used
1	0	0	0	0	0	0	Not used
1	0	0	1	0	1	1	Complement of Hall states
1	0	1	0	1	0	1	Complement of Hall states
1	0	1	1	0	0	1	Complement of Hall states
1	1	0	0	1	1	0	Complement of Hall states
1	1	0	1	0	1	0	Complement of Hall states
1	1	1	0	1	0	0	Complement of Hall states
1	1	1	1	0	0	0	Not used

62.6.1.11.8 Truth table for generating switching pulses for phases A and B

Table 328. Truth table for generating switching pulses for phases A and B

Inputs				Outputs				Comments
PWM	S3	S2	S1	Q1H	Q1L	Q2H	Q2L	
0	0	0	0	0	0	0	0	Not used
0	0	0	1	0	0	0	0	—
0	0	1	0	0	1	0	0	—
0	0	1	1	0	1	0	0	—
0	1	0	0	0	0	0	1	—
0	1	0	1	0	0	0	0	—
0	1	1	0	0	0	0	1	—
0	1	1	1	0	0	0	0	Not used
1	0	0	0	0	0	0	0	Not used
1	0	0	1	0	0	1	0	—
1	0	1	0	0	1	0	0	—
1	0	1	1	0	1	1	0	—
1	1	0	0	1	0	0	1	—
1	1	0	1	1	0	0	0	—
1	1	1	0	0	0	0	1	—
1	1	1	1	0	0	0	0	Not used

62.6.1.11.9 Truth table for generating switching pulses for phase C

Table 329. Truth table for generating switching pulses for phase C

Inputs				Outputs		Comments
PWM	S3	S2	S1	Q3H	Q3L	
0	0	0	0	0	0	Not used
0	0	0	1	0	1	—
0	0	1	0	0	0	—
0	0	1	1	0	0	—
0	1	0	0	0	0	—
0	1	0	1	0	1	—
0	1	1	0	0	0	—
0	1	1	1	0	0	Not used
1	0	0	0	0	0	Not used
1	0	0	1	0	1	—

Table continues on the next page...

Table 329. Truth table for generating switching pulses for phase C (continued)

Inputs				Outputs		Comments
PWM	S3	S2	S1	Q3H	Q3L	
1	0	1	0	1	0	—
1	0	1	1	0	0	—
1	1	0	0	0	0	—
1	1	0	1	0	1	—
1	1	1	0	1	0	—
1	1	1	1	0	0	Not used

62.6.1.11.10 Configuration for generating switching states

Table 330. Configuration for generating switching states

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	542Ah	—	—	—
LUTCTRL1	—	—	—	—	—	324Ch	—	—
LUTCTRL2	—	—	—	—	—	—	E70h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0h			
FCTRL	—	—	—	—	0h			
SCTRL	—	—	—	—	0h			
MUXSEL0	—	—	—	1h	—	—	—	—
MUXSEL1	—	—	2h	—	—	—	—	—
MUXSEL2	—	3h	—	—	—	—	—	—
MUXSEL3	4h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	7h			

62.6.1.11.11 Configuration for switching pulses for phases A and B

Table 331. Configuration for switching pulses for phases A and B

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	3000h	—	—	—
LUTCTRL1	—	—	—	—	—	C0Ch	—	—
LUTCTRL2	—	—	—	—	—	—	A00h	—
LUTCTRL3	—	—	—	—	—	—	—	5050h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	F00_0000h			
FCTRL	—	—	—	—	101_0101h			
SCTRL	—	—	—	—	0h			
MUXSEL4	—	—	—	Dh	—	—	—	—
MUXSEL5	—	—	Eh	—	—	—	—	—
MUXSEL6	—	Fh	—	—	—	—	—	—
MUXSEL7	8h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	F0h			

62.6.1.11.12 Configuration for switching pulses for phase C

Table 332. Configuration for switching pulses for phase C

Register	I3	I2	I1	I0	O0	O1	O2	O3
LUTCTRL0	—	—	—	—	4400h	—	—	—
LUTCTRL1	—	—	—	—	—	2222h	—	—
LUTCTRL2	—	—	—	—	—	—	0h	—
LUTCTRL3	—	—	—	—	—	—	—	0h
FILT0	—	—	—	—	0h	—	—	—
FILT1	—	—	—	—	—	0h	—	—
FILT2	—	—	—	—	—	—	0h	—
FILT3	—	—	—	—	—	—	—	0h

Table continues on the next page...

Table 332. Configuration for switching pulses for phase C (continued)

Register	I3	I2	I1	I0	O0	O1	O2	O3
INTDMAEN	—	—	—	—	0h			
OUTPOL	—	—	—	—	0h			
FFILT	—	—	—	—	0300_0000h			
FCTRL	—	—	—	—	101h			
SCTRL	—	—	—	—	0h			
MUXSEL8	—	—	—	Dh	—	—	—	—
MUXSEL9	—	—	Eh	—	—	—	—	—
MUXSEL10	—	Fh	—	—	—	—	—	—
MUXSEL11	8h	—	—	—	—	—	—	—
SWEN	—	—	—	—	0h			
SWVALUE	—	—	—	—	0h			
OUTEN	—	—	—	—	300h			

62.6.1.11.13 Waveforms for reversing BLDC motor

This figure illustrates the waveforms for controlling a reversing BLDC motor. The DIR input indicates the direction of rotation:

- Logic 0 for CW rotation
- Logic 1 for CCW rotation

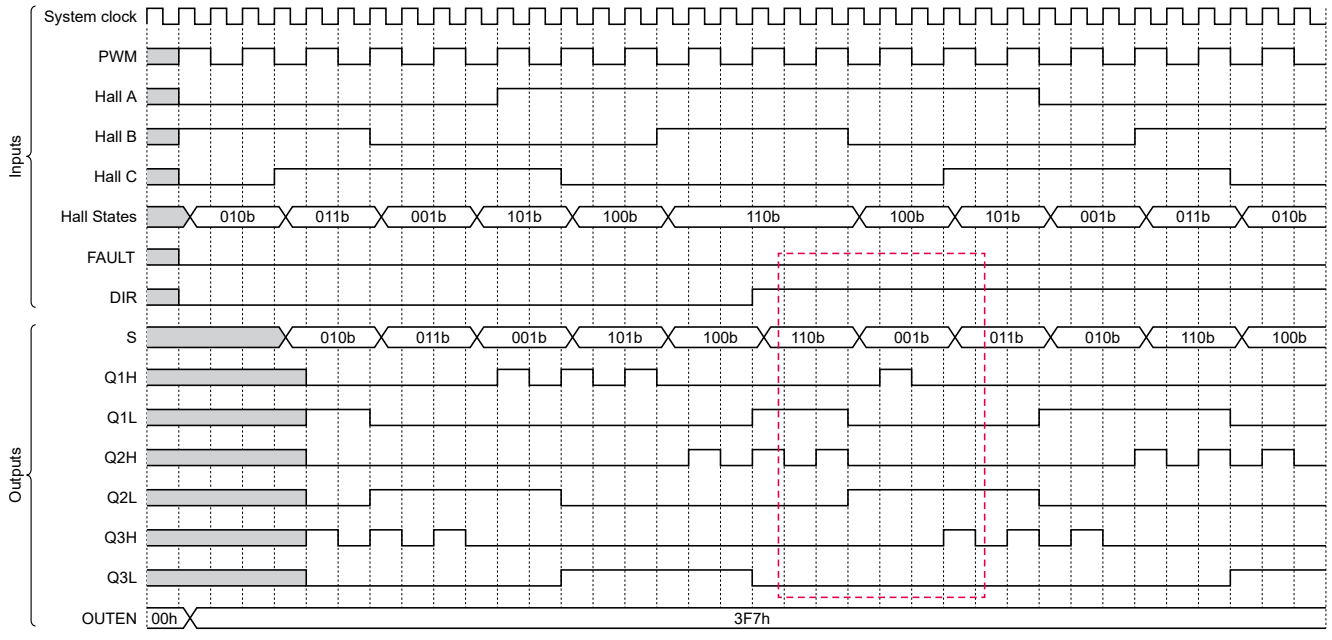


Figure 356. Waveforms for reversing BLDC motor

62.6.1.11.14 Waveforms for reversing BLDC motor with fault assertion

This figure illustrates the waveforms for the reaction to an external fault in addition to reversing the BLDC motor. On the occurrence of an external fault event, the power switches transition to the inactive state (logic 0). Two clock cycles after external fault deassertion, the power switches start operating normally.

Switching state outputs S1, S2, and S3, generated by LC0, receive an additional delay of one clock cycle on their way to the inputs of other LCs (digital filters bypassed).

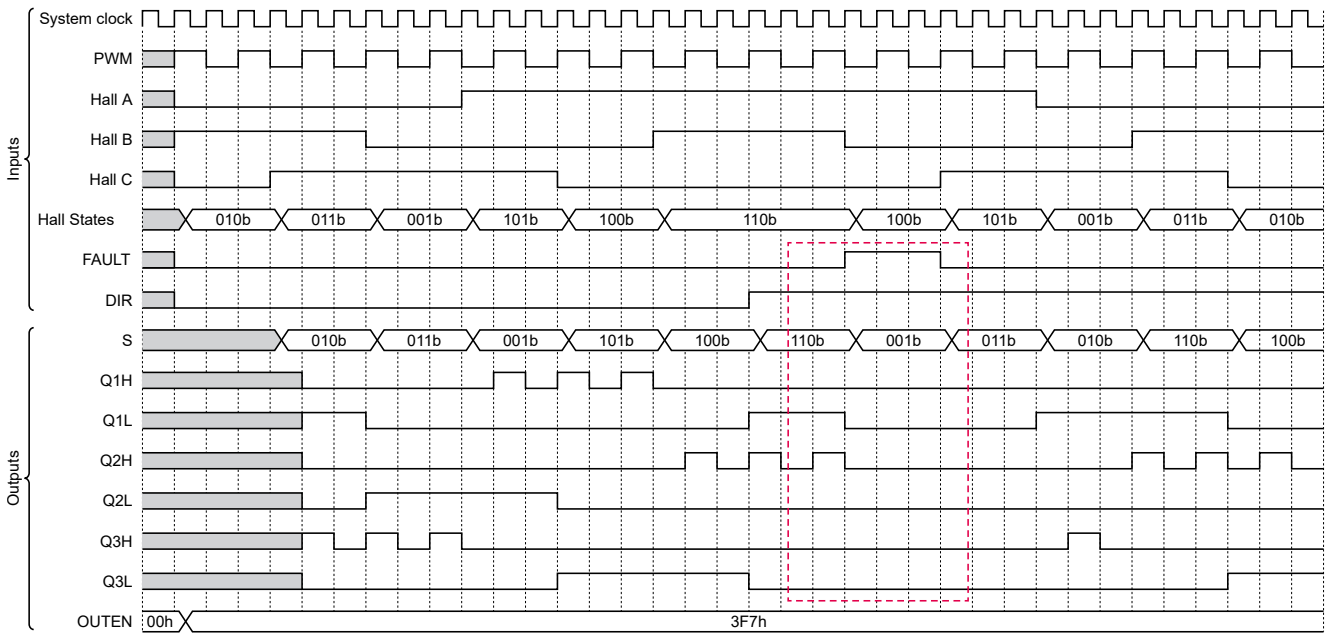


Figure 357. Waveforms for reversing BLDC motor with fault assertion

62.7 Mapping of 12-bit input, output, and state fields

This table maps inputs, outputs, or states to the bit positions in the following 12-bit fields:

- SWEN[SWEN]
- SWVALUE[SWVALUE]
- OUTEN[OUTEN]
- LCIN[LC_INPUTS]
- SWOUT[SWOUT]
- LCOUT[LCOUT]
- FORCEOUT[FORCEOUT]
- FORCESTS[FORCESTS]
- DBGEN[DBGEN]

LC	Input, output, or state	Bit
0	0	0
	1	1

Table continues on the next page...

Table continued from the previous page...

LC	Input, output, or state	Bit
	2	2
	3	3
1	0	4
	1	5
	2	6
	3	7
2	0	8
	1	9
	2	10
	3	11

62.8 LCU register descriptions

NOTE

Access to address offset 2A4h does not generate a transfer error.

62.8.1 LCU memory map

LCU_0 base address: 4009_8000h

LCU_1 base address: 4009_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	LC 0 Output 0 LUT Control (LC0_LUTCTRL0)	32	RW	0000_0000h
4h	LC 0 Output 1 LUT Control (LC0_LUTCTRL1)	32	RW	0000_0000h
8h	LC 0 Output 2 LUT Control (LC0_LUTCTRL2)	32	RW	0000_0000h
Ch	LC 0 Output 3 LUT Control (LC0_LUTCTRL3)	32	RW	0000_0000h
10h	LC 0 Output 0 Filter (LC0_FILT0)	32	RW	0000_0000h
14h	LC 0 Output 1 Filter (LC0_FILT1)	32	RW	0000_0000h
18h	LC 0 Output 2 Filter (LC0_FILT2)	32	RW	0000_0000h
1Ch	LC 0 Output 3 Filter (LC0_FILT3)	32	RW	0000_0000h
20h	LC 0 Interrupt and DMA Enable (LC0_INTDMAEN)	32	RW	0000_0000h
24h	LC 0 Status (LC0_STS)	32	RW	0000_0000h
28h	LC 0 Output Polarity Control (LC0_OUTPOL)	32	RW	0000_0000h
2Ch	LC 0 Force Filter (LC0_FFILT)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
30h	LC 0 Force Control (LC0_FCTRL)	32	RW	0000_0000h
34h	LC 0 Sync Control (LC0_SCTRL)	32	RW	0000_0000h
40h	LC 1 Output 0 LUT Control (LC1_LUTCTRL0)	32	RW	0000_0000h
44h	LC 1 Output 1 LUT Control (LC1_LUTCTRL1)	32	RW	0000_0000h
48h	LC 1 Output 2 LUT Control (LC1_LUTCTRL2)	32	RW	0000_0000h
4Ch	LC 1 Output 3 LUT Control (LC1_LUTCTRL3)	32	RW	0000_0000h
50h	LC 1 Output 0 Filter (LC1_FILT0)	32	RW	0000_0000h
54h	LC 1 Output 1 Filter (LC1_FILT1)	32	RW	0000_0000h
58h	LC 1 Output 2 Filter (LC1_FILT2)	32	RW	0000_0000h
5Ch	LC 1 Output 3 Filter (LC1_FILT3)	32	RW	0000_0000h
60h	LC 1 Interrupt and DMA Enable (LC1_INTDMAEN)	32	RW	0000_0000h
64h	LC 1 Status (LC1_STS)	32	RW	0000_0000h
68h	LC 1 Output Polarity Control (LC1_OUTPOL)	32	RW	0000_0000h
6Ch	LC 1 Force Filter (LC1_FFILT)	32	RW	0000_0000h
70h	LC 1 Force Control (LC1_FCTRL)	32	RW	0000_0000h
74h	LC 1 Sync Control (LC1_SCTRL)	32	RW	0000_0000h
80h	LC 2 Output 0 LUT Control (LC2_LUTCTRL0)	32	RW	0000_0000h
84h	LC 2 Output 1 LUT Control (LC2_LUTCTRL1)	32	RW	0000_0000h
88h	LC 2 Output 2 LUT Control (LC2_LUTCTRL2)	32	RW	0000_0000h
8Ch	LC 2 Output 3 LUT Control (LC2_LUTCTRL3)	32	RW	0000_0000h
90h	LC 2 Output 0 Filter (LC2_FILT0)	32	RW	0000_0000h
94h	LC 2 Output 1 Filter (LC2_FILT1)	32	RW	0000_0000h
98h	LC 2 Output 2 Filter (LC2_FILT2)	32	RW	0000_0000h
9Ch	LC 2 Output 3 Filter (LC2_FILT3)	32	RW	0000_0000h
A0h	LC 2 Interrupt and DMA Enable (LC2_INTDMAEN)	32	RW	0000_0000h
A4h	LC 2 Status (LC2_STS)	32	RW	0000_0000h
A8h	LC 2 Output Polarity Control (LC2_OUTPOL)	32	RW	0000_0000h
ACh	LC 2 Force Filter (LC2_FFILT)	32	RW	0000_0000h
B0h	LC 2 Force Control (LC2_FCTRL)	32	RW	0000_0000h
B4h	LC 2 Sync Control (LC2_SCTRL)	32	RW	0000_0000h
200h - 22Ch	Mux Select (MUXSEL0 - MUXSEL11)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
280h	Configuration (CFG)	32	RW	0304_0280h
284h	Software Override Enable (SWEN)	32	RW	0000_0000h
288h	Software Override Value (SWVALUE)	32	RW	0000_0000h
28Ch	Output Enable (OUTEN)	32	RW	0000_0000h
290h	Logic Inputs (LCIN)	32	R	0000_0000h
294h	Overridden Inputs (SWOUT)	32	R	0000_0000h
298h	Logic Outputs (LCOUT)	32	R	0000_0000h
29Ch	Forced Outputs (FORCEOUT)	32	R	0000_0000h
2A0h	Force Status (FORCESTS)	32	RW	0000_0000h
2A8h	Debug Mode Enable (DBGEN)	32	RW	0000_0000h

62.8.2 LC n Output m LUT Control (LC0_LUTCTRL0 - LC2_LUTCTRL3)

Offset

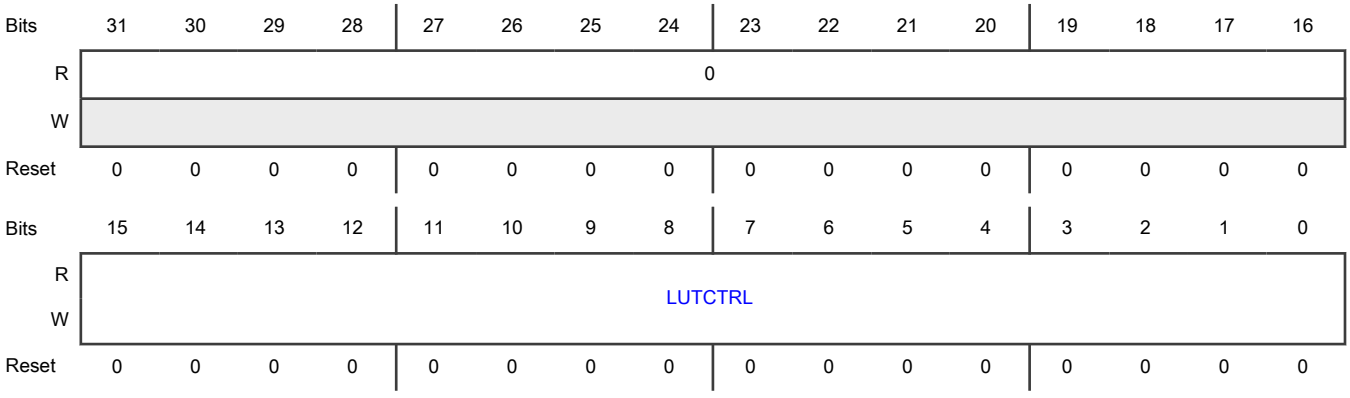
For n = 0 to 2; m = 0 to 3:

Register	Offset
LCn_LUTCTRLm	0h + (n × 40h) + (m × 4h)

Function

See LUTCTRL.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 LUTCTRL	LUT Control Specifies the LUT positions, based on the combined LC input value, that result in assertion of this output. For more information, see Logic operations.

62.8.3 LC n Output m Filter (LC0_FILT0 - LC2_FILT3)

Offset

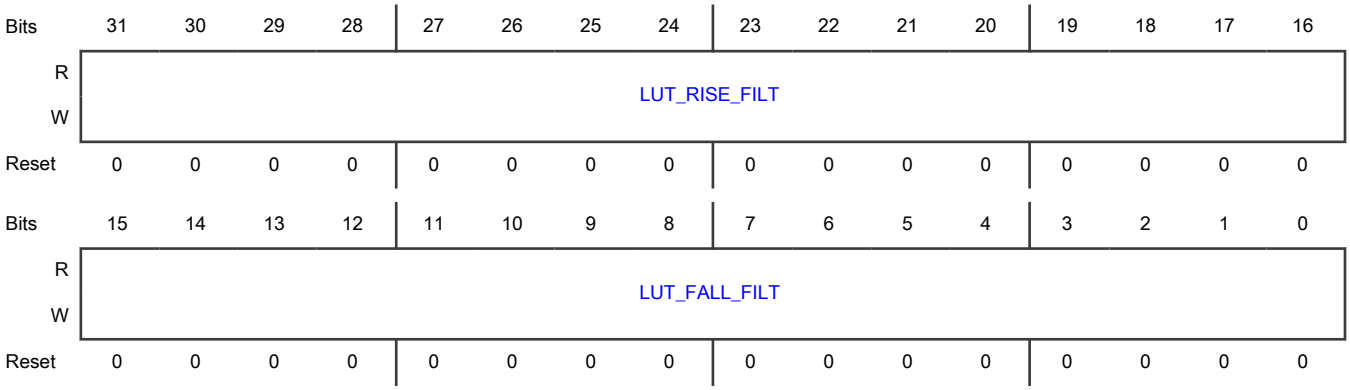
For n = 0 to 2; m = 0 to 3:

Register	Offset
LCn_FILTm	10h + (n × 40h) + (m × 4h)

Function

Specifies the rising- and falling-edge thresholds for the LC output filters.

Diagram



Fields

Field	Function
31-16 LUT_RISE_FILT	Rise Filter Specifies the number of consecutive clock cycles the filter output must be logic 1 before the output signal goes high. 0000_0000_0000_0000b - Bypass filter All other values - Filter threshold

Table continues on the next page...

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Field	Function
15-0 LUT_FALL_FILT	Fall Filter Specifies the number of consecutive clock cycles the filter output must be logic 0 before the output signal goes low. 0000_0000_0000_0000b - Bypass filter All other values - Filter threshold

62.8.4 LC n Interrupt and DMA Enable (LC0_INTDMAEN - LC2_INTDMAEN)

Offset

Register	Offset
LC0_INTDMAEN	20h
LC1_INTDMAEN	60h
LC2_INTDMAEN	A0h

Function
Enables interrupt and DMA requests for LUT and force events.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				FORCE_DMA_EN				0				FORCE_INT_EN			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				LUT_DMA_EN				0				LUT_INT_EN			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27-24	Force DMA Enable Enables the generation of a DMA request when a force event occurs (LC*n*_STS[FORCESTS]).

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>FORCE_DMA_EN</td><td>For each bit:
0b - Disable
1b - Enable
Mapping of bits:<table><tr><th>Output</th><th>Register bit</th></tr><tr><td>0</td><td>24</td></tr><tr><td>1</td><td>25</td></tr><tr><td>2</td><td>26</td></tr><tr><td>3</td><td>27</td></tr></table></td></tr>
<tr><td>23-20
—</td><td>Reserved</td></tr>
<tr><td>19-16
FORCE_INT_EN</td><td>Force Interrupt Enable
Enables the generation of an interrupt request when a force event occurs (LCn_STS[FORCESTS]).
For each bit:
0b - Disable
1b - Enable
Mapping of bits:<table><tr><th>Output</th><th>Register bit</th></tr><tr><td>0</td><td>16</td></tr><tr><td>1</td><td>17</td></tr><tr><td>2</td><td>18</td></tr><tr><td>3</td><td>19</td></tr></table></td></tr>
<tr><td>15-12
—</td><td>Reserved</td></tr>
<tr><td>11-8
LUT_DMA_EN</td><td>LUT DMA Enable
Enables the generation of a DMA request when an LUT event occurs (LCn_STS[LUT_STS]).
For each bit:
0b - Disable</td></tr>
</table>

Table continues on the next page...

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Field	Function
	1b - Enable Mapping of bits: **Output** / **Register bit** 0 / 8 1 / 9 2 / 10 3 / 11
7-4 —	Reserved
3-0 LUT_INT_EN	LUT Interrupt Enable Enables the generation of an interrupt request when an LUT event occurs (LC*n*_STS[LUT_STS]). For each bit: 0b - Disable 1b - Enable Mapping of bits: **Output** / **Register bit** 0 / 0 1 / 1 2 / 2 3 / 3

62.8.5 LC n Status (LC0_STS - LC2_STS)

Offset

Register	Offset
LC0_STS	24h
LC1_STS	64h
LC2_STS	A4h

Function

Indicates the occurrence of LUT and force events.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				FORCESTS				0				LUT_STS			
W					W1C								W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12 —	Reserved
11-8 FORCESTS	Force Event Indicates that a force event has occurred on the associated output. For each bit: 0b - No event 1b - Event occurred Mapping of bits:

Output	Register bit
0	8
1	9
2	10
3	11

When you enable DMA for a force output (LC*n*_INTDMAEN[FORCE_DMA_EN]) and a force event occurs on that output, LCU generates a DMA request. The resulting DMA done signal causes LCU to change the bit to 0, or you can write 1 to the bit.

You can also change these bits to 0 by writing to the corresponding Force Status bits (FORCESTS[FORCESTS]).

The timing of status clearing depends on the selected Force Mode (LC*n*_FCTRL[FORCE_MODEm]).

7-4 —	Reserved
3-0	LUT Event

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>LUT_STS</td><td>Indicates that an LUT event has occurred for the associated LC output.
For each bit:
0b - No event
1b - Event occurred
Mapping of bits:
<table>
<tr><th>Output</th><th>Register bit</th></tr>
<tr><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>2</td><td>2</td></tr>
<tr><td>3</td><td>3</td></tr>
</table>
When you enable DMA for an LUT event on an output (LCn_INTDMAEN[LUT_DMA_EN]) and an LUT event occurs on that output, LCU generates a DMA request. The resulting DMA done signal causes LCU to change the bit to 0.
When you enable interrupt request for an output (LCn_INTDMAEN[LUT_INT_EN]) and an LUT event occurs on that output, LCU generates an interrupt request. Write 1 to the bit to change it to 0.</td></tr>
</table>

62.8.6 LC n Output Polarity Control (LC0_OUTPOL - LC2_OUTPOL)

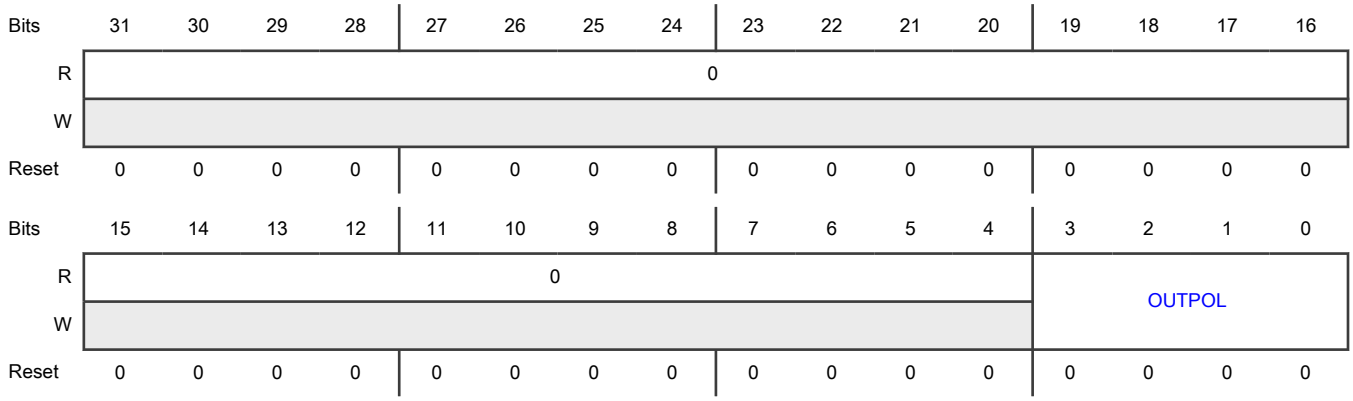
Offset

Register	Offset
LC0_OUTPOL	28h
LC1_OUTPOL	68h
LC2_OUTPOL	A8h

Function

Specifies the polarity of the LC outputs.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 OUTPOL	Output Polarity Specifies the polarity of the outputs. For each bit: 0b - Not inverted 1b - Inverted Mapping of bits:

Output	Bit
0	0
1	1
2	2
3	3

62.8.7 LC n Force Filter (LC0_FFILT - LC2_FFILT)

Offset

Register	Offset
LC0_FFILT	2Ch
LC1_FFILT	6Ch
LC2_FFILT	ACh

Function

Controls the force filter for this LC.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	COMB_FORCE				COMB_EN				0				FORCE_POL			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								FORCE_FILT							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 COMB_FORCE	Combined Sensed Force Input Indicates the combined value of force inputs to each output. For each bit: 0b - Logic low 1b - Logic high Mapping of bits:

Output	Bit
0	28
1	29
2	30
3	31

Field	Function
27-24 COMB_EN	Combinational Force Path (CFP) Enable Enables an active force input to combinationally affect the LC outputs. When CFP is not enabled, force inputs must be synchronized and then optionally filtered. When you enable CFP (write 1 to one of these bits), the corresponding force input bypasses synchronization and filtering and immediately affects the LC output. The Force Filter (FORCE_FILT) is still in effect. Force inputs that do not meet the pulse width requirements for synchronization and filtering are not registered in Force Status (FORCESTS) and you do not need to write 1 to change the bit to 0. CFP provides a safety factor when the LC outputs drive a motor and immediate response is required. In some topologies, an oscillation can result if the assertion of the force input causes the LC output to turn off. This situation in turn leads to deassertion of the force input and the output turning back on. In general, you

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>must disable CFP unless the LCU outputs drive a motor or similar safety-critical application, which requires an immediate response without synchronization delays.</td></tr>
<tr><td>23-20
—</td><td>Reserved</td></tr>
<tr><td>19-16
FORCE_POL</td><td>Force Input Polarity
Specifies the polarity of the force inputs to this LC.
For each bit:
0b - Not inverted
1b - Inverted
Mapping of bits:
<table><tr><th>Input</th><th>Bit</th></tr><tr><td>0</td><td>16</td></tr><tr><td>1</td><td>17</td></tr><tr><td>2</td><td>18</td></tr><tr><td>3</td><td>19</td></tr></table></td></tr>
<tr><td>15-8
—</td><td>Reserved</td></tr>
<tr><td>7-0
FORCE_FILT</td><td>Force Filter
Specifies the count, in clock cycles, that a force input must remain at a given logic state before the filtered force input switches state.
0000_0000b - Bypass filter
All other values - Filter threshold</td></tr>
</table>

62.8.8 LC n Force Control (LC0_FCTRL - LC2_FCTRL)

Offset

Register	Offset
LC0_FCTRL	30h
LC1_FCTRL	70h
LC2_FCTRL	B0h

Function

Provides control of the force inputs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SYNC_SEL3		FORCE_MODE 3		FORCE_SENSE3				SYNC_SEL2		FORCE_MODE 2		FORCE_SENSE2			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SYNC_SEL1		FORCE_MODE 1		FORCE_SENSE1				SYNC_SEL0		FORCE_MODE 0		FORCE_SENSE0			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 SYNC_SEL3	Sync Select Selects which sync input to use for output 3 of this LC. 00b - Sync input 0 01b - Sync input 1 10b - Reserved 11b - Reserved
29-28 FORCE_MODE 3	Force Clearing Mode Specifies the timing for clearing force events for output 3 in this LC. 00b - Deassertion. Cleared on deassertion of force inputs 01b - Rising sync after deassertion. Cleared on rising sync after deassertion of force inputs 10b - Writing 1 after deassertion. Cleared by writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits after deassertion of force inputs 11b - Rising sync after writing 1 and deassertion. Cleared on rising sync after writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits and deassertion of force inputs
27-24 FORCE_SENSE3	Force Input Sensitivity Selects which force inputs affect output 3 of this LC. For each bit: 0b - Does not affect 1b - Affects Mapping of bits:

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td><table>
<tr><th>Input</th><th>Bit</th></tr>
<tr><td>0</td><td>24</td></tr>
<tr><td>1</td><td>25</td></tr>
<tr><td>2</td><td>26</td></tr>
<tr><td>3</td><td>27</td></tr>
</table>
Example: 011b selects force inputs 0 and 1, but not 2.</td></tr>
<tr><td>23-22
SYNC_SEL2</td><td>Sync Select
Selects which sync input to use for output 2 of this LC.
00b - Sync input 0
01b - Sync input 1
10b - Reserved
11b - Reserved</td></tr>
<tr><td>21-20
FORCE_MODE2</td><td>Force Clearing Mode
Specifies the timing for clearing force events for output 2 in this LC.
00b - Deassertion. Cleared on deassertion of force inputs
01b - Rising sync after deassertion. Cleared on rising sync after deassertion of force inputs
10b - Writing 1 after deassertion. Cleared by writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits after deassertion of force inputs
11b - Rising sync after writing 1 and deassertion. Cleared on rising sync after writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits and deassertion of force inputs</td></tr>
<tr><td>19-16
FORCE_SENSE2</td><td>Force Input Sensitivity
Selects which force inputs affect output 2 of this LC.
For each bit:
0b - Does not affect
1b - Affects
Mapping of bits:<table>
<tr><th>Input</th><th>Bit</th></tr>
<tr><td>0</td><td>16</td></tr>
<tr><td>1</td><td>17</td></tr>
<tr><td>2</td><td>18</td></tr>
</table></td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td><table>
<tr><th>Input</th><th>Bit</th></tr>
<tr><td>3</td><td>19</td></tr>
</table>
Example: 011b selects force inputs 0 and 1, but not 2.</td></tr>
<tr><td>15-14
SYNC_SEL1</td><td>Sync Select
Selects which sync input to use for output 1 of this LC.
00b - Sync input 0
01b - Sync input 1
10b - Reserved
11b - Reserved</td></tr>
<tr><td>13-12
FORCE_MODE1</td><td>Force Clearing Mode
Specifies the timing for clearing force events for output 1 in this LC.
00b - Deassertion. Cleared on deassertion of force inputs
01b - Rising sync after deassertion. Cleared on rising sync after deassertion of force inputs
10b - Writing 1 after deassertion. Cleared by writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits after deassertion of force inputs
11b - Rising sync after writing 1 and deassertion. Cleared on rising sync after writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits and deassertion of force inputs</td></tr>
<tr><td>11-8
FORCE_SENSE1</td><td>Force Input Sensitivity
Selects which force inputs affect output 1 of this LC.
For each bit:
0b - Does not affect
1b - Affects
Mapping of bits:<table>
<tr><th>Input</th><th>Bit</th></tr>
<tr><td>0</td><td>8</td></tr>
<tr><td>1</td><td>9</td></tr>
<tr><td>2</td><td>10</td></tr>
<tr><td>3</td><td>11</td></tr>
</table>
Example: 011b selects force inputs 0 and 1, but not 2.</td></tr>
<tr><td>7-6</td><td>Sync Select</td></tr>
</table>

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Field	Function
SYNC_SEL0	Selects which sync input to use for output 0 of this LC. 00b - Sync input 0 01b - Sync input 1 10b - Reserved 11b - Reserved
5-4 FORCE_MODE0	Force Clearing Mode Specifies the timing for clearing force events for output 0 in this LC. 00b - Deassertion. Cleared on deassertion of force inputs 01b - Rising sync after deassertion. Cleared on rising sync after deassertion of force inputs 10b - Writing 1 after deassertion. Cleared by writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits after deassertion of force inputs 11b - Rising sync after writing 1 and deassertion. Cleared on rising sync after writing 1 to the correct LCn_STS[FORCESTS] or FORCESTS[FORCESTS] bits and deassertion of force inputs
3-0 FORCE_SENSE0	Force Input Sensitivity Selects which force inputs affect output 0 of this LC. For each bit: 0b - Does not affect 1b - Affects Mapping of bits: Example: 011b selects force inputs 0 and 1, but not 2.

Input	Bit
0	0
1	1
2	2
3	3

62.8.9 LC n Sync Control (LC0_SCTRL - LC2_SCTRL)

Offset

Register	Offset
LC0_SCTRL	34h

Table continues on the next page...

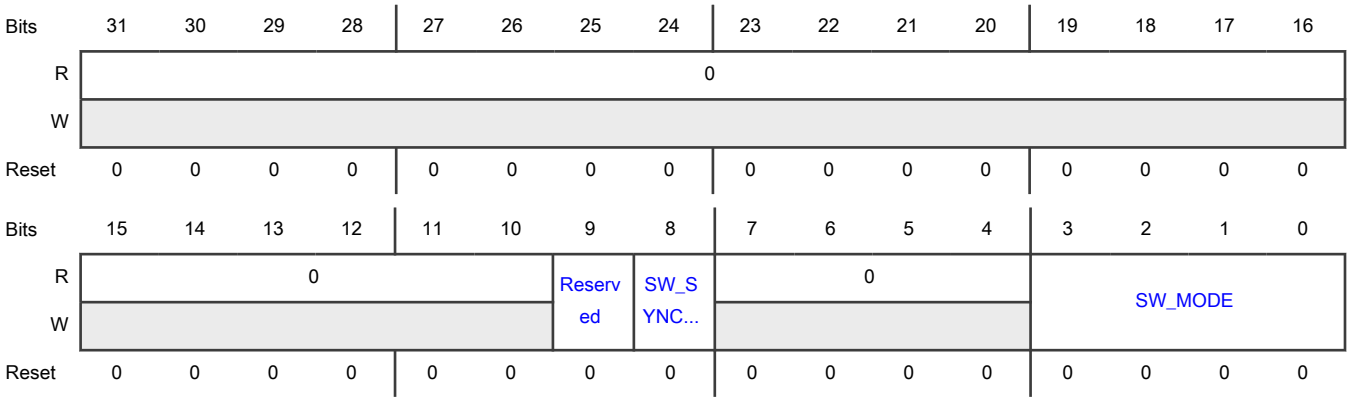
Table continued from the previous page...

Register	Offset
LC1_SCTRL	74h
LC2_SCTRL	B4h

Function

Controls the software sync behavior.

Diagram



Fields

Field	Function
31-10 —	Reserved
9 —	Reserved
8 SW_SYNC_SEL	Software Sync Select Selects which sync input to use for software synced mode. 0b - Sync input 0 1b - Sync input 1
7-4 —	Reserved
3-0 SW_MODE	Software Sync Mode Specifies the software sync mode for the inputs to this LC. When Software Override is enabled (SWEN), these bits control whether Software Override Value (SWVALUE) changes occur immediately or on the rising edge of the selected sync pulse. For each bit:

Table continued from the previous page...

Field	Function
	0b - Immediate 1b - On rising edge of sync Mapping of bits:

Input	Bit
0	0
1	1
2	2
3	3

62.8.10 Mux Select (MUXSEL0 - MUXSEL11)

Offset

For a = 0 to 11:

Register	Offset
MUXSELa	200h + (a × 4h)

Function

Selects the sources for inputs to the LCs.

NOTE

Access to Address space 200h + (48 to (124)) does not generate a transfer error.

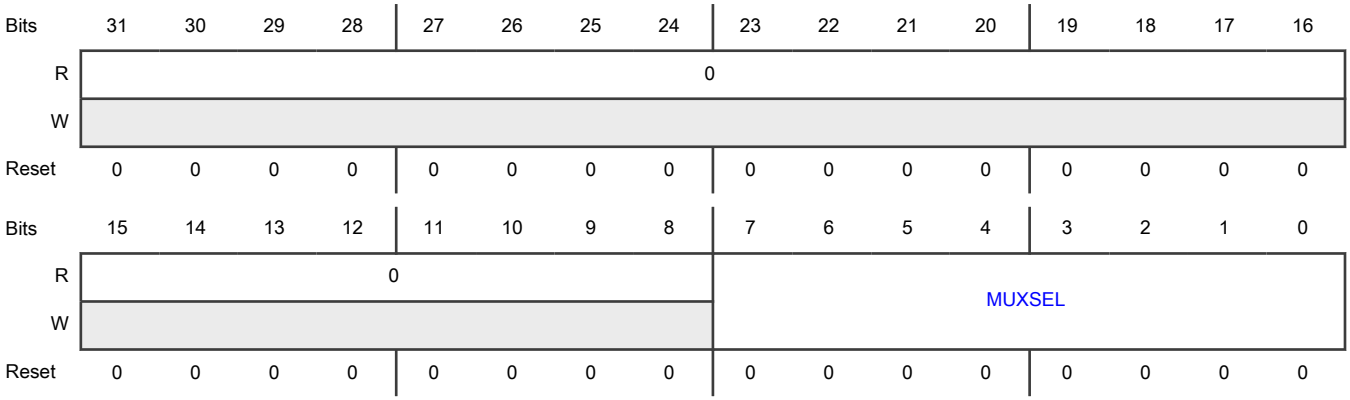
Register	LC	Input
MUXSEL0	0	0
MUXSEL1		1
MUXSEL2		2
MUXSEL3		3
MUXSEL4	1	0
MUXSEL5		1
MUXSEL6		2
MUXSEL7		3
MUXSEL8	2	0

Table continues on the next page...

Table continued from the previous page...

Register	LC	Input
MUXSEL9		1
MUXSEL10		2
MUXSEL11		3

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 MUXSEL	Mux Select Selects the source of the LC input. All LU_IN inputs go through a two-stage synchronizer, but the LU_OUT signals fed back to this mux do not have this two-stage delay because they are already synchronous to LCU clock. 0000_0000b - Logic 0 0000_0001b-0000_1100b - LU_IN0 to LU_IN11 0000_1101b-0001_1000b - LU_OUT0 to LU_OUT11 All other values are reserved.

62.8.11 Configuration (CFG)

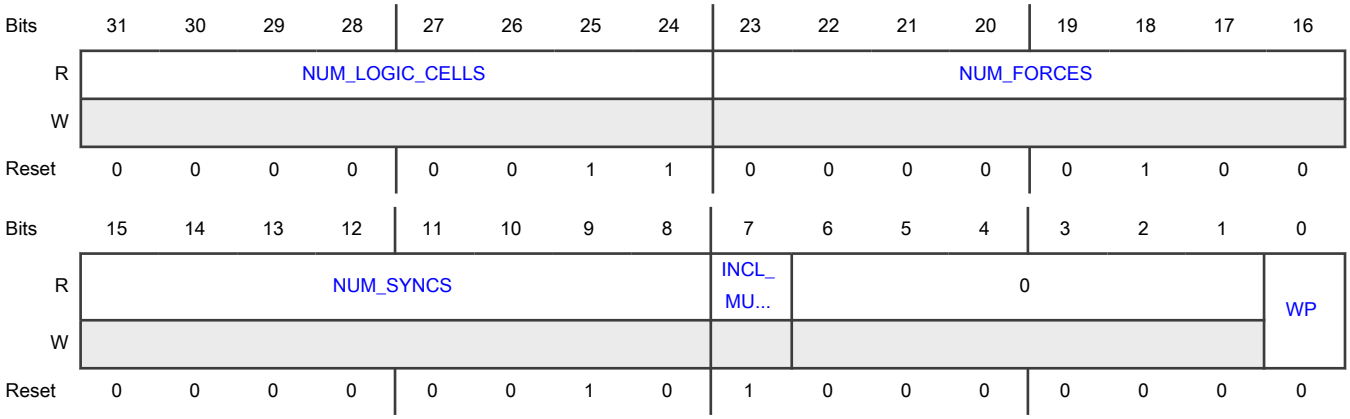
Offset

Register	Offset
CFG	280h

Function

Indicates the LCU configuration, and provides write protection.

Diagram



Fields

Field	Function
31-24 NUM_LOGIC_CELLS	LCs Indicates the number of LCs.
23-16 NUM_FORCES	Force Inputs Indicates the number of force inputs for each LC.
15-8 NUM_SYNCS	Sync Inputs Indicates the number of sync inputs for each LC.
7 INCL_MUXES	Input Muxing Indicates whether LCU supports input muxing. 0b - Not supported 1b - Supported
6-1 —	Reserved
0 WP	Write Protect Turns on write protection for all LCU registers except SWVALUE, LC*n*_STS, and FORCESTS. 0b - No effect 1b - Turn on write protection

62.8.12 Software Override Enable (SWEN)

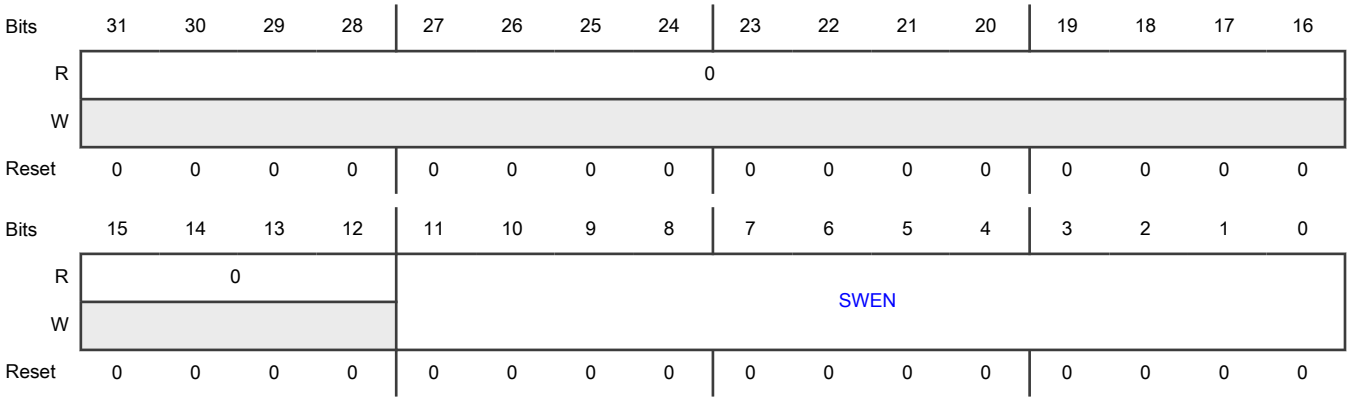
Offset

Register	Offset
SWEN	284h

Function

Enables overrides for LC inputs.

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 SWEN	Software Override Enable Enables software override of LC inputs. For each bit: 0b - Disable 1b - Enable Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.13 Software Override Value (SWVALUE)

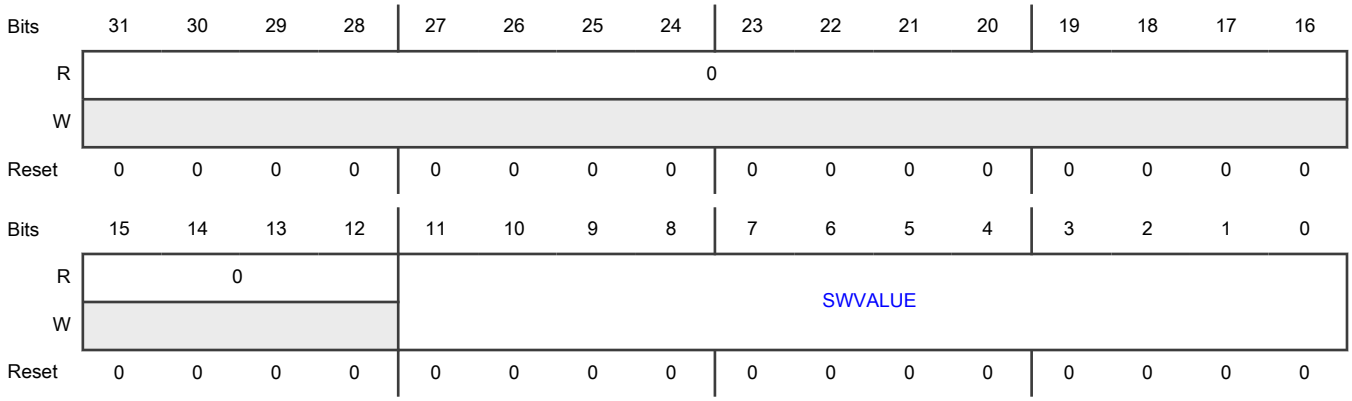
Offset

Register	Offset
SWVALUE	288h

Function

Specifies the software override value for each LC input.

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 SWVALUE	Software Override Value Specifies the software override value for each LC input. For each bit: 0b - 0 1b - 1 Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.14 Output Enable (OUTEN)

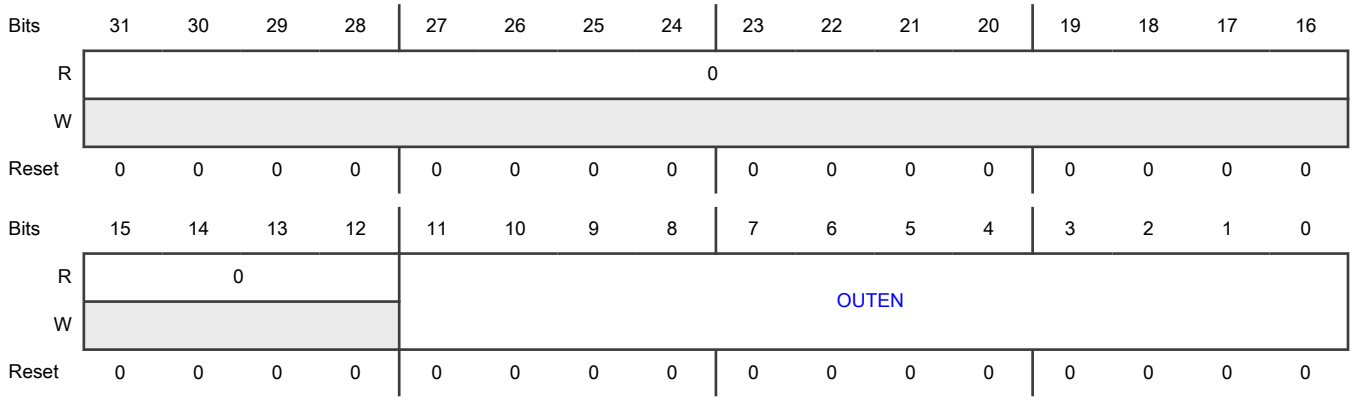
Offset

Register	Offset
OUTEN	28Ch

Function

Enables LC outputs.

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 OUTEN	Output Enables Enables LC outputs. For each bit: 0b - Disable 1b - Enable Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.15 Logic Inputs (LCIN)

Offset

Register	Offset
LCIN	290h

Function

Indicates states of LC inputs.

If you write to this register, LCU generates a bus transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				LC_INPUTS											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12 —	Reserved
11-0 LC_INPUTS	Logic Inputs Indicates states of LC inputs. For each bit: 0b - 0 1b - 1 Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.16 Overridden Inputs (SWOUT)

Offset

Register	Offset
SWOUT	294h

Function

Indicates states of LC inputs or states of software-overridden inputs, depending upon the state of the corresponding SWEN bit.

If you write to this register, LCU generates a bus transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				SWOUT											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12 —	Reserved
11-0 SWOUT	Overridden Inputs Indicates states of LC inputs or software-overridden inputs. For each bit, when the corresponding SWEN bit is 0: 0b - LC input is 0 1b - LC input is 1 For each bit, when the corresponding SWEN bit is 1: 0b - Software-overridden input is 0 1b - Software-overridden input is 1 Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.17 Logic Outputs (LCOUT)

Offset

Register	Offset
LCOUT	298h

Function

Indicates states of LC outputs.

If you write to this register, LCU generates a bus transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				LCOUT											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12 —	Reserved
11-0 LCOUT	Logic Outputs Indicates states of LC outputs. For each bit: 0b - 0 1b - 1 Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.18 Forced Outputs (FORCEOUT)

Offset

Register	Offset
FORCEOUT	29Ch

Function

Indicates the current state of the force outputs for all LCU logic outputs. Writing to this register generates a bus transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				FORCEOUT											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12 —	Reserved
11-0 FORCEOUT	Forced Outputs Indicates the current state of force outputs for the logic outputs. For each bit: 0b - Not asserted 1b - Asserted Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.19 Force Status (FORCESTS)

Offset

Register	Offset
FORCESTS	2A0h

Function

See FORCESTS.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				FORCESTS											
W					W1C											
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12 —	Reserved
11-0 FORCESTS	Force Status Indicates the current force states of all LCs, mirrored from LC*n*_STS[FORCESTS]. Change these bits to 0 by writing 1 to them or to the corresponding bit in the specific LC*n*_STS register. This field allows you to simultaneously change FORCESTS bits to 0 across multiple LCs. For each bit: 0b - Not in force state 1b - Read: In force state — Write: Clear force state bit Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.8.20 Debug Mode Enable (DBGEN)

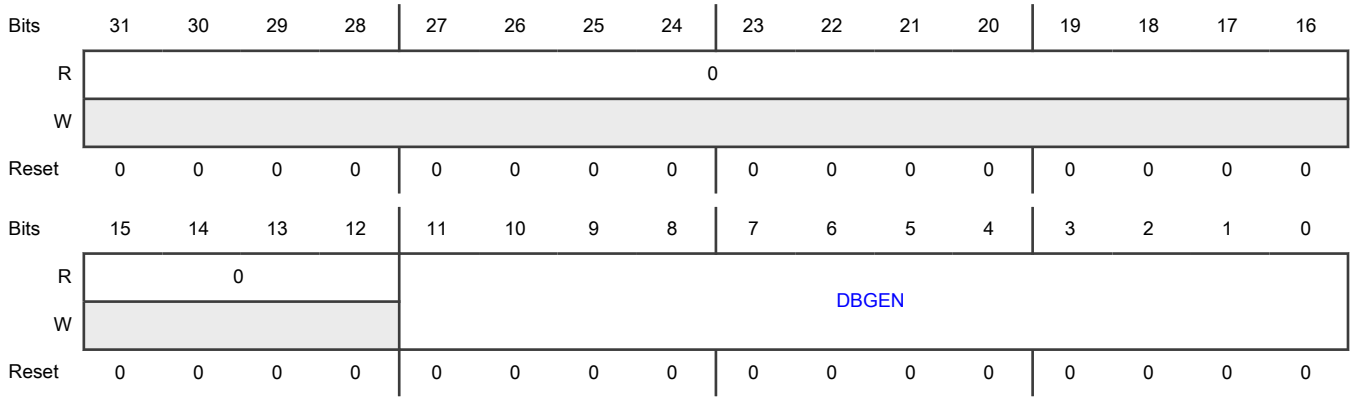
Offset

Register	Offset
DBGEN	2A8h

Function

Enables outputs to continue operation when the chip is in Debug mode.

Diagram



Fields

Field	Function
31-12 —	Reserved
11-0 DBGEN	Debug Mode Enable Enables outputs to continue operation in Debug mode. For each bit: 0b - Debug mode inactive 1b - Debug mode active Mapping of bits: See Mapping of 12-bit input, output, and state fields.

62.9 Glossary

CCW	Counterclockwise
CW	Clockwise
LC	Logic cell
LUT	Lookup table

Chapter 63
Enhanced Modular IO Subsystem (eMIOS)

63.1 Chip-specific eMIOS information

63.1.1 eMIOS configuration

This chip has only 1 instances of eMIOS as shown in the table below:

Table 333. eMIOS instances

Instance	eMIOS_0

Table 334. eMIOS configuration

Parameter	eMIOS_0
Timer width	24 bits
Number of channels[1]	24
Channels configuration	See EMIOS channel configuration figure below
Local Channel prescaler width	4
Number of global counter buses	2
Number of global prescaler	1
Global channel prescaler width	8

1. Channels 0-7 are not available in S32K36x.

NOTE

eMIOS is clocked by CORE_CLK.

EMIOS shall have an option for each channel to support the reload of updated PWM values after 2, 3 or 4 PWM periods.

63.1.2 Channel types

eMIOS contains the following TypeZ channels, which is listed below.

Table 335. eMIOS channel types

Mode Description	Name	Ch TypeZ
General Purpose Input / Output	GPIO	X
Single Action Input Capture	SAIC	X
Single Action Output Compare	SAOC	X
Modulus Counter	MC	X
Modulus Counter Buffered (Up / Down)	MCB	X
Input Pulse Width Measurement	IPWM	X
Input Period Measurement	IPM	X
Double Action Output Compare	DAOC	X

Table continues on the next page...

Table 335. eMIOS channel types (continued)

Mode Description	Name	Ch TypeZ
Output Pulse Width and Frequency Modulation Buffered	OPWFMB	X
Center aligned Output PWM Buffered with dead time	OPWMCB	X
Output Pulse Width Modulation Buffered	OPWMB	X
Output Pulse Width Modulation Trigger	OPWMT	X
Pulse Edge Counting	PEC	X

NOTE

ChType Z has internal counters.

Table 336. eMIOS channel configuration

Channel number	eMIOS0
CH0	Z
CH8	Z
CH16	Z
CH22	Z
CH23	Z
CH1	Z
CH2	Z
CH3	Z
CH4	Z
CH5	Z
CH6	Z
CH7	Z
CH9	Z
CH10	Z
CH11	Z
CH12	Z
CH13	Z
CH14	Z
CH15	Z
CH17	Z
CH18	Z
CH19	Z

Table continues on the next page...

Table 336. eMIOS channel configuration (continued)

CH20	Z
CH21	Z

63.1.3 Channel configuration

The eMIOS channel configuration with respect to Type and Counter_bus is shown below.

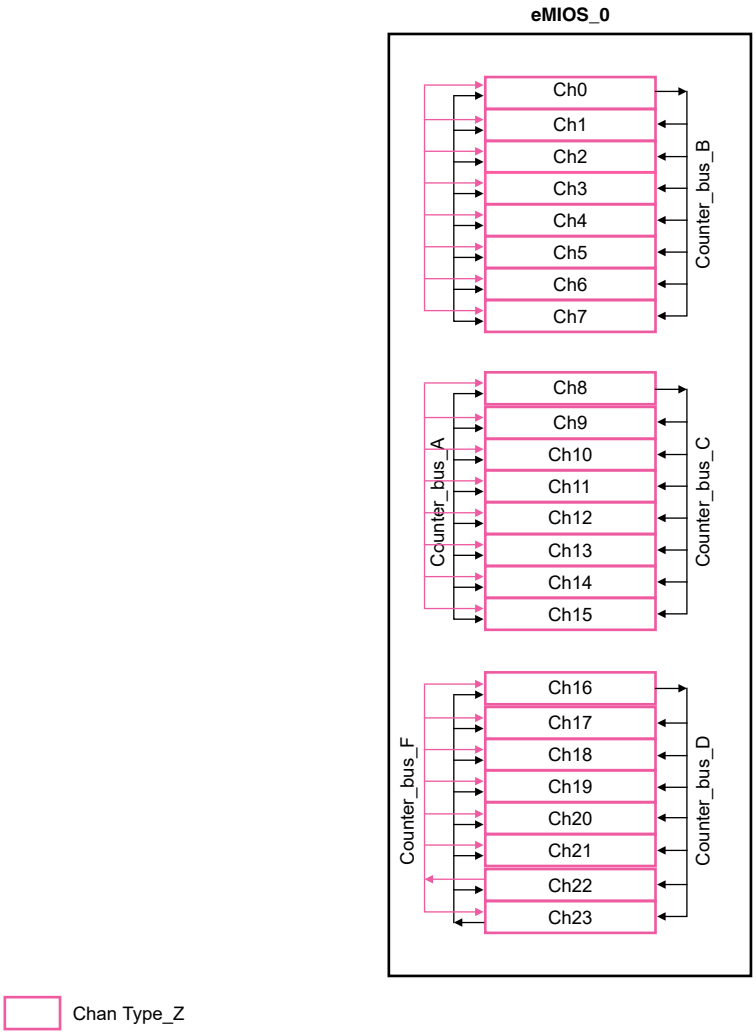


Figure 358. EMIOS channel types

63.1.4 eMIOS disabling

eMIOS can disable it's output using it's disable inputs. Disable inputs[3:0] are driven from the flag out bits[11:8].

Disable inputs	
eMIOS0 Output disable input[3:0]	trgmux_output[71:68]

For details, see the TRGMUX connectivity file attached to this document.

63.1.5 BCTU Interface

Each eMIOS channel, with the exception of the main counterbus channel (ch[23]) is capable of triggering the BCTU. See BCTU chapter for mapping. BCTU allows triggering from as many eMIOS modes as possible.

63.2 Introduction

eMIOS provides independent channels, UCs, that you configure to generate or measure time events for different functions in different chip applications.

eMIOS distributes these channels across a number of global and local counter buses. Each local bus is dedicated to a group of eight contiguous channels. Each channel can generate its own timebase, and each counter bus has its timebase provided by a dedicated channel. For a list of counter buses with their assigned channels and timebase sources, see Counter buses, channels, and timebase sources.

63.3 Block diagram

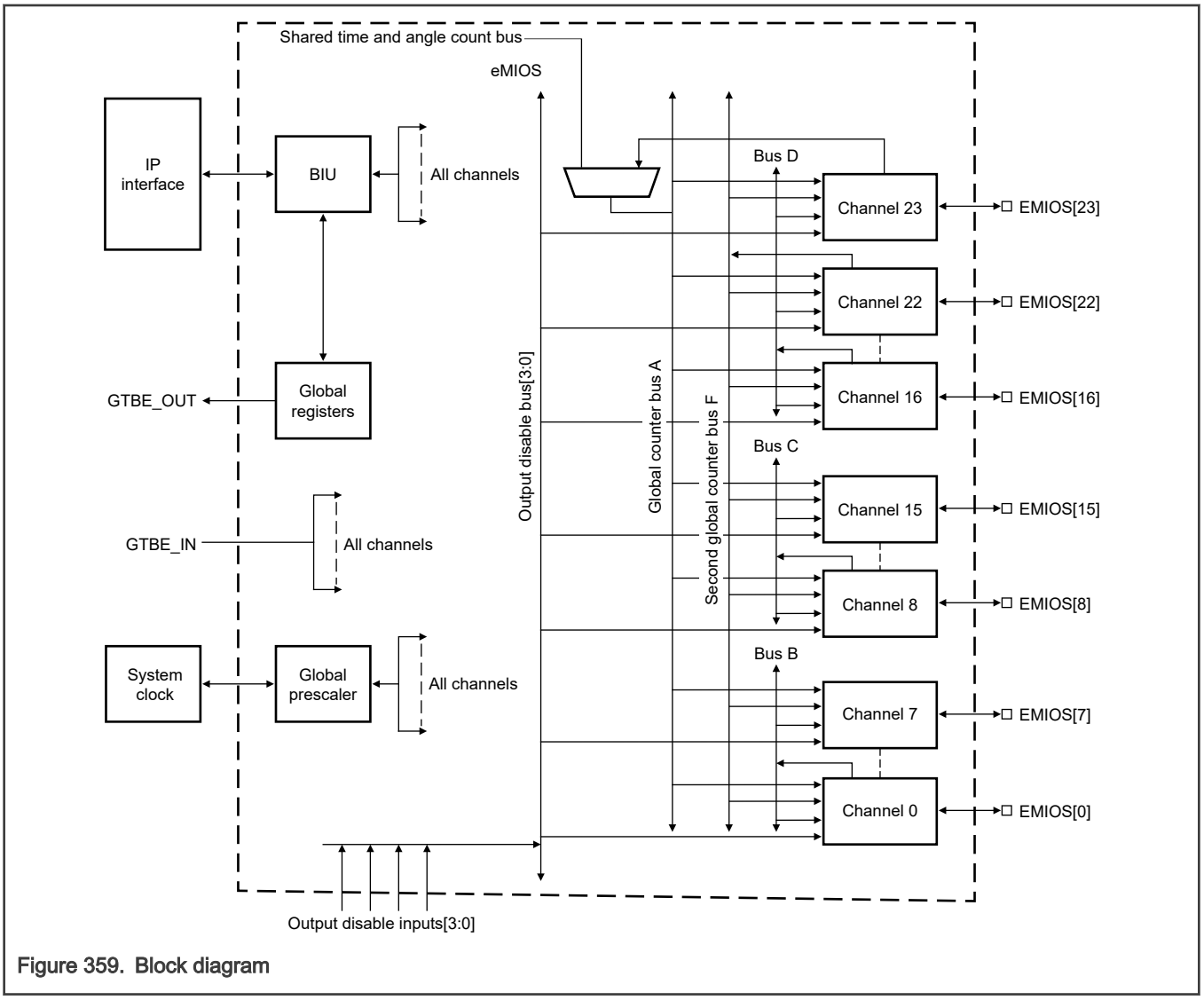


Figure 359. Block diagram

63.4 Features

- 24 UCs distributed across local counter buses as shown in Counter buses, channels, and timebase sources

- Global counter bus A driven by UC23 or by the external shared timer bus (STAC client)
- Global counter bus F driven by UC22
- Synchronized timebases shared through the counter buses
- Dedicated timebase for each channel, distinct from the counter buses
- Global clock prescaler (GCP)
- One CP per channel
- STAC client
- Dedicated set of control and status registers for each UC
- 24-bit–wide data registers
- Shadow flag register (GFLAG) to access all channel flags with one read access
- Ability to freeze the UC state for debug purposes
- Motor control capability

63.5 Functional description

63.5.1 Reset

eMIOS resets asynchronously. Reset affects all registers.

On reset, UCs enter GPIO input mode.

63.5.2 Counter buses, channels, and timebase sources

Table 337. Counter buses, channels, and timebase sources

Counter bus	Channels	Timebase channel
Global bus A	All UCs	23 or the external shared timer bus (STAC client)
Local bus B	• UC0 • UC1 • UC2 • UC3 • UC4 • UC5 • UC6 • UC7	0
Local bus C	• UC8 • UC9 • UC10 • UC11 • UC12	8

Table continues on the next page...

Table 337. Counter buses, channels, and timebase sources (continued)

Counter bus	Channels	Timebase channel
	• UC13 • UC14 • UC15	
Local bus D	• UC16 • UC17 • UC18 • UC19 • UC10 • UC21 • UC22 • UC23	16
Global bus F	All UCs	22

63.5.3 Unified channels (UC)

63.5.3.1 Overview

Each UC contains the following:

- Two double-buffered data registers, A*n* and B*n*, that allow up to two events—input capture, output compare, or both—to occur before software intervention is needed
- Two comparators, A and B, that indicate when the selected counter bus is equal to the value in A*n* and B*n*
- An internal counter (CNT*n*[C]) that runs in all modes except GPIO.

  You can use this counter as a local timebase or to count input events. You can use it as a timebase if CNT*n*[C] is not used in the current mode.
- An output flip-flop that holds the logic level to be applied to the output pin
- A status register, UC Status n (S0 - S23), that flags input capture and match events, indicates flag overruns and overflows, and shows the input and output pin states
- A control register, UC Control n (C0 - C23), that controls UC operation

You control the following operational characteristics for each UC:

- The logic (C*n*[MODE]) that specifies the behavior of the UC (see UC modes)
- The counter bus (C*n*[BSL]) that provides the timebase for all timing functions
- The CP (C*n*[UCPRE] and C2_*n*[UCEXTPRE])
- The minimum input pulse width (C*n*[IF]) for the input filter that determines valid pin transitions
- Which input edges to detect (C*n*[EDSEL])
- Which of four output disable input signals (C*n*[ODISSL]) to use for disabling outputs
- For all output modes except GPIO, whether to disable the output flip-flop (C*n*[ODIS])

UC block diagram illustrates the basic UC architecture.

For a list of counter buses and their assigned channels and timebase sources, see Counter buses, channels, and timebase sources.

63.5.3.2 UC block diagram

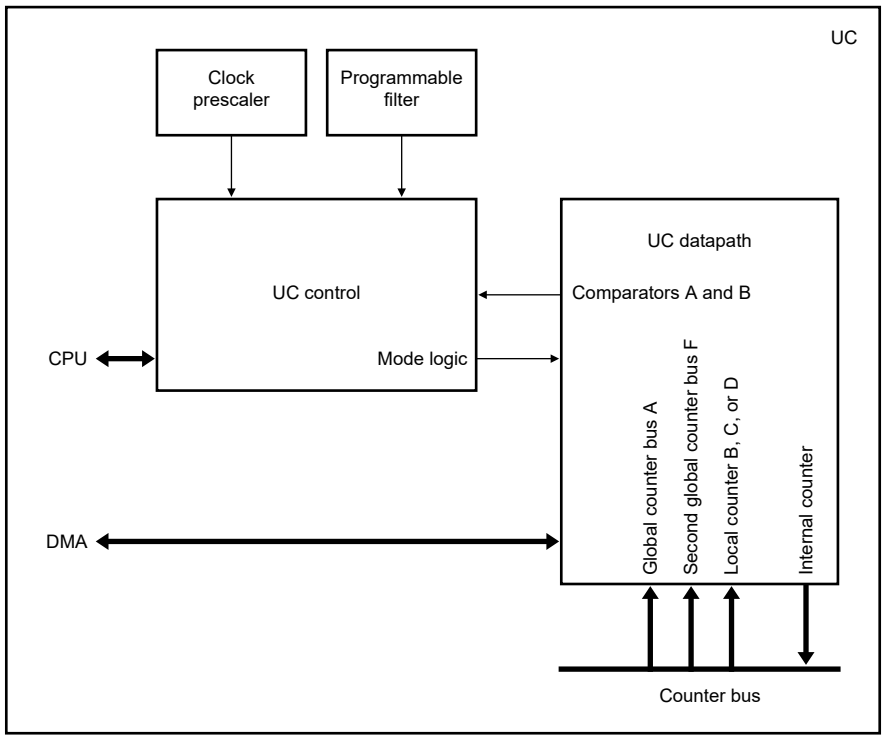


Figure 360. UC block diagram

63.5.3.3 Buffered modes

To provide smooth waveform generation even when A*n*[A] and B*n*[B] are changing, the following modes double buffer the A*n* and B*n* registers:

- Modulus Counter Buffered (MCB) mode
- Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode
- Output PWM Buffered (OPWMB) mode

These modes appear in separate sections because there are several basic differences in UC operation between them and their corresponding nonbuffered modes.

63.5.3.4 UC control and datapath

As illustrated in UC control and datapath diagram, the UC contains control and datapath sub-blocks.

The control sub-block generates signals to control the multiplexers in the datapath sub-block. eMIOS implements each UC mode in dedicated logic independent from the other modes. The UC modes share a set of registers allowing the storing of sequential events.

The datapath block contains the channel A and B registers, the internal timebase, and the comparators. Multiplexers receive inputs from the control sub-block to configure the datapath for the specific channel modes. This configuration consists of selecting the input of comparators and data for the register inputs. The outputs of the A and B comparators connect to the control block.

63.5.3.5 UC control and datapath diagram

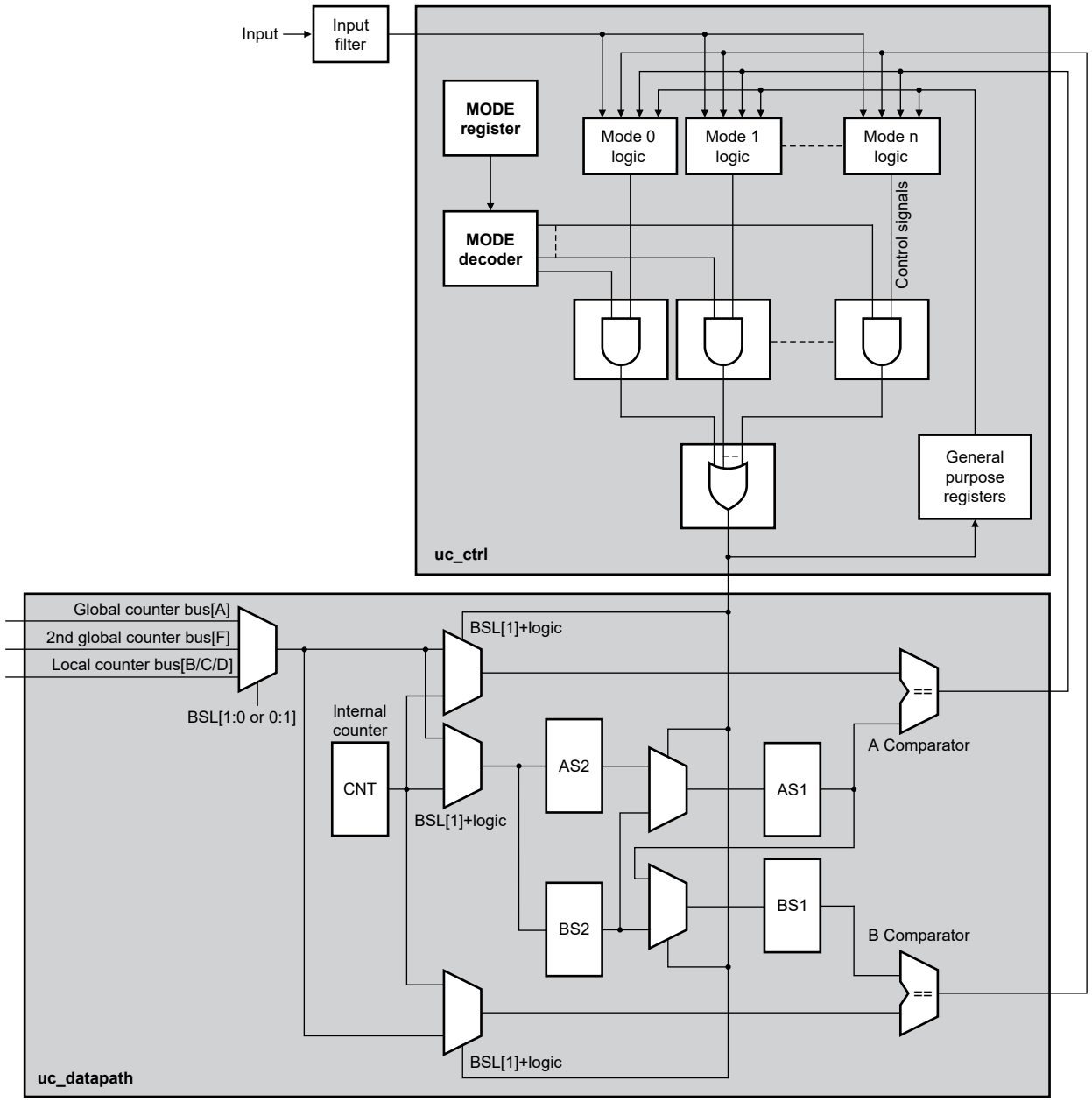


Figure 361. UC control and datapath diagram

63.5.3.6 UC modes

You can configure UCs to operate in the following modes:

- General-Purpose Input and Output (GPIO) mode
- Single Action Input Capture (SAIC) mode
- Single Action Output Capture (SAOC) mode
- Input Pulse Width Measurement (IPWM) mode
- Input Period Measurement (IPM) Mode

- Double Action Output Compare (DAOC) mode
- Pulse or Edge Accumulation (PEA) mode
- Pulse Edge Counting (PEC) mode
- Quadrature Decode (QDEC) mode
- Windowed Programmable Time Accumulation (WPTA) mode
- Modulus Counter (MC) mode
- Modulus Counter Buffered (MCB) mode
- Output Pulse Width and Frequency Modulation (OPWFM) mode
- Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode
- Center Aligned Output PWM with Dead Time Insertion (OPWMC) mode
- Center Aligned Output PWM with Dead Time Insertion Buffered (OPWMCB) mode
- Output PWM (OPWM) mode
- Output PWM Buffered (OPWMB) mode
- Output PWM with Trigger (OPWMT) mode

Each channel supports a specific subset of these modes. See the chip-configuration information to see which modes each channel supports.

63.5.3.7 General-Purpose Input and Output (GPIO) mode

63.5.3.7.1 Overview

This mode disables all UC input-capture and output-compare functions, and resets and disables the internal counter (C*n*[C]). All control fields remain accessible.

To change the UC from one operation mode to another, you must first change to GPIO mode and then change to the desired final mode. To prepare the UC for a new operation mode, you must configure AS1, BS1, AS2, and BS2 before exiting GPIO mode and entering the desired final mode (see AS1, AS2, BS1, and BS2 shadow registers). Specifically:

- Writing to A*n*[A] stores the same value in AS1 and AS2.
- Writing to B*n*[B] stores the same value in BS1 and BS2.
- Writing to ALTA*n*[ALTA] stores a value only in AS2.

As its name implies, GPIO mode supports both input and output submodes. See Differences for input and output submodes.

63.5.3.7.2 Differences for input and output submodes

Table 338. Differences for input and output submodes

Submode	To enter submode, write this value to C*n*[MODE]	Characteristics
Input	0	• You control the generation of input-capture flags with C*n*[EDPOL] and C*n*[EDSEL]. • You can determine the input pin status by reading S*n*[UCIN].
Output	1	• The UC performs as a single output port pin. • The value of C*n*[EDPOL] permanently drives the output flip-flop.

63.5.3.8 Single Action Input Capture (SAIC) mode

63.5.3.8.1 Overview

In this mode, when a triggering event occurs on the input pin, eMIOS:

- Captures the selected timebase into AS2
- Changes S*n*[FLAG] to 1 to indicate that an input capture has occurred

A*n*[A] returns the value of AS2. As soon as the UC enters SAIC mode after exiting GPIO mode, the channel is ready to capture events.

eMIOS captures the events as soon as they occur. Therefore, reading A*n*[A] always returns the value of the latest captured event. Subsequent capture events occur regardless of whether you read the previous event from A*n*[A]. Each new capture event sets the input capture flag (writes 1 to S*n*[FLAG]).

The input capture is triggered by an edge transition on the input pin as configured by C*n*[EDPOL] and C*n*[EDSEL].

SAIC with rising edge triggering and SAIC with both edges triggering show how to use the UC for input capture.

63.5.3.8.2 SAIC submodes and MODE field values

Table 339. SAIC submodes and MODE field values

Capture behavior	C*n*[MODE] (binary)
The UC only captures the timestamp.	000_0010
• The UC captures a timestamp. • AS2 bit 31 indicates the input signal level.	100_0010

63.5.3.8.3 Effect of C*n*[EDPOL] on edge capturing

Table 340. Effect of C*n*[EDPOL] on edge capturing

C*n*[EDPOL]	Input signal transition	Resulting value of AS2 bit 31
0	0→1	0
	1→0	1
1	0→1	1
	1→0	0

63.5.3.8.4 SAIC with rising edge triggering

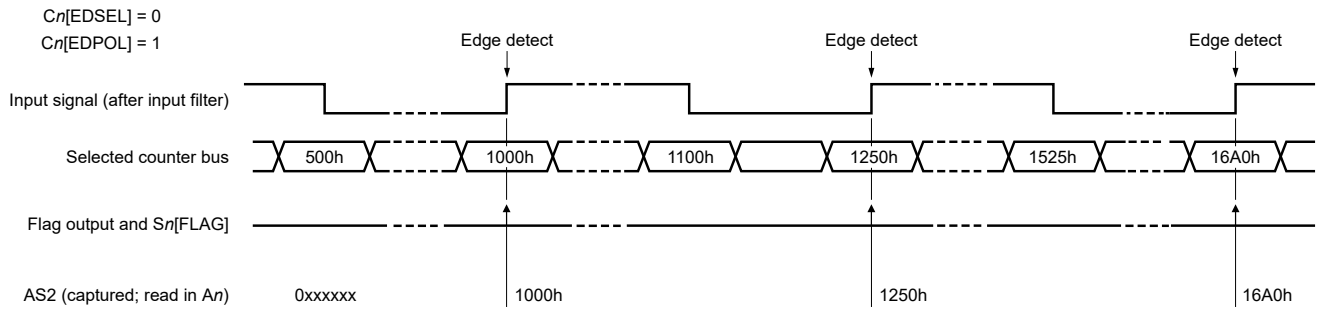


Figure 362. SAIC with rising edge triggering

63.5.3.8.5 SAIC with both edges triggering

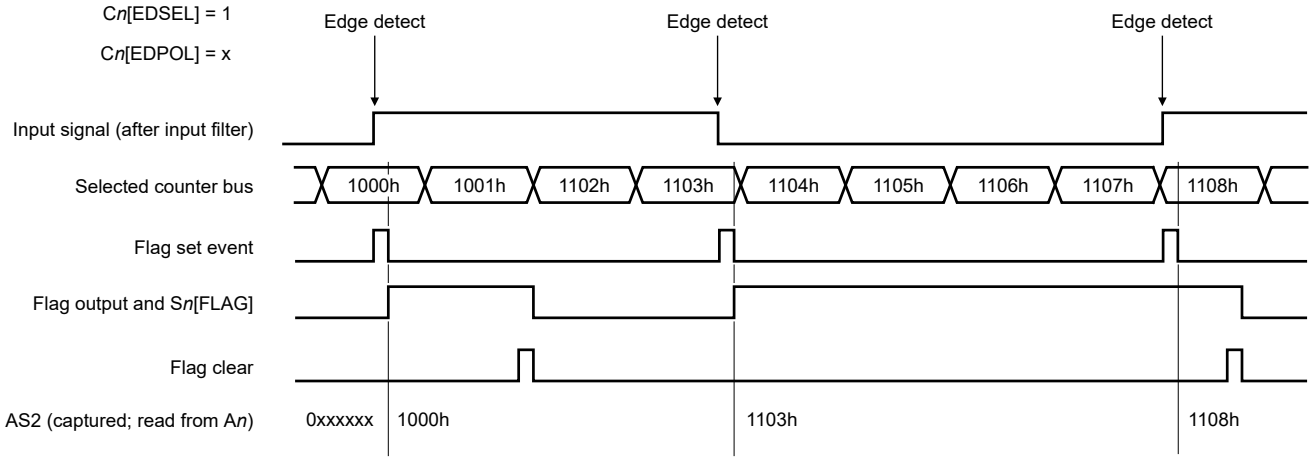


Figure 363. SAIC with both edges triggering

63.5.3.9 Single Action Output Capture (SAOC) mode

63.5.3.9.1 Overview

In this mode, eMIOS loads a match value into AS2 and then immediately transfers it to AS1 for comparison with the selected timebase. When an output-compare match occurs, eMIOS:

- Either toggles the output flip-flop or transfers C*n*[EDPOL] to the output flip-flop, as determined by C*n*[EDSEL].
- Sets the input capture flag (changes S*n*[FLAG] to 1).

Along with the match, S*n*[FLAG] becomes 1 to indicate that the output-compare match has occurred. Writing to A*n*[A] stores the value in AS2, and reading A*n*[A] returns the AS1 value.

The channel internal counter in SAOC mode is free-running. It starts counting as soon as the UC enters SAOC mode.

You can force an output-compare match by writing 1 to C*n*[FORCMA]. A forced output-compare match does not set the input capture flag (S*n*[FLAG]).

When the UC enters SAOC mode after exiting GPIO mode, the output flip-flop value becomes the complement of C*n*[EDPOL].

You select the internal or external counter bus with C*n*[BSL].

SAOC with C*n*[EDPOL] transferred to the output flip-flop shows how to perform a single output compare and transfer C*n*[EDPOL] to the output flip-flop.

SAOC toggling the output flip-flop shows how to perform a single output compare and toggle the output flip-flop at each match.

63.5.3.9.2 Preload the desired match value

eMIOS enables matches immediately after the UC enters SAOC mode. Therefore, you must write the desired match value to AS1 before the UC enters SAOC mode. You can update AS1 at any time. This modifies the match value reflected in the channel-generated output signal. Subsequent capture events occur regardless of whether you write to A*n*[A] again. Each new capture event sets the input capture flag (S*n*[FLAG]). See SAOC with flag behavior.

63.5.3.9.3 SAOC with C*n*[EDPOL] transferred to the output flip-flop

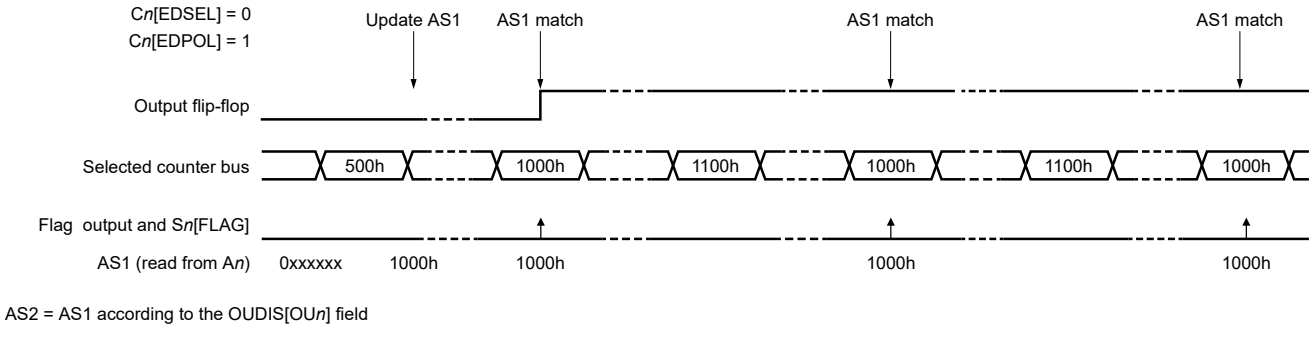


Figure 364. SAOC with C*n*[EDPOL] transferred to the output flip-flop

63.5.3.9.4 SAOC toggling the output flip-flop

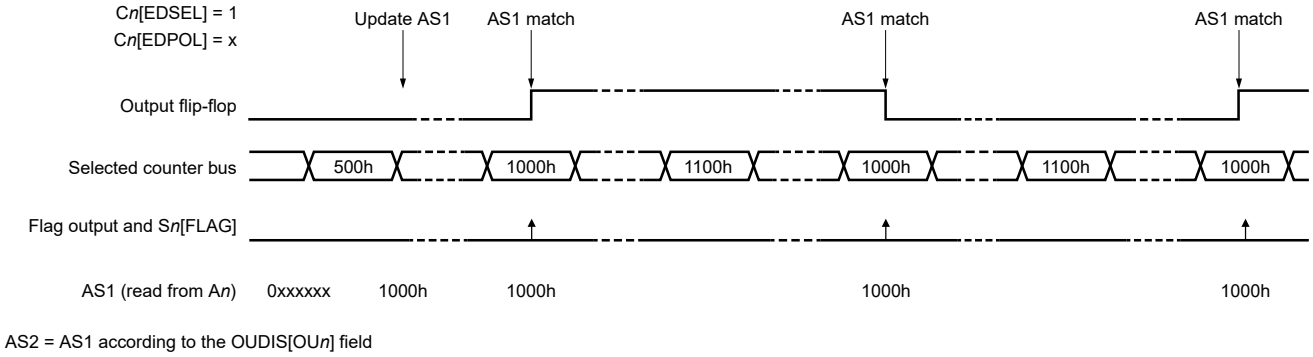


Figure 365. SAOC toggling the output flip-flop

63.5.3.9.5 SAOC with flag behavior

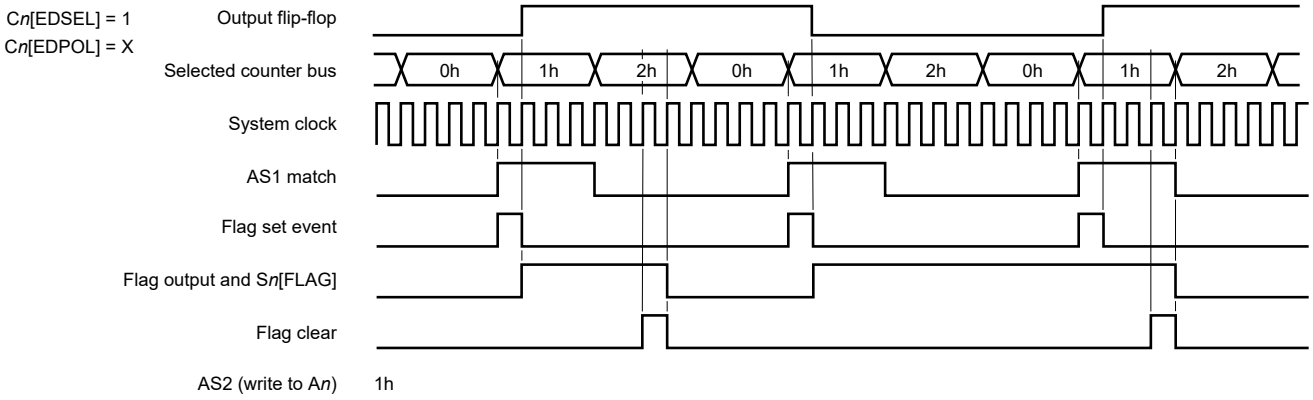


Figure 366. SAOC with flag behavior

63.5.3.10 Input Pulse Width Measurement (IPWM) mode

63.5.3.10.1 Overview

This mode allows you to measure the width of a positive or negative pulse. Select whether to measure from the rising or falling edge with Edge Polarity (Cn[EDPOL]).

The first leading edge:

- Triggers the first input capture, which latches the count value of the selected timebase into BS2 (see AS1, AS2, BS1, and BS2 shadow registers)
- Does not set the input-capture flag (Sn[FLAG])
- Enables AS2 capture

The next trailing edge:

- Latches the selected timebase into AS2
- Sets the input-capture flag (Sn[FLAG])
- Transfers BS2 to BS1 and AS1

eMIOS captures successive values on consecutive edges of opposite polarity. If you initiate subsequent input capture events while the input-capture flag (Sn[FLAG]) is set, eMIOS updates AS2, BS1, and AS1 with the latest captured values and keeps the flag set.

63.5.3.10.2 Coherency

Reading A*n*[A] updates BS1 with AS1. It also disables transfers from BS2 and BS1 until the next read of B*n*[B].

Reading Bn updates BS1 with AS1. It also re-enables transfers from BS2 to BS1, which takes effect at the next trailing edge capture.

Because transfers from BS2 to AS1 are never blocked, to guarantee data coherency you must read An, then read Bn.

If you do not require coherent data, you should read Bn before you read An, although doing so requires a second read of Bn to unblock BS1 updates.

63.5.3.10.3 Timing example: measure pulse width

This figure shows how to measure the input pulse width by subtracting BS1 from AS2.

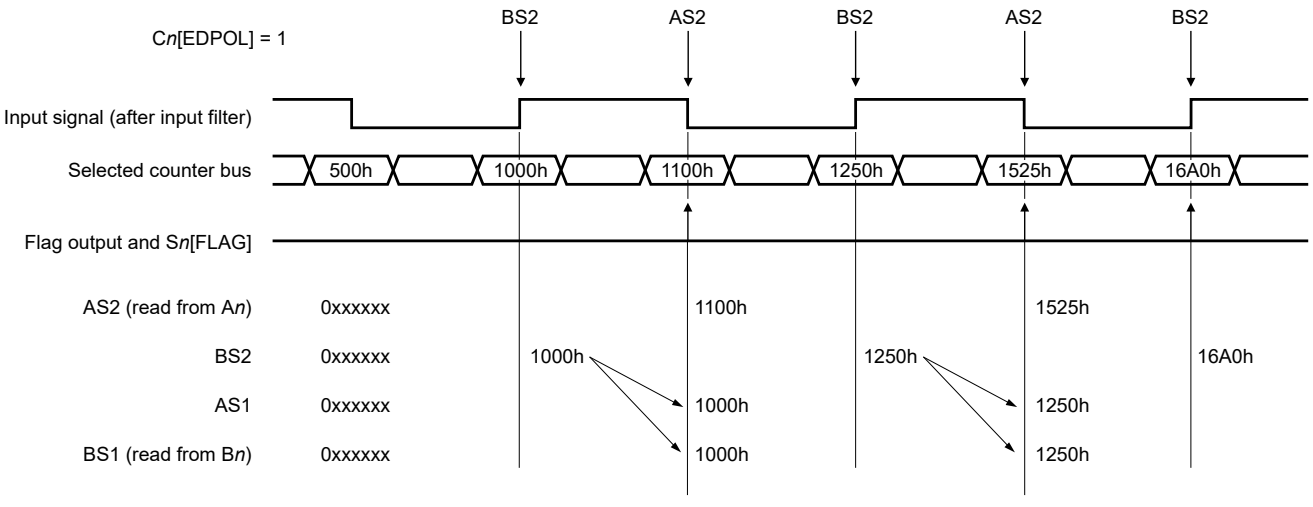


Figure 367. Timing example: measure pulse width

63.5.3.10.4 Timing example: AS1 and BS1 updates on channel reads

This example illustrates AS1 and BS1 updates when you read A*n*[A] and B*n*[B]. AS1 always has coherent data related to AS2 (see Coherency).

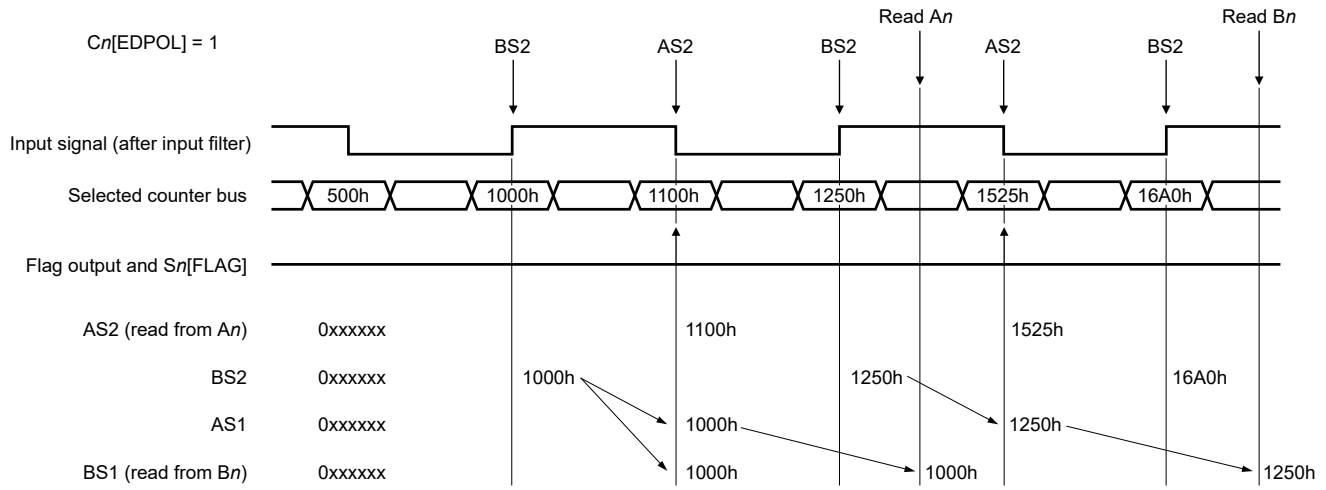


Figure 368. Timing example: BS1 and AS1 updates on channel reads

63.5.3.11 Input Period Measurement (IPM) Mode

63.5.3.11.1 Overview

This mode allows you to measure the period of an input signal. Select whether to measure from the rising or falling edges with Edge Polarity (C*n*[EDPOL]).

The first edge of selected polarity:

- Latches the selected timebase into AS2 and BS2 (see AS1, AS2, BS1, and BS2 shadow registers)
- Transfers BS2 to BS1
- Does not set the input-capture flag (S*n*[FLAG])

The second edge of the same polarity:

- Latches the counter bus value into AS2 and BS2
- Transfers BS2 to BS1 and AS1
- Sets the input-capture flag (S*n*[FLAG])

eMIOS repeats this process for each subsequent capture.

eMIOS captures successive values on two consecutive edges of the same polarity. The measured input signal must have a period of at least four system clock cycles to be properly captured by the synchronization logic at the channel input, even if the input filter is in bypass mode.

63.5.3.11.2 Coherency

Reading A*n*[A] updates BS1 with AS1, which provides coherent data in AS2 and BS1 (see Timing example: AS1 and BS1 updates on channel reads). It also disables transfers from BS2 and BS1 until the next read of B*n*[B].

Reading B*n*[B] updates BS1 with AS1. It also re-enables transfers from BS2 to BS1, which takes effect at the next edge capture.

63.5.3.11.3 Timing example: measure input period

This example illustrates how to measure the input period by subtracting BS1 from AS2.

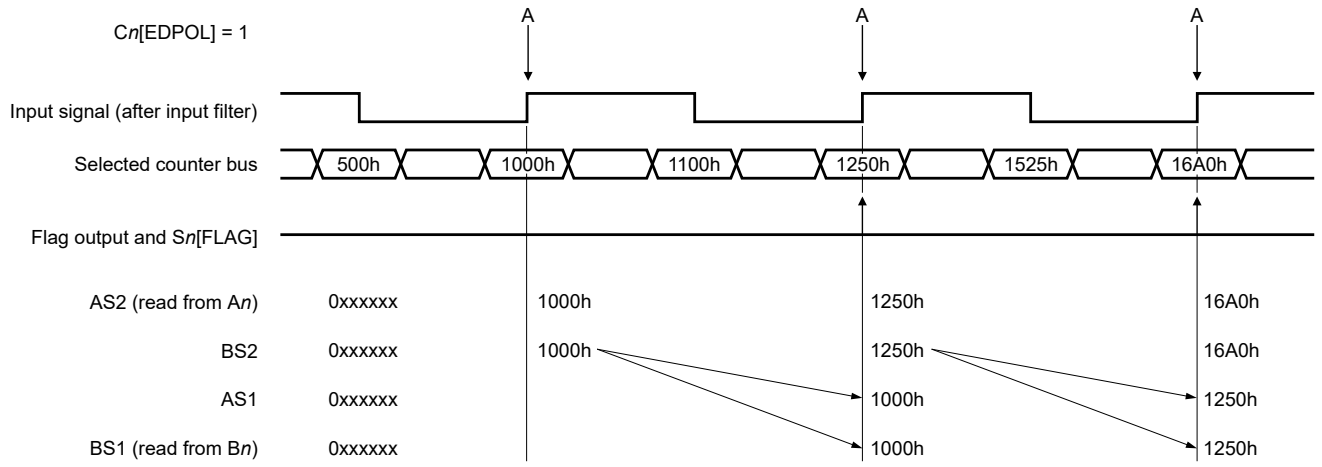


Figure 369. Timing example: measure input period

63.5.3.11.4 Timing example: AS1 and BS1 updates on channel reads

This diagram illustrates AS1 and BS1 updates when you read A*n*[A] and B*n*[B].

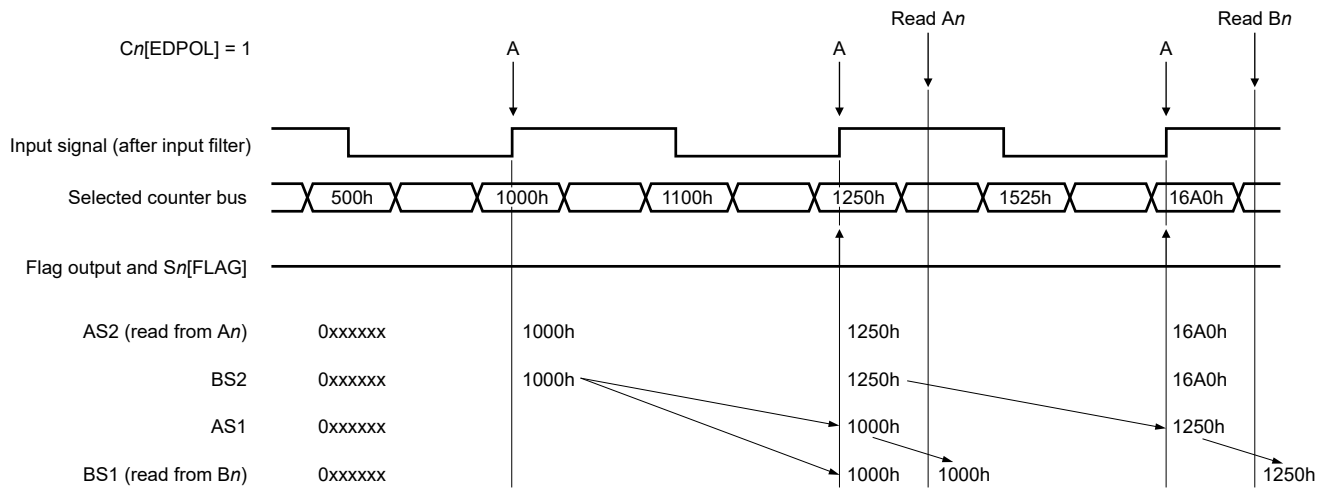


Figure 370. Timing example: AS1 and BS1 updates on channel reads

63.5.3.12 Double Action Output Compare (DAOC) mode

63.5.3.12.1 Overview

In this mode, matches on comparators A and B cause the UC to generate the leading and trailing edges of the variable pulse width output. See DAOC submodes and MODE field values. There is no restriction on the order in which A and B matches occur.

When the UC enters DAOC mode from GPIO mode, eMIOS disables both comparators and drives the complement of Edge Polarity (C*n*[EDPOL]) onto the output flip-flop.

63.5.3.12.2 DAOC submodes and MODE field values

Table 341. DAOC submodes and MODE field values

When set flag event occurs	C*n*[MODE] (binary)
Only on B matches	000_0110
On A or B matches	000_0111

63.5.3.12.3 Data transfer and compare

If you enable output (write 0 to OUDIS[OU*n*]), on the next clock cycle the UC transfers AS2 and BS2 to AS1 and BS1 respectively (see Timing example: leading dead time insertion). If you disable output (write 1 to OUDIS[OU*n*]), no transfer occurs.

eMIOS enables and disables the A and B comparators independently. It enables comparator A only after the transfer to AS1 completes, and disables comparator A on the next A match. Similarly, eMIOS enables comparator B only after the transfer to BS1 completes, and disables comparator B on the next B match.

When a match occurs on comparator A, the output flip-flop acquires the value of Edge Polarity (C*n*[EDPOL]). When a match occurs on comparator B, the output flip-flop acquires the complement of Edge Polarity (C*n*[EDPOL]).

63.5.3.12.4 Differences between flag on A match and flag on A and B matches

In the flag on B match submode (see DAOC submodes and MODE field values), the UC sets the input-capture flag (S*n*[FLAG]) only for matches on the B comparator. In the flag on both A and B matches submode, it sets the flag for matches on either comparator.

If subsequent enabled output compares occur on AS1 or BS1, the UC continues generating pulses regardless of the flag state.

If you load both AS1 and BS1 with the same value, the B match takes precedence and the UC drives the complement of Edge Polarity (C*n*[EDPOL]) onto the output flip-flop.

63.5.3.12.5 Forced operation by Cn[FORCMA] and Cn[FORCMB]

Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to the comparator, Edge Polarity (C*n*[EDPOL]) for an A match, or the complement of Edge Polarity for a B match. The force-match operations do not set the input-capture flag (S*n*[FLAG]).

63.5.3.12.6 Timing example: flag on both matches

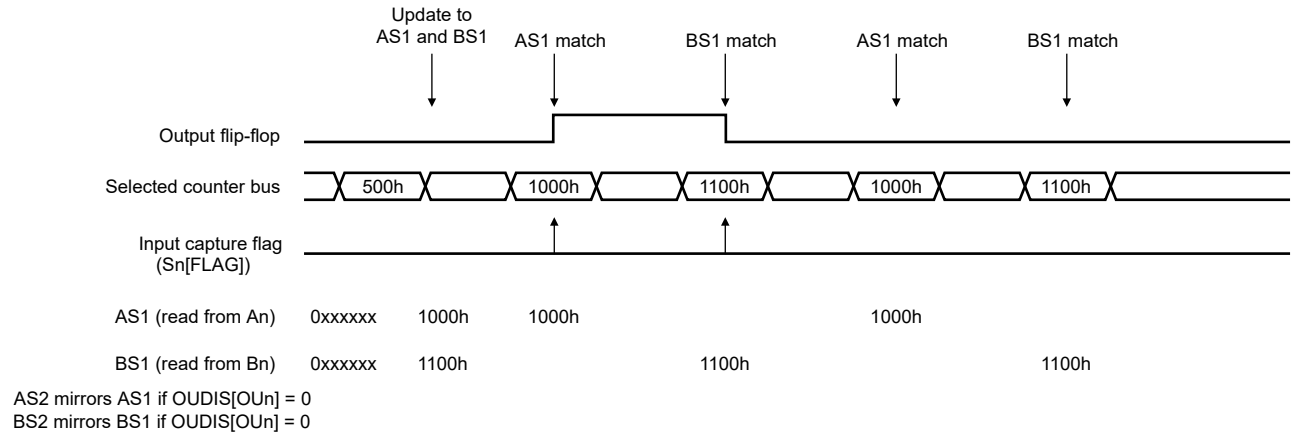


Figure 371. Timing example: flag on both matches

63.5.3.12.7 Timing example: flag on second match

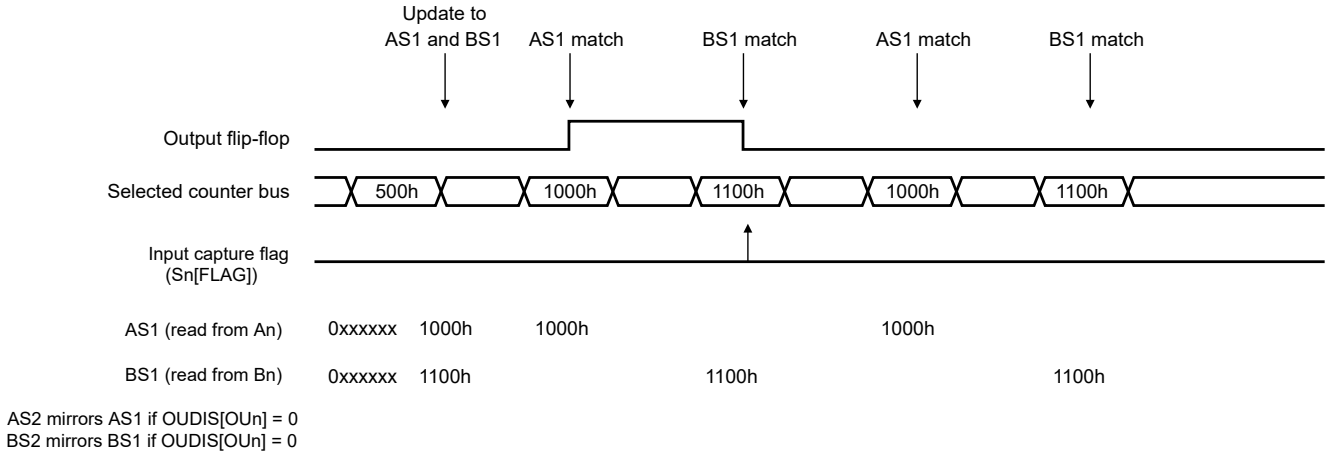


Figure 372. Timing example: flag on second match

63.5.3.12.8 Timing example: transfer disabling

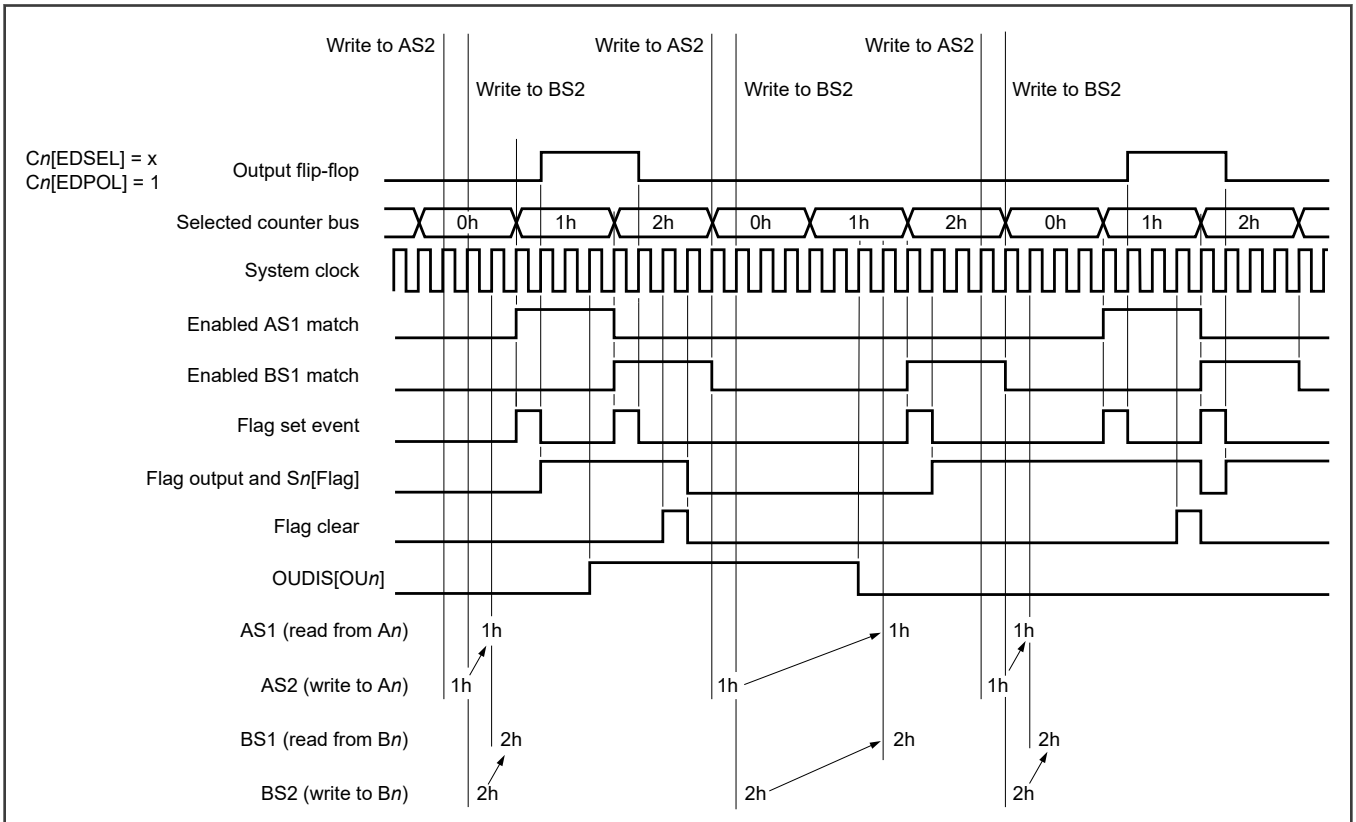


Figure 373. Timing example: transfer disabling

63.5.3.13 Pulse or Edge Accumulation (PEA) mode

63.5.3.13.1 Overview

This mode returns the time taken to detect a desired number of input events.

See PEA submodes and MODE field values for the values that you must write to C*n*[MODE] to enter this mode.

You begin timing by writing the target number of input events to AS1. After you write to AS1, eMIOS:

- Resets the internal counter after the first input event.
- Prepares to start counting input events.
- Stores the selected timebase in BS2.

When the internal counter (CNT*n*[C])matches AS1, eMIOS:

- Captures the counter bus value and stores it in AS2 and BS2.
- Transfers the data previously held in BS2 to BS1.
- Sets the input-capture flag (S*n*[FLAG]) to indicate that an event has occurred.

You determine the desired time interval by subtracting BS1 (read from B*n*[B]) from AS2 (read from A*n*[A]).

Accumulation cycles may be lost if you do not read the data registers in a timely manner. If the input-capture flag is set (S*n*[FLAG] = 1), one or more cycles have been lost.

An edge transition on the input pin—rising, falling, or both—triggers the counter clock (input event). C*n*[EDSEL] and C*n*[EDPOL] select the polarity of the triggering edge.

Timing example continuous and Timing example single-shot show how to use the UC in continuous and single-shot operation.

63.5.3.13.2 PEA submodes and MODE field values

Table 342. PEA submodes and MODE field values

Operation	C*n*[MODE] (binary)
Continuous; eMIOS resets the counter on the next input event after a set-flag event and continues to operate as described in Overview.	000_1000
Single-shot; eMIOS does not reset or increment the counter after a set-flag event until you write to A*n*[A] again.	000_1001

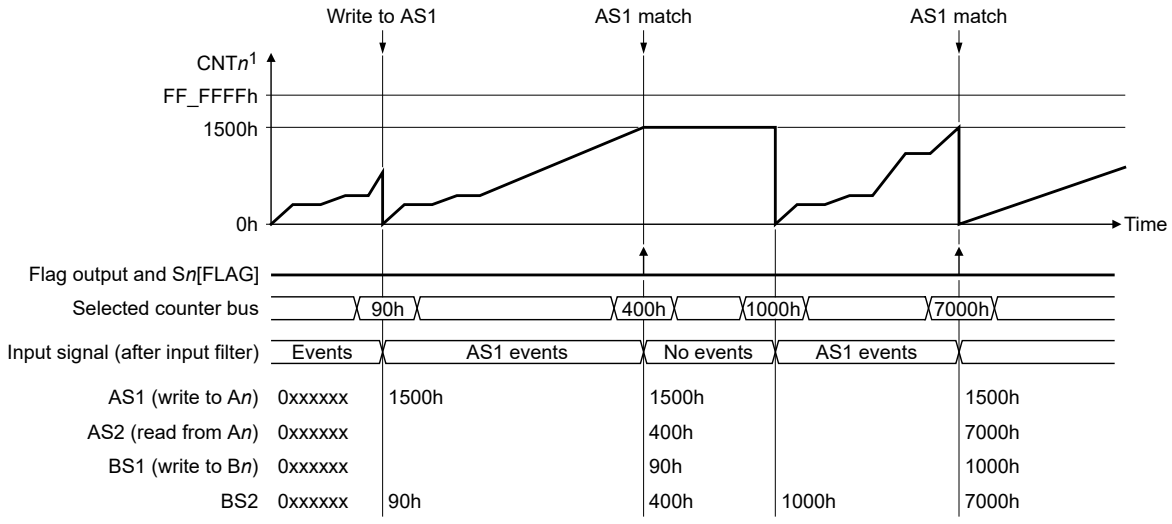
63.5.3.13.3 Data coherency in PEA mode

As part of the coherency mechanism, reading A*n* disables BS2→BS1 transfers. These transfers remain disabled until the next read of B*n*. Reading B*n* re-enables BS2→BS1 transfers, to take effect at the next transfer event, as described above. If BS1 was not updated because you disabled a BS2→BS1 transfer by reading A*n*, further reads of A*n* and B*n* do not return coherent data until a new bus capture is triggered to AS2 and BS2. This capture event is indicated by the set input-capture flag (S*n*[FLAG] = 1). If you enable interrupts (write 0 to C*n*[DMA] and 1 to C*n*[FEN]), the setting of the input-capture flag (S*n*[FLAG]) also generates an interrupt.

To ensure coherent data in continuous operation, perform the following steps. This procedure assumes that S*n*[FLAG] is initially 0.

1. Wait for S*n*[FLAG] to become 1.
2. Read A*n*.
3. Read B*n*.
4. Write 1 to S*n*[FLAG] to clear it.
5. Return to step 1.

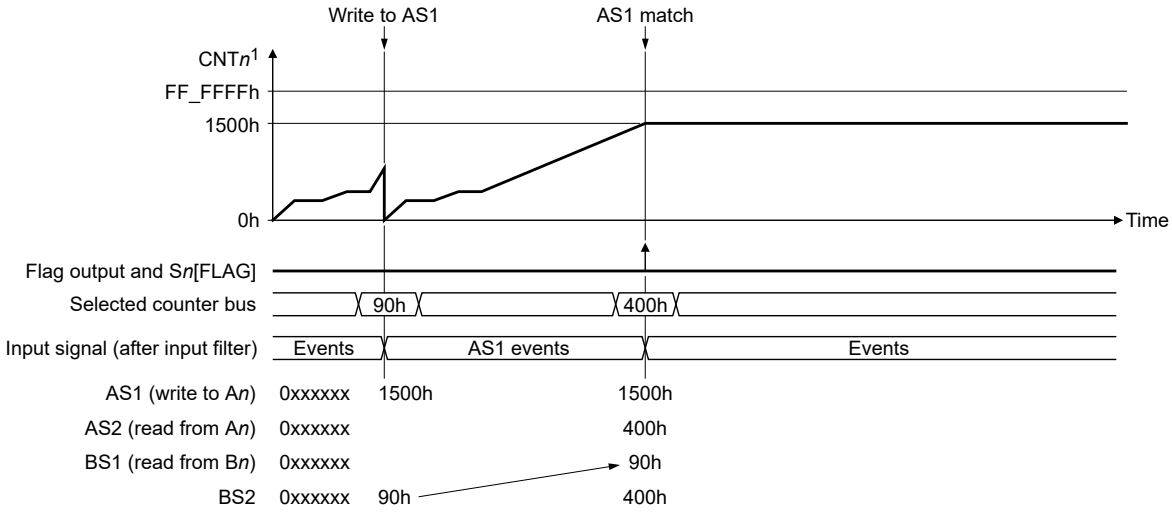
63.5.3.13.4 Timing example continuous



Note: 1. Cleared on the first input event after writing to AS1.

Figure 374. Timing example continuous

63.5.3.13.5 Timing example single-shot



Note: 1. Cleared on the first input event after writing to AS1.

Figure 375. Timing example single-shot

63.5.3.14 Pulse Edge Counting (PEC) mode

63.5.3.14.1 Overview

This mode counts the number of pulses or edges detected on the input for a desired time window. C*n*[EDSEL] and C*n*[EDPOL] determine which edges the UC counts.

Specify the window start time in AS1 and the end time in BS1. After you write to AS1, when the selected timebase matches comparator A, eMIOS resets the internal counter and starts counting input events. When the timebase matches comparator B, eMIOS:

- Disables the internal counter.
- Transfers the counter's content to AS2.
- Sets the input-capture flag (changes S*n*[FLAG] to 1).

You obtain the number of detected pulses by reading C*n*[C] or AS2.

Timing example continuous and Timing example single-shot show how to use the UC in continuous or single-shot operation.

63.5.3.14.2 PEC submodes and MODE field values

Table 343. PEC submodes and MODE field values

Operation	C*n*[MODE] (binary)
Continuous; the next match between comparator A and the selected timebase resets the internal counter and enables counting again. To guarantee coherent measurements when you read C*n*[C] after S*n*[FLAG] becomes 1, you must check if the timebase value is out of the time interval defined by AS1 and BS1. Alternately, AS2 (available in ALTA*n*[ALTA]) always holds the latest available measurement, providing coherent data at any time after the first set-flag event.	000_1010
Single-shot; The next match between comparator A and the selected timebase has no effect until you write to A*n*[A]. eMIOS also transfers the C*n*[C] value to AS2 when a match in the B comparator occurs.	000_1011

63.5.3.14.3 Timing example continuous

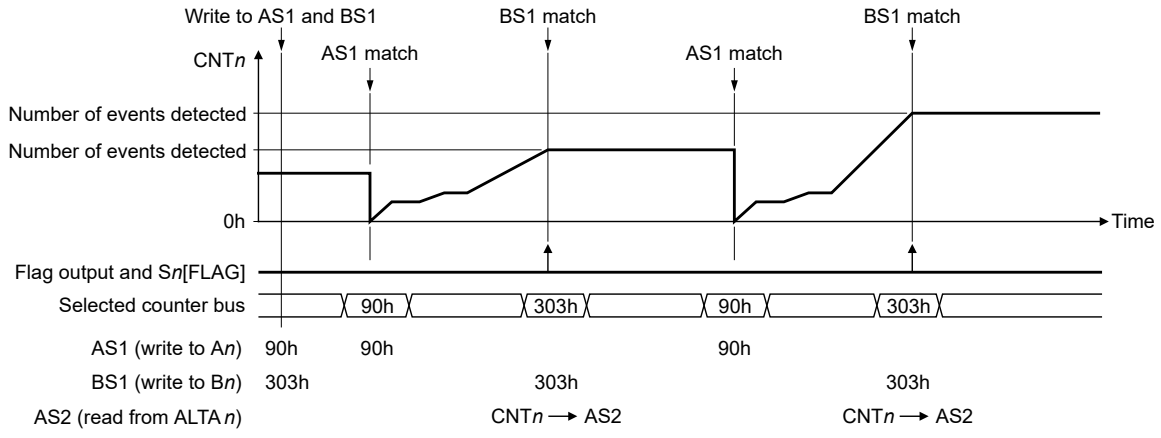


Figure 376. Timing example continuous

63.5.3.14.4 Timing example single-shot

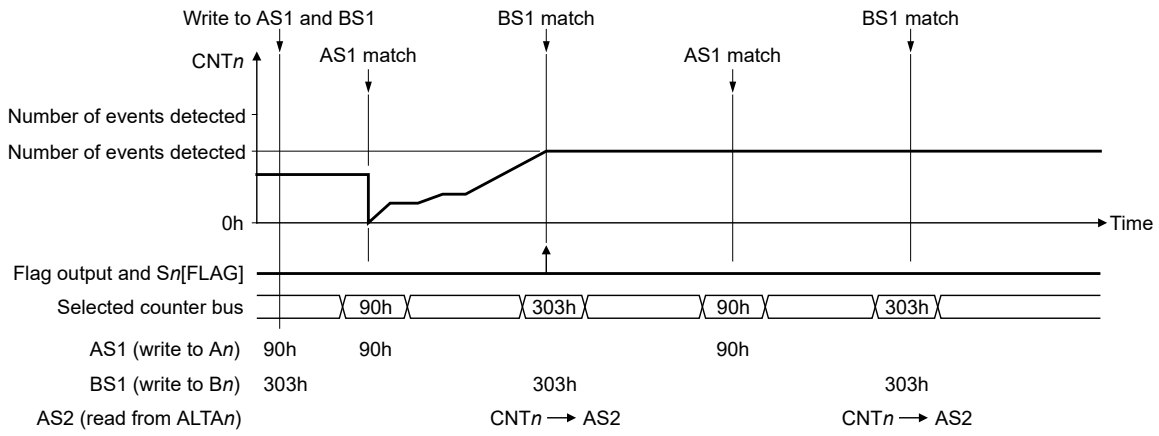


Figure 377. Timing example single-shot

63.5.3.15 Quadrature Decode (QDEC) mode

63.5.3.15.1 Overview

This mode implements a quadrature decoder on input signals corresponding to the current UC and its preceding UC. See QDEC submodes and MODE field values.

Entering QDEC mode automatically selects but does not reset the internal counter. You need to write a target counter value to AS1. The UC sets the input-capture flag (S*n*[FLAG]) when the internal counter matches the target value in AS1.

In QDEC mode, the UC uses the PIF from the next lower numbered UC. This arrangement is circular: the lowest numbered UC uses the PIF from the highest numbered UC.

You can use UC*n*–1 in an operation mode that does not use I/O pins, such as MC mode.

63.5.3.15.2 QDEC submodes and MODE field values

Table 344. QDEC submodes and MODE field values

Type of encoder	C*n*[MODE] (binary)
Count and direction	000_1100
Phase_A and phase_B	000_1101

63.5.3.15.3 Count and direction encoder

When you select the count and direction encoder submode (C*n*[MODE] = 000_1100b), illustrated in Timing example: count and direction encoder:

- Ensure the UC input pin is connected to the direction signal (see the SIUL2 chapter).
- Ensure the next lower numbered UC input pin is connected to the count signal of the quadrature encoder (see the SIUL2 chapter).
- Select the count direction (increment or decrement) according to the direction signal using Edge Polarity (C*n*[EDPOL]).
- Select whether the internal counter is clocked on the rising or falling edge of the count signal using the Edge Polarity of the next lower UC (C*n-1*[EDPOL]).

63.5.3.15.4 Timing example: count and direction encoder

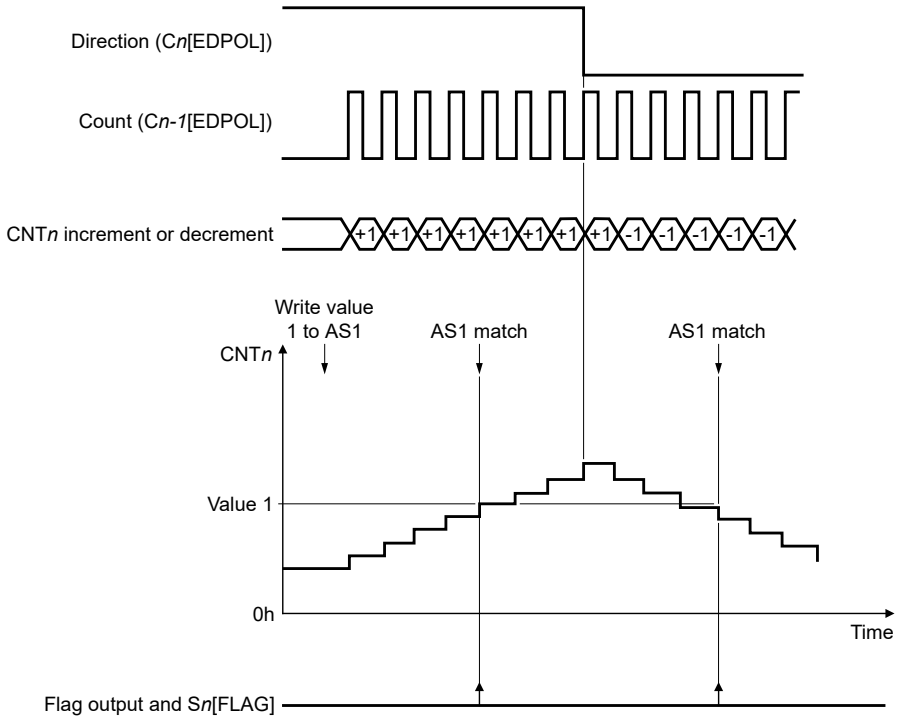


Figure 378. Timing example: count and direction encoder

63.5.3.15.5 Phase_A and phase_B encoder

When you select the phase_A and phase_B encoder submode (C*n*[MODE] = 000_1101b), illustrated in Timing example: phase_A and phase_B encoder:

- Ensure the UC input pin is connected to the phase_A signal
- Ensure the next lower numbered UC input pin is connected to the phase_B signal of the quadrature encoder
- Select the count direction according to the phase difference between the phase_A and phase_B signals using Edge Polarity (C*n*[EDPOL]):
  - If phase_A leads phase_B, count direction is up (increments)
  - If phase_A lags phase_B, count direction is down (decrements)

63.5.3.15.6 Timing example: phase_A and phase_B encoder

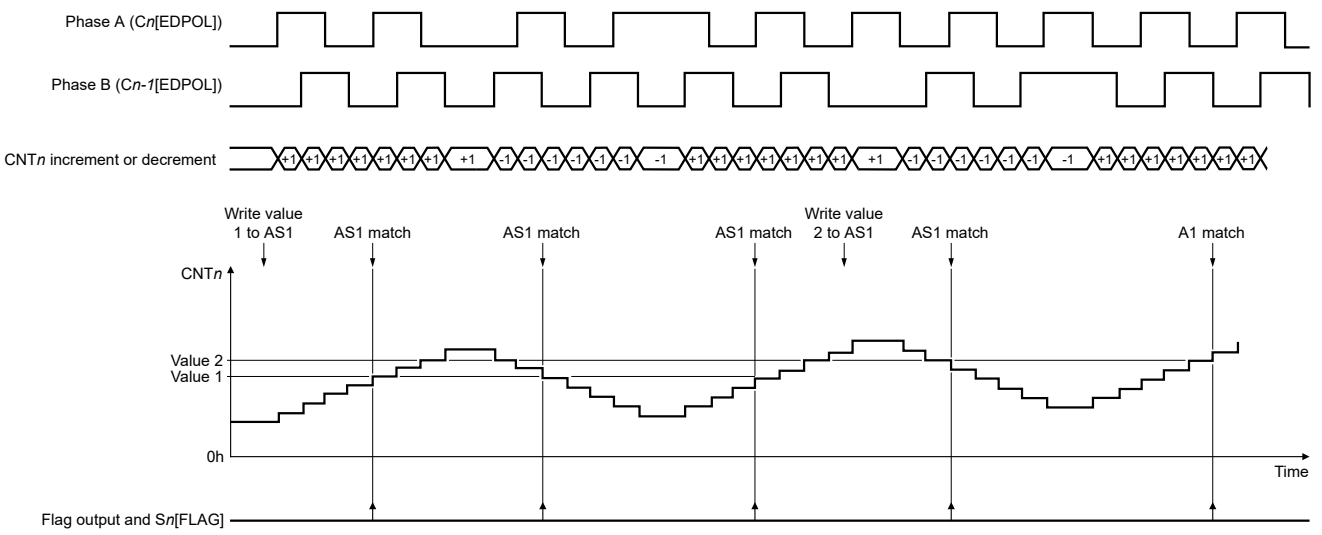


Figure 379. Timing example: phase_A and phase_B encoder

63.5.3.16 Windowed Programmable Time Accumulation (WPTA) mode

63.5.3.16.1 Overview

In this mode (C*n*[MODE] = 000_1110b), eMIOS accumulates the sum of an input signal's total high or low time over a programmable time window.

You control the increment rate of the internal counter by specifying the CP (C*n*[UCPRE]). Specify the window start time in AS1 and the end time in BS1.

When a match occurs between A*n*[A] and the selected timebase, eMIOS resets CNT*n*[C] and starts counting. The internal counter serves as a time accumulator—it counts up when the input-signal polarity matches C*n*[EDPOL], and does not count otherwise. When a match occurs in comparator B, eMIOS:

- Disables the internal counter regardless of the input signal polarity.
- Sets the input-capture flag (changes S*n*[FLAG] to 1).
- Transfers the count (CNT*n*[C]) to AS2.

Reading CNT*n*[C] or AS2 (available in ALTA*n*[ALTA]) returns the high or low time of the input signal.

Timing example illustrates how you can use the UC to accumulate high time.

63.5.3.16.2 Counter and AS2 stability

The internal counter (CNT*n*[C]) is stable only outside the time window defined by AS1 and BS1. Inside the time window, CNT*n*[C] is actively counting and does not reflect the final value. In contrast, AS2 returns the latest available measurement. Because eMIOS updates AS2 only when a comparator B match occurs, AS2 always contains stable and up-to-date data.

63.5.3.16.3 Timing example

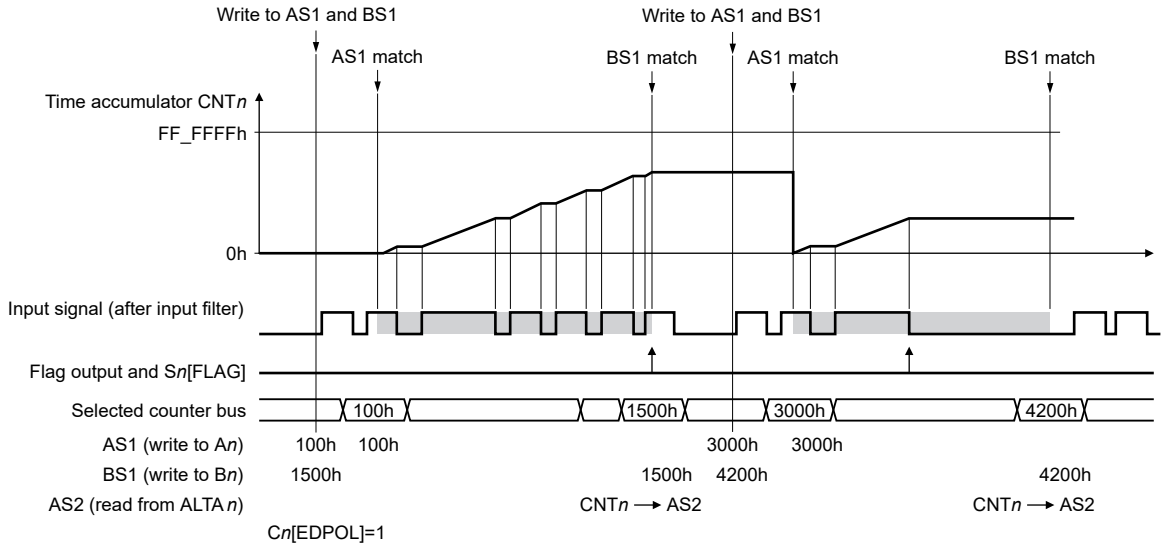


Figure 380. Timing example

63.5.3.17 Modulus Counter (MC) mode

63.5.3.17.1 Overview

In this mode, the UC produces a timebase for a counter bus or as a general purpose timer. The internal counter (C*n*[C]) counts up from the current value until it matches AS1.

Selecting external clock source (see MC submodes and MODE field values) causes the UC to uses the input signal pin as the source. You select the triggering polarity edge using Edge Polarity (C*n*[EDPOL]) and Edge Select (C*n*[EDSEL]).

You must write only non-zero values to A*n*[A]. Writing to A*n*[A] or the internal counter may cause a match to be missed and the counter to roll over and resume operation in the next cycle. The channel writes 0 to BS1, which is not accessible by the MCU. You can read and write BS2, but it is not used in this mode.

63.5.3.17.2 MC submodes and MODE field values

Table 345. MC submodes and MODE field values

Submode or function	C*n*[MODE] (binary)
Internal clock source	001_0pp0[1]
External clock source	001_0pp1[1]
Internal counter reset on match start	001_0p0p[1]
Internal counter reset on match end	001_0p1p[1]
Up Count	001_00pp[1]
Up Count-Down Count	001_01pp[1]

1. *p* = Adjust parameters for submodes and options. See Unified channels (UC).

63.5.3.17.3 Up Count submode

Table 346. Up Count submode operation

Counter reset timing[1]	C*n*[MODE]		
	Bit 1	External clock (Bit 0 = 1)	Internal clock (Bit 0 = 0)
Reset on match start	0	When the AS1 match occurs, the UC: • Writes 0 to the internal counter. • Sets the input-capture flag (S*n*[FLAG]). • Increments the internal counter at the next input event, resulting in a short zero count.	When the AS1 match occurs, the UC: • Writes 0 to the internal counter. • Sets the input-capture flag (S*n*[FLAG]). • Maintains the internal counter at 0 on the next prescaler tick after the match. • Resumes counting on the next prescaler tick.
		See Timebase with the fastest prescaler ratio and Timebase generation with clear on match start and internal clock.	
Clear on match end	1	When the next input event after the AS1 match occurs, the UC: • Writes 0 to the internal counter. • Sets the input-capture flag (S*n*[FLAG]).	When the next internal counter tick after the AS1 match occurs, the UC: • Writes 0 to the internal counter. • Sets the input-capture flag (S*n*[FLAG]).
		See Timebase with the fastest prescaler ratio and Timebase generation with clear on match end.	

1. If you select internal clock source and a prescaler value of 1 for the internal counter, the behavior is the same for both submodes.

See Timing example: Up Count submode.

63.5.3.17.4 Timing example: Up Count submode

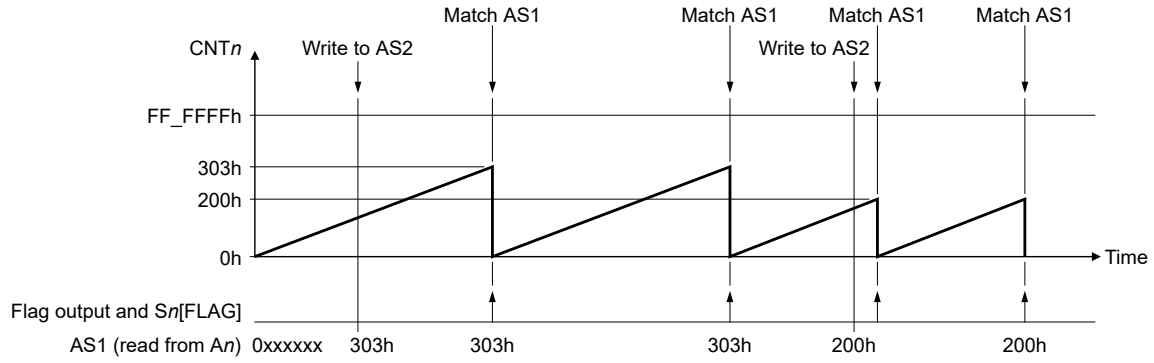


Figure 381. Timing example: Up Count submode

63.5.3.17.5 Up Count-Down Count submode operation

In Up Count-Down Count submode:

- When the internal counter matches AS1, the counter begins decrementing and the UC sets the input-capture flag (S*n*[FLAG]).
- When the internal counter matches BS1, the counter begins incrementing and, if in clear on match end operation (C*n*[1] = 1), the UC sets the input-capture flag (S*n*[FLAG]).

See Timing example: Up Count-Down Count submode.

63.5.3.17.6 Timing example: Up Count-Down Count submode

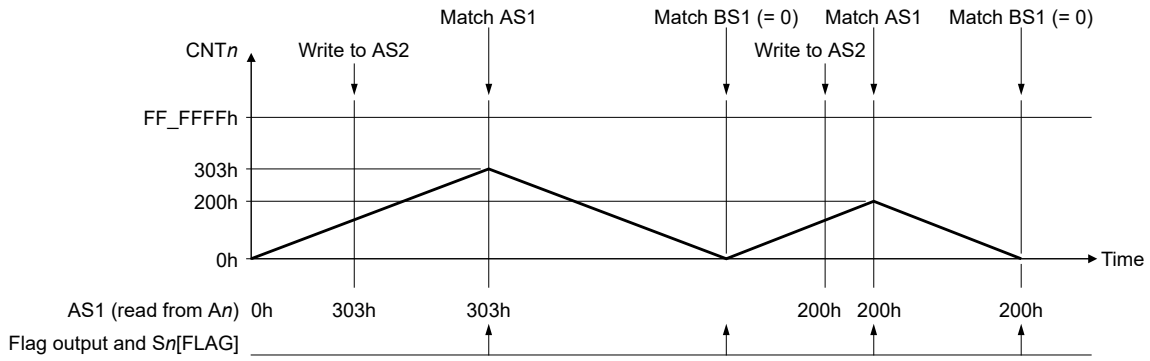


Figure 382. Timing example: Up Count-Down Count submode

63.5.3.17.7 Up Count with delayed reload operation

When the internal counter matches AS1 in the Up Count submode or BS1 in the Up Count-Down Count submode, the UC asserts the counter bus reload signal. You can read the counter bus reload signal in the following modes:

- Output PWM Buffered (OPWMB) mode
- Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode
- Center Aligned Output PWM with Dead Time Insertion Buffered (OPWMCB) mode

You can use the Reload Signal Output Delay Interval (C2*n*[UCRELDEL_INT]) to cause the UC to assert the reload signal only after a specified number of match events (from 2 to 32).

See Timing example: Up Count mode with delayed reload.

63.5.3.17.8 Timing example: Up Count mode with delayed reload

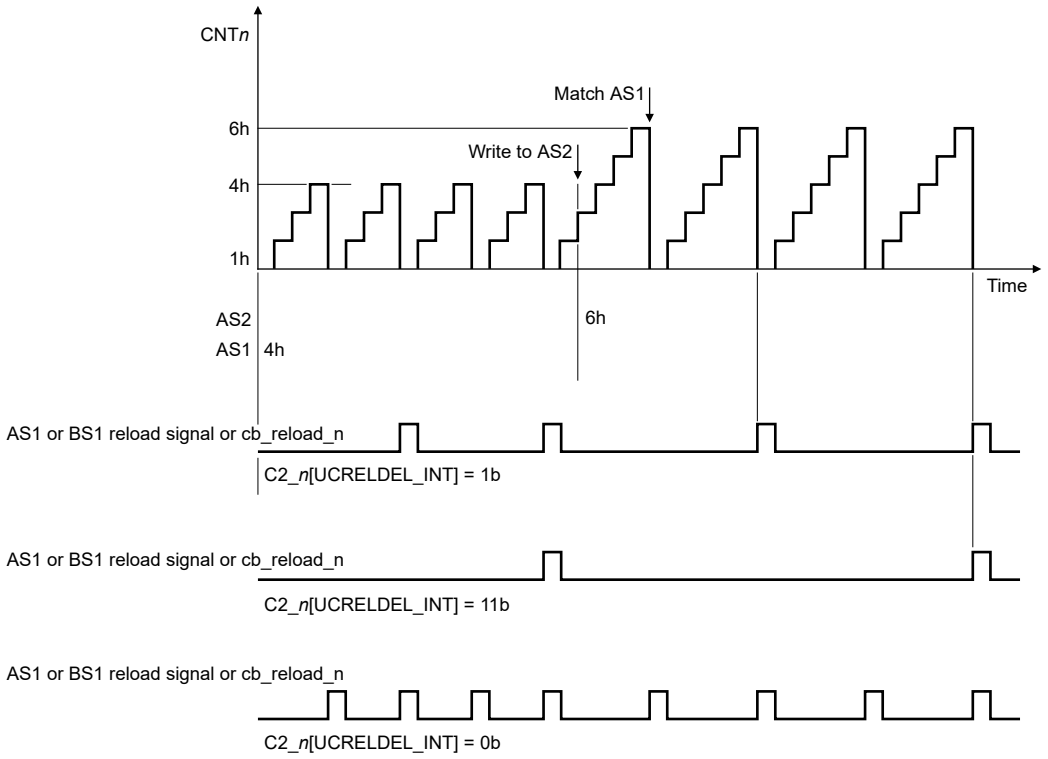


Figure 383. Timing example: Up Count mode with delayed reload

63.5.3.18 Modulus Counter Buffered (MCB) mode

63.5.3.18.1 Overview

In this mode, the UC generates a timebase that can be shared with other channels through the internal counter buses. AS1 is double-buffered, so you can change AS2 at any time with smooth transitions. The UC updates AS1 at the counter period boundary, which is when the internal counter (CNT*n*[C]) transitions to 1h.

Selecting external clock (see MCB submodes and MODE field values) causes the UC to use the input signal as the source. You select the triggering edge with Edge Polarity (C*n*[EDPOL]) and Edge Select (C*n*[EDSEL]).

You must ensure the internal counter is in the range from 1h to the AS1 value; otherwise, the A*n*[A] match does not occur and this causes the internal counter to wrap at the maximum counter value (FF_FFFFh for a 24-bit counter). After a counter wrap occurs, the UC resets the counter to 1h and resumes normal operation.

NOTE

Do not write 1h to the internal counter when the UC is in Freeze state. Doing so can cause the match to be missed and the counter to overflow.

63.5.3.18.2 Changing to MCB mode

To avoid causing an unexpected interrupt or DMA request, you must use the following procedure to change to MCB mode:

1. Put the UC in GPIO mode (write 0b or 1b to C*n*[MODE]).
2. Disable the UC input capture flag (write 0 to C*n*[FEN]).
3. Write the correct values for MCB mode to A*n* and B*n*.

4. Put the UC in MCB mode (write the appropriate value to C*n*[MODE], as described in MCB submodes and MODE field values).
5. Clear the UC input capture flag (write 1 to S*n*[FLAG]).
6. Enable the UC input capture flag (write 1 to C*n*[FEN]).

63.5.3.18.3 MCB submodes and MODE field values

Table 347. MCB submodes and MODE field values

Submode or function	C*n*[MODE] (binary)
Internal clock source	101_0pp0b[1]
External clock source	101_0pp1b[1]
Up Count	101_000p[1]
Reserved	101_001p[1]
Up Count-Down Count	101_01pp[1]
Flag set only on match start	101_010p[1]
Flags also set at counter period boundary	101_011p[1]

1. *p* = Adjust parameters for submodes and options. See Unified channels (UC).

63.5.3.18.4 Up Count submode

In the Up Count submode:

- The internal counter (CNT*n*[C]) starts counting up (incrementing) from its current value.
- When the internal counter matches AS1 and a clock tick occurs (either prescaled clock or input pin event), the UC resets the internal counter to 1h.
- The UC sets the input-capture flag (S*n*[FLAG]) one system clock cycle after the match occurs.

You must write only values greater than 1h to AS1.

The boundary between counter period *n* and period *n*+1 occurs when the UC changes the internal counter from the AS1 value in period *n* to 1h in period *n*+1. AS1 defines the counter period.

The UC asserts the AS1 load signal (which has a duration of one system clock cycle) at the last system clock cycle of a counter period. This causes the UC to update AS1 with AS2 at the period boundary, at the same time that it resets the counter to 1h. Therefore, any value you write to AS2 during period *n* updates AS1 at the next period boundary and the UC uses it in period *n*+1. See Timing example: Up Count submode.

You can use Output Update Disable (OUDIS) to delay the update of AS1 for synchronization.

The UC sets the input-capture flag (S*n*[FLAG]) at the period boundary. See Timing example: Up Count submode flag assertion.

63.5.3.18.5 Timing example: Up Count submode

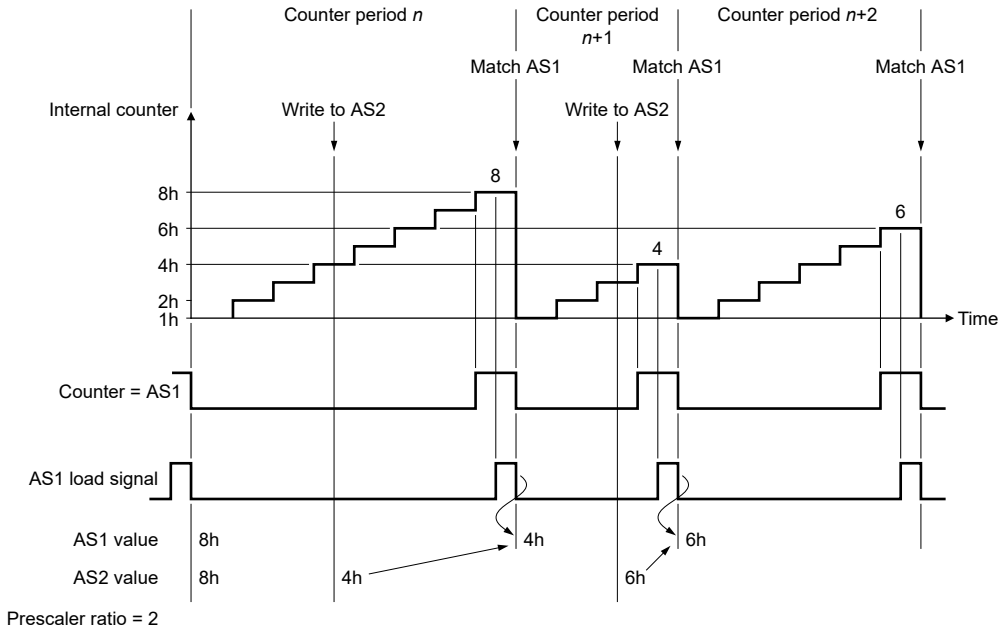


Figure 384. Timing example: Up Count submode

63.5.3.18.6 Timing example: Up Count submode flag assertion

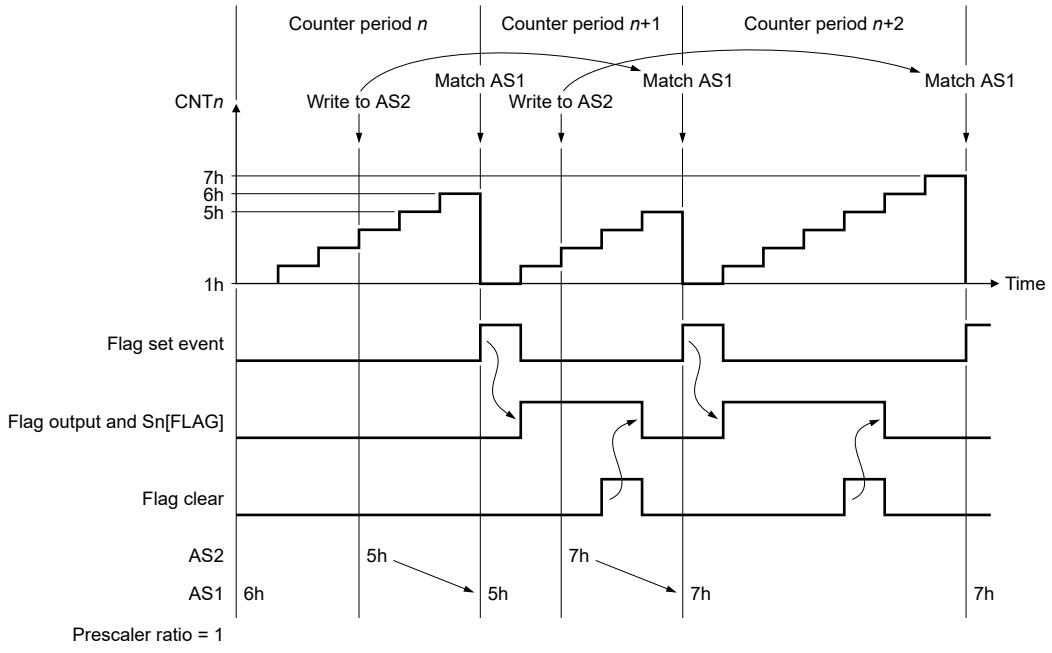


Figure 385. Timing example: Up Count submode flag assertion

63.5.3.18.7 Up Count-Down Count submode

In Up Count-Down Count submode:

- The counter period is: (2 x AS1) – 2. The counter changes direction at AS1 match and counts down (decrements) until it reaches 1h, then counts up (increments) again.
- BS1 generates a match to start the internal counter incrementing, and BS1 cannot be changed in this submode.

The UC updates AS1 at the counter period boundary. If you write AS2 (write A*n*[A]) during period *n*, the UC uses this new value in period *n*+1 for AS1 match. You can disable updates of AS1 (OUDIS[OU*n*]). See Timing example: Up Count-Down Count submode.

The UC sets the input-capture flag (S*n*[FLAG]) at AS1 match start, and may also do so at the period boundary. See Overview and Timing example: Up Count-Down Count submode flag assertion.

63.5.3.18.8 Timing example: Up Count-Down Count submode

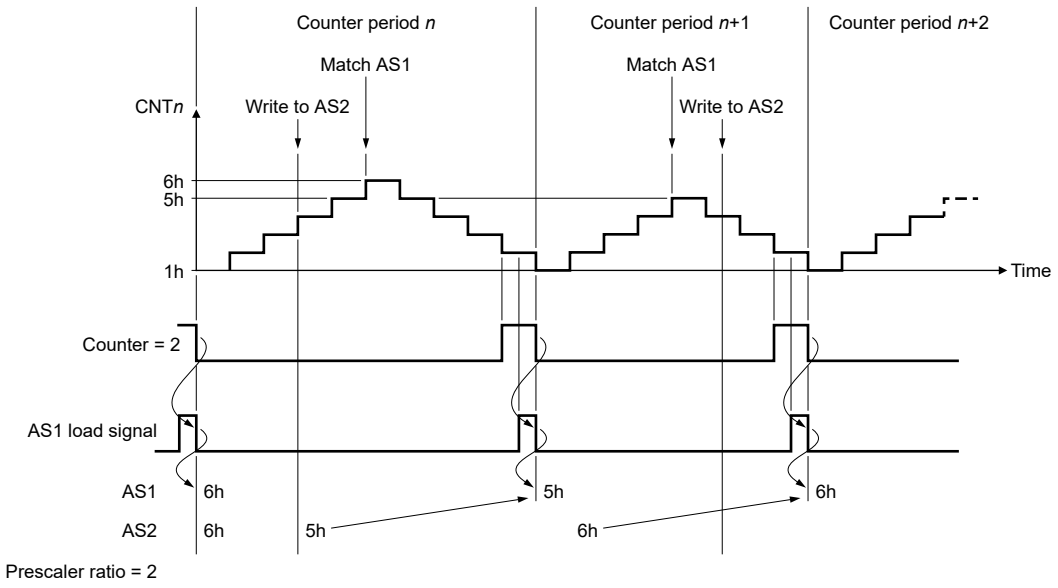


Figure 386. Timing example: Up Count-Down Count submode

63.5.3.18.9 Timing example: Up Count-Down Count submode flag assertion

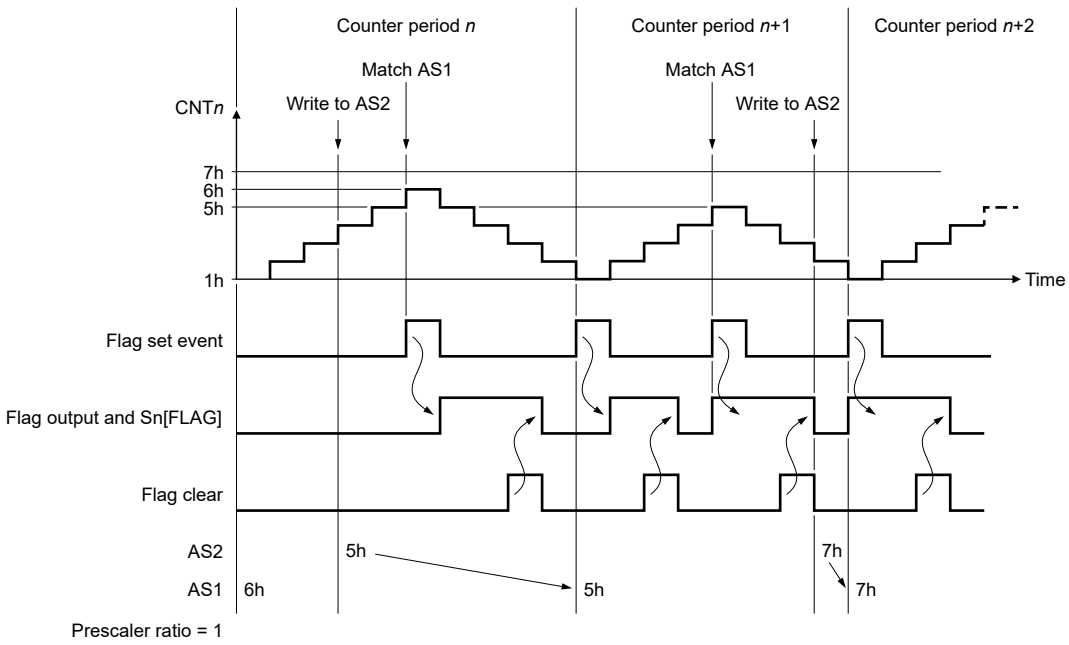


Figure 387. Timing example: Up Count-Down Count submode flag assertion

63.5.3.18.10 Up Count mode with delayed reload operation

When the internal counter matches AS1 in the Up Count submode or 1h in the Up Count-Down Count submode (see MCB submodes and MODE field values), the UC asserts the counter bus reload signal. You can read the counter bus reload signal in the following modes:

- Output PWM Buffered (OPWMB) mode
- Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode
- Center Aligned Output PWM with Dead Time Insertion Buffered (OPWMCB) mode

You can use the Reload Signal Output Delay Interval (C2[UCRELDEL_INT]) to cause the UC to assert the reload signal only after a specified number of match events (from 2 to 32).

See Timing example: Up Count mode with delayed reload.

63.5.3.18.11 Timing example: Up Count mode with delayed reload

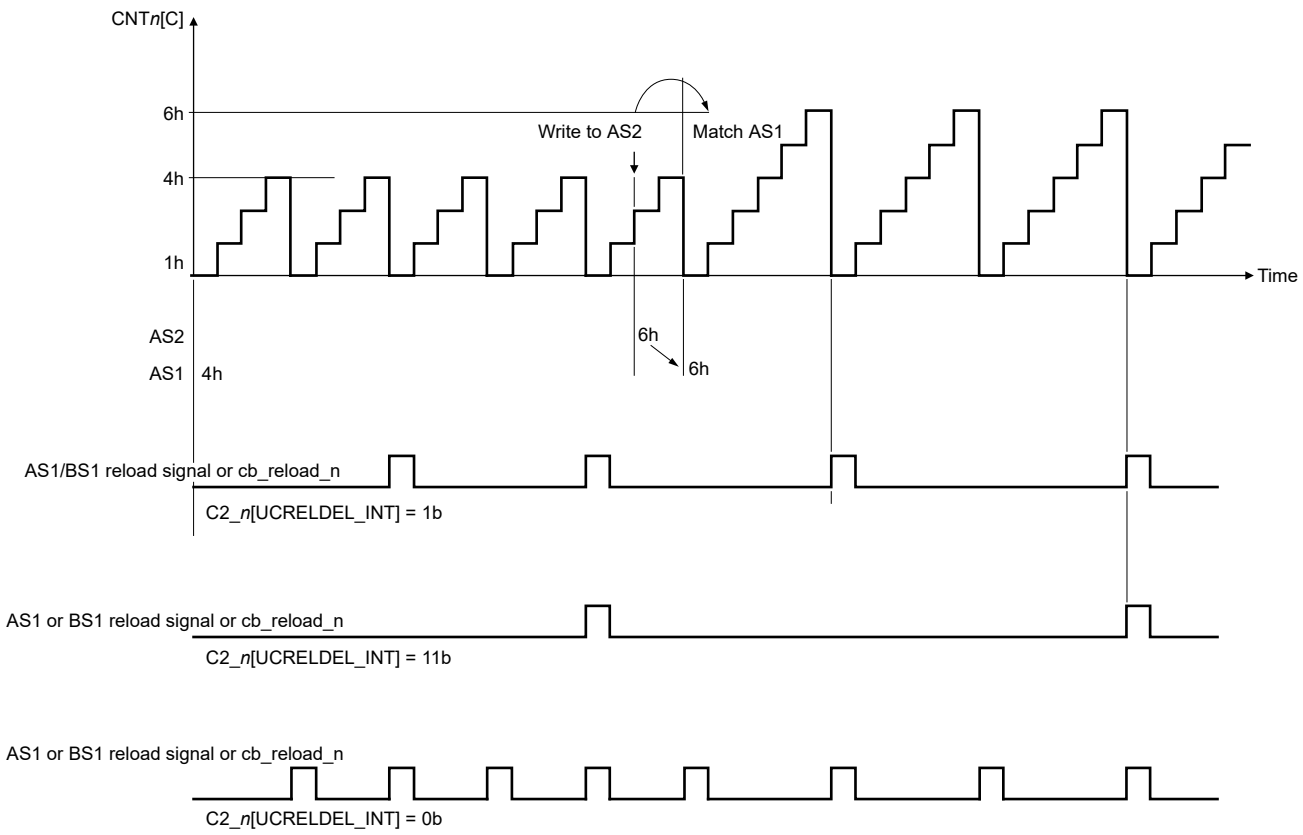


Figure 388. Timing example: Up Count mode with delayed reload

63.5.3.19 Output Pulse Width and Frequency Modulation (OPWFM) mode

63.5.3.19.1 Overview

In this mode, the UC produces an output signal that has:

- A period of (BS1 + 1) eMIOS clock cycles.
- A duty cycle as calculated by Equation for duty cycle in OPWFM mode.

See OPWFM submodes and MODE field values for the values that you must write to C*n*[MODE] to enter this mode.

You request a value for BS1 by writing to BS2. After you write to BS2, eMIOS transfers the value to BS1. This transfer can occur immediately or with a delay, as described in this section.

When the UC enters OPWFM mode from GPIO mode, the UC drives the complement of C*n*[EDPOL] onto the output flip-flop.

eMIOS automatically selects the internal counter as a timebase. Therefore, C*n*[BSL] has no meaning. When a match on comparator A occurs, the UC drives the value of C*n*[EDPOL] onto the output flip-flop. When a match on comparator B occurs, the UC drives the complement of C*n*[EDPOL] onto the output flip-flop and resets the internal counter.

Timing example: immediate update shows the UC running in OPWFM mode with immediate register update. Timing example: next period update shows the UC running in OPWFM mode with next period update.

63.5.3.19.2 Equation for duty cycle in OPWFM mode

$$Duty\ cycle\ (\%) = \frac{ASI + 1}{BSI + 1} \times 100$$

Equation 12. Equation for duty cycle in OPWFM mode

63.5.3.19.3 OPWFM submodes and MODE field values

Table 348. OPWFM submodes and MODE field values

When BS2→BS1 transfer occurs	When FLAG generation occurs	C*n*[MODE] (binary)
Immediately (resulting in the fastest change of the duty cycle); see Timing example: immediate update.	When BS1 matches the selected counter	010_0000
	When AS1 or BS1 match the selected counter	010_0010
Whenever AS1 matches the selected counter; see Timing example: next period update.	When BS1 matches the selected counter	010_0001
	When AS1 or BS1 match the selected counter	010_0011

63.5.3.19.4 Force match

Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to a match on comparators A or B, respectively. Also, writing to C*n*[FORCMB] resets the internal counter (CNT*n*[C]. If subsequent matches occur on comparators A and B, the UC continues to generate PWFM pulses regardless of the input capture flag (S*n*[FLAG]). The force-match operations do not set the input-capture flag (S*n*[FLAG]).

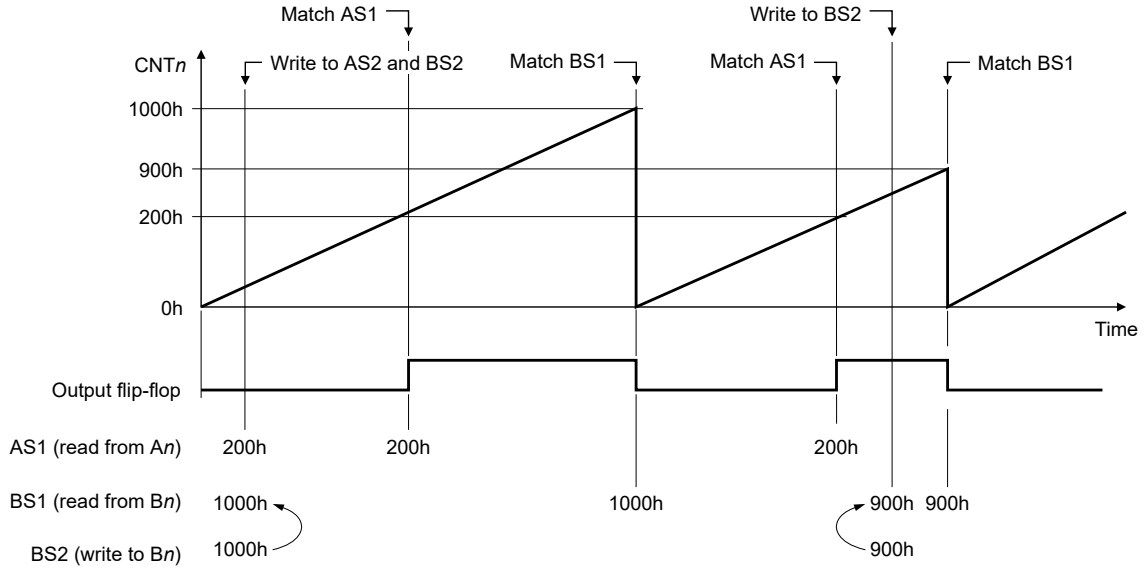
63.5.3.19.5 Duty cycle

To achieve 100% duty cycle, you must write the same value to both AS1 and BS1. When a simultaneous match occurs on comparators A and B, the output flip-flop acquires the value of C*n*[EDPOL]. To achieve 0% duty cycle, write 0 to AS1. When a match occurs, the output flip-flop changes at every period to the value of C*n*[EDPOL]. Bit 0 of C*n*[MODE] still controls the BS2→BS1 transfer as described in OPWFM submodes and MODE field values.

NOTE

Writing 0 to AS1 and BS1 produces a duty cycle of 0%.

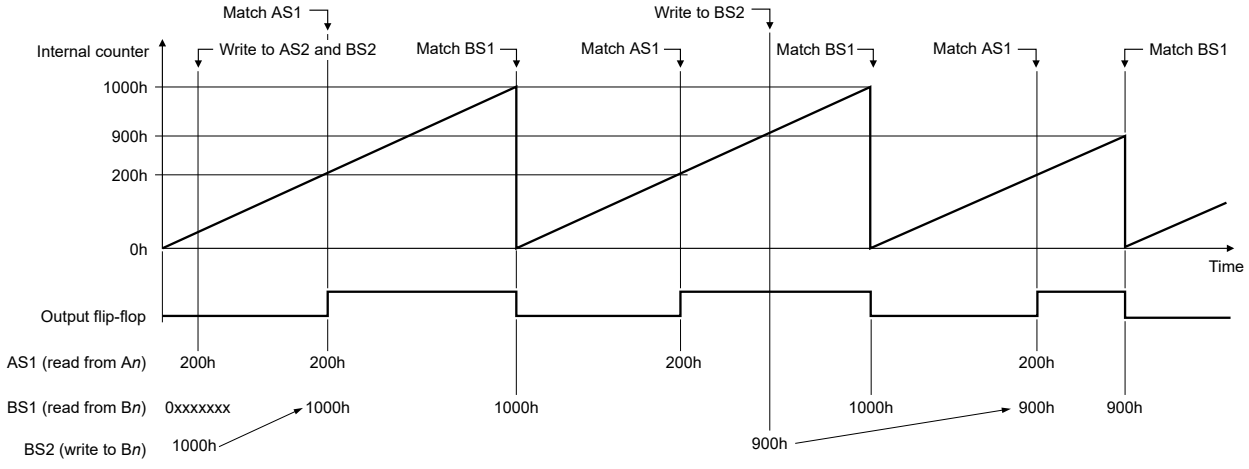
63.5.3.19.6 Timing example: immediate update



AS2 = AS1 according to the OUDIS[OU*n*] field
BS2 = BS1 according to the OUDIS[OU*n*] field

Figure 389. Timing example: immediate update

63.5.3.19.7 Timing example: next period update



AS2 = AS1 according to the OUDIS[OU*n*] field
BS2 = BS1 according to the OUDIS[OU*n*] field

Figure 390. Timing example: next period update

63.5.3.20 Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode

63.5.3.20.1 Overview

In this mode, the UC produces an output signal that has:

- A duty cycle determined by AS1.
- A period of BS1.

The double-buffered AS1 and BS1 registers produce smooth duty-cycle and period transitions when you change AS1 and BS1 during runtime.

See Table 357 for the values that you must write to C*n*[MODE] to enter this mode.

To provide smooth and consistent channel operation, this mode differs substantially from Output Pulse Width and Frequency Modulation (OPWFM) mode. In OPWFMB mode:

- AS1 and BS1 are both double-buffered to allow smooth signal generation when changing the register values.
- There is a delay from the AS1 match to the output pin transition (see AS1 and BS1 match timing).
- The internal counter ranges from 1h to BS1. When you write to BS1, you must write only values greater than 1h. Writing 0h or 1h leads to unpredictable results.

When a match on comparator A occurs, the UC drives C*n*[EDPOL] onto the output flip-flop. When a match on comparator B occurs, the UC drives the complement of C*n*[EDPOL] onto the output flip-flop. A BS1 match also causes the internal counter to transition to 1h, thus restarting the counter cycle.

The UC automatically selects the internal channel counter as the timebase when you select this mode. The mode supports duty cycles ranging from 0% to 100%.

63.5.3.20.2 OPWFMB submodes and MODE field values

Table 349. OPWFMB submodes and MODE field values

Match behavior	C*n*[MODE] (binary)
When BS1 matches the selected counter	101_1000
When AS1 or BS1 match the selected counter	101_1010

63.5.3.20.3 Avoid counter wrapping

When the UC enters OPWFMB mode, the output flip-flop acquires the value of C*n*[EDPOL]. If the UC transitions from GPIO to OPWFMB mode when the internal counter value is not within the range 1h–BS1, then the B match never occurs. Because the match never occurs, the internal counter wraps at the maximum counter value—FF_FFFFh for a 24-bit counter. When the counter wrap occurs, the counter returns to 1h and normal OPWFMB operation resumes. Therefore, to avoid this counter wrapping, ensure that the counter value is within the range 1h–BS1 before the UC enters OPWFMB mode.

63.5.3.20.4 AS1 and BS1 match timing

As illustrated in Timing example: AS1 and BS1 match, the output pin transition occurs when the AS1 or BS1 match signal deasserts, as indicated by the AS1 match negative-edge detection signal. If you write 4h to AS1, the output pin transitions 4 counter increments plus one system clock cycle after the counter period starts.

63.5.3.20.5 Timing example: AS1 and BS1 match

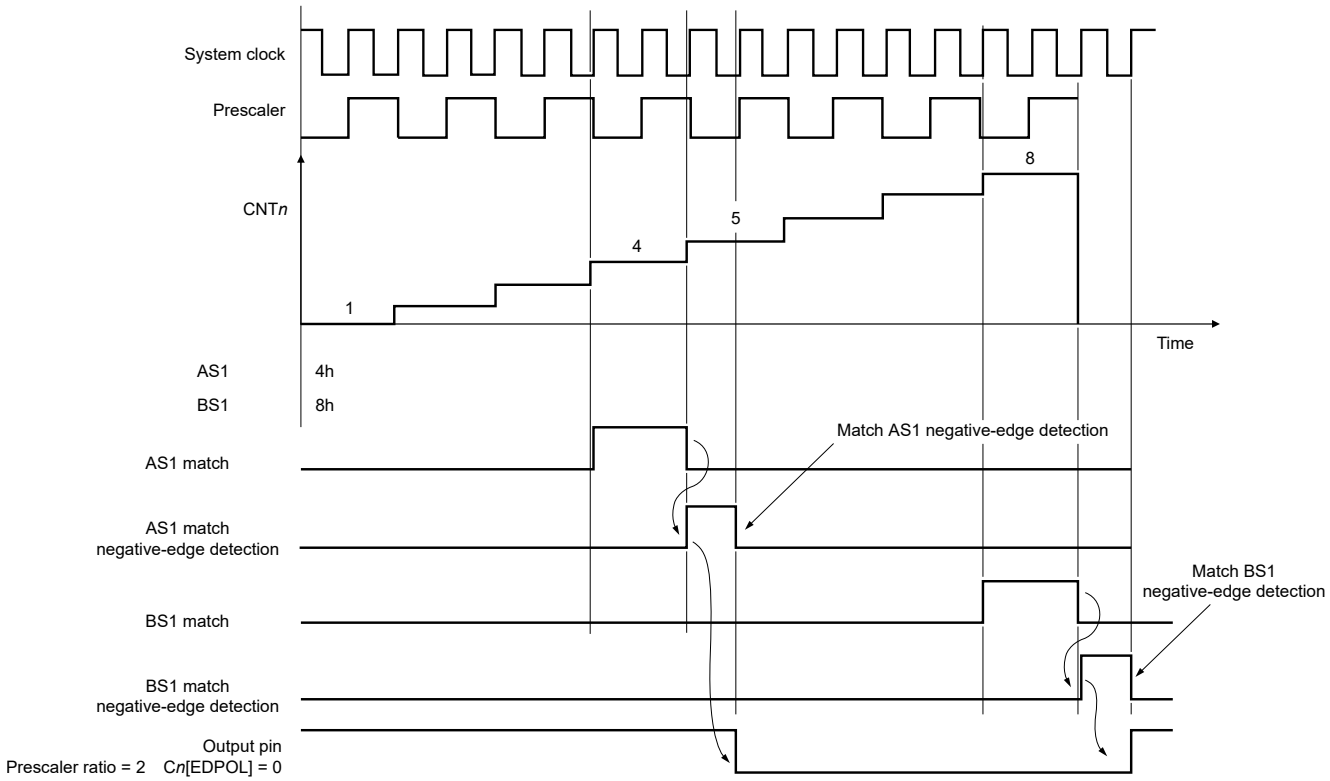


Figure 391. Timing example: AS1 and BS1 match

63.5.3.20.6 0% duty cycle

Timing example: AS1 = 0 illustrates the generated output signal when AS1 = 0, which results in a 0% duty cycle.

Because the internal counter never reaches zero in this situation, the UC infers a match as if AS1 = 1h. However, it is the positive edge of the match signal that triggers the output pin transition instead of the negative edge, which is what happens when AS1 = 1h. The AS1 positive-edge match signal from period *n*+1 occurs at the same time as the BS1 negative-edge match signal from period *n*. This timing allows the AS1 positive-edge match to mask the BS1 negative-edge match when they occur at the same time. As a result, no transition occurs on the output flip-flop and the UC generates a 0% duty cycle.

63.5.3.20.7 Timing example: AS1 = 0

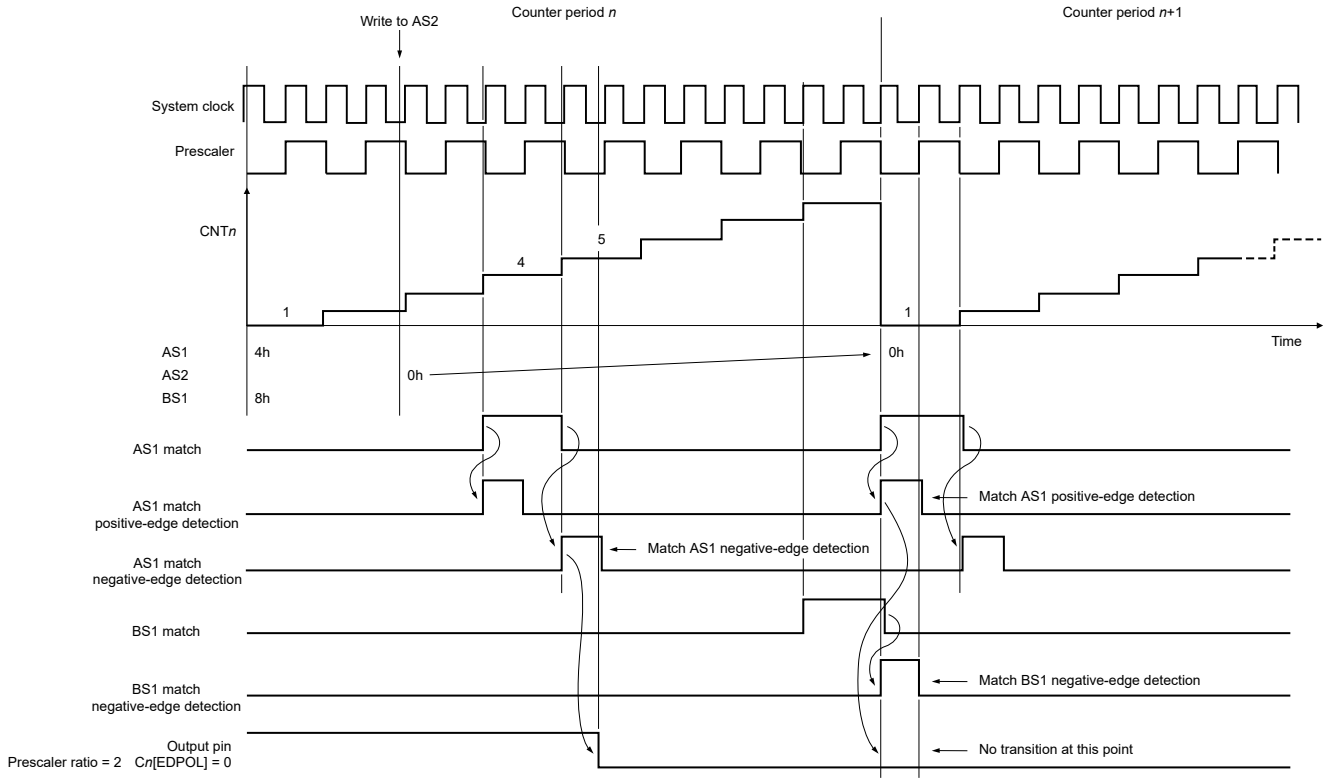


Figure 392. Timing example: AS1 = 0

63.5.3.20.8 Loading AS1 and BS1

As illustrated in Timing example: AS1 and BS1 update and FLAGs, AS1 and BS1 both use the same signal, generated at the last system clock cycle of a counter period. Therefore, eMIOS updates AS1 and BS1 with AS2 and BS2 values, respectively, at the same time that it changes the internal counter (CNT*n*[C]) to 1h. This event is the counter period boundary. The load signal pulse lasts for one system clock cycle. If you write AS2 and BS2 within counter period *n*, their values are available in AS1 and BS1, respectively, at the first clock cycle of counter period *n*+1. The UC then uses these new values for matches at counter period *n*+1. You can use Output Update Disable (OUDIS) to delay updating AS1 and BS1 for synchronization purposes.

63.5.3.20.9 Timing example: AS1 and BS1 update and FLAGs

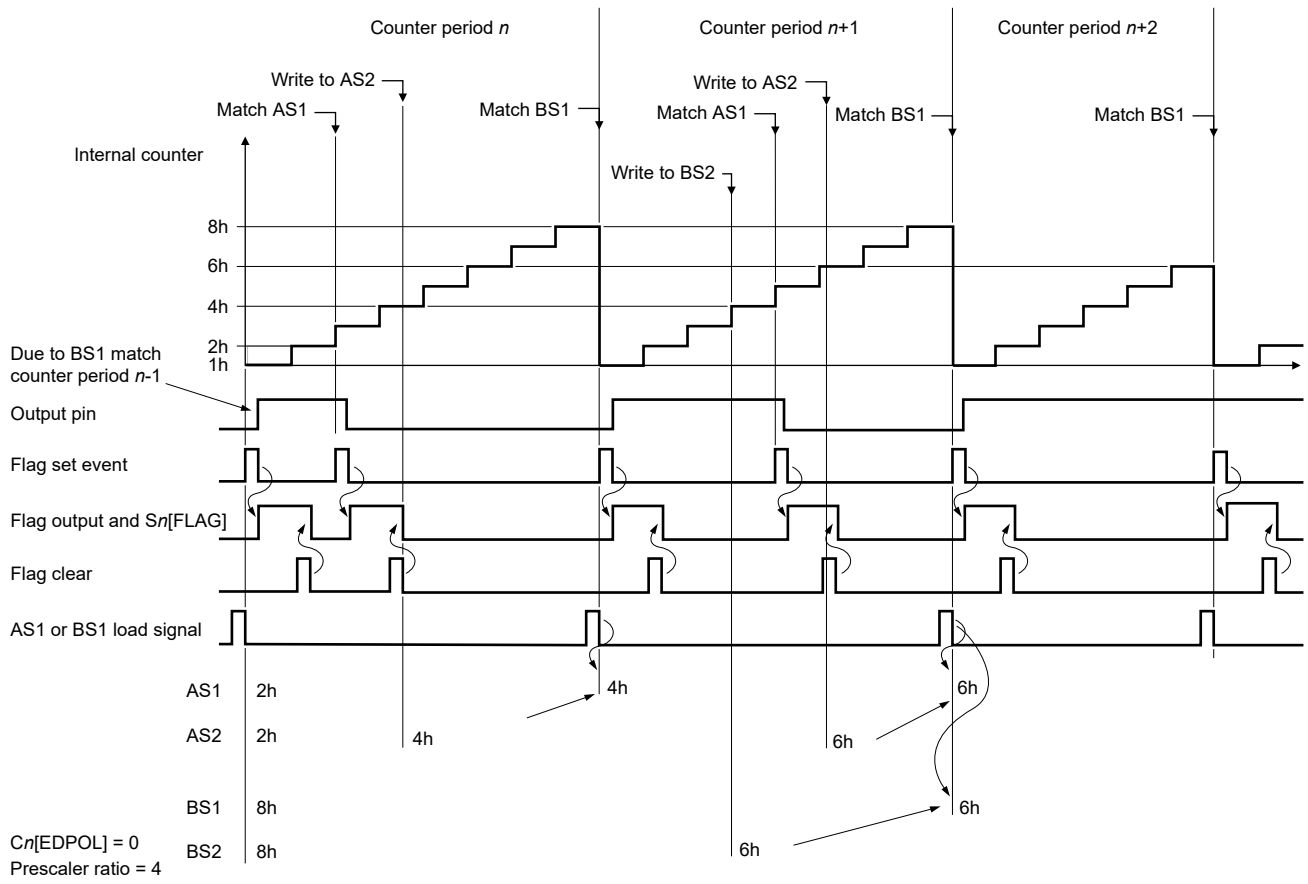


Figure 393. Timing example: AS1 and BS1 update and FLAGs

63.5.3.20.10 Flag generation

Timing example: AS1 and BS1 update and FLAGs assumes that both the channel and global prescalers are 1h (divide ratio of 2), causing the internal counter to transition every four system clock cycles. You can configure flags to be generated only on BS1 matches when bit 1 of C*n*[MODE] is 0, or on both AS1 and BS1 matches when that bit is 1. Because the BS1 flag occurs at the period boundary, you can use this flag to indicate that the AS2 or BS2 data written in period *n* has been loaded to AS1 or BS1, respectively, thereby generating matches in period *n*+1. Flag operation is synchronous, which means the flag sets one system clock cycle after the set-flag event.

63.5.3.20.11 Output disable

As illustrated in Timing example: active output disabled, the output-disable feature in OPWFMB mode forces the channel output flip-flop to the value of C*n*[EDPOL]. This functionality supports applications that use active-high signals and a high-to-low transition at an AS1 match. In this case, you must write 0 to C*n*[EDPOL]. You also must configure the internal counter to transition on every system clock cycle (write 0 to both GCP and CP).

The output-disable feature operates synchronously, meaning that the assertion of the Output Disable input signal causes the channel output flip-flop to transition to C*n*[EDPOL] at the next system clock cycle. If the Output Disable input pin deasserts, the output-signal transition occurs at the next AS1 or BS1 match.

Timing example: active output disabled assumes that the Output Disable input is enabled (using C*n*[ODIS]) and selected (using C*n*[ODISSL]). See UC Control n (C0 - C23) for a detailed description of the ODIS and ODISSL fields that enable and select the Output Disable inputs, respectively.

63.5.3.20.12 Timing example: active output disabled

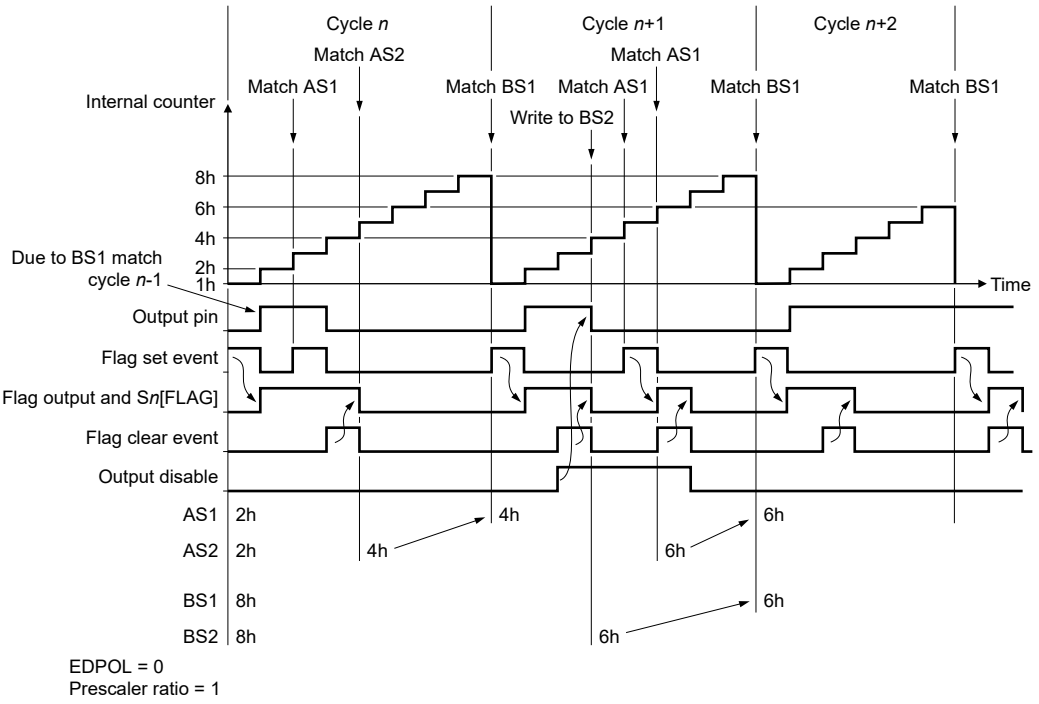


Figure 394. Timing example: active output disabled

63.5.3.20.13 Force match

Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to a match on comparators A or B, respectively. Similarly to a BS1 match, Force Match B changes the internal counter to 1h. The force-match operations do not set the input-capture flag (S*n*[FLAG]).

63.5.3.20.14 100% and 0% duty cycles

Timing example: from 100% to 0% duty cycle illustrates the generation of 100% and 0% duty-cycle signals. Initially, AS1 = 8h and BS1 = 8h. In this case, a BS1 match has precedence over an AS1 match—therefore, the output flip-flop acquires the complement of C*n*[EDPOL]. This configuration corresponds to a 100% duty-cycle signal. The same output signal can be generated for any AS1 value greater than or equal to BS1.

If AS1 is 0, the UC generates a 0% duty-cycle signal. In this case, the BS1 = 8h match from period 8 occurs at the same time as the AS1 = 0h match from period 9. See Timing example: AS1 = 0 for AS1 and BS1 match generation. In this case, an AS1 match has precedence over a BS1 match, and the output signal transitions to C*n*[EDPOL].

63.5.3.20.15 Timing example: from 100% to 0% duty cycle

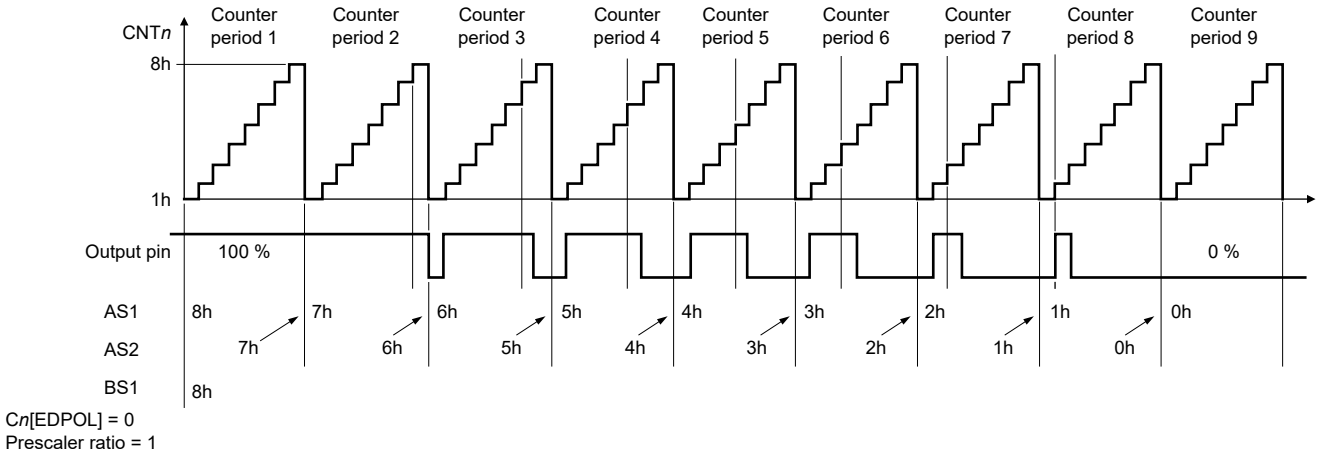


Figure 395. Timing example: from 100% to 0% duty cycle

63.5.3.21 Center Aligned Output PWM with Dead Time Insertion (OPWMC) mode

63.5.3.21.1 Overview

This mode generates a center-aligned PWM pulse with dead time insertion in the leading or trailing edge. See OPWMC functions and MODE field values.

When the UC enters OPWMC mode from GPIO mode:

- The UC drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.
- Select the timebase using Bus Select (C*n*[BSL]).
- The counter bus you select must be running an Up Count-Down Count timebase. See Timing example: Up Count-Down Count submode.
- Store the ideal duty cycle for the PWM signal in AS1 (write to A*n*[A]), which the UC compares with the selected timebase.
- Store the dead time value in BS1 (write to B*n*[B]), which the UC compares with the internal counter (CNT*n*[C]).
- You must ensure that BS1 is greater than AS1.

The internal counter may use the internal prescaler ratio, while the selected timebase may use a different prescaler ratio.

See Leading edge dead time insertion and Timing example: leading dead time insertion.

See Trailing edge dead time insertion and Timing example: trailing dead time insertion.

63.5.3.21.2 OPWMC functions and MODE field values

Table 350. OPWMC functions and MODE field values

Function	C*n*[MODE] (binary)
Trailing edge dead time insertion, with duty cycle determined by BS1 + AS1	001_11p0[1]
Leading edge dead time insertion, with duty cycle determined by BS1 - AS1	001_11p1[1]
Set the input-capture flag (S*n*[FLAG]) on the trailing edge of the PWM output	001_110p[1]
Set the input-capture flag (S*n*[FLAG]) on both edges of the PWM output	001_111p[1]

1. *p* = Adjust parameters for submodes and options. See Unified channels (UC).

63.5.3.21.3 Leading edge dead time insertion

When the first match between AS1 and the selected timebase occurs:

- The UC resets the internal counter to 0.
- The UC switches the selected timebase to the internal counter.

When a match between BS1 and the selected timebase occurs:

- The UC drives the value of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.
- The UC switches the timebase to the selected counter bus.

When the next match between AS1 and the selected timebase occurs, the UC drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

The UC repeats this process continuously.

See Timing example: leading dead time insertion.

63.5.3.21.4 Timing example: leading dead time insertion

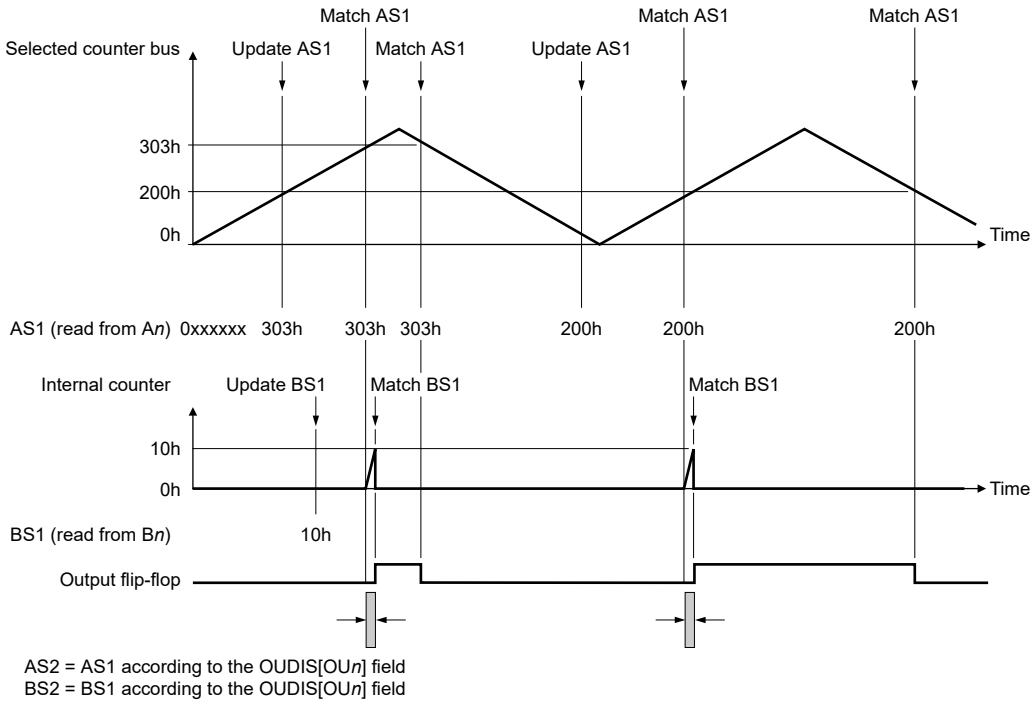


Figure 396. Timing example: leading dead time insertion

63.5.3.21.5 Trailing edge dead time insertion

When the first match between AS1 and the selected timebase occurs, the UC drives the value of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

When the next match between AS1 and the selected timebase occurs:

- The UC resets the internal counter to 0.
- The UC switches the selected timebase to the internal counter.

When a match between BS1 and the selected timebase occurs:

- The UC drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

- The UC switches the timebase to the selected counter bus.

The UC repeats this process continuously.

See Timing example: trailing dead time insertion.

63.5.3.21.6 Timing example: trailing dead time insertion

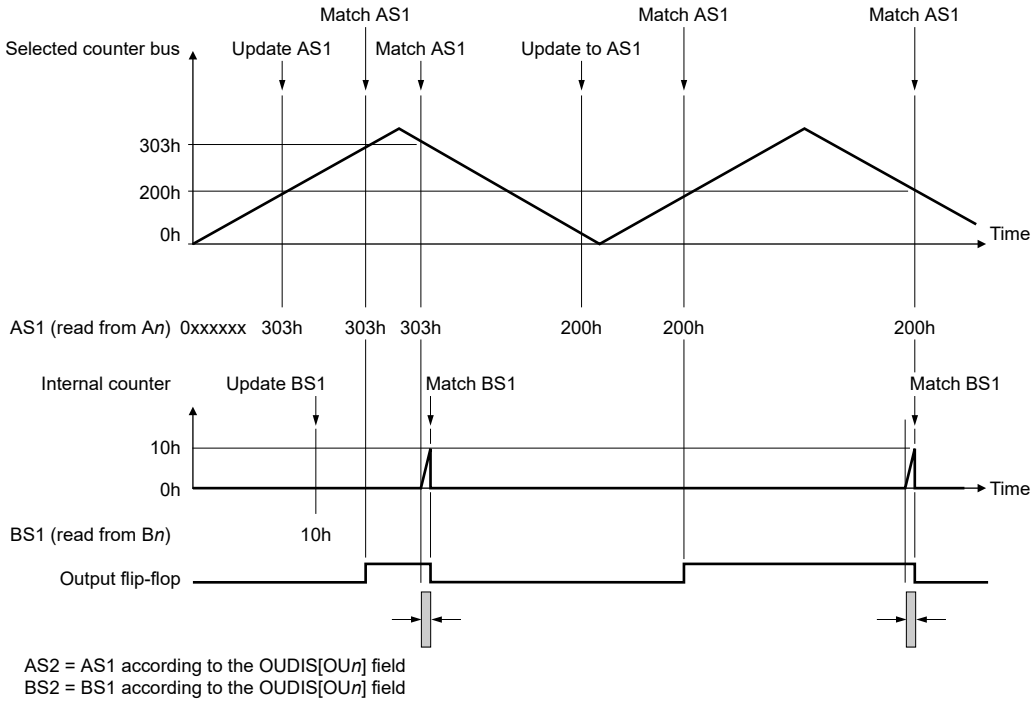


Figure 397. Timing example: trailing dead time insertion

63.5.3.21.7 Duty cycle

To generate a 100% duty cycle waveform, write the same non-zero value to both AS1 and BS1. When a simultaneous match occurs on AS1 and BS1:

- The UC drives the value of EDPOL (C*n*[EDPOL]) on the output flip-flop.
- The UC switches the selected timebase to the selected counter bus, allowing a new cycle to begin at any time.

To generate a 0% duty cycle waveform, write 0h to both AS1 and BS1. When a match occurs:

- The UC drives the complement of EDPOL (C*n*[EDPOL]) on the output flip-flop.
- The UC switches the selected timebase to the selected counter bus, allowing a new cycle to begin at any time.

Both of the above cases set the input-capture flag (S*n*[FLAG]) regardless of trailing or leading edge dead time insertion operation.

63.5.3.21.8 Force match

Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to a match on comparators A or B, respectively. If subsequent matches occur on comparators A and B, the UC continues to generate PWM pulses.

In Freeze state, comparison matches do not occur, and therefore the only way to set the output flip-flop is through a Force Match operation.

The Force Match operations do not set the input-capture flag (S*n*[FLAG]).

63.5.3.22 Center Aligned Output PWM with Dead Time Insertion Buffered (OPWMCB) mode

63.5.3.22.1 Overview

In this mode, the UC generates a center-aligned PWM pulse with dead time insertion in the leading or trailing edge. See OPWMCB functions and MODE field values. AS1 and BS1 are double-buffered to allow smooth output signal generation when you change the AS2 or BS2 values.

When the UC enters OPWMCB mode from GPIO mode:

- The UC drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.
- Select the timebase using Bus Select (C*n*[BSL]). The timebase you select must be running in Up Count-Down Count mode. See Timing example: Up Count submode flag assertion. You must start the MCB timebase after the UC enters OPWMCB mode to avoid missing a match on the first duty cycle.
- Store the ideal duty cycle for the PWM signal in AS1 (write to A*n*[A]), which the UC compares with the selected timebase.
- Store the dead time value in BS1 (write to B*n*[B]), which the UC compares with the internal counter (CNT*n*[C]).

The internal counter may use the internal prescaler ratio, while the selected timebase may use a different prescaler ratio. The UC always resets the internal counter to 1h when an AS1 match occurs.

As in OPWMB and OPWFMB modes, the UC generates the match signal which compares the selected timebase with AS1 or BS1. When the UC deasserts the channel's combinational comparator output signal, it uses the match signal to assert or negate the channel's output flip-flop. See Timing example: AS1 and BS1 match for an illustration of the delay from match to output flip-flop transition in OPWFMB mode. The operation of OPWMCB mode is similar to OPWFMB mode with respect to match behavior and output pin transition.

See Entering OPWMCB mode.

63.5.3.22.2 OPWMCB functions and MODE field values

Table 351. OPWMCB functions and mode field values

Function	C*n*[MODE] (binary)
Insert trailing edge dead time with duty cycle determined by BS1 + AS1	101_11p0[1]
Insert leading edge dead time with duty cycle determined by BS1 – AS1	101_11p1[1]
Assert the input capture flag (Sn[FLAG]) on the trailing edge of the output PWM signal	101_110p[1]
Assert the input capture flag (Sn[FLAG]) on both edges of the output PWM signal	101_111p[1]

1. *p* = Adjust parameters for submodes and options. See Unified channels (UC).

63.5.3.22.3 Entering OPWMCB mode

To enter OPWMCB mode (this procedure assumes the channel is initially in GPIO mode):

1. Disable the GCP (write 0 to MCR[GPREN]).
2. For the timebase (MCB) channel:
    a. Disable the CP (write 0 to C*n*[UCPREN]).
    b. Initialize the internal counter (write 1h to CNT*n*[C]).
    c. Initialize the A data (write appropriate value to A*n*[A]).

d. Configure the UC for MCB Up Count-Down Count mode (write 101_01*xy*b to C*n*[MODE], where *x* = 0 for flag set on match start or *x* = 1 for flag set at period boundary, and *y* = 0 for internal clock source or *y* = 1 for external clock source).

e. Select the CP ratio (C*n*[UCPRE]).

f. Enable the CP (write 1 to C*n*[UCPREN]).

3. For the OPWMCB channel:

a. Disable the CP (write 0 to C*n*[UCPREN]).

b. Initialize the A data (write appropriate value to A*n*[A]).

c. Initialize the B data (write appropriate value to B*n*[B]).

d. Select the timebase input (C*n*[BSL]).

e. Configure the UC for MCB Up Count-Down Count mode (write 101_01*xy*b to C*n*[MODE], where *x* = 0 for flag set on match start or *x* = 1 for flag set at period boundary, and *y* = 0 for internal clock source or *y* = 1 for external clock source).

f. Select the CP ratio (C*n*[UCPRE]).

g. Enable the CP (write 1 to C*n*[UCPREN]).

4. Enable the GPC (write 1 to MCR[GPREN]).

63.5.3.22.4 Timing example: AS1 and BS1 load

When the selected counter bus transitions from 2h to 1h:

- The UC loads AS1 and BS1 as shown in the following figure.
- This event defines the counter period boundary.

The UC loads the values you write to AS2 or BS2 within period *n* into AS1 or BS1, respectively, and uses them to generate matches in period *n*+1.

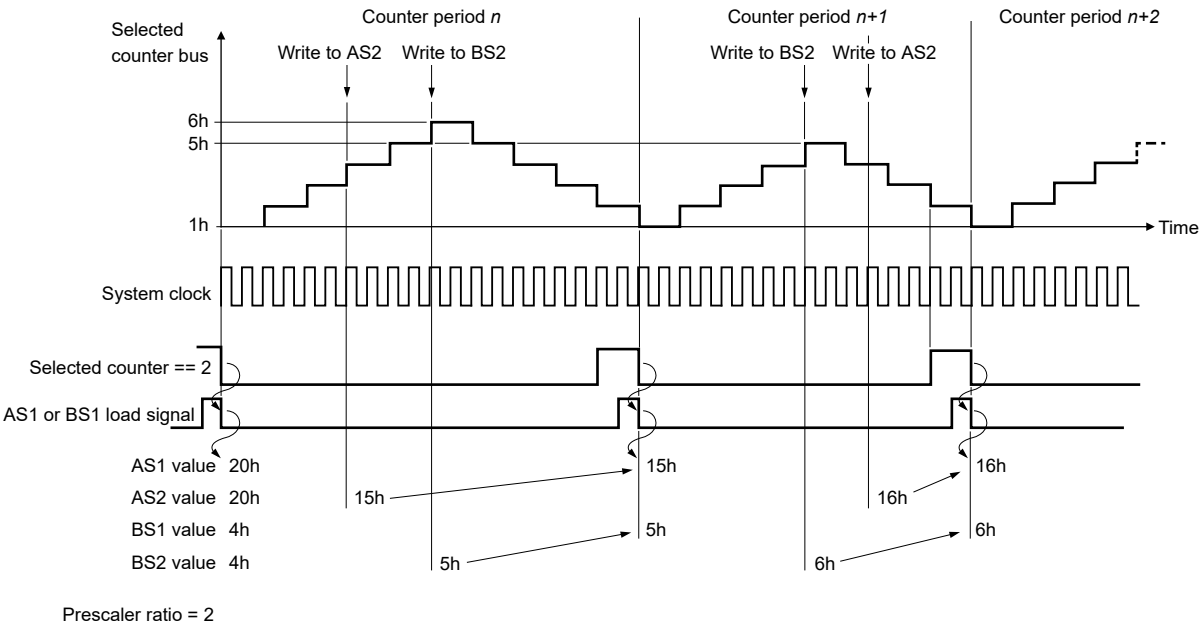


Figure 398. Timing example: AS1 and BS1 load

63.5.3.22.5 Operation sequence with leading edge dead time insertion

When operating with leading edge dead time insertion:

1. When the first AS1 match occurs, the UC writes 1h to the internal counter.
2. When a match between BS1 and the internal timebase occurs, the UC drives the value of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.
3. When the next match between AS1 and the selected timebase occurs, the UC drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

The UC repeats the above sequence continuously.

You must not allow the internal counter to reach 0h as the result of a rollover. To avoid this, you must not write a value greater than

2 x ((external Count Up limit) – A*n*[A])

into B*n*[B].

See Timing example: leading dead time insertion.

63.5.3.22.6 Timing example: leading dead time insertion

This example illustrates two cycles of a center-aligned PWM signal. AS1 and BS1 values change within the same period, which allows you to change the duty cycle and dead time values at the same time.

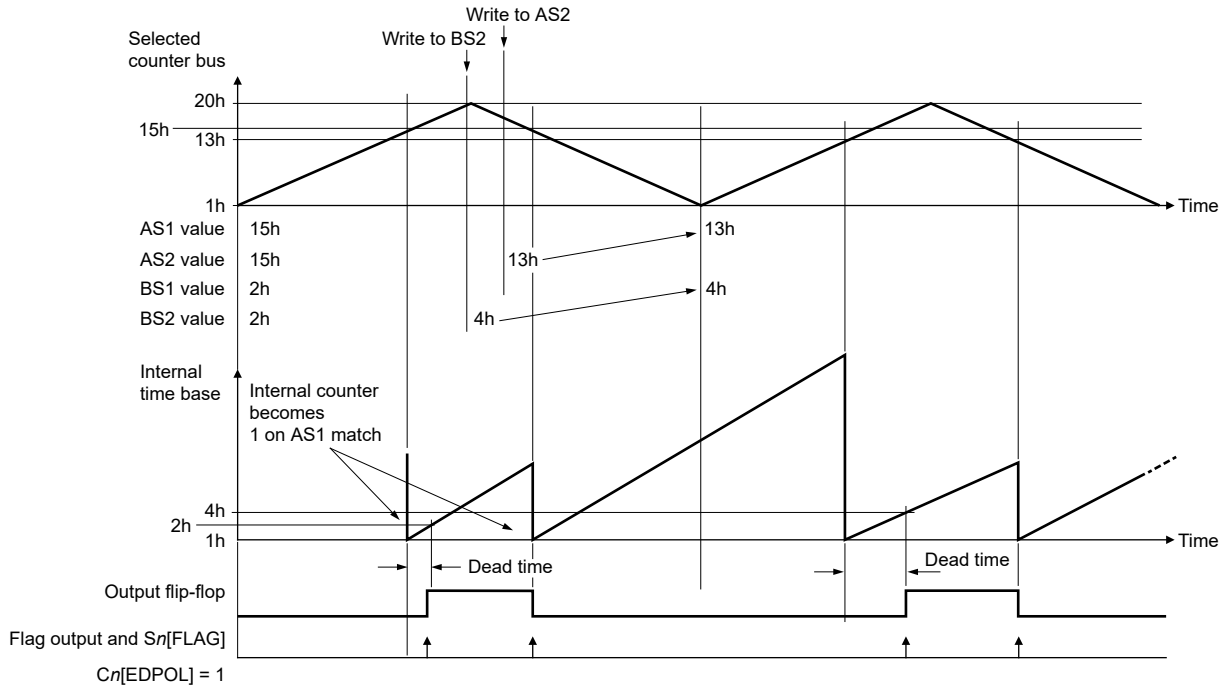


Figure 399. Timing example: leading dead time insertion

63.5.3.22.7 Operation sequence with trailing edge dead time insertion

When operating with trailing edge dead time insertion:

1. When the first match between AS1 and the selected timebase occurs, the UC:
   a. Drives the value of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.
   b. Writes the internal counter (CNT*n*[C]) to 1h.
2. When the second match between AS1 and the selected timebase occurs, the UC:

a. Writes the internal counter to 1h.

b. Enables BS1 matches.

3. When a match between BS1 and the selected timebase occurs, the UC drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

The UC repeats this sequence continuously.

63.5.3.22.8 Timing example: trailing dead time insertion

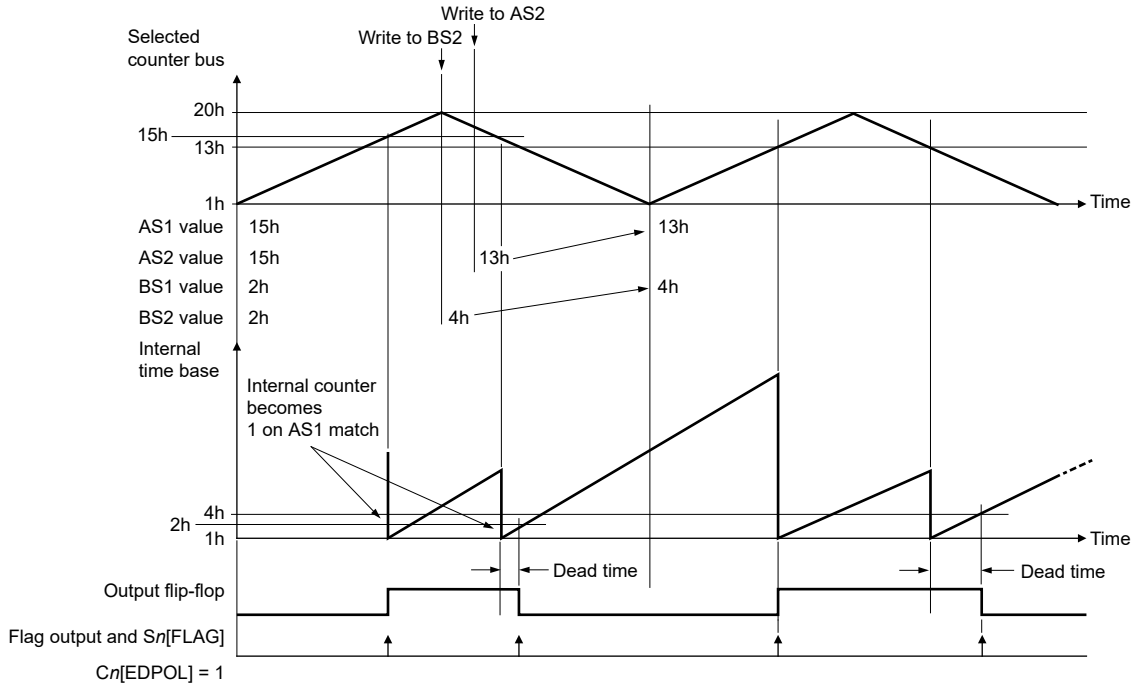


Figure 400. Timing example: trailing dead time insertion

63.5.3.22.9 Force match

Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to a match on comparators A or B, respectively. If subsequent matches occur on comparators A and B, the UC continues to generate PWM pulses regardless of the input capture flag (S*n*[FLAG]). The force-match operations do not set the input-capture flag (S*n*[FLAG]).

When you select leading edge dead time insertion:

- Force Match A drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.
- Force Match B drives the value of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

When you select trailing edge dead time insertion:

- Force Match A drives the value of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.
- Force Match B drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

Force Match operation does not write 1h to the internal timebase.

Force Match operation does not set the input-capture flag.

When you assert Force Match A and Force Match B at the same time, the UC drives the complement of Edge Polarity (C*n*[EDPOL]) on the output flip-flop. This is the equivalent of saying that Force Match A has precedence over Force Match B when you select

leading edge dead time insertion, and Force Match B has precedence over Force Match A when you select trailing edge dead time insertion.

Force Match A and Force Match B have the same output transition behavior in both Freeze state and unfrozen state.

63.5.3.22.10 Duty cycle

You generate a duty cycle from 0% to 100% by writing appropriate values to AS1 and BS1 relative to the period of the external timebase.

To generate a 100% duty cycle waveform:

- Select trailing edge dead time insertion (see OPWMCB functions and MODE field values).
- Write 1h to Edge Polarity (C*n*[EDPOL]).
- The BS1 match must occur on or after the counter period boundary (external counter = 1).

You can also generate a 100% duty cycle waveform by writing 1h to AS1. However, if you do this before the UC enters OPWMCB mode, a 100% duty cycle may not occur in the first PWM period depending upon the pin state at mode entry.

To generate a 0% duty cycle waveform:

- AS1 must be greater than the maximum value of the selected counter period.
- The pin must start the current period with the complement value of Edge Polarity (C*n*[EDPOL]). If starting at 100% duty cycle, you can change Edge Polarity (C*n*[EDPOL]) to its complement by forcing the pin (see Force match).

You must write only non-zero values to AS1. If you write the maximum value of the external counter given by

(external counter period)/2

to AS1, the UC constantly drives the value of Edge Polarity (C*n*[EDPOL]) on the output flip-flop.

UC logic prevents matches from one period propagating to the next period. In trailing edge dead time insertion, the UC masks out BS1 matches that occur late in period *n*, so matches in period *n*+1 are unaffected and the output flip-flop does not transition.

63.5.3.22.11 Timing example: duty cycle

To generate a 100% duty cycle output waveform, write 4h to AS1 and 3h to BS1, as illustrated in this diagram. In this case, the trailing edge is at the boundary of counter period *n*+1, which actually belongs to period *n*+2 and therefore does not cause the output flip-flip to transition.

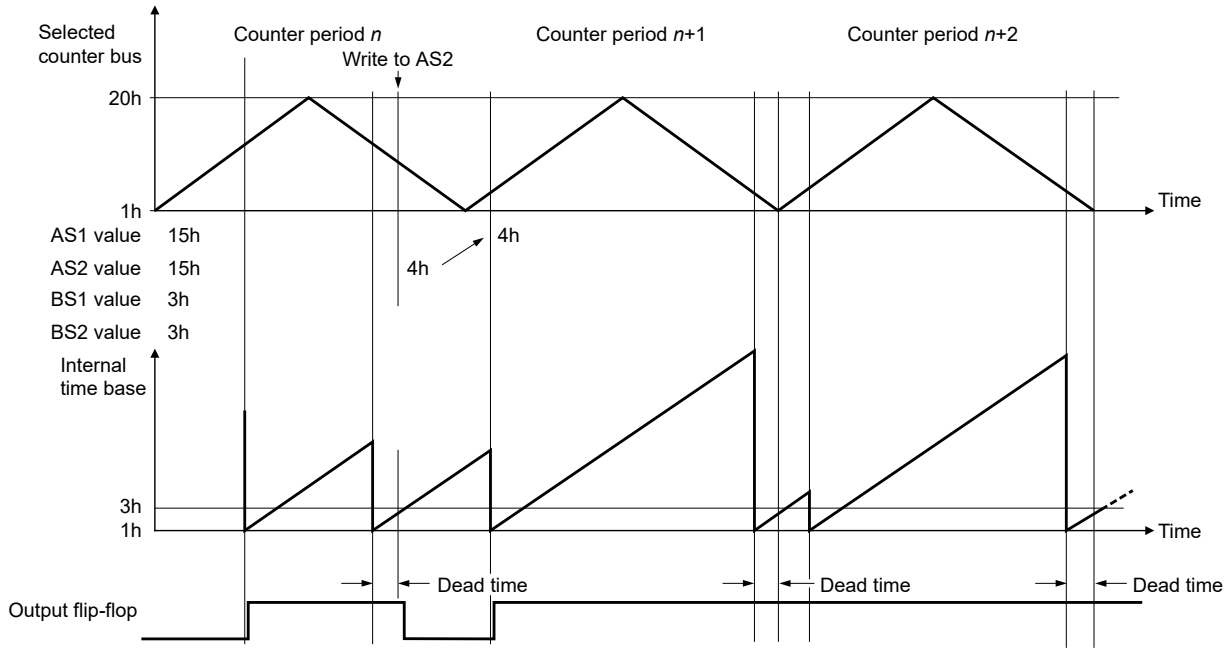


Figure 401. Timing example: duty cycle

63.5.3.22.12 Output disable

You can use Output Update Disable (write 0 to OUDIS[OU*n*]) to disable AS1 and BS1 updates. This allows you to update AS1 and BS1 in the same counter period and synchronize the loading of these registers with the loading of AS1 or BS1 in other channels.

Asserting Output Update Disable drives the complement of Edge Polarity (C*n*[EDPOL]) on output flip-flop. The internal channel matches continue to occur, and therefore the UC continues to set flags.

When you deassert Output Update Disable, the output flip-flop is again controlled by AS1 and BS1 matches. The UC transitions the output flip-flop only on system clock edges.

63.5.3.23 Output PWM (OPWM) mode

63.5.3.23.1 Overview

In this mode, the UC produces an output PWM pulse for which:

- AS1 defines the leading edge.
- BS1 defines the trailing edge.

See OPWM submodes and MODE field values for the values that you must write to C*n*[MODE] to enter this mode.

The UC compares the AS1 value with the value of the selected timebase. When a match on comparator A occurs, the output flip-flop acquires the value of C*n*[EDPOL]. When a match occurs on comparator B, the output flip-flop acquires the complement of C*n*[EDPOL].

Depending on the OPWM submode, eMIOS sets the input-capture flag on match B, or on either match A or match B. See OPWM submodes and MODE field values.

When the UC enters OPWM mode, the output flip-flop acquires the complement of C*n*[EDPOL].

Timing example: immediate update and Timing example: next-period update show the UC running in OPWM mode with immediate update and next-period update, respectively.

63.5.3.23.2 OPWM submodes and MODE field values

Table 352. OPWM submodes and MODE field values

When BS2→BS1 transfer occurs	When FLAG generation occurs	C*n*[MODE] (binary)
Immediately (resulting in the fastest change of the duty cycle); see Timing example: immediate update	When match B occurs	010_0000
	When match A or match B occur	010_0010
Whenever AS1 matches the selected counter; see Timing example: next-period update	When match B occurs	010_0001
	When match A or match B occur	010_0011

63.5.3.23.3 Force match

Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to a match on comparators A or B, respectively. If subsequent matches occur on comparators A and B, the UC continues to generate PWM pulses regardless of the input capture flag (S*n*[FLAG]). The force-match operations do not set the input-capture flag (S*n*[FLAG]).

63.5.3.23.4 Duty cycle

To generate a waveform with 100% duty cycle, write the same nonzero value to AS1 and BS1. When a simultaneous match occurs on comparators A and B, the UC drives C*n*[EDPOL] on the output flip-flop at every period.

To generate a waveform with 0% duty cycle, write 0h to AS1. When a match occurs, the UC drives the complement of C*n*[EDPOL] on the output flip-flop at every period. Bit 0 of C*n*[MODE] still controls when the BS2→BS1 transfer occurs.

NOTE

If AS1 = BS1 = 0h, the UC produces a waveform with 0% duty cycle.

63.5.3.23.5 Timing example: immediate update

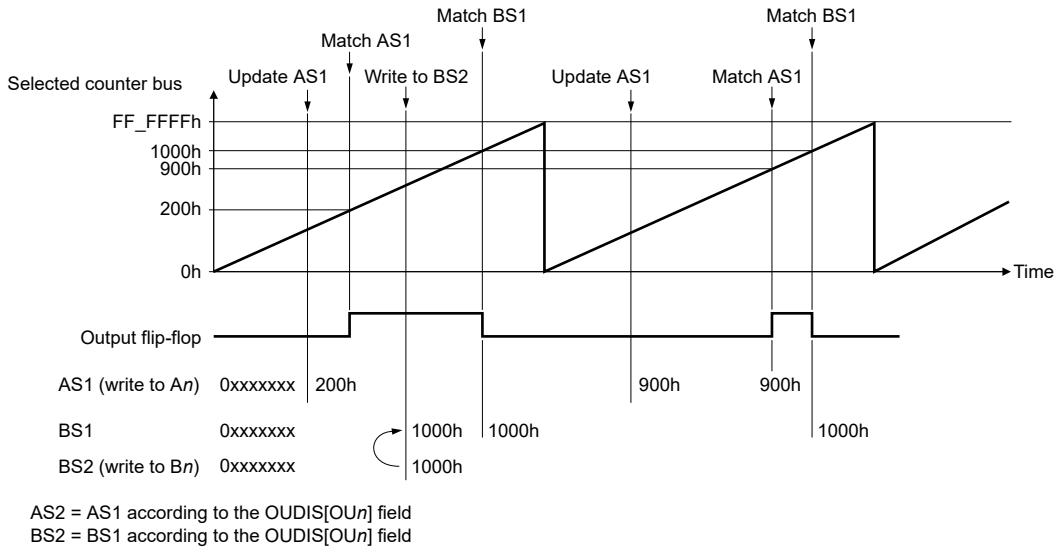


Figure 402. Timing example: immediate update

63.5.3.23.6 Timing example: next-period update

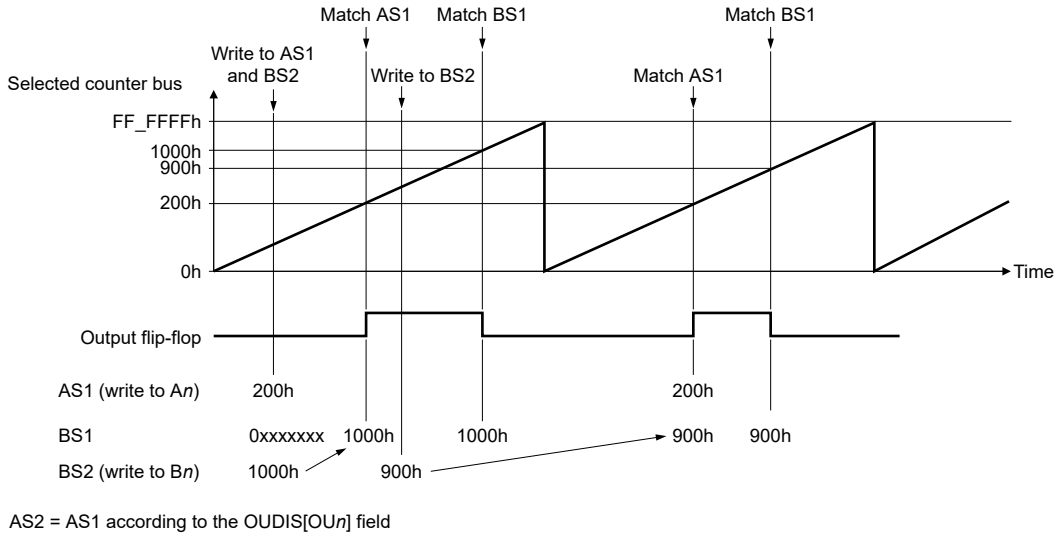


Figure 403. Timing example: next-period update

63.5.3.24 Output PWM Buffered (OPWMB) mode

63.5.3.24.1 Overview

In this mode, the UC produces PWM pulses with programmable leading and trailing edge placement. You must select an external counter driven in MCB Up mode from one of the counter buses. AS1 and BS1 define the first and second edges, respectively. C*n*[EDPOL] defines the output signal polarity. If C*n*[EDPOL] = 0, a negative edge occurs when AS1 matches the selected counter bus and a positive edge occurs when BS1 matches the selected counter bus.

See OPWMB submodes and MODE field values for the values that you must write to C*n*[MODE] to enter this mode.

AS1 and BS1 are double-buffered and updated from AS2 and BS2, respectively, at the cycle boundary. The load operation is similar to the one that occurs in OPWFMB mode. See Timing example: AS1 and BS1 update and FLAGs for more information about AS1 and BS1 updates.

When the UC enters OPWMB mode, the UC drives C*n*[EDPOL] on the output flip-flop.

These rules apply to OPWMB mode:

- If the AS1 and BS1 matches occur at the same time within the same counter period, the BS1 match has precedence over the AS1 match.
- An AS1 = 0 match in period *n* has precedence over a BS1 match in period *n*-1.
- The UC masks out AS1 matches if they occur after a BS1 match within the same period.
- The UC loads any value that you write to AS2 or BS2 in period *n* into AS1 and BS1 at the following period boundary (assuming that the corresponding OU*n* field of Output Update Disable (OUDIS) is 0). Therefore, the UC uses the new values for AS1 and BS1 matches in period *n*+1.

Timing example: 100% to 0% duty cycle illustrates a waveform changing from 100% to 0% duty cycle. In this example, BS1 is programmed to the same value as the period of the external selected timebase. If you write a value smaller than 8h to BS1, you cannot achieve a 0% duty cycle by only changing AS1. Because BS1 matches have precedence over AS1 matches, the flag output transitions to the complement of C*n*[EDPOL] at a BS1 match. For another example, if you write 9h to BS1, a BS1 match does not occur, and the UC generates a 0% duty-cycle signal.

63.5.3.24.2 OPWMB submodes and MODE field values

Table 353. OPWMB submodes and MODE field values

When FLAG generation occurs	C*n*[MODE] (binary)
At a BS1 match	110_0000
At an AS1 or BS1 match	110_0010

63.5.3.24.3 Force match

Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to a match on comparators A or B, respectively. If subsequent matches occur on comparators A and B, the UC continues to generate PWM pulses regardless of the input capture flag (S*n*[FLAG]). The force-match operations do not set the input-capture flag (S*n*[FLAG]).

63.5.3.24.4 Matches and flag operation

Timing example: matches and flags illustrates the operation of OPWMB mode with an emphasis on AS1 and BS1 matches and the transition of the channel output pin. The output pin transitions are based on the negative edges of the AS1 and BS1 match signals. AS1 becomes zero in period *n*+1. In this case, the UC uses the match positive edge instead of the negative edge to transition the output flip-flop.

63.5.3.24.5 Timing example: matches and flags

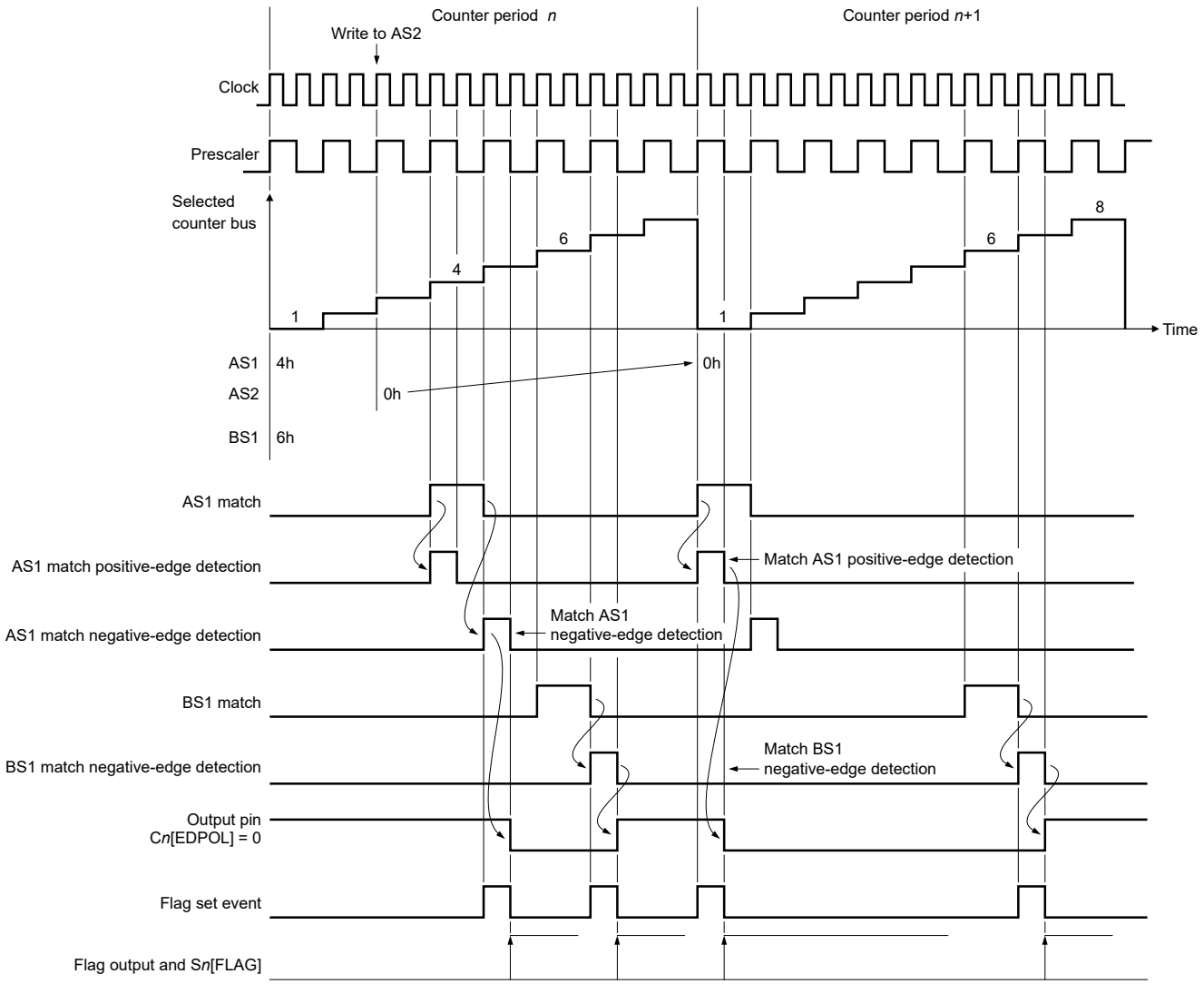


Figure 404. Timing example: matches and flags

63.5.3.24.6 0% duty cycle

Timing example: 0% duty cycle illustrates the channel operation for a 0% duty cycle. The AS1 match positive-edge signal occurs at the same time as the BS1 = 8h negative-edge signal. In this case, the AS1 match has precedence over the BS1 match, causing the output pin to remain at the value of C*n*[EDPOL] and generating a 0% duty-cycle signal.

63.5.3.24.7 Timing example: 0% duty cycle

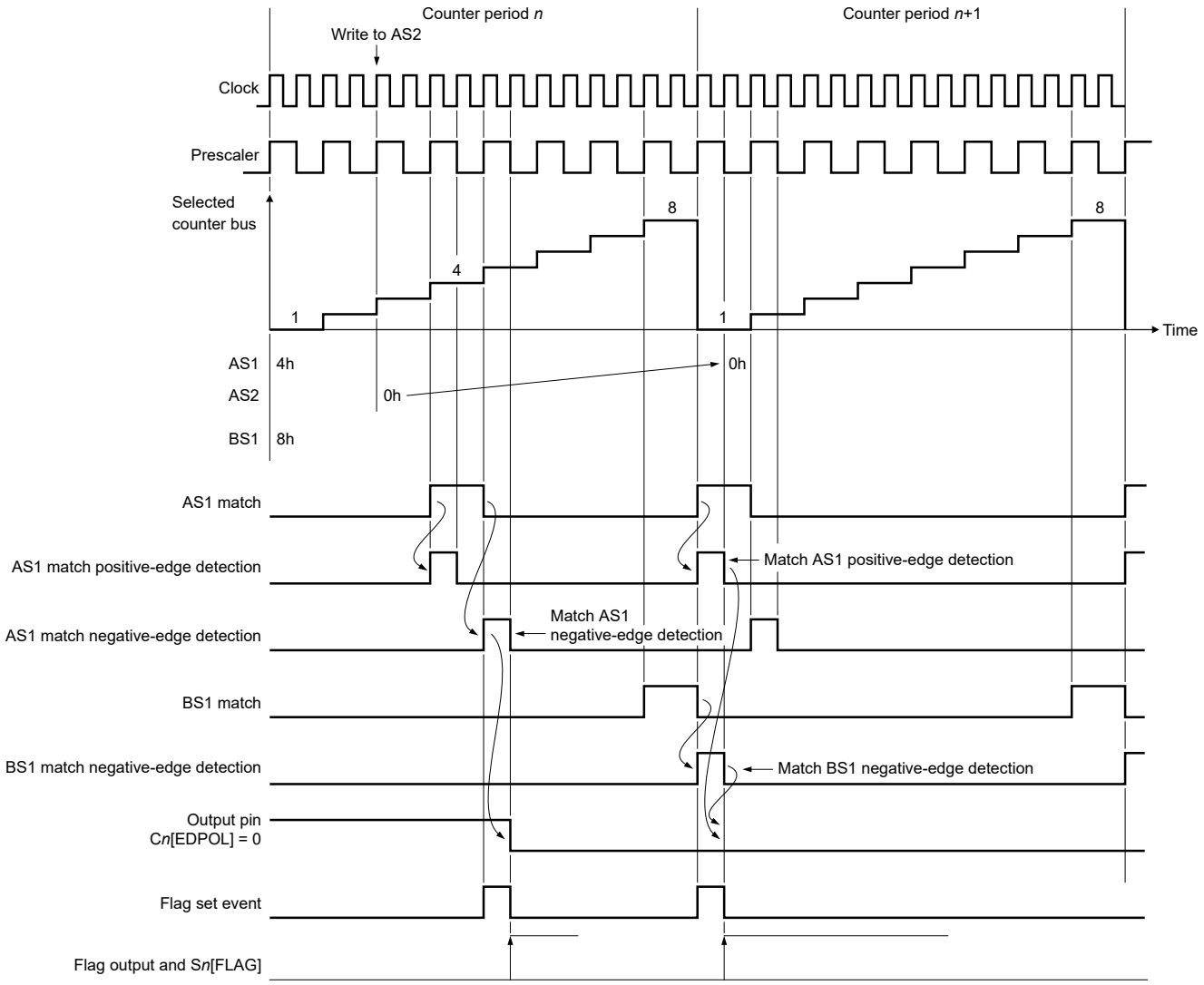


Figure 405. Timing example: 0% duty cycle

63.5.3.24.8 Active output disabled

Timing example: active output disabled illustrates the operation of the OPWMB mode with an emphasis on the assertion of the output-disable signal. The output disable forces a transition in the output pin to the value of C*n*[EDPOL]. The deassertion of the output-disable signal allows the output pin to transition at the following AS1 or BS1 match. The output disable does not modify the behavior of S*n*[FLAG]. A delay of one system clock cycle exists between the assertion of the output-disable signal and the transition of the output pin to C*n*[EDPOL].

63.5.3.24.9 Timing example: active output disabled

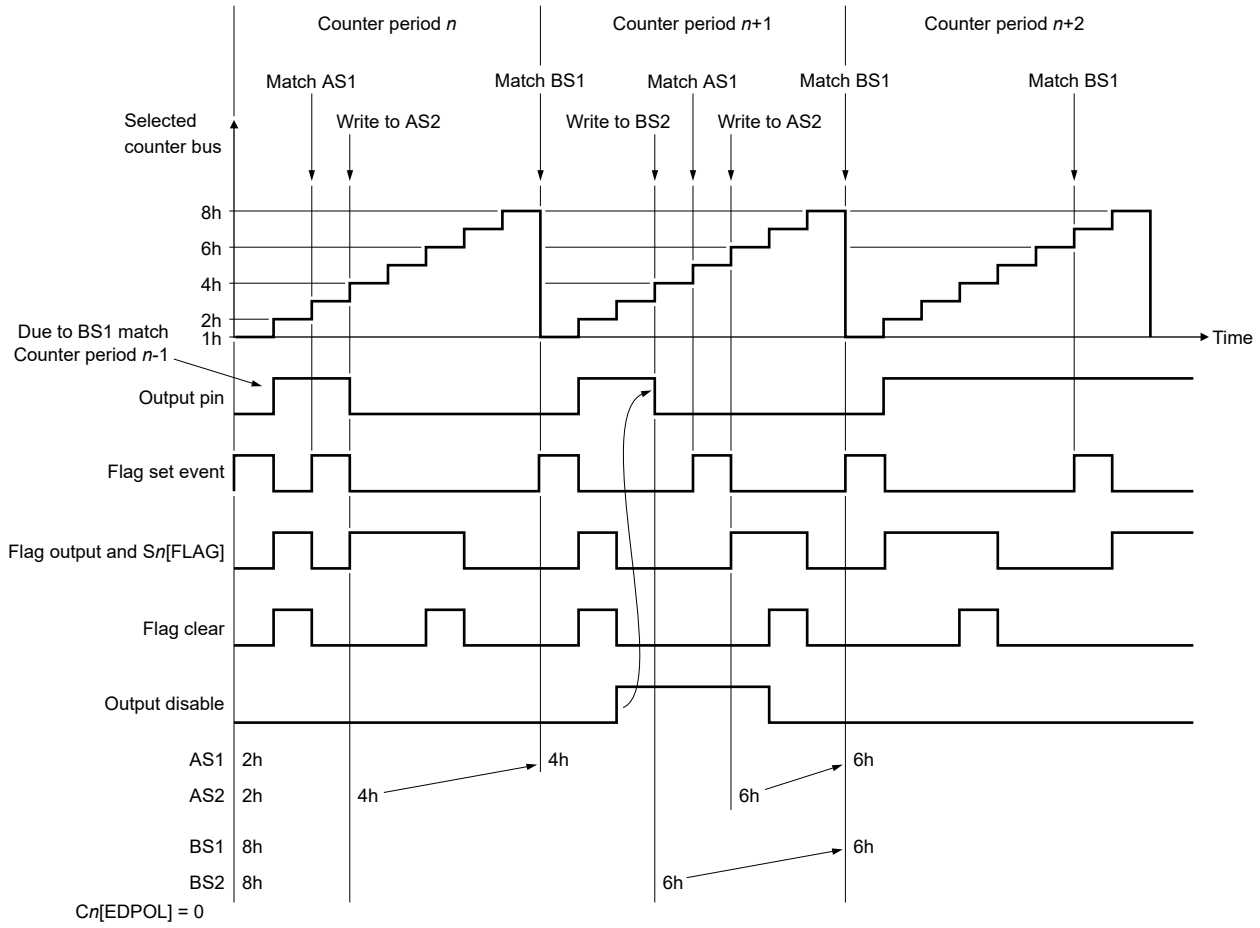


Figure 406. Timing example: active output disabled

63.5.3.24.10 Changing from 100% to 0% duty cycle

Timing example: 100% to 0% duty cycle illustrates a waveform changing from 100% to 0% duty cycle. In this example, BS1 has the same value as the period of the external selected timebase. If you write a value smaller than 8h to BS1, you cannot achieve a 0% duty cycle by only changing AS1. Because BS1 matches have precedence over AS1 matches, the output pin transitions to the complement of C*n*[EDPOL] at a BS1 match. For another example, if you write 9h to BS1, a BS1 match does not occur, and the UC generates a 0% duty-cycle signal.

63.5.3.24.11 Timing example: 100% to 0% duty cycle

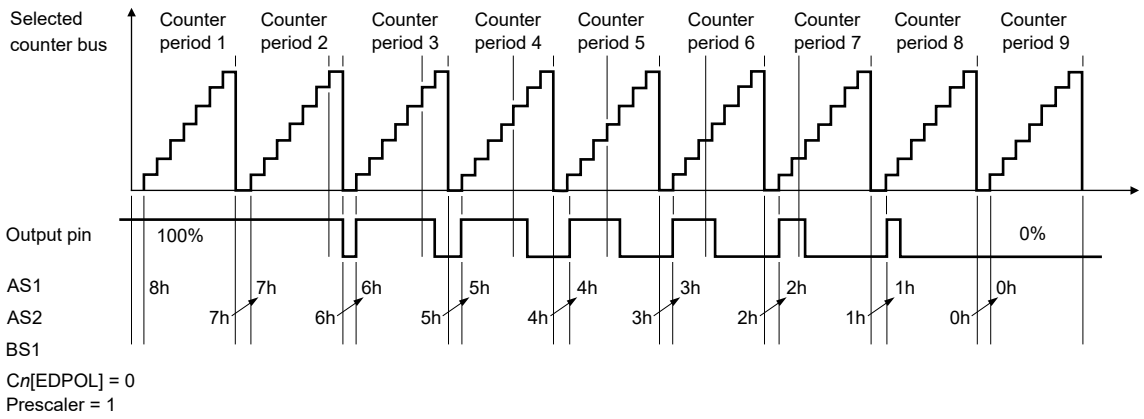


Figure 407. Timing example: 100% to 0% duty cycle

63.5.3.25 Output PWM with Trigger (OPWMT) mode

63.5.3.25.1 Overview

In this mode, the UC generates PWM pulses where the period does not change while the UC outputs the signal, but the duty cycle changes. When the duty cycle changes, it must not create glitches. The mode supports multiple UCs executing in the same mode and sharing a common timebase. Each UC can have a fixed PWM leading-edge position with respect to the other UCs. It can also generate a trigger signal at any point in the period. eMIOS can output this trigger signal to initiate activity in other parts of the chip—for example, to start ADC conversions.

You must select an external counter, driven in either MC Up or MCB Up mode (see Modulus Counter Buffered (MCB) mode), from one of the counter buses.

AS1 in OPWMT mode, AS2 in OPWMT mode, and BS1 and BS2 in OPWMT mode describe the configuration and behavior of the individual shadow registers in this mode.

To account for the shift in the AS1-defined leading edge of the waveform, the BS1-defined trailing edge may roll over into the next period. This means that a match against BS1 does not have to be qualified by a match in AS1. This also means that if you incorrectly write a value less than AS1 to BS1, the output persists over a period boundary until the UC encounters the BS1 value.

This mode provides a buffered update of the trailing edge by updating BS1 with BS2 contents only at a match of AS1.

The positive edges of the AS1, BS1, and AS2 match signals drive the output pin and flag transitions. See Timing example: matches and flags for details on positive-edge matches.

The UC sets the input capture flag (S*n*[FLAG]) only at an AS2 match. An AS1, BS1, or BS2 match has no effect on the flag.

When the UC enters OPWMT mode, it drives the complement of C*n*[EDPOL] on the output flip-flop.

Timing example: OPWMT illustrates the UC running in OPWMT mode with trigger-event generation and duty-cycle update after the next-period update.

63.5.3.25.2 Timing example: OPWMT

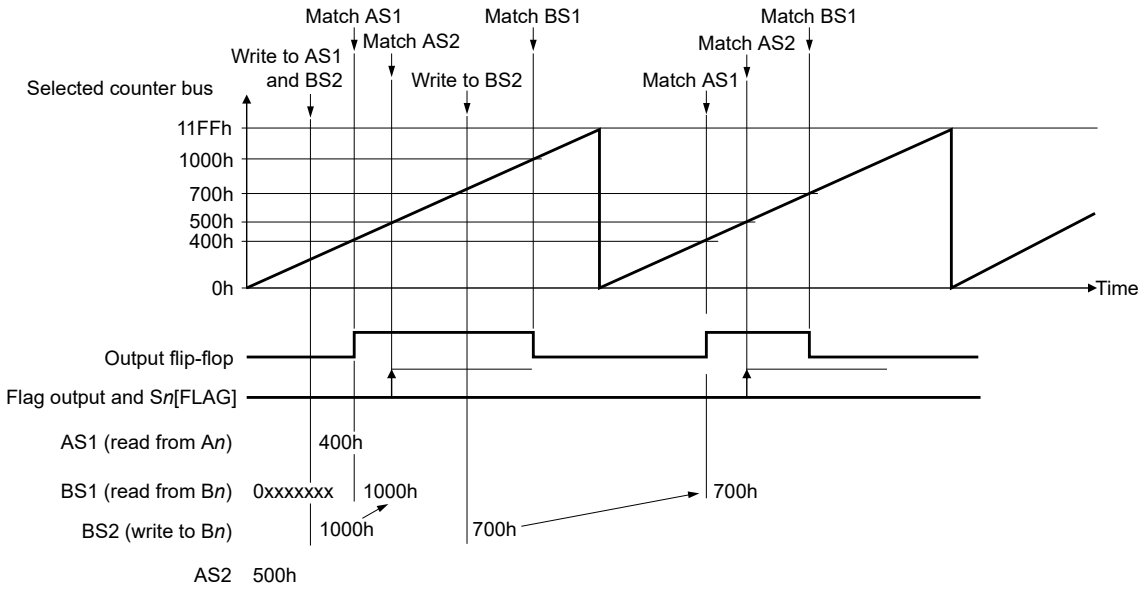


Figure 408. Timing example: OPWMT

63.5.3.25.3 AS1 in OPWMT mode

AS1 defines the leading edge of the PWM pulse output, and therefore the beginning of the PWM period. Using this fact, you can ensure that, when using a shared timebase, the leading edges of multiple UCs in OPWMT mode occur at specific times with respect to the other UCs. You can also introduce a fixed offset for each UC, which is particularly useful in the generation of lighting control signals. For this application, to reduce or eliminate noise generation, you can shift the PWM pulse of each UC with respect to the selected timebase by adjusting the AS1 value for each channel. The value you write to AS1 must be within the range of the selected timebase. Shadow registers (AS1, AS2, BS1, and BS2) loaded with 0h do not produce matches if the channel driving the timebase is in MCB mode.

AS1 is not buffered, because the shift of a PWM channel must not change while the UC generates the PWM signal. If you modify AS1, it updates immediately and one PWM pulse could be lost.

The UC compares AS1 to the selected timebase. When a match on AS1 occurs, the UC drives C*n*[EDPOL] on the output flip-flop. When a match occurs on comparator B, the UC drives the complement of C*n*[EDPOL] on the output flip-flop.

63.5.3.25.4 AS2 in OPWMT mode

AS2 defines the generation of a trigger event within the PWM period. The value you write to AS2 must be within the range of the selected timebase—otherwise the UC does not generate a trigger. A match on the comparator asserts the input-capture flag, but the match has no effect on the PWM output signal generation. The typical setup to obtain a trigger with a flag is to enable DMA and drive the DMA acknowledgement or DMA completion input high.

AS2 is not buffered, and therefore the UC updates it immediately. If the UC is running when you make a change, this could cause either of the following:

- The loss of one trigger event
- The generation of two trigger events within the same period

You access AS2 by reading or writing ALTA*n*[ALTA].

63.5.3.25.5 BS1 and BS2 in OPWMT mode

You access BS1 and BS2 using B*n*[B]:

- When you read B*n*[B], you read BS1.
- When you write to B*n*[B], you write to BS2.

BS1 defines the trailing edge of the PWM pulse output, and therefore the duty cycle of the PWM signal. To synchronize the BS1 update with the PWM signal and to ensure a correct output pulse generation, the BS2→BS1 transfer occurs at every AS1 match. This behavior is the same as in OPWM mode with next-period update.

Output Update Disable (OUDIS) affects transfers between BS2 and BS1 only.

63.5.3.25.6 Force match

At any time, Force Match A (C*n*[FORCMA]) and Force Match B (C*n*[FORCMB]) allow you to force the output flip-flop to the level corresponding to a match on AS1 or BS1, respectively. Similarly to a BS1 match, Force Match B changes the internal counter to 1h. The force-match operations do not set the input-capture flag (S*n*[FLAG]). Any match resulting from writing 1 to FORCMA or FORCMB has priority over any simultaneous match regarding output pin transitions. BS2→BS1 transfer at an A match is not inhibited by writing 1 simultaneously to both FORCMA or FORCMB. If you write 1 to both FORCMA and FORCMB simultaneously, the output pin acquires the complement of C*n*[EDPOL], as if AS1 and BS1 had the same value. FORCMA assertion causes the UC to process the BS2→BS1 transfer as a regular A match comparison and not due to FORCMA assertion, regardless of FORCMB assertion. If subsequent matches occur on comparators AS1 and B, the UC continues to generate PWM pulses, regardless of the state of S*n*[FLAG].

63.5.3.25.7 Duty cycle

To achieve 0% duty cycle, you must write the same value to AS1 and BS2. When a simultaneous match on comparators A and B occurs, the UC drives the complement of C*n*[EDPOL] on the output flip-flop at every period.

To achieve 100% duty cycle, you must write a value to BS1 that is greater than the maximum value of the selected timebase. The maximum counter value for the timebase is FF_FFFEh for a 24-bit counter and FFFEh for a 16-bit counter. When a match on comparator AS1 occurs, the UC drives C*n*[EDPOL] on the output flip-flop at every period. The match at comparator A still triggers the BS2→BS1 transfer.

Timing example: 0% duty cycle illustrates the UC running in OPWMT mode with trigger-event generation and a 0% duty cycle.

Timing example: 100% duty cycle illustrates the UC running in OPWMT mode with trigger-event generation and a 100% duty cycle.

63.5.3.25.8 Timing example: 0% duty cycle

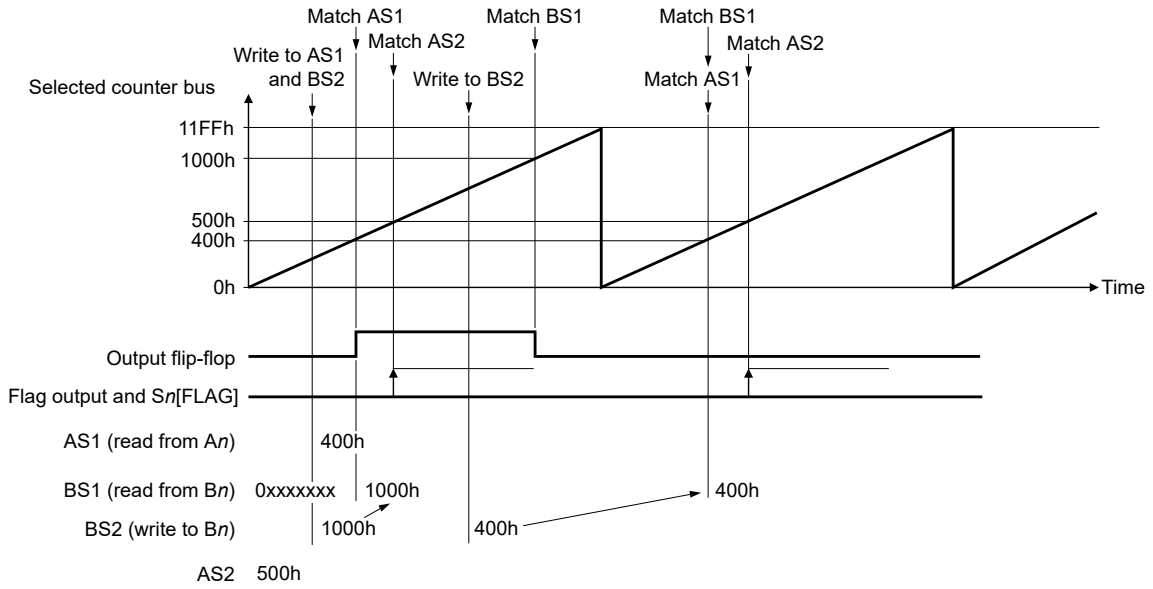


Figure 409. Timing example: 0% duty cycle

63.5.3.25.9 Timing example: 100% duty cycle

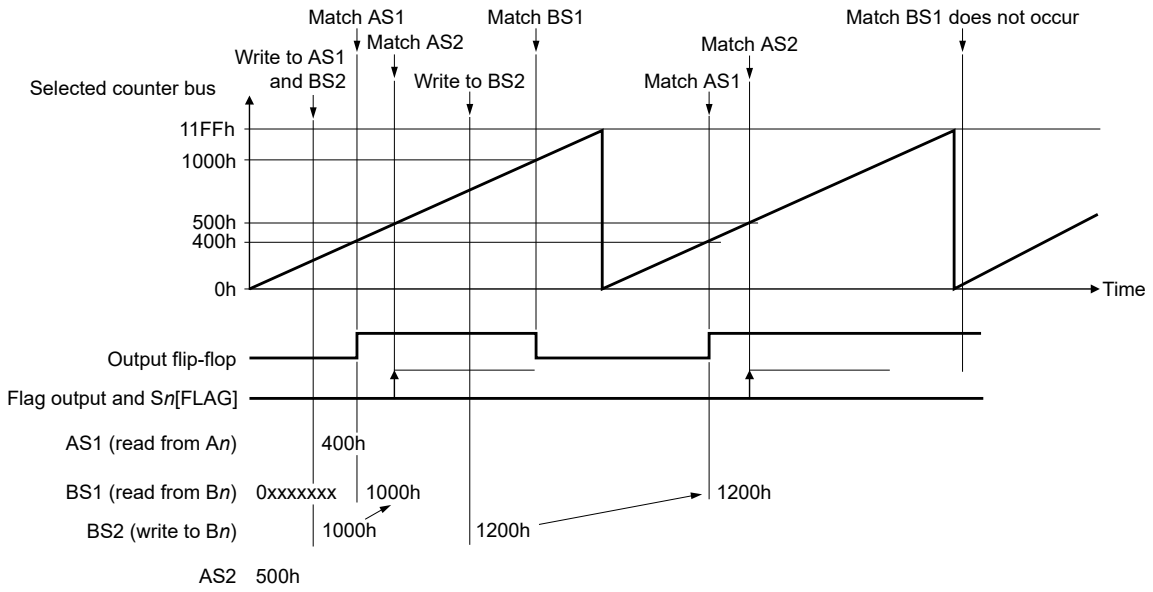


Figure 410. Timing example: 100% duty cycle

63.5.3.25.10 Output disable

As with other UC modes, OPWMT mode implements the output-disable function. When C*n*[ODIS] = 1, assertion of the output-disable input causes the UC to drive C*n*[EDPOL] on the output. Other than the fixed output, the UC continues to operate normally. When the output-disable signal deasserts, the UC returns to full normal operation.

63.5.3.26 Programmable input filter (PIF)

63.5.3.26.1 Overview

The PIF specifies the minimum input pulse width, in clock cycles, that can pass through the filter. It supports bypass operation (C*n*[IF]), with the input signal synchronized before arriving at the digital filter, or from 2 to 16 clock cycles in powers of 2.

63.5.3.26.2 Counter

The PIF is a 5-bit programmable up counter. The selected clock source increments the up counter after the number of clock cycles specified by the input filter (C*n*[IF]0.

The system clock synchronizes the input signal. When this signal changes state, the counter begins incrementing. As long as the new signal state is stable, the counter continues incrementing. If the counter overflows, eMIOS validates the new signal value. In this case, it transmits the value as a pulse edge to the edge detector. If the opposite edge appears on the signal before validation (overflow), eMIOS resets the counter. At the next transition, the counter starts incrementing again. A glitch does not occur on the edge detector for any pulse shorter than the full range of the masked counter.

Neither Freeze state nor deasserted GTBE disables the filter.

63.5.3.26.3 UC PIF logic

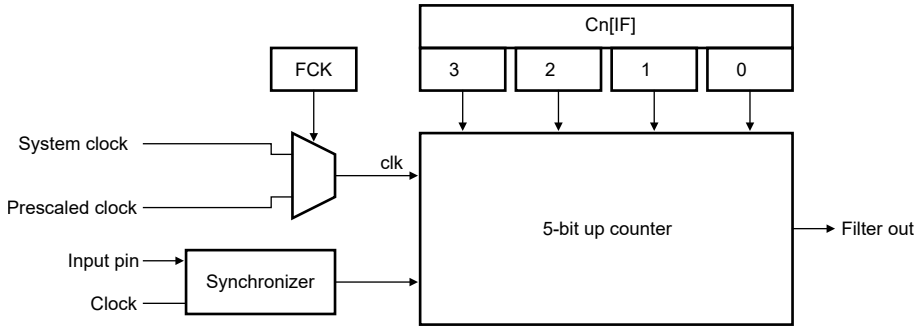


Figure 411. UC PIF logic

63.5.3.26.4 Timing example: UC PIF at 4 cycles

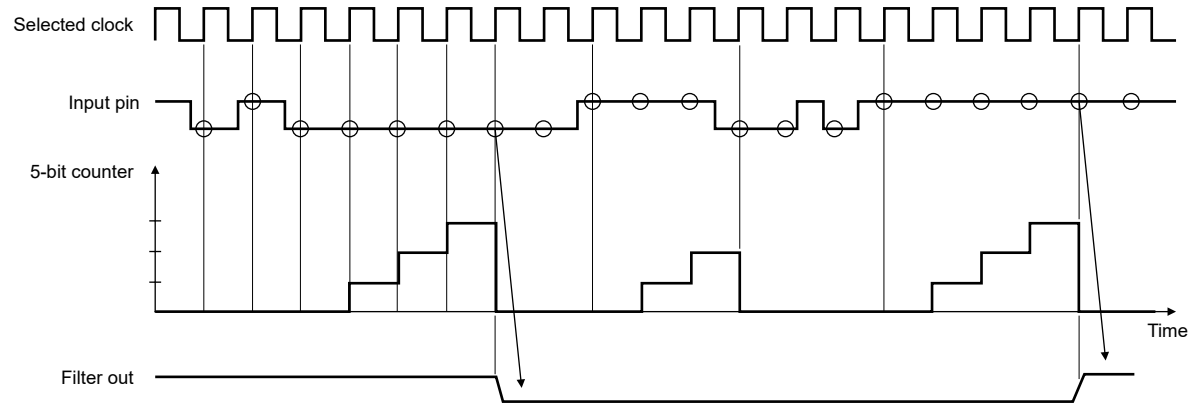


Figure 412. Timing example: UC PIF at 4 cycles

63.5.3.27 UC clock prescaler (CP)

eMIOS divides the GCP output signal by the UC CP (C*n*[UCPRE] + 1) to generate a clock enable for the UC internal counter. See Global clock prescaler (GCP). You enable the UC CP by writing 1 to C*n*[UCPREN]. If you disable the CP (write 0 to the same field), eMIOS stops the UC internal counter.

To ensure safe operation and avoid glitches, you must perform the following steps to change the UC CP:

1. Disable the GCP (write 0 to MCR[GPREN]).
2. Disable the UC CP (write 0 to C*n*[UCPREN]).
3. Specify the new prescaler value (write CP – 1 to C*n*[GPRE].
4. Enable the UC CP (write 1 to C*n*[UCPREN]).
5. Enable the GCP (write 1 to MCR[GPREN]).

63.5.4 Peripheral bus interface unit (BIU)

The BIU provides the interface between the IIB and the peripheral bus, which allows communication among all submodules and the IP interface. The BIU supports 8-, 16-, and 32-bit accesses performed over a 32-bit data bus in a single clock cycle.

63.5.5 STAC bus client

63.5.5.1 Overview

The STAC bus client provides one external timebase, imported from the STAC bus, to the UCs (see STAC block diagram). You select the Server Time Slot (MCR[SRV]) for output to the STAC bus. Every time the selected time slot occurs, eMIOS updates the STAC output (see Timing example: STAC output).

See the chip-specific information for the STAC server IDs.

63.5.5.2 STAC block diagram

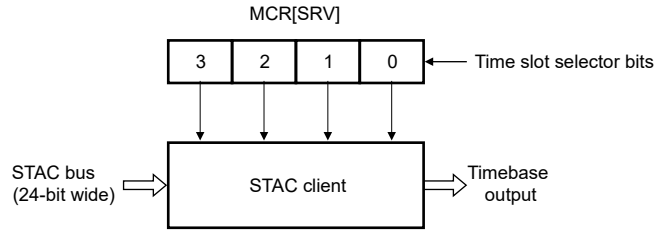
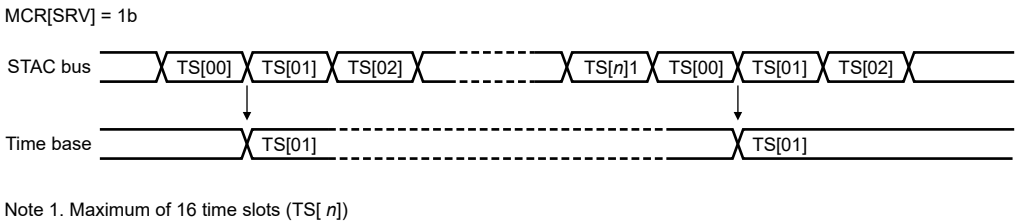


Figure 413. STAC block diagram

63.5.5.3 Timing example: STAC output



Note 1. Maximum of 16 time slots (TS[*n*])

Figure 414. Timing example: STAC output

63.5.6 Global clock prescaler (GCP)

eMIOS divides the system clock by the GCP (MCR[GPRE] + 1) and routes the resulting prescaled clock output to the channel CPs. You enable the GCP by writing 1 to MCR[GPREN]. If you disable the GCP (write 0 to the same field), eMIOS clears the prescaler counter and stops the prescaler clock.

To ensure safe operation and avoid glitches, you must perform the following steps to change the GCP:

1. Disable the GCP (write 0 to MCR[GPREN]).
2. Specify the new prescaler value (write GCP – 1 to MCR[GPRE].
3. Enable the GCP (write 1 to MCR[GPREN]).

63.5.7 Freeze and chip Debug mode

63.5.7.1 Enter and exit Freeze state

When the chip is in Debug mode (the chip Debug signal is asserted), you can freeze individual UCs. For the effects of Freeze state on eMIOS functions, see Freeze effects.

To put a channel in Freeze state, you must meet all of the following conditions:

- The chip must assert Debug.
- Prepare eMIOS for the Freeze state (write 1 to MCR[FRZ]).
- Enable Freeze for each channel you want to freeze:
  - Write 1 to C*n*[FREN].

A channel exits Freeze state when any of the following conditions occur:

- The chip deasserts Debug.
- You take eMIOS out of the Freeze state (write 0 to MCR[FRZ]).
- You disable Freeze for the channel:
  - write 0 to C*n*[FREN].

63.5.7.2 Freeze effects

Function	Effects of freeze
GCP	No effect
UC	• Halts counter, capture, and compare operation. • Freezes UC in its current state. • Makes all registers accessible. • In output modes, force match remains operational, allowing software to force the output to the desired level. • In input modes, the UC ignores input events. • When eMIOS exits Freeze state then UC operations resume, but they may be inconsistent until the UC reenters GPIO mode.
STAC	No effect
BIU	No effect

63.6 Initialization information

When initializing eMIOS, take the following considerations into account.

For eMIOS behavior on reset, see Reset.

Before changing the UC operating mode, you must:

1. Put the UC in GPIO mode (write 0b or 1b to C*n*[MODE]).
2. Write the correct values for the next operating mode to A*n* and B*n*.
3. Put the UC in the new operating mode (write the appropriate value to C*n*[MODE]).

If you change a UC from one mode to another without performing this procedure, the first operation cycle of the selected timebase can be random; that is, matches can occur in random time because you did not update A*n* and B*n* with correct values before the timebase matches the previous contents of either register.

NOTE

To to avoid causing an unexpected interrupt or DMA request when changing from GPIO to MCB mode, you must use the procedure described in Changing to MCB mode.

When you enable interrupts, any interrupt service routine must clear the flag before exiting.

63.7 Application information

63.7.1 Overview

All output operation modes can generate correlated output signals. You can disable updates of the output signals for each UC (OUDIS).

To guarantee that incrementing of the internal counters of correlated channels occurs in the same clock cycle, you must configure the internal CPs before enabling the GCP. If you configure the internal CPs after enabling the GCP, the internal counters may increment in the same ratio, but at different clock cycles.

You should drive the Output Disable Input signals with the flag signals of some UCs running in SAIC mode. When an output disable condition happens, the interrupt service routine must process the output channels before processing the channels running SAIC. This sequence avoids glitches in the output pins.

63.7.2 Timebase generation

In the MC and OPWFM modes with internal clock sources, you can modify the internal counter rate by configuring the CP ratio. Timebase with the fastest prescaler ratio illustrates a timebase with a prescaler ratio of one.

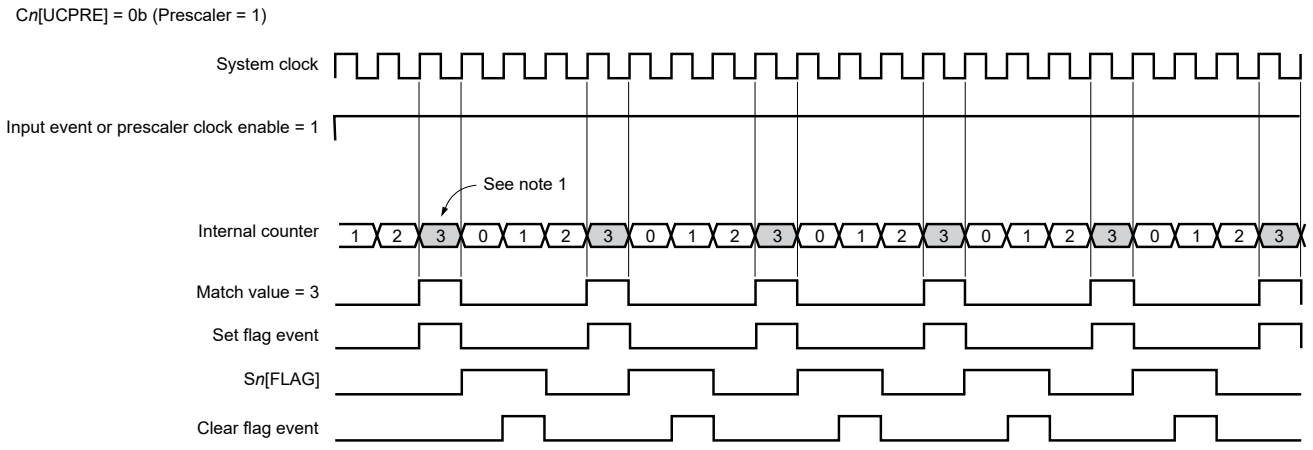
NOTE

The buffered modes, MCB and OPWFMB, behave differently.

If the prescaler ratio is greater than one or you select an external clock, the internal counter behaves in one of four different ways depending on the channel mode:

- In MC mode with Clear on Match Start and External Clock: Timebase generation with clear on match start and external clock.
- In MC mode with Clear on Match Start and Internal Clock source: Timebase generation with clear on match start and internal clock.
- In MC mode with Clear on Match End: Timebase generation with clear on match end.
- In OPWFM mode: Timebase generation with clear on match start and internal clock. The internal counter clears at the start of the match signal, skips the next prescaled clock edge, and then increments in the subsequent prescaled clock edge.

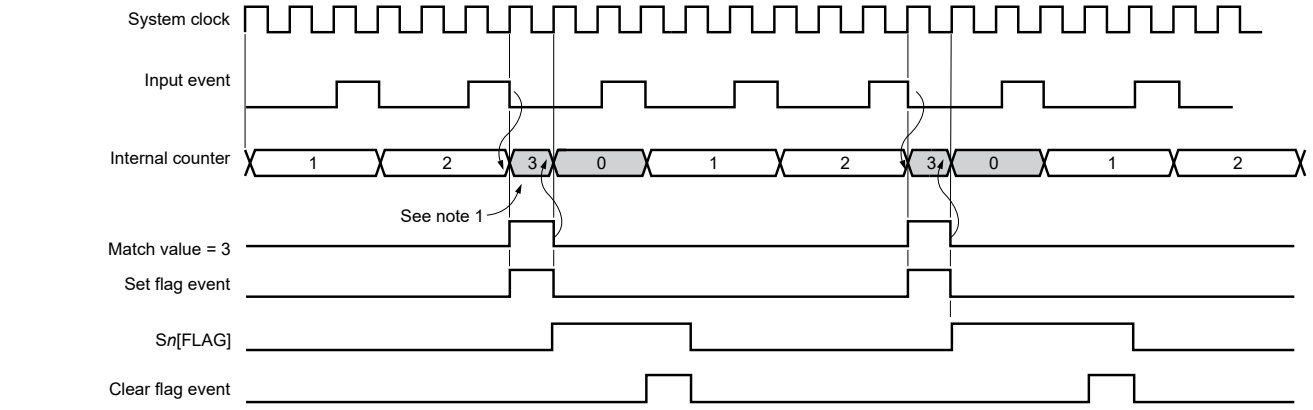
63.7.3 Timebase with the fastest prescaler ratio



Note 1: When a match occurs, eMIOS resets the internal counter in the first cycle, which starts another period.

Figure 415. Timebase with fastest prescaler ratio

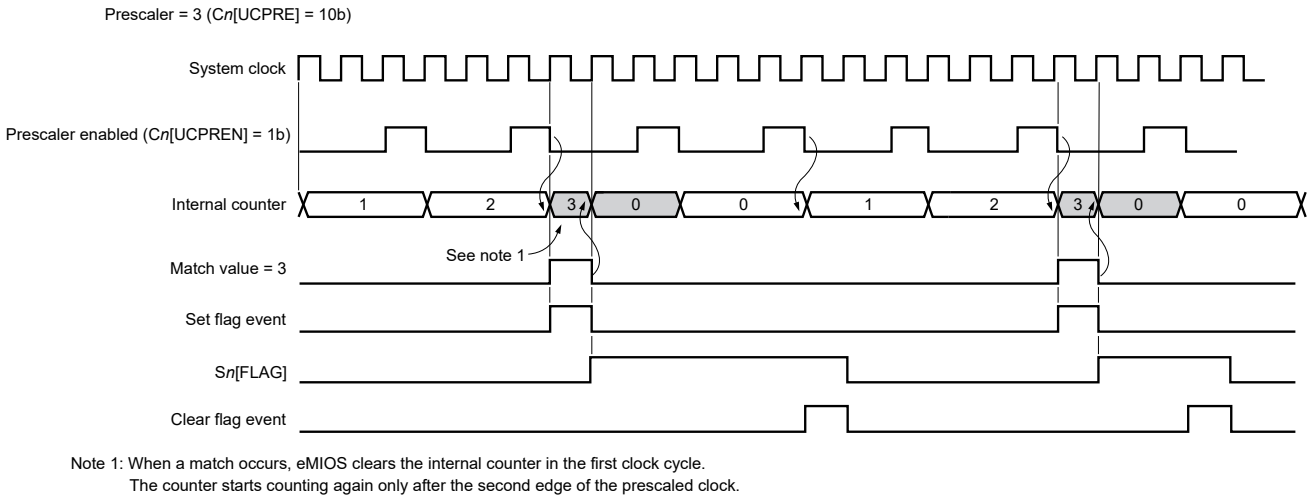
63.7.4 Timebase generation with clear on match start and external clock



Note 1: When a match occurs, eMIOS resets the internal counter in the first clock cycle. The counter starts counting at the next edge of the prescaler clock enable.

Figure 416. Timebase generation with clear on match start and external clock

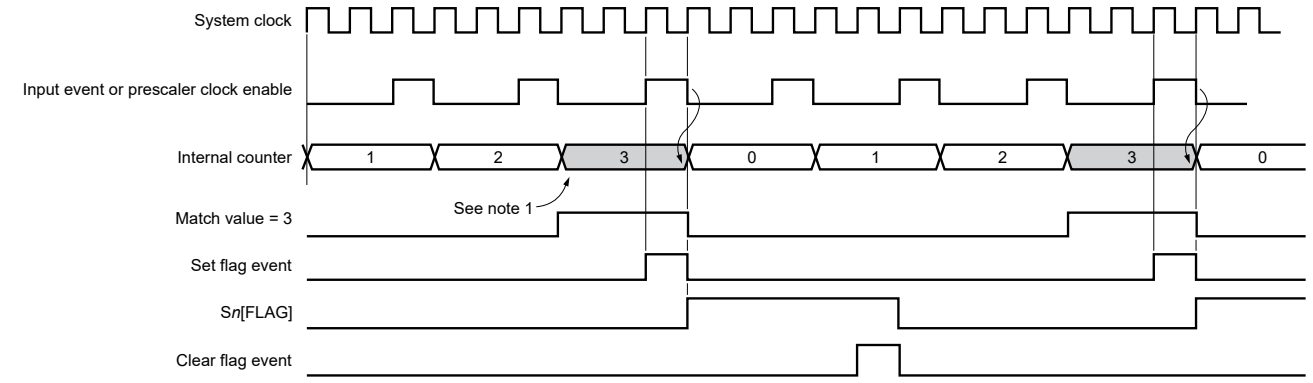
63.7.5 Timebase generation with clear on match start and internal clock



Note 1: When a match occurs, eMIOS clears the internal counter in the first clock cycle.
The counter starts counting again only after the second edge of the prescaled clock.

Figure 417. Timebase generation with clear on match start and internal clock

63.7.6 Timebase generation with clear on match end



Note 1: The match occurs only when the input event or prescaler clock enable is active.
When the match occurs, eMIOS resets the internal counter immediately.

Figure 418. Timebase generation with clear on match end

63.7.7 Coherent accesses

Reading An[A] again in the same period as the last read of Bn[B] results in incoherent results if the last read of Bn[B] occurred after a disabled BS2→BS1 transfer.

63.7.8 Initializing channels and modes

Perform the following basic steps for output mode startup. This procedure assumes the channels are initially in GPIO mode:

1. Disable the GPC (write 0 to MCR[GPREN]).
2. For each timebase UC:
   a. Disable the CP (write 0 to Cn[UCPREN]).
   b. Write an initial value to the internal counter (CNTn[C]).

c. Write initial values to A*n*[A] and B*n*[B].

d. Configure the UC for MC or MCB Up mode (write the appropriate value to C*n*[MODE]).

e. Select the CP ratio (C*n*[UCPRE]).

f. Enable the CP (write 1 to C*n*[UCPREN]).

3. For each output UC:

a. Disable the CP (write 0 to C*n*[UCPREN]).

b. Write initial values to A*n*[A] and B*n*[B].

c. Select the timebase input (C*n*[BSL]).

d. Specify the output mode (write the appropriate value to C*n*[MODE]).

e. Select the same CP ratio as the timebase UC (C*n*[UCPRE]).

f. Enable the CP (write 1 to C*n*[UCPREN]).

4. Enable the GPC (write 1 to MCR[GPREN]).

5. Enable GBTE (write 1 to MCR[GBTE]).

The timebase channel and the output channel may be the same for some applications such as in OPWFM or OPWFMB mode, or whenever the output channel drives the timebase itself.

You may configure flags at any time.

63.8 Memory maps and registers

63.8.1 Overall address map organization

All address locations not explicitly mentioned in this table are reserved. When you access an absent register, absent channel, or reserved address space, the transfer terminates with an error.

Table 354. Overall address map organization

Base address (hex)	Description
0	Module Configuration (MCR)
4	Global Flag (GFLAG)
8	Output Update Disable (OUDIS)
C	Disable Channel (UCDIS)
20	Channels 0–7
120	Channels 8–15
220	Channels 16–23

63.8.2 UC memory overview

Table 355. UC memory overview

Offset from UC *n* base address (hex)	Description
0	UC A n (A0 - A23)

Table continues on the next page...

Table 355. UC memory overview (continued)

Offset from UC *n* base address (hex)	Description
4	UC B n (B0 - B23)
8	UC Counter n (CNT0 - CNT23)
C	UC Control n (C0 - C23)
10	UC Status n (S0 - S23)
14	Alternate Address n (ALTA0 - ALTA23)
18	UC Control 2 n (C2_0 - C2_23)
1C–1F	Reserved

63.8.3 AS1, AS2, BS1, and BS2 shadow registers

When you use eMIOS UC modes, you rely heavily on four shadow registers:

- AS1
- AS2
- BS1
- BS2

You use A*n*[A], B*n*[B], and ALTA*n*[ALTA] to access these shadow registers:

- Each instance of A*n*[A] has a separate associated instance of AS1 and AS2. In some UC modes, you also use ALTA*n*[ALTA] to access AS2.
- Each instance of B*n*[B] has a separate associated instance of BS1 and BS2.

See Relationship between A*n*, B*n*, ALTA*n*, and shadow registers.

Each UC mode uses the AS1-AS2 and BS1-BS2 shadow register pairs for various match and capture functions, as described in Unified channels (UC).

A reset clears all shadow registers.

Assignment of values for A*n*[A], B*n*[B], and ALTA*n*[ALTA] describes how you write to and read from the shadow registers for all operation modes. Values not listed are reserved. For more information, see Unified channels (UC).

63.8.4 Relationship between A*n*, B*n*, ALTA*n*, and shadow registers

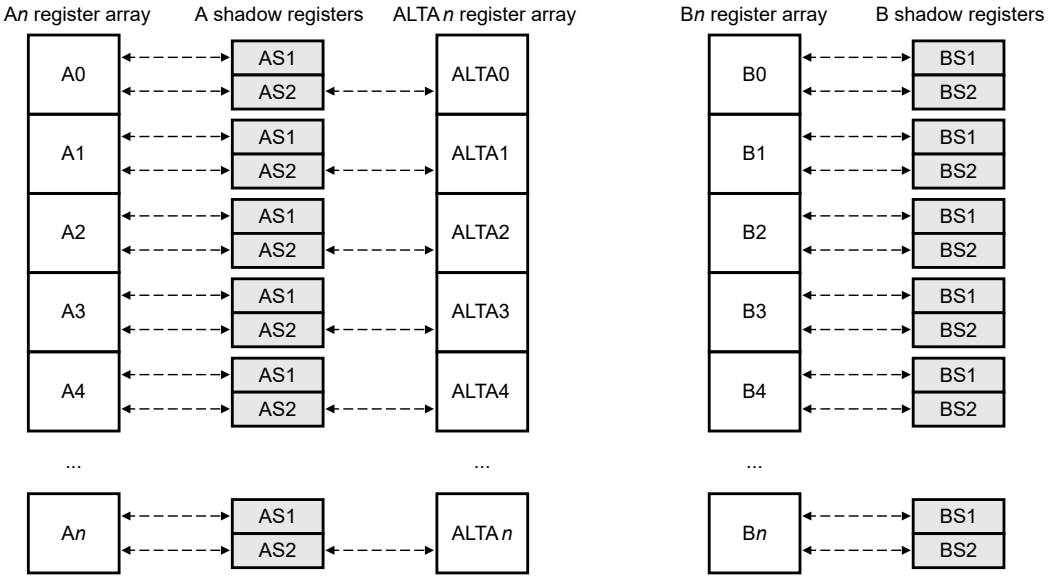


Figure 419. Relationship between A*n*, B*n*, ALTA*n*, and shadow registers

63.8.5 Assignment of values for A*n*[A], B*n*[B], and ALTA*n*[ALTA]

This table describes how you write to and read from the following registers for all operation modes:

- UC A n (A0 - A23)
- UC B n (B0 - B23)
- Alternate Address n (ALTA0 - ALTA23)

Values not listed are reserved. For more information, see Unified channels (UC).

Table 356. Assignment of values for A*n*[A], B*n*[B], and ALTA*n*[ALTA]

Operation mode	Register access					
	A*n*		B*n*		ALTA*n*	
	Write	Read	Write	Read	Write	Read
GPIO	AS1 and AS2[1]	AS1	BS1 and BS2[2]	BS1	AS2	AS2
SAIC[3]	—	AS2	BS2	BS2	—	—
SAOC[3]	AS2	AS1	BS2	BS2	—	—
IPWM	—	AS2	—	BS1	—	—
IPM	—	AS2	—	BS1	—	—
DAOC	AS2	AS1	BS2	BS1	—	—
PEA	AS1	AS2	—	BS1	—	—
PEC[3]	AS1	AS1	BS1	BS1	—	AS2
QDEC[3]	AS1	AS1	BS2	BS2	—	—

Table continues on the next page...

Table 356. Assignment of values for A*n*[A], B*n*[B], and ALTA*n*[ALTA] (continued)

Operation mode	Register access					
	A*n*		B*n*		ALTA*n*	
	Write	Read	Write	Read	Write	Read
WPTA	AS1	AS1	BS1	BS1	—	AS2
MC[3]	AS2	AS1	BS2	BS2	—	—
OPWFM	AS2	AS1	BS2	BS1	—	—
OPWMC	AS2	AS1	BS2	BS1	—	—
OPWM	AS2	AS1	BS2	BS1	—	—
OPWMT	AS1	AS1	BS2	BS1	AS2	AS2
MCB[3]	AS2	AS1	BS2	BS1	—	—
OPWFMB	AS2	AS1	BS2	BS1	—	—
OPWMCB	AS2	AS1	BS2	BS1	—	—
OPWMB	AS2	AS1	BS2	BS1	—	—

1. This operation writes the same value to AS1 and AS2.
2. This operation writes the same value to BS1 and BS2.
3. These modes do not require UC B n (B0 - B23), but you can still use it to access BS2.

63.8.6 eMIOS_0 register descriptions

All control registers are 32 bits wide. Data fields are 24 bits wide. There are 24 UCs, as mapped in Counter buses, channels, and timebase sources.

63.8.6.1 eMIOS_0 memory map

eMIOS_0 base address: 4008_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration (MCR)	32	RW	0000_0000h
4h	Global Flag (GFLAG)	32	R	0000_0000h
8h	Output Update Disable (OUDIS)	32	RW	0000_0000h
Ch	Disable Channel (UCDIS)	32	RW	0000_0000h
20h	UC A 0 (A0)	32	RW	0000_0000h
24h	UC B 0 (B0)	32	RW	0000_0000h
28h	UC Counter 0 (CNT0)	32	RW	0000_0000h
2Ch	UC Control 0 (C0)	32	RW	0000_0000h
30h	UC Status 0 (S0)	32	RW	See section
34h	Alternate Address 0 (ALTA0)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
38h	UC Control 2 0 (C2_0)	32	RW	0000_0000h
40h	UC A 1 (A1)	32	RW	0000_0000h
44h	UC B 1 (B1)	32	RW	0000_0000h
48h	UC Counter 1 (CNT1)	32	RW	0000_0000h
4Ch	UC Control 1 (C1)	32	RW	0000_0000h
50h	UC Status 1 (S1)	32	RW	See section
54h	Alternate Address 1 (ALTA1)	32	RW	0000_0000h
58h	UC Control 2 1 (C2_1)	32	RW	0000_0000h
60h	UC A 2 (A2)	32	RW	0000_0000h
64h	UC B 2 (B2)	32	RW	0000_0000h
68h	UC Counter 2 (CNT2)	32	RW	0000_0000h
6Ch	UC Control 2 (C2)	32	RW	0000_0000h
70h	UC Status 2 (S2)	32	RW	See section
74h	Alternate Address 2 (ALTA2)	32	RW	0000_0000h
78h	UC Control 2 2 (C2_2)	32	RW	0000_0000h
80h	UC A 3 (A3)	32	RW	0000_0000h
84h	UC B 3 (B3)	32	RW	0000_0000h
88h	UC Counter 3 (CNT3)	32	RW	0000_0000h
8Ch	UC Control 3 (C3)	32	RW	0000_0000h
90h	UC Status 3 (S3)	32	RW	See section
94h	Alternate Address 3 (ALTA3)	32	RW	0000_0000h
98h	UC Control 2 3 (C2_3)	32	RW	0000_0000h
A0h	UC A 4 (A4)	32	RW	0000_0000h
A4h	UC B 4 (B4)	32	RW	0000_0000h
A8h	UC Counter 4 (CNT4)	32	RW	0000_0000h
ACh	UC Control 4 (C4)	32	RW	0000_0000h
B0h	UC Status 4 (S4)	32	RW	See section
B4h	Alternate Address 4 (ALTA4)	32	RW	0000_0000h
B8h	UC Control 2 4 (C2_4)	32	RW	0000_0000h
C0h	UC A 5 (A5)	32	RW	0000_0000h
C4h	UC B 5 (B5)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
C8h	UC Counter 5 (CNT5)	32	RW	0000_0000h
CCh	UC Control 5 (C5)	32	RW	0000_0000h
D0h	UC Status 5 (S5)	32	RW	See section
D4h	Alternate Address 5 (ALTA5)	32	RW	0000_0000h
D8h	UC Control 2 5 (C2_5)	32	RW	0000_0000h
E0h	UC A 6 (A6)	32	RW	0000_0000h
E4h	UC B 6 (B6)	32	RW	0000_0000h
E8h	UC Counter 6 (CNT6)	32	RW	0000_0000h
ECh	UC Control 6 (C6)	32	RW	0000_0000h
F0h	UC Status 6 (S6)	32	RW	See section
F4h	Alternate Address 6 (ALTA6)	32	RW	0000_0000h
F8h	UC Control 2 6 (C2_6)	32	RW	0000_0000h
100h	UC A 7 (A7)	32	RW	0000_0000h
104h	UC B 7 (B7)	32	RW	0000_0000h
108h	UC Counter 7 (CNT7)	32	RW	0000_0000h
10Ch	UC Control 7 (C7)	32	RW	0000_0000h
110h	UC Status 7 (S7)	32	RW	See section
114h	Alternate Address 7 (ALTA7)	32	RW	0000_0000h
118h	UC Control 2 7 (C2_7)	32	RW	0000_0000h
120h	UC A 8 (A8)	32	RW	0000_0000h
124h	UC B 8 (B8)	32	RW	0000_0000h
128h	UC Counter 8 (CNT8)	32	RW	0000_0000h
12Ch	UC Control 8 (C8)	32	RW	0000_0000h
130h	UC Status 8 (S8)	32	RW	See section
134h	Alternate Address 8 (ALTA8)	32	RW	0000_0000h
138h	UC Control 2 8 (C2_8)	32	RW	0000_0000h
140h	UC A 9 (A9)	32	RW	0000_0000h
144h	UC B 9 (B9)	32	RW	0000_0000h
148h	UC Counter 9 (CNT9)	32	RW	0000_0000h
14Ch	UC Control 9 (C9)	32	RW	0000_0000h
150h	UC Status 9 (S9)	32	RW	See section

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
154h	Alternate Address 9 (ALTA9)	32	RW	0000_0000h
158h	UC Control 2 9 (C2_9)	32	RW	0000_0000h
160h	UC A 10 (A10)	32	RW	0000_0000h
164h	UC B 10 (B10)	32	RW	0000_0000h
168h	UC Counter 10 (CNT10)	32	RW	0000_0000h
16Ch	UC Control 10 (C10)	32	RW	0000_0000h
170h	UC Status 10 (S10)	32	RW	See section
174h	Alternate Address 10 (ALTA10)	32	RW	0000_0000h
178h	UC Control 2 10 (C2_10)	32	RW	0000_0000h
180h	UC A 11 (A11)	32	RW	0000_0000h
184h	UC B 11 (B11)	32	RW	0000_0000h
188h	UC Counter 11 (CNT11)	32	RW	0000_0000h
18Ch	UC Control 11 (C11)	32	RW	0000_0000h
190h	UC Status 11 (S11)	32	RW	See section
194h	Alternate Address 11 (ALTA11)	32	RW	0000_0000h
198h	UC Control 2 11 (C2_11)	32	RW	0000_0000h
1A0h	UC A 12 (A12)	32	RW	0000_0000h
1A4h	UC B 12 (B12)	32	RW	0000_0000h
1A8h	UC Counter 12 (CNT12)	32	RW	0000_0000h
1ACh	UC Control 12 (C12)	32	RW	0000_0000h
1B0h	UC Status 12 (S12)	32	RW	See section
1B4h	Alternate Address 12 (ALTA12)	32	RW	0000_0000h
1B8h	UC Control 2 12 (C2_12)	32	RW	0000_0000h
1C0h	UC A 13 (A13)	32	RW	0000_0000h
1C4h	UC B 13 (B13)	32	RW	0000_0000h
1C8h	UC Counter 13 (CNT13)	32	RW	0000_0000h
1CCh	UC Control 13 (C13)	32	RW	0000_0000h
1D0h	UC Status 13 (S13)	32	RW	See section
1D4h	Alternate Address 13 (ALTA13)	32	RW	0000_0000h
1D8h	UC Control 2 13 (C2_13)	32	RW	0000_0000h
1E0h	UC A 14 (A14)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
1E4h	UC B 14 (B14)	32	RW	0000_0000h
1E8h	UC Counter 14 (CNT14)	32	RW	0000_0000h
1ECh	UC Control 14 (C14)	32	RW	0000_0000h
1F0h	UC Status 14 (S14)	32	RW	See section
1F4h	Alternate Address 14 (ALTA14)	32	RW	0000_0000h
1F8h	UC Control 2 14 (C2_14)	32	RW	0000_0000h
200h	UC A 15 (A15)	32	RW	0000_0000h
204h	UC B 15 (B15)	32	RW	0000_0000h
208h	UC Counter 15 (CNT15)	32	RW	0000_0000h
20Ch	UC Control 15 (C15)	32	RW	0000_0000h
210h	UC Status 15 (S15)	32	RW	See section
214h	Alternate Address 15 (ALTA15)	32	RW	0000_0000h
218h	UC Control 2 15 (C2_15)	32	RW	0000_0000h
220h	UC A 16 (A16)	32	RW	0000_0000h
224h	UC B 16 (B16)	32	RW	0000_0000h
228h	UC Counter 16 (CNT16)	32	RW	0000_0000h
22Ch	UC Control 16 (C16)	32	RW	0000_0000h
230h	UC Status 16 (S16)	32	RW	See section
234h	Alternate Address 16 (ALTA16)	32	RW	0000_0000h
238h	UC Control 2 16 (C2_16)	32	RW	0000_0000h
240h	UC A 17 (A17)	32	RW	0000_0000h
244h	UC B 17 (B17)	32	RW	0000_0000h
248h	UC Counter 17 (CNT17)	32	RW	0000_0000h
24Ch	UC Control 17 (C17)	32	RW	0000_0000h
250h	UC Status 17 (S17)	32	RW	See section
254h	Alternate Address 17 (ALTA17)	32	RW	0000_0000h
258h	UC Control 2 17 (C2_17)	32	RW	0000_0000h
260h	UC A 18 (A18)	32	RW	0000_0000h
264h	UC B 18 (B18)	32	RW	0000_0000h
268h	UC Counter 18 (CNT18)	32	RW	0000_0000h
26Ch	UC Control 18 (C18)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
270h	UC Status 18 (S18)	32	RW	See section
274h	Alternate Address 18 (ALTA18)	32	RW	0000_0000h
278h	UC Control 2 18 (C2_18)	32	RW	0000_0000h
280h	UC A 19 (A19)	32	RW	0000_0000h
284h	UC B 19 (B19)	32	RW	0000_0000h
288h	UC Counter 19 (CNT19)	32	RW	0000_0000h
28Ch	UC Control 19 (C19)	32	RW	0000_0000h
290h	UC Status 19 (S19)	32	RW	See section
294h	Alternate Address 19 (ALTA19)	32	RW	0000_0000h
298h	UC Control 2 19 (C2_19)	32	RW	0000_0000h
2A0h	UC A 20 (A20)	32	RW	0000_0000h
2A4h	UC B 20 (B20)	32	RW	0000_0000h
2A8h	UC Counter 20 (CNT20)	32	RW	0000_0000h
2ACh	UC Control 20 (C20)	32	RW	0000_0000h
2B0h	UC Status 20 (S20)	32	RW	See section
2B4h	Alternate Address 20 (ALTA20)	32	RW	0000_0000h
2B8h	UC Control 2 20 (C2_20)	32	RW	0000_0000h
2C0h	UC A 21 (A21)	32	RW	0000_0000h
2C4h	UC B 21 (B21)	32	RW	0000_0000h
2C8h	UC Counter 21 (CNT21)	32	RW	0000_0000h
2CCh	UC Control 21 (C21)	32	RW	0000_0000h
2D0h	UC Status 21 (S21)	32	RW	See section
2D4h	Alternate Address 21 (ALTA21)	32	RW	0000_0000h
2D8h	UC Control 2 21 (C2_21)	32	RW	0000_0000h
2E0h	UC A 22 (A22)	32	RW	0000_0000h
2E4h	UC B 22 (B22)	32	RW	0000_0000h
2E8h	UC Counter 22 (CNT22)	32	RW	0000_0000h
2ECh	UC Control 22 (C22)	32	RW	0000_0000h
2F0h	UC Status 22 (S22)	32	RW	See section
2F4h	Alternate Address 22 (ALTA22)	32	RW	0000_0000h
2F8h	UC Control 2 22 (C2_22)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
300h	UC A 23 (A23)	32	RW	0000_0000h
304h	UC B 23 (B23)	32	RW	0000_0000h
308h	UC Counter 23 (CNT23)	32	RW	0000_0000h
30Ch	UC Control 23 (C23)	32	RW	0000_0000h
310h	UC Status 23 (S23)	32	RW	See section
314h	Alternate Address 23 (ALTA23)	32	RW	0000_0000h
318h	UC Control 2 23 (C2_23)	32	RW	0000_0000h

63.8.6.2 Module Configuration (MCR)

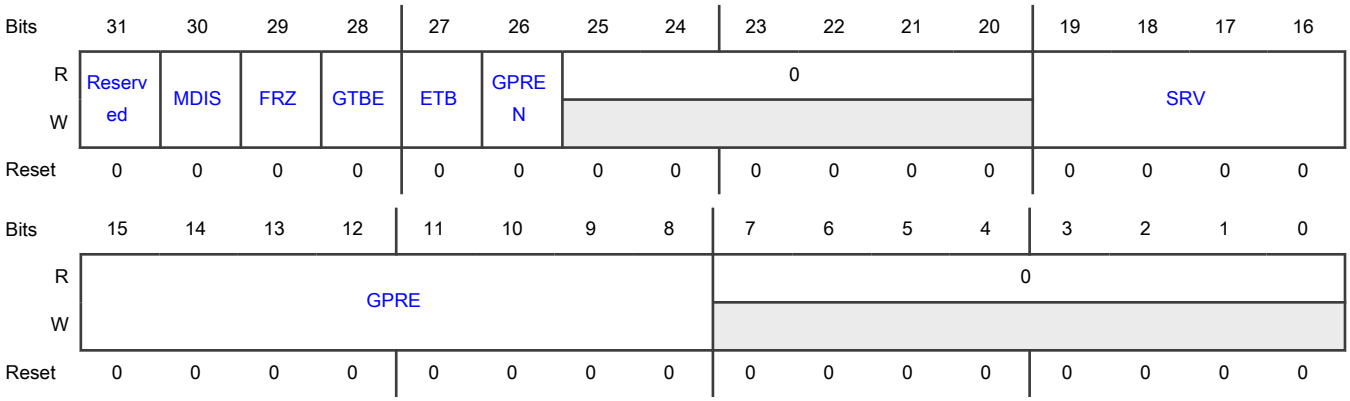
Offset

Register	Offset
MCR	0h

Function

Configures eMIOS operation.

Diagram



Fields

Field	Function
31 —	Reserved Write only the reset value to this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
30 MDIS	Module Disable Disables eMIOS by stopping the clock. When you disable eMIOS, its clock stops, it consumes less power, and you can access only the following registers: • Module Configuration (MCR) • Output Update Disable (OUDIS) • Disable Channel (UCDIS) 0b - Enable 1b - Disable
29 FRZ	Freeze Prepares eMIOS to enter Freeze state (see Freeze and chip Debug mode). eMIOS does not enter Freeze state until both of the following conditions occur: • The chip asserts Debug mode. • You enable Freeze for each UC (write 1 to C*n*[FREN]). A channel remains frozen until one or more of the following occur: • You force eMIOS to exit the Freeze state (write 0 to FRZ). • The chip deasserts Debug mode. • You disable Freeze for that UC (write 0 to C*n*[FREN]). 0b - Exit Freeze state 1b - Enter Freeze state
28 GTBE	Global Timebase Enable Asserts the GTBE_OUT signal. If GTBE_OUT is connected to the GTBE_IN input of one or more eMIOS instances, asserting the signal turns on the internal counters of those eMIOS instances simultaneously. **NOTE** The GTBE_IN input enables (asserted) or disables (deasserted) the internal counters. 0b - Deassert GTBE_OUT 1b - Assert GTBE_OUT
27 ETB	External Time Base Selects the time base source to drive counter bus A. 0b - Unified Channel 1b - STAC
26 GPREN	Global Prescaler Enable

Table continues on the next page...

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Field	Function
	Enables the global prescaler counter. Disabling the global prescaler clears the prescaler counter and stops the prescaler clock. 0b - Disable 1b - Enable
25-20 —	Reserved
19-16 SRV	Server Time Slot Selects the time slot for output of the STAC bus.
15-8 GPRE	Global Prescaler Specifies the global clock prescaler. Write the desired clock divide ratio minus 1. For example, for a divide ratio of 8, write 111b. The prescaler can range from 1 (0b) to 256 (11111111b).
7-0 —	Reserved

63.8.6.3 Global Flag (GFLAG)

Offset

Register	Offset
GFLAG	4h

Function

Groups the flag fields from all channels into one register to improve interrupt handling.

For UCs, each field mirrors the corresponding channel flag (S*n*[FLAG]).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	F23	F22	F21	F20	F19	F18	F17	F16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	F15	F14	F13	F12	F11	F10	F9	F8	F7	F6	F5	F4	F3	F2	F1	F0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29 —	Reserved
28 —	Reserved
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 F23	Mirror of UC 23 FLAG
22 F22	Mirror of UC 22 FLAG
21 F21	Mirror of UC 21 FLAG
20 F20	Mirror of UC 20 FLAG
19 F19	Mirror of UC 19 FLAG
18 F18	Mirror of UC 18 FLAG
17	Mirror of UC 17 FLAG

Table continues on the next page...

Table continued from the previous page...

Field	Function
F17	
16 F16	Mirror of UC 16 FLAG
15 F15	Mirror of UC 15 FLAG
14 F14	Mirror of UC 14 FLAG
13 F13	Mirror of UC 13 FLAG
12 F12	Mirror of UC 12 FLAG
11 F11	Mirror of UC 11 FLAG
10 F10	Mirror of UC 10 FLAG
9 F9	Mirror of UC 9 FLAG
8 F8	Mirror of UC 8 FLAG
7 F7	Mirror of UC 7 FLAG
6 F6	Mirror of UC 6 FLAG
5 F5	Mirror of UC 5 FLAG
4 F4	Mirror of UC 4 FLAG
3 F3	Mirror of UC 3 FLAG

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 F2	Mirror of UC 2 FLAG
1 F1	Mirror of UC 1 FLAG
0 F0	Mirror of UC 0 FLAG

63.8.6.4 Output Update Disable (OUDIS)

Offset

Register	Offset
OUDIS	8h

Function

Disables transfers from AS2 to AS1 and BS2 to BS1 on a per-channel basis. This applies to any channel operating in MC, MCB, or any output mode that writes to AS2 and BS2.

When a field is 0, transfers on that channel occur immediately or in the next period, depending on the operation mode. Unless that mode's description states otherwise, the transfer occurs immediately.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	OU23	OU22	OU21	OU20	OU19	OU18	OU17	OU16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	OU15	OU14	OU13	OU12	OU11	OU10	OU9	OU8	OU7	OU6	OU5	OU4	OU3	OU2	OU1	OU0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
30 —	Reserved
29 —	Reserved
28 —	Reserved
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 OU23	Channel 23 Output Update Disable 0b - Enable 1b - Disable
22 OU22	Channel 22 Output Update Disable 0b - Enable 1b - Disable
21 OU21	Channel 21 Output Update Disable 0b - Enable 1b - Disable
20 OU20	Channel 20 Output Update Disable 0b - Enable 1b - Disable
19 OU19	Channel 19 Output Update Disable 0b - Enable 1b - Disable

Table continues on the next page...

Table continued from the previous page...

Field	Function
18 OU18	Channel 18 Output Update Disable 0b - Enable 1b - Disable
17 OU17	Channel 17 Output Update Disable 0b - Enable 1b - Disable
16 OU16	Channel 16 Output Update Disable 0b - Enable 1b - Disable
15 OU15	Channel 15 Output Update Disable 0b - Enable 1b - Disable
14 OU14	Channel 14 Output Update Disable 0b - Enable 1b - Disable
13 OU13	Channel 13 Output Update Disable 0b - Enable 1b - Disable
12 OU12	Channel 12 Output Update Disable 0b - Enable 1b - Disable
11 OU11	Channel 11 Output Update Disable 0b - Enable 1b - Disable
10 OU10	Channel 10 Output Update Disable 0b - Enable 1b - Disable
9 OU9	Channel 9 Output Update Disable 0b - Enable 1b - Disable
8 OU8	Channel 8 Output Update Disable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Enable 1b - Disable
7 OU7	Channel 7 Output Update Disable 0b - Enable 1b - Disable
6 OU6	Channel 6 Output Update Disable 0b - Enable 1b - Disable
5 OU5	Channel 5 Output Update Disable 0b - Enable 1b - Disable
4 OU4	Channel 4 Output Update Disable 0b - Enable 1b - Disable
3 OU3	Channel 3 Output Update Disable 0b - Enable 1b - Disable
2 OU2	Channel 2 Output Update Disable 0b - Enable 1b - Disable
1 OU1	Channel 1 Output Update Disable 0b - Enable 1b - Disable
0 OU0	Channel 0 Output Update Disable 0b - Enable 1b - Disable

63.8.6.5 Disable Channel (UCDIS)

Offset

Register	Offset
UCDIS	Ch

Function

Allows you to disable a UC by stopping its clock. Each field controls the clock for the corresponding UC.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0	0	0	0	0	0	0	UCDIS 23	UCDIS 22	UCDIS 21	UCDIS 20	UCDIS 19	UCDIS 18	UCDIS 17	UCDIS 16
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	UCDIS 15	UCDIS 14	UCDIS 13	UCDIS 12	UCDIS 11	UCDIS 10	UCDIS 9	UCDIS 8	UCDIS 7	UCDIS 6	UCDIS 5	UCDIS 4	UCDIS 3	UCDIS 2	UCDIS 1	UCDIS 0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29 —	Reserved
28 —	Reserved
27 —	Reserved
26 —	Reserved
25 —	Reserved
24 —	Reserved
23 UCDIS23	Disable UC 23 0b - Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Disable
22 UCDIS22	Disable UC 22 0b - Enable 1b - Disable
21 UCDIS21	Disable UC 21 0b - Enable 1b - Disable
20 UCDIS20	Disable UC 20 0b - Enable 1b - Disable
19 UCDIS19	Disable UC 19 0b - Enable 1b - Disable
18 UCDIS18	Disable UC 18 0b - Enable 1b - Disable
17 UCDIS17	Disable UC 17 0b - Enable 1b - Disable
16 UCDIS16	Disable UC 16 0b - Enable 1b - Disable
15 UCDIS15	Disable UC 15 0b - Enable 1b - Disable
14 UCDIS14	Disable UC 14 0b - Enable 1b - Disable
13 UCDIS13	Disable UC 13 0b - Enable 1b - Disable

Table continues on the next page...

Table continued from the previous page...

Field	Function
12 UCDIS12	Disable UC 12 0b - Enable 1b - Disable
11 UCDIS11	Disable UC 11 0b - Enable 1b - Disable
10 UCDIS10	Disable UC 10 0b - Enable 1b - Disable
9 UCDIS9	Disable UC 9 0b - Enable 1b - Disable
8 UCDIS8	Disable UC 8 0b - Enable 1b - Disable
7 UCDIS7	Disable UC 7 0b - Enable 1b - Disable
6 UCDIS6	Disable UC 6 0b - Enable 1b - Disable
5 UCDIS5	Disable UC 5 0b - Enable 1b - Disable
4 UCDIS4	Disable UC 4 0b - Enable 1b - Disable
3 UCDIS3	Disable UC 3 0b - Enable 1b - Disable
2 UCDIS2	Disable UC 2

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Enable 1b - Disable
1 UCDIS1	Disable UC 1 0b - Enable 1b - Disable
0 UCDIS0	Disable UC 0 0b - Enable 1b - Disable

63.8.6.6 UC A n (A0 - A23)

Offset

For n = 0 to 23:

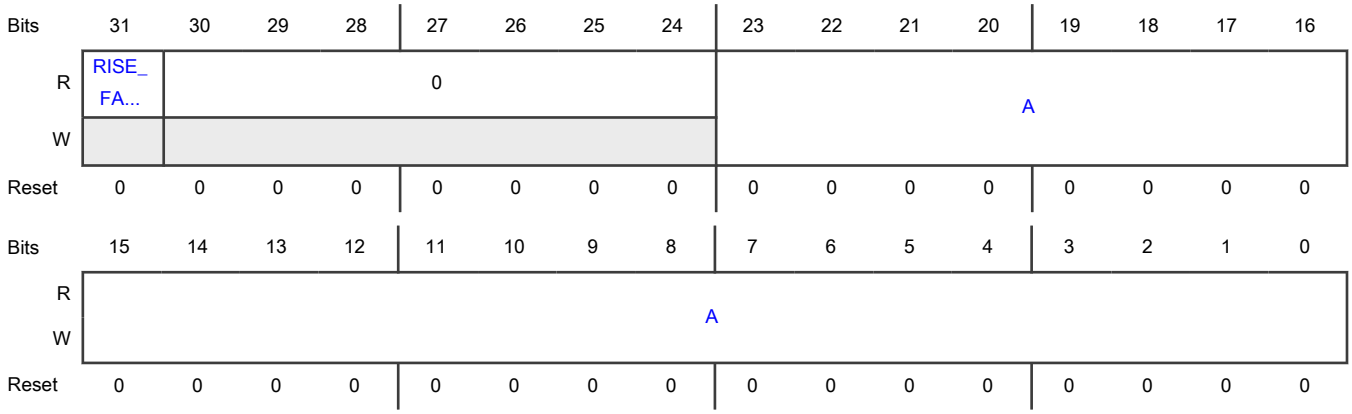
Register	Offset
An	20h + (n × 20h)

Function

Accesses the AS1 and AS2 shadow registers for each UC, depending on the selected UC mode. See AS1, AS2, BS1, and BS2 shadow registers.

For information about how you write to and read from A*n*, B*n*, and ALTA*n* for all UC modes, see Assignment of values for A*n*[A], B*n*[B], and ALTA*n*[ALTA].

Diagram



Fields

Field	Function
31 RISE_FALL	Rising and falling edge detection Indicates rising and falling edge in SAIC sub-mode.
30-24 —	Reserved
23-0 A	A See the register description.

63.8.6.7 UC B n (B0 - B23)

Offset

For n = 0 to 23:

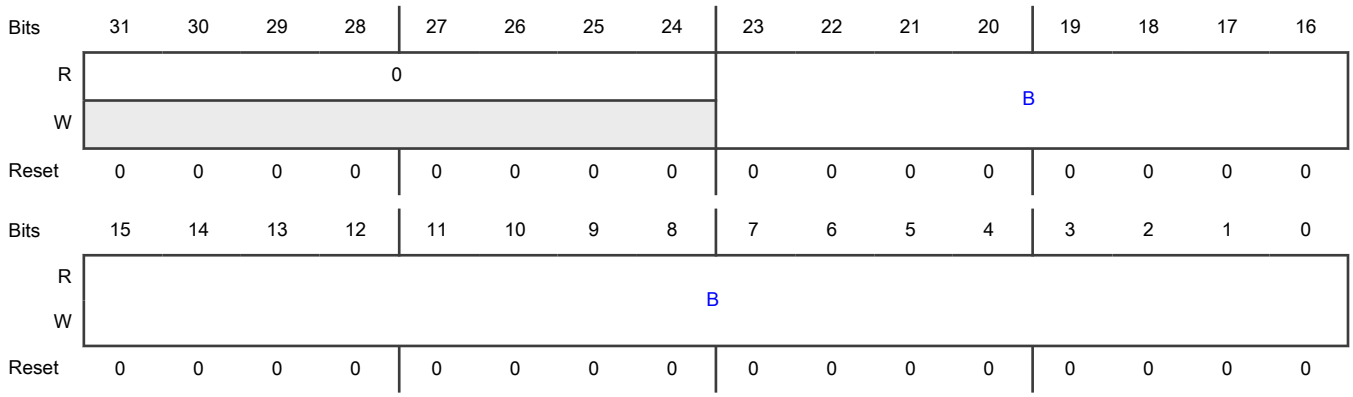
Register	Offset
Bn	24h + (n × 20h)

Function

Accesses the BS1 and BS2 shadow registers for each UC, depending on the selected UC mode. See AS1, AS2, BS1, and BS2 shadow registers.

For information about how you write to and read from A*n*, B*n*, and ALTA*n* for all UC modes, see Assignment of values for A*n*[A], B*n*[B], and ALTA*n*[ALTA].

Diagram



Fields

Field	Function
31-24	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
23-0 B	B See the register description.

63.8.6.8 UC Counter n (CNT0 - CNT23)

Offset

For n = 0 to 23:

Register	Offset
CNTn	28h + (n × 20h)

Function

Indicates the value of the UC internal counter.

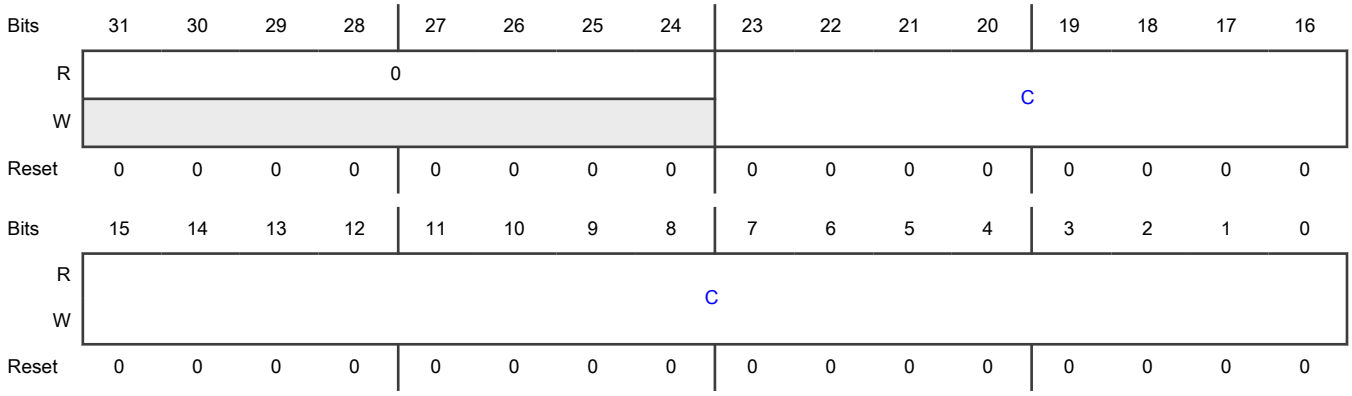
When eMIOS is in GPIO mode or the UC is frozen, this register is read-write. For all other modes, this register is read-only. When entering some UC modes, eMIOS automatically clears this register. See Unified channels (UC) for details.

The following modes use the UC counter:

- Output Pulse Width and Frequency Modulation (OPWFM) mode
- Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode
- Center Aligned Output PWM with Dead Time Insertion (OPWMC) mode
- Center Aligned Output PWM with Dead Time Insertion Buffered (OPWMCB) mode
- Pulse or Edge Accumulation (PEA) mode
- Pulse Edge Counting (PEC) mode
- Windowed Programmable Time Accumulation (WPTA) mode
- Quadrature Decode (QDEC) mode
- Modulus Counter (MC) mode
- Modulus Counter Buffered (MCB) mode

All other modes not in this list do not use the internal counter.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 C	Internal Counter Value Indicates the value of the internal counter.

63.8.6.9 UC Control n (C0 - C23)

Offset

For n = 0 to 23:

Register	Offset
Cn	2Ch + (n × 20h)

Function

Controls UC operation.

Table 357. MODE field values

UC mode	MODE (binary)
GPIO (input)	000_0000
GPIO (output)	000_0001
SAIC	000_0010
SAIC with edge capturing	100_0010
SAOC	000_0011
IPWM	000_0100

Table continues on the next page...

Table 357. MODE field values (continued)

UC mode	MODE (binary)
IPM	000_0101
DAOC (with FLAG = 1 on B match)	000_0110
DAOC (with FLAG = 1 on A and B match)	000_0111
PEA (continuous)	000_1000
PEA (single shot)	000_1001
PEC (continuous)	000_1010
PEC (single shot)	000_1011
QDEC (for count and direction encoders type)	000_1100
QDEC (for phase_A and phase_B encoders type)	000_1101
WPTA	000_1110
Reserved	000_1111
MC (up counter with clear on match start)	001_000p[1]
MC (up counter with clear on match end)	001_001p[1]
MC (up/down counter)	001_01pp[1]
OPWFM (immediate update)	001_10p0[1]
OPWFM (next period update)	001_10p1[1]
OPWMC (with trailing edge dead time)	001_11p0[1]
OPWMC (with leading edge dead time)	001_11p1[1]
OPWM (immediate update)	010_00p0[1]
OPWM (next period update)	010_00p1[1]
Reserved	010_0100–010_0101
OPWMT	010_0110
Reserved	010_0111–100_1111
MCB (up counter)	101_000p[1]
Reserved	101_001p
MCB (up or down counter)	101_01pp[1]
OPWFMB	101_10p0[1]
Reserved	101_10p1
OPWMCB (with trailing edge dead time)	101_11p0[1]
OPWMCB (with leading edge dead time)	101_11p1[1]
OPWMB	110_00p0[1]
Reserved	110_0001–111_1111

1. p = Adjust parameters for the mode of operation. See Unified channels (UC) for details.

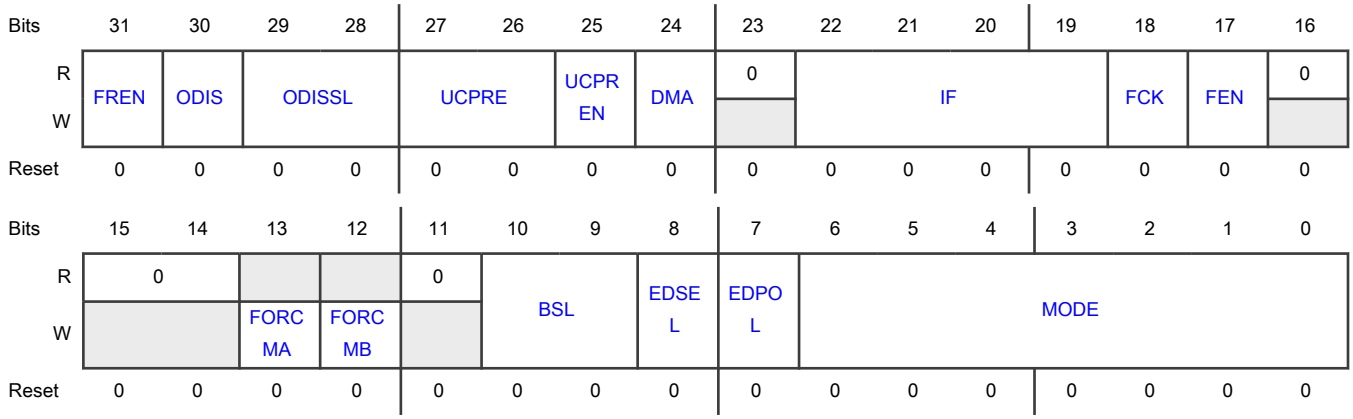
Table 358. Edge Polarity (EDPOL) settings

For these modes:	EDPOL does this:	and EDPOL values mean:
Input except QDEC	Selects which edge triggers the internal counter, an input capture, or the input capture flag. If EDPOL does not appear in the UC mode description, it has no effect on UC operation.	0b - Trigger on a falling edge 1b - Trigger on a rising edge
QDEC with bit 0 in MODE = 0	Selects the count direction according to the direction signal (UC*n* input). The EDPOL value in C*n-1* selects the edge that clocks the UC*n* internal counter.	0b - Counts down (decrements) when UC*n* asserts 1b - Counts up (increments) when UC*n* asserts
QDEC with bit 0 in MODE = 1	Selects the count direction according to the phase difference. To operate properly, EDPOL must be the same for C(*n* - 1) and C*n*.	0b - Counts down (decrements) if phase_A is ahead of phase_B 1b - Counts up (increments) if phase_A is ahead of phase_B
Output	Selects the logic level on the output pin.	0b - A match on comparator A deasserts the output flip-flop, while a match on comparator B sets it 1b - A match on comparator A asserts the output flip-flop, while a match on comparator B clears it

Table 359. Edge Select (EDSEL) settings

For these modes:	EDSEL does this:	and EDSEL values mean:
Input	Selects whether the internal counter is triggered by both edges of a pulse or by a single edge as defined by EDPOL. If EDSEL does not appear in the UC mode description, it has no effect on UC operation.	0b - Single-edge triggering on edge specified in EDPOL 1b - Both-edges triggering
GPIO in	Selects whether an edge asserts the input capture flag (S*n*[FLAG]).	0b - Sets S*n*[FLAG] on the edge specified in EDPOL 1b - Does not set S*n*[FLAG]
SAOC	Selects the behavior of the output flip-flop at each match.	0b - Drive the EDPOL value on the output flip-flop 1b - Toggle output flip-flop

Diagram



Fields

Field	Function
31 FREN	Freeze Enable Enables putting the UC in Freeze state. See Freeze and chip Debug mode. 0b - Disable 1b - Enable
30 ODIS	Output Disable Disables the output pin when running any of the output modes except GPIO. When you assert ODIS: • If the selected Output Disable Input signal asserts, the output pin reflects: — For OPWFMB and OPWMB modes, EDPOL (see Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode and Output PWM Buffered (OPWMB) mode). — For all other modes, the complement of EDPOL, but the UC continues to operate normally—it continues to generate flags and matches. • If the selected Output Disable Input signal deasserts, the output pin operates normally. 0b - Enables output pin (the output pin operates normally) 1b - Disables output pin
29-28 ODISSL	Output Disable Select Selects one of four output disable input signals. 00b - 0 01b - 1 10b - 2 11b - 3
27-26	Prescaler Selects the clock divider value for the UC internal prescaler.

Table continues on the next page...

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Field	Function
UCPRE	**NOTE** The two least-significant bits of C2_*n*[UCEXTPRE] mirror UCPRE. Any write to UCPRE also affects UCEXTPRE. 00b - 1 01b - 2 10b - 3 11b - 4
25 UCPREN	Prescaler Enable Enables the prescaler counter. 0b - Disable (no clock) 1b - Enable
24 DMA	Direct Memory Access Selects whether the input capture flag (S*n*[FLAG]) or overrun (S*n*[OVR]) triggers an interrupt or DMA request. 0b - Interrupt request 1b - DMA request
23 —	Reserved
22-19 IF	Input Filter Selects the minimum input pulse width, in filter clock cycles, that can pass through the input filter. This field does not apply to output modes. The filter latency—the difference in time between the input and the response—is three clock edges. 0000b - Bypassed; the input signal is synchronized before arriving at the digital filter 0001b - 2 cycles 0010b - 4 cycles 0100b - 8 cycles 1000b - 16 cycles All other values are reserved.
18 FCK	Filter Clock Select Selects the clock source for the programmable input filter. 0b - Prescaled clock 1b - eMIOS module clock

Table continues on the next page...

Table continued from the previous page...

Field	Function
17 FEN	Flag Enable Enables the input capture flag (S*n*[FLAG]) to generate an interrupt request or a DMA request, as selected in DMA. 0b - Disable 1b - Enable
16-14 —	Reserved
13 FORCMA	Force Match A For output modes, asserting Force Match A causes the comparator to report a successful comparison on comparator A regardless of whether a comparison actually occurred. It does not set the input capture flag (S*n*[FLAG]). This field always reads 0. This bit is meaningful for every output operation mode that uses comparator A. Otherwise it has no effect. 0b - No effect 1b - Force a match at comparator A
12 FORCMB	Force Match B For output modes, asserting Force Match B causes the comparator to report a successful comparison on comparator B regardless of whether a comparison actually occurred. It does not set the input capture flag (S*n*[FLAG] does not become 1). This field always reads 0. This field applies only if the UC is in one of the following output modes. • Single Action Output Capture (SAOC) mode • Double Action Output Compare (DAOC) mode • Output Pulse Width and Frequency Modulation (OPWFM) mode • Center Aligned Output PWM with Dead Time Insertion (OPWMC) mode • Output PWM (OPWM) mode • Output Pulse Width and Frequency Modulation Buffered (OPWFMB) mode • Center Aligned Output PWM with Dead Time Insertion Buffered (OPWMCB) mode • Output PWM Buffered (OPWMB) mode • Output PWM with Trigger (OPWMT) mode This field has no effect in all other modes. 0b - No effect 1b - Force a match at comparator B
11 —	Reserved
10-9	Bus Select

Table continues on the next page...

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Field	Function
BSL	Selects one of the counter buses or the internal counter for the UC. Not all chips support all counter buses. See the chip-specific eMIOS information for details. 00b - • Channels 0-22: counter bus A • Channel 23: reserved 01b - • Channels 1-7: counter bus B • Channels 9-15: counter bus C • Channels 17-23: counter bus D • Channels 25-31: counter bus E • Channels 0, 8, 16, 24: reserved 10b - • Channels 0-21, 23: counter bus F • Channel 22: reserved 11b - Internal counter for all channels
8 EDSEL	Edge Selection Controls several functions as shown in Table 359.
7 EDPOL	Edge Polarity Controls several functions as shown in Table 358.
6-0 MODE	Mode Selection Selects the UC mode as shown in Table 357. **NOTE** If you write a reserved value to this field, the results are unpredictable. When you change the value of MODE, you must first enter GPIO mode to reset the UC's internal functions. Failure to do this can result in invalid and unexpected output compare or input capture results or incorrectly set input capture flags (S*n*[FLAG]).

63.8.6.10 UC Status n (S0 - S23)

Offset

For n = 0 to 23:

Register	Offset
Sn	30h + (n × 20h)

Function

Indicates the status of the UC input-output signals and the overflow condition of the internal counter.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	OVR	0														
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	OVFL	0												UCIN	UCOUT	FLAG
W	W1C															W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	u[1]	0	0

1. Reset value is undefined.

Fields

Field	Function
31 OVR	Overrun Indicates that FLAG generation occurred when FLAG was already 1. Return OVR to 0 by writing 1 to either OVR or FLAG. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No overrun 1b - Overrun When writing 0b - No overrun 1b - Return OVR to 0
30-16 —	Reserved
15 OVFL	Overflow Indicates that an overflow has occurred in the internal counter. **NOTE** This field behaves differently for register reads and writes. When reading

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No overflow 1b - Overflow When writing 0b - No overflow 1b - Return OVFL to 0
14-3 —	Reserved
2 UCIN	UC Input Pin Indicates the input pin state after the input pin has been filtered and synchronized. 0b - Negated 1b - Asserted
1 UCOUT	UC Output Pin Indicates the output pin state. 0b - Negated 1b - Asserted
0 FLAG	Flag Indicates that an input capture or a match event in the comparators has occurred. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No event 1b - Event has occurred When writing 0b - No event 1b - Clear the flag (FLAG returns to 0)

63.8.6.11 Alternate Address n (ALTA0 - ALTA23)

Offset

For n = 0 to 23:

Register	Offset
ALTAn	34h + (n × 20h)

Function

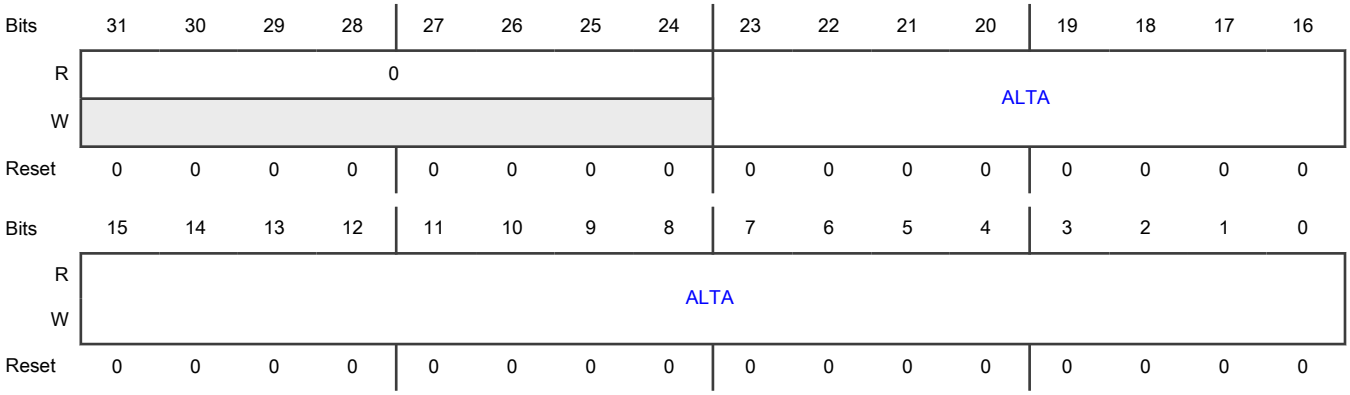
Provides an alternate address to access AS2 shadow registers in these restricted modes:

- General-Purpose Input and Output (GPIO) mode
- Pulse Edge Counting (PEC) mode
- Windowed Programmable Time Accumulation (WPTA) mode
- Output PWM with Trigger (OPWMT) mode

In these modes, you can use A*n*[A] together with ALTA*n*[ALTA] to access both AS1 and AS2. Assignment of values for A*n*[A], B*n*[B], and ALTA*n*[ALTA] summarizes the ALTA*n* writing and reading accesses for all ALTA*n* operation modes.

In modes that do not require this register, any write access is ignored and any read access returns unspecified data.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 ALTA	Alternate Address See the register description.

63.8.6.12 UC Control 2 n (C2_0 - C2_23)

Offset

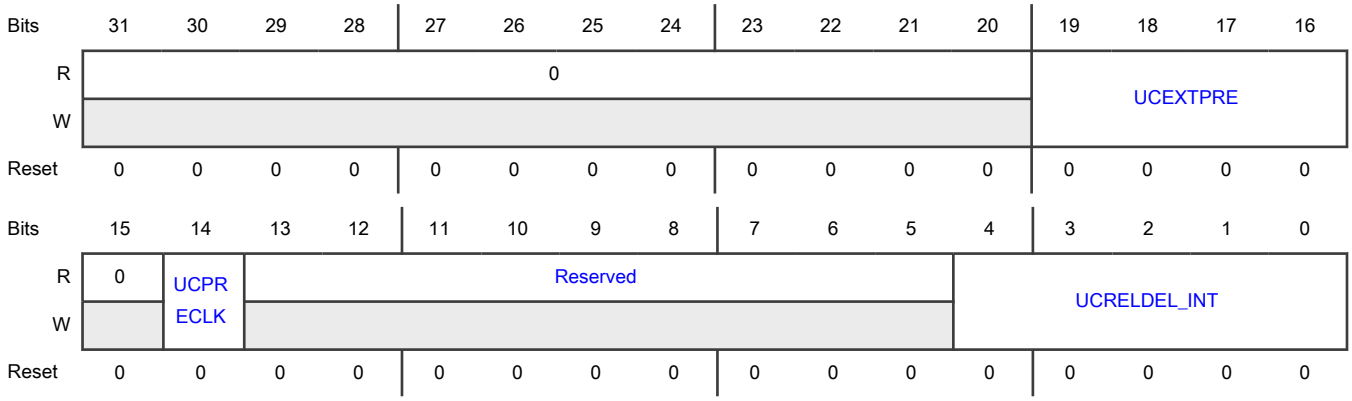
For n = 0 to 23:

Register	Offset
C2_n	38h + (n × 20h)

Function

Provides additional controls for the UC.

Diagram



Fields

Field	Function
31-20 —	Reserved
19-16 UCEXTPRE	Extended Prescaler Specifies the clock divider for the internal UC prescaler. Write the desired divider value minus 1. For example, for a divider of 1, write 0. **NOTE** The two least-significant bits of UCEXTPRE mirror C*n*[UCPRE]. Any write operation to UCEXTPRE also affects UCPRE.
15 —	Reserved
14 UCPRECLK	Prescaler Clock Source Selects the clock source for the internal prescaler. 0b - Prescaled clock 1b - eMIOS module clock
13-5 —	Reserved
4-0 UCRELDEL_INT	Reload Signal Output Delay Interval Specifies the delay interval, in counter bus reload events, between each assertion of AS1-BS1 reload in MC and MCB modes. 00000b - Every event 00001b - Every 2nd event 00010b - Every 3rd event

Table continues on the next page...

Table continued from the previous page...

Field	Function
	. . . 11111b - Every 32nd event

63.9 Glossary

BIU	IP bus interface unit
CP	Clock prescaler
GCP	Global clock prescaler
IIB	Internal interface bus
PIF	Programmable input filter
STAC	Shared time and angle count
UC	Unified channel

Chapter 64
Body Cross-triggering Unit (BCTU)

64.1 Chip-specific BCTU information

64.1.1 BCTU configuration

The following table lists the configuration supported by the BCTU instances:

Table 360. BCTU configuration

Parameter	BCTU_0[1]	BCTU_1
NUM_DATA_FIFO (Number of FIFO)	3	3
DATA_FIFO1_DEPTH (Depth of FIFO1: Defines the depth of FIFO1)	16	16
DATA_FIFO2_DEPTH , DATA_FIFO3_DEPTH (Depth of FIFO2-3 : Defines the depth of FIFO1)	8	8
ADC_DATA_WIDTH (ADC data bus width)	15	15
NB_OF_ADC (Number of ADC)	3	4
NB_OF_TRG(Number of trigger inputs)	45	45

1. BCTU_0 is not available in S32K36x.

64.1.2 Trigger sources

There are three kind of hardware triggers based on their implementation/source:

- eMIOS trigger (Directly from eMIOS):
  - To request an ADC conversion through the BCTU, eMIOS asserts its output signal, which is connected to a BCTU trigger input. When BCTU detects the asserted trigger, it routes that request to the ADCs selected in the corresponding Trigger Configuration (TRGCFG_n[ADC_SELm]). The trigger remains asserted until the requested conversion begins, at which time BCTU clears the trigger. If the eMIOS asserts the trigger input when the trigger is already set, BCTU ignores the new trigger.
- TRGMUX trigger (Through TRGMUX):
  - To request an ADC conversion through the BCTU, selected source in TRGMUX generate the positive pulse, which is connected to a BCTU trigger input via edge detection block. When BCTU detects the asserted trigger, it routes that request to the ADCs selected in the corresponding Trigger Configuration (TRGCFG_n[ADC_SELm]). Because of this edge detection logic , regardless of the pulse width , only one ADC conversion is triggered. If the source in TRGMUX generate the trigger input when the trigger is already set, BCTU ignores the new trigger.
- eTPU trigger (Directly from eTPU):
  - To request an ADC conversion through the BCTU, eTPU generate the positive pulse, which is connected to a BCTU trigger input. When BCTU detects the asserted trigger, it routes that request to the ADCs selected in the corresponding Trigger Configuration (TRGCFG_n[ADC_SELm]). The length of the trigger pulse needs to be equal to one BCTU clock because there is direct connection between the eTPU and BCTU. When the pulse will be shorted, the trigger can be missed by the BCTU and when the pulse will be longer, it can trigger multiple ADC conversion.

If the eTPU generates the trigger input when the trigger is already set, BCTU ignores the new trigger.

The following table lists the BCTU trigger sources.

Table 361. BCTU Trigger sources

BCTU Trigger Number	Module	Source
0	eMIOS_0	Channel_0
1	eMIOS_0	Channel_1
2	eMIOS_0	Channel_2
3	eMIOS_0	Channel_3
4	eMIOS_0	Channel_4
5	eMIOS_0	Channel_5
6	eMIOS_0	Channel_6
7	eMIOS_0	Channel_7
8	eMIOS_0	Channel_8
9	eMIOS_0	Channel_9
10	eMIOS_0	Channel_10
11	eMIOS_0	Channel_11
12	eMIOS_0	Channel_12
13	eMIOS_0	Channel_13
14	eMIOS_0	Channel_14
15	eMIOS_0	Channel_15
16	eMIOS_0	Channel_16
17	eMIOS_0	Channel_17
18	eMIOS_0	Channel_18
19	eMIOS_0	Channel_19
20	eMIOS_0	Channel_20
21	eMIOS_0	Channel_21
22	eMIOS_0	Channel_22
23	eTPU A pad ports	Channel_0
24	eTPU A pad ports	Channel_1
25	eTPU A pad ports	Channel_2
26	eTPU A pad ports	Channel_3
27	eTPU A pad ports	Channel_4
28	eTPU A pad ports	Channel_5
29	eTPU A pad ports	Channel_6
30	eTPU A pad ports	Channel_7
31	eTPU B pad ports	Channel_0

Table continues on the next page...

Table 361. BCTU Trigger sources (continued)

BCTU Trigger Number	Module	Source
32	eTPU B pad ports	Channel_1
33	eTPU B pad ports	Channel_2
34	eTPU B pad ports	Channel_3
35	eTPU B pad ports	Channel_4
36	eTPU B pad ports	Channel_5
37	eTPU B pad ports	Channel_6
38	eTPU B pad ports	Channel_7
39	TRGMUX	output ports 52 ,56 for BCTU_0 , BCTU_1 respectively
40	TRGMUX	output ports 53 ,57 for BCTU_0 , BCTU_1 respectively
41	TRGMUX	output ports 54 ,58 for BCTU_0 , BCTU_1 respectively
42	eMIOS_0 (Tied)	Reserved
43	eMIOS_0 (Tied)	Reserved
44	eMIOS_0 (Tied)	Reserved

64.2 Overview

BCTU accepts ADC conversion-request trigger inputs and routes those requests to one or more ADCs.

BCTU accepts the following trigger sources:

- Hardware triggers (outputs from on-chip timer modules)
- Software triggers through the SFTRGRn register

BCTU maps each trigger input to a Trigger Configuration (TRGCFG_0 - TRGCFG_44) register, which specifies the target ADC channel and other control data for the requested conversion.

You can configure a list of ADC channels, the CL, that processes a sequence of conversions in response to a single trigger input. See the Conversion list (CL) section.

BCTU stores each ADC conversion result for CPU access or routing to memory through DMA.

If the same ADC is targeted by multiple triggers, priority logic selects the next trigger to process from all active trigger inputs. See Priority of simultaneous triggers.

BCTU input trigger signals are level-sensitive; thus, if a logical level 1 is detected, an event is captured by the BCTU.

64.2.1 Block diagram

The following figure shows the top-level block diagram of BCTU.

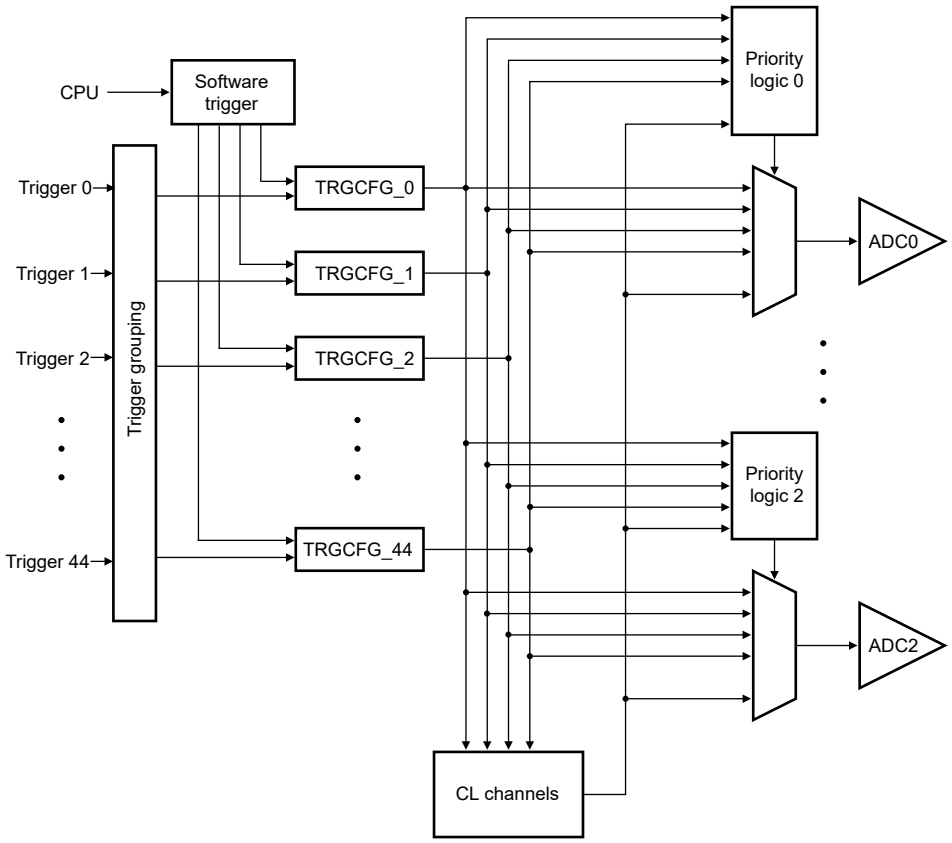


Figure 420. BCTU block diagram

64.2.2 Features

BCTU supports:

- 45 Trigger inputs, configured with the Trigger Configuration (TRGCFG_0 - TRGCFG_44) registers
- Trigger outputs to 3 ADCs
- One priority selection logic block per ADC
- Selection multiplexers to select one trigger at a time for each ADC
- A CL of 32 ADC channels
- A trigger grouping block to latch the hardware triggers. BCTU clears these triggers when the ADC sends an acknowledgement for conversion completion.

64.2.3 Interaction with other peripherals

BCTU works together with timer and ADC modules on the chip. Use the trigger configuration registers (TRGCFG_*n*) to map BCTU triggers to ADC inputs. When a timer output asserts a BCTU trigger, BCTU passes the trigger to an ADC input and stores the trigger assertion until the corresponding ADC begins the requested conversion. When the ADC completes the conversion, BCTU asserts a trigger clear signal to clear both the internally stored trigger and the external trigger source if they are still asserted. Implementation illustrates the modules that interact with BCTU.

NOTE

A timer trigger can remain active until the corresponding ADC initiates conversion. Therefore, another match may occur in the timer before the ADC conversion begins. BCTU does not detect this trigger overrun. Your application must look for and respond to such conditions.

64.2.4 Implementation

The following figure shows the implementation structure of the BCTU.

NOTE

For more details of the actual trigger sources implemented in this device, see the chip-specific information section.

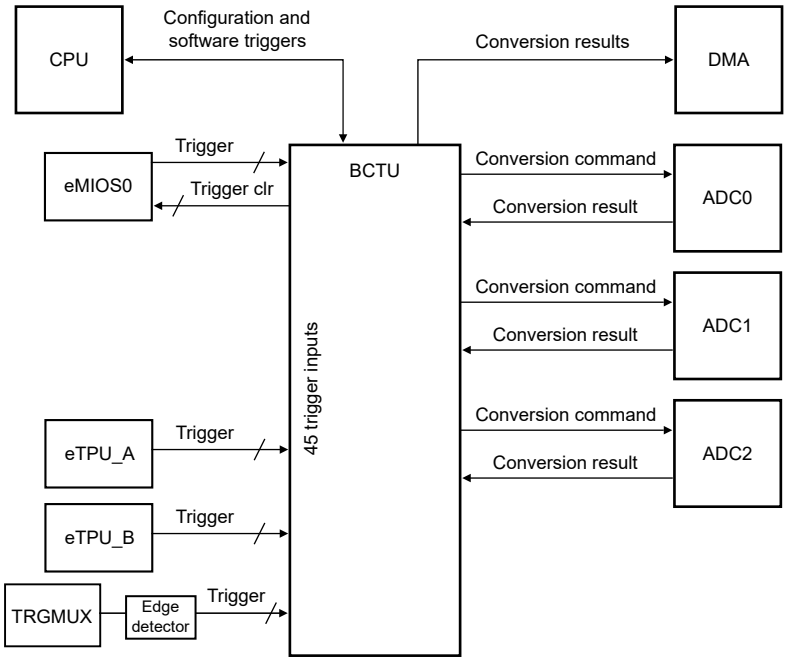


Figure 421. Implementation

64.3 Functional description

64.3.1 Triggers

64.3.1.1 Overview

BCTU prioritizes ADC trigger inputs based on the input number: the lower the number, the higher the priority associated with it. Therefore, trigger 0 is the highest priority trigger and trigger 44 is the lowest priority. The trigger input priority scheme determines which trigger takes precedence when more than one trigger occurs at the same time, or when the triggered ADC is busy with a conversion. Therefore, there are two possible scenarios for the trigger priority selection:

- When there are no ongoing conversions
- When a triggered ADC is executing a conversion

BCTU supports two types of trigger sources:

- Hardware triggers from timer modules
- Software triggers (SFTRGR*n*)

64.3.1.2 Hardware triggers

To request an ADC conversion through the BCTU, a timer module such as eMIOS asserts its output signal, which is connected to a BCTU trigger input. When BCTU detects the asserted trigger, it routes that request to the ADCs selected in the corresponding Trigger Configuration (TRGCFG_*n*[ADC_SEL*m*]). The trigger remains asserted until the requested conversion begins, at which time BCTU clears the trigger. If the timer asserts the trigger input when the trigger is already set, BCTU ignores the new trigger. If BCTU receives a new trigger input at the same time it is clearing the trigger, then the trigger remains asserted and BCTU initiates a new conversion.

If you configure the trigger for CL, trigger assertion begins a sequence of conversions controlled by the CL Channel Address (LISTCHR_0 - LISTCHR_15) registers. In this event, BCTU clears the trigger when the last conversion in the CL begins.

NOTE

Any new trigger input participates in the trigger priority selection scheme and therefore may not trigger the next conversion.

64.3.1.3 Software triggers

You assert a software trigger by writing 1 to the corresponding field of the appropriate software trigger (SFTRGR*n*) register. Similar to the hardware triggers, BCTU changes the software trigger field to 0 when the requested conversion begins. If you write 1 to the software trigger field while the conversion is still in progress, BCTU ignores the request. If you write 1 to the field at the same time BCTU is attempting to clear the trigger (change the field to 0), the trigger remains asserted and BCTU triggers a new conversion following the trigger priority criteria.

64.3.1.4 Configure all triggers

Global trigger enable (MCR[GTRGEN]) allows you to configure the BCTU trigger inputs and then activate them all at one time.

To configure and then activate all BCTU triggers:

1. Clear any currently active and asserted trigger inputs (write 0 to TRGFG_*n*[TRG_FLAG]), which also causes BCTU to assert trigger clear to the trigger sources.
2. Disable global triggers (MCR[GTRGEN]). This action deactivates all trigger inputs and prevents BCTU from generating any ADC conversion requests.
3. Configure the individual trigger inputs (see Configure individual triggers).
4. Enable global triggers (MCR[GTRGEN]). This action activates all individually enabled triggers at the same time.

64.3.1.5 Configure individual triggers

Using Trigger Configuration (TRGCFG_0 - TRGCFG_44), for each trigger:

- Enable the trigger (TRIGEN).
- Specify the target ADC (ADC_SEL*n*).
- Specify the ADC channel (CHANNEL_VALUE_OR_LADDR).
- Specify whether the trigger initiates a single conversion or a CL (TRS).
- For a CL trigger, specify a pointer to the CL element (TRGCFG_x[CHANNEL_VALUE_OR_LADDR]).

64.3.1.6 Reconfigure triggers on-the-fly

NOTE

Reconfigure BCTU triggers only when the individual trigger is not active (TRG_FLAG). If TRG_FLAG is 1, the requested conversion is still in progress and it is not safe to modify the trigger configuration.

To reconfigure a trigger on-the-fly (while BCTU is in full operation):

1. Disable the trigger (TRIGEN) to prevent it from requesting a new conversion.
2. Check the current state of the trigger (TRG_FLAG) to be sure no conversion or CL is in progress.
3. When any in-progress conversion or CL completes (TRG_FLAG == 0), clear the trigger source by writing 1 to TRG_FLAG. This action ensures that only trigger inputs that assert after you reconfigure and re-enable the trigger are able to request a new conversion or CL.
4. Reconfigure the trigger (see Configure individual triggers).
5. Enable the trigger (TRIGEN).

64.3.1.7 Enable software triggers

To allow software triggers (SFTRGRn) to request conversions, you must enable global trigger enable (MCR[GTRGEN]). If you disable global trigger enable, software triggers do not initiate a conversion but asserted triggers remain asserted. However, when you enable global trigger enable, any asserted software triggers initiate conversions following the priority scheme of lowest to highest trigger number.

Software triggers operate regardless of individual trigger enable (TRGCFG_x[TRIGEN]). That is, writing 1 to any Software Trigger (SFTRGRn) initiates a conversion (following the priority scheme) regardless of the value of trigger enable. This software trigger independence supports the elimination of conflict between software and hardware triggers.

64.3.1.8 Trigger timing

There are four clock cycles from assertion of a BCTU trigger input to assertion of the trigger output to the ADC. For single conversions, BCTU asserts trigger clear back to the trigger source simultaneous to asserting the trigger to the ADC.

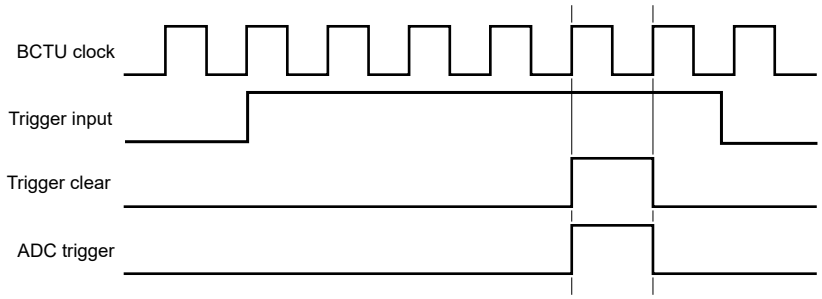


Figure 422. Trigger timing

64.3.1.9 Priority of simultaneous triggers

When more than one trigger input asserts a conversion request to the same ADC at the same time—that is, in the same BCTU clock cycle—BCTU employs a priority scheme to determine which asserted trigger to process next. BCTU prioritizes trigger inputs based on the trigger number. The lowest number, trigger 0, has the highest priority, and the highest number, trigger 44, has the lowest priority.

If two triggers assert in the same clock cycle, BCTU gives priority to the lower numbered trigger. For example, if trigger 0 and trigger 1 both assert in the same cycle, BCTU selects trigger 0 for trigger generation. Trigger 1 remains active (pending) until the conversion requested by trigger 0 completes. See Simultaneous trigger priority management.

If trigger 0 asserts again before the next trigger selection opportunity at the end of the current conversion, then BCTU selects it again and trigger 1 remains asserted (pending) during the next ADC conversion time frame.

As illustrated in Trigger timing, BCTU requires four clock cycles to transmit a conversion request to an ADC if that ADC is not already executing a conversion. However, if the ADC is busy at the time of trigger assertion, BCTU requires only three clock cycles to generate the conversion request for a subsequent conversion.

Triggers that assert in the same clock cycle but target different ADCs are not in conflict, and BCTU processes both triggers at the same time.

64.3.1.10 Simultaneous trigger priority management

The following figure shows the simultaneous triggers for priority management.

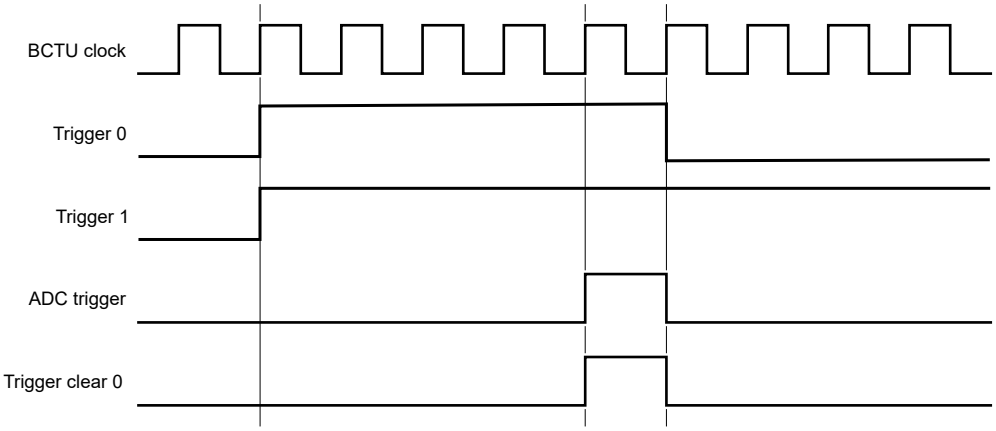


Figure 423. Simultaneous trigger priority management

64.3.1.11 Trigger management when ADC is busy

When a trigger input asserts a conversion request to an ADC that is already processing a conversion requested by a different trigger, the new trigger remains active (pending) until the conversion in progress completes. This behavior is the same as if the two triggers had been simultaneous (occurred in the same clock cycle). When the in-progress conversion completes, the pending trigger then competes for priority with any other active trigger for that ADC.

64.3.1.12 Trigger clearing mechanism

There are two sources of ADC conversion triggers: hardware trigger, from the trigger inputs and software triggers, from SFTRGRn register.

A logical level 1 is detected in the input and captured into an input trigger register. This register remains set until the related conversion starts. At this time, the input trigger register is cleared. If another logical level 1 is detected while the trigger register is already set, the new level is not considered by the BCTU hardware. If a new logical level 1 occurs at the same time the trigger register is being cleared, then the register remains set and a new conversion is triggered by this input.

NOTE

The new triggered conversion will participate in the trigger priority selection thus may not trigger the next conversion.

The software trigger behaves similarly to the hardware trigger. The difference is that the trigger register is set by a CPU write operation. The trigger register is cleared by the BCTU hardware when the related conversion starts. If the CPU tries to set the trigger register by writing to the SFTRGR register corresponding bit, while the register is already set, the new attempt to set the register is not considered by the BCTU hardware. If a set occurs at the same time the hardware is attempting to clear the same trigger register, then the set has precedence and the register remains set. A new conversion will be triggered following the trigger priority criteria implemented in the hardware.

In case a LIST of conversions is triggered, instead of a single conversion, the trigger register is cleared at the start of the last conversion in the LIST.

64.3.2 Conversion list (CL)

64.3.2.1 CL overview

A CL executes a sequence of conversions on one or more target ADCs. See CL architecture and operation. It also stores information from the last conversion executed in a sequence except for the target ADC, which is stored in ADC select n (TRGCFG_*m*[ADC_SEL*n*]).

If the channel or CL address (TRGCFG_x[CHANNEL_VALUE_OR_LADDR]) points to a CL element containing one or more entries:

1. The trigger initiates a sequence of conversions starting with the target CL element.
2. The sequence executes until the LAST channel (LISTCHR_*n*[LAST_y] is 1), and stops after that channel is converted.

When you configure the CL element for next channel wait for trigger (write 1 to LISTCHR_*n*[NEXT_CH_WAIT_ON_TRIG_y]):

1. BCTU clears the trigger source.
2. CL execution pauses after the current conversion is completed.
3. CL execution resumes when the same trigger asserts again.

BCTU determines trigger priority before executing any CL. See Priority of simultaneous triggers.

64.3.2.2 CL architecture and operation

The following figure shows the CL architecture and operation.

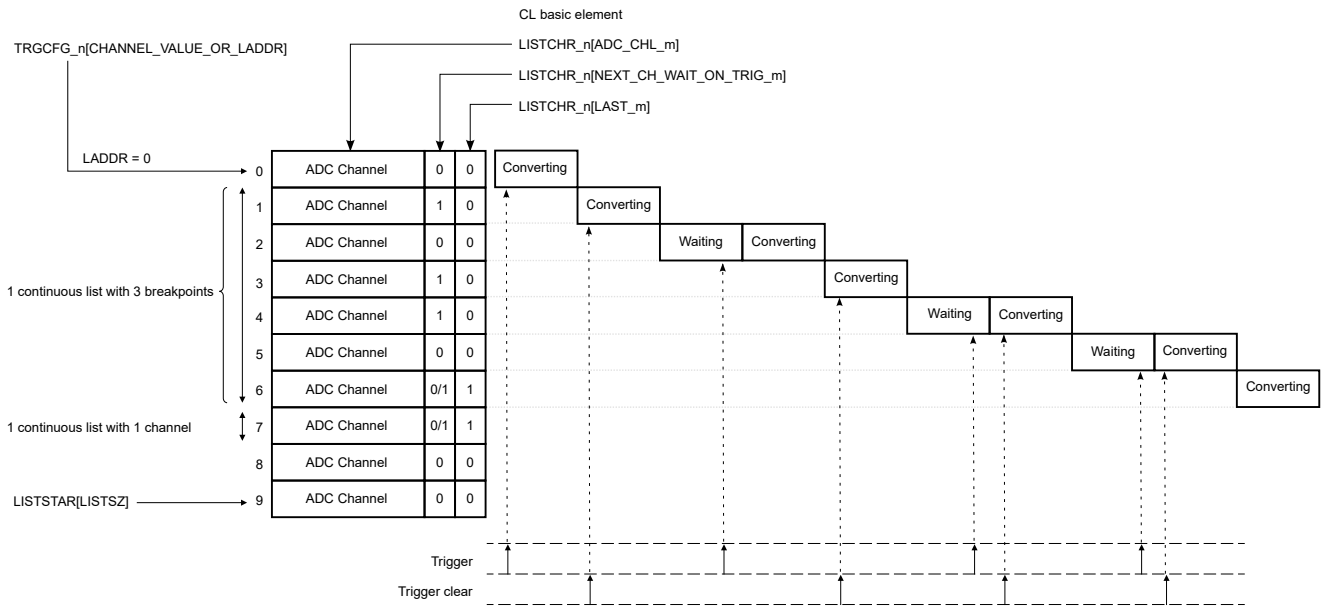


Figure 424. CL architecture and operation

64.3.2.3 CL channel rules

CL conversion obeys the following rules:

- The sequence of conversions executes until the Last Channel (LISTCHR_*n*[LAST_y] is 1).
- A CL conversion sequence precludes other conversions on the same ADC. If the CL is waiting (LISTCHR_*n*[NEXT_CH_WAIT_ON_TRIG_y] is 1), BCTU cannot route a non-CL conversion to that ADC (although that ADC remains available for normal and injected conversions).
- Two or more triggers for different ADCs may point to the same CL. This CL can drive parallel execution on the selected ADCs.

- If the Channel or CL Address (TRGCFG_x[CHANNEL_VALUE_OR_LADDR]) does not point to a valid list address, BCTU uses address 0 by default.
- When the CL pointer reaches the last available list address (LISTSTAR[LISTSZ] minus 1), the pointer wraps to list address 0.
- You can select more than one ADC per trigger using the ADC Select n (TRGCFG_x[ADC_SELn]) fields, but selecting more than one ADC is valid only for multiple parallel CL operation. If you select more than one ADC for a single-conversion trigger, BCTU ignores the trigger.

64.3.3 ADC conversion results access

64.3.3.1 Overview

The value of DATA_DEST determines access to ADC results.

- DATA_DEST = 000: ADC results are available in the ADC data registers.
- DATA_DEST = 001: ADC results are available in FIFO 1 Result Data (FIFO Result Data (FIFO1DR - FIFO3DR)). See Route conversion data to FIFO.
- DATA_DEST = 010: ADC results are available in FIFO 2 Result Data (FIFO Result Data (FIFO1DR - FIFO3DR)). See Route conversion data to FIFO.
- DATA_DEST = 011: ADC results are available in FIFO 3 Result Data (FIFO Result Data (FIFO1DR - FIFO3DR)). See Route conversion data to FIFO.

You can access ADC results using flags and interrupt requests (see Access on interrupt request) or DMA (see Access on DMA request). Interrupt requests are based on Module Status (MSR) flags. ADC*n*DR provides the following information, with one register used for each ADC:

- The conversion results
- The channel that was used for the conversion
- The trigger input that initiated the conversion
- Whether a CL element generated the conversion
- Whether the data was the last conversion of a CL

64.3.3.2 Access on interrupt request

If interrupts are enabled for ADC*n* Result Data (MCR[IEN*n*] is 1) and DMAs are disabled for ADC*n* Result Data (MCR[DMA*n*] is 0), BCTU generates an interrupt request for each available conversion data in ADC*n*DR. Because BCTU executes conversions on different ADCs in parallel, conversion results may be available on multiple ADCs at the same time. New Data (MSR[NDATAn] is 1) indicates that new conversion data is available in the corresponding ADC Data Result (ADC*n*DR). To clear the New Data flag, write 1 to MSR[NDATAn_CLR].

64.3.3.3 Access on DMA request

If you enable DMA requests (MCR[DMA*n*]):

- You must select one channel for DMA per ADC.
- New conversion result data (ADC*n*DR) generates a DMA request.
- The DMA controller deasserts the DMA request and writes 1 to MSR[NDATAn_CLR] to clear the flag.

When an ADC generates new data (MSR[NDATAn]), BCTU processes the DMA request. See Clear a DMA request.

64.3.3.4 Clear an interrupt request

BCTU clears an interrupt request when:

- The number of valid entries is less than or equal to the FIFOn watermark level (FIFOWM[WM_FIFO*n*]).

- You write 1 to FIFO watermark interrupt status (FIFOERR[WM_INT_FIFO*n*]).

64.3.3.5 Clear a DMA request

BCTU clears a DMA request when:

- The number of valid entries is less than or equal to the FIFOn watermark level (FIFOWM[WM_FIFO*n*]).
- The DMA controller sends acknowledgment to BCTU.

64.3.3.6 Clear an error-generated interrupt request

Clear an interrupt generated because of an error condition by writing 1 to the appropriate error flag:

- FIFOERR[OVR_ERR_FIFO1]
- FIFOERR[UNDR_ERR_FIFO1]
- FIFOERR[OVR_ERR_FIFO2]
- FIFOERR[UNDR_ERR_FIFO2]
- FIFOERR[OVR_ERR_FIFO3]
- FIFOERR[UNDR_ERR_FIFO3]

64.3.3.7 Conversion data overrun

If new ADC conversion data becomes available before you read the previous data (ADC*n*DR), then BCTU indicates a data overrun (MSR[DATAOVRn] is 1).

If you enable interrupts for the ADC (MCR[IEN*n*]), a data overrun also generates an interrupt request, regardless of the DMA request configuration.

To clear a data overrun (MSR[DATAOVRn]), write 1 to data overrun clear (MSR[DATAOVRn_CLR]). See Clear an error-generated interrupt request.

64.3.3.8 Route conversion data to FIFO

BCTU allows you to route multiple ADC conversion results to one of 3 internal data FIFOs. Any trigger source can route results to an available FIFO based on the trigger index. Each FIFO has a dedicated counter (FIFOCNTR[CNTR_FIFO*n*]) to indicate the number of entries in the FIFO.

Each FIFO also has its own result data register (FIFO*n*DR) that contains the following information about the last conversion result routed to the FIFO.

- ADC result data
- Trigger source index
- ADC number
- ADC channel number

64.3.3.9 Read ADC result from FIFO

Each FIFO has DMA and interrupt interfaces. The DMA interface reads data. The interrupt interface indicates watermark and error conditions:

- An overrun error (FIFOERR[OVR_ERR_FIFO*n*]) occurs when you attempt to write data to an already full FIFO.
- An underrun error (FIFOERR[UNDR_ERR_FIFO*n*]) occurs when you attempt to read data from an empty FIFO.
- BCTU asserts a watermark interrupt request if the number of valid FIFO entries exceeds the watermark level (FIFOWM[WM_FIFO*n*]).

You can read a FIFO:

- by enabling DMA requests (FIFOCR[DMA_EN_FIFO*n*])
- by polling the FIFO full status (FIFOSR[FULL_FIFO*n*])

See Configuration of DMA and interrupt behavior.

64.3.3.10 Configuration of DMA and interrupt behavior

Table 362. Configuration of DMA and interrupt behavior

FIFOCR[DMA_EN_FIFO*n*]	FIFOCR[IEN_FIFO*n*]	Condition
0	0	No DMA request; no interrupt request
0	1	Interrupt request when FIFO exceeds watermark level; interrupt request on error
1	0	DMA request when FIFO exceeds watermark level
1	1	DMA request when FIFO exceeds watermark level; interrupt request on error

64.3.4 Multiple parallel conversions (MPC)

64.3.4.1 Overview

The MPC mechanism allows you to execute a series of simultaneous ADC conversions by selecting more than one ADC for any CL-configured trigger.

64.3.4.2 Configure MPC

To configure a CL to perform MPC:

1. Select CL for the trigger resolution (write 1 to TRGCFG_*m*[TRS]).
2. Select more than one ADC for the trigger (TRGCFG_*m*[ADC_SEL*n*]).
3. Specify the CL address for the first CL element (TRGCFG_*m*[CHANNEL_VALUE_OR_LADDR]).

64.3.4.3 CL address selection for MPC

When the trigger input for the CL asserts, BCTU uses the channel or list address (CHANNEL_VALUE_OR_LADDR) as an index into the CL for the lowest numbered ADC selected (ADC_SEL*n*), and each subsequent element of the CL for each remaining selected ADC. The set of selected ADC channels perform their conversions in parallel. When that set of conversions is complete, the next set of CL elements determine the next set of ADC channels to perform parallel conversions, as illustrated in:

- Example: MPC with two ADCs
- Example: MPC with three ADCs

64.3.4.4 Example: MPC with two ADCs

The following figure shows the example of MPC with two ADCs.

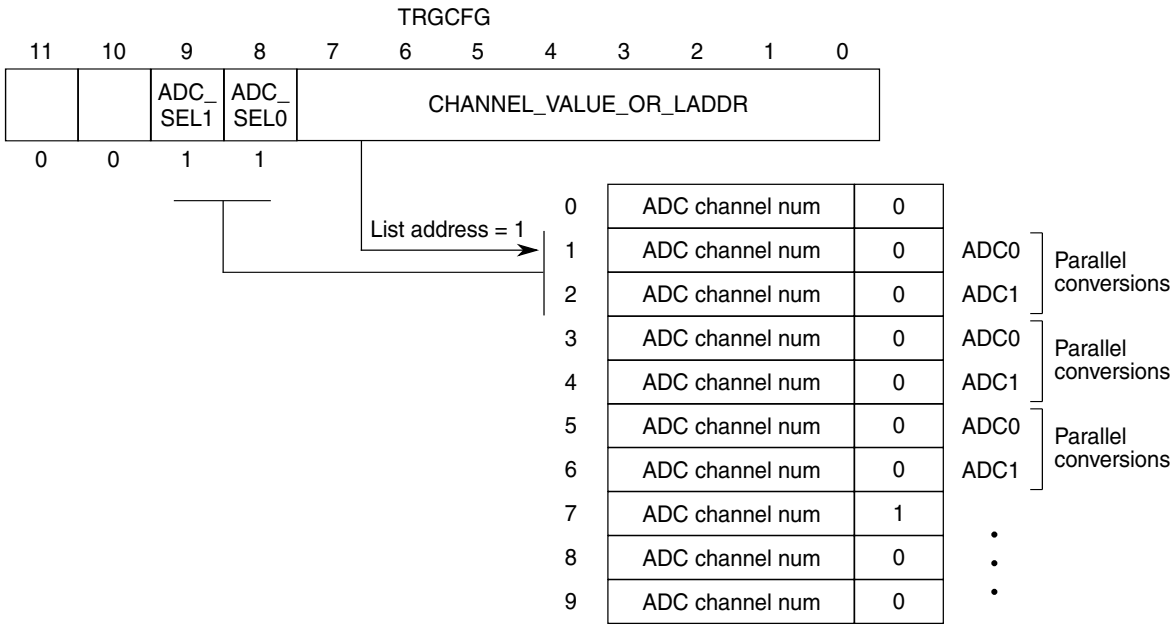


Figure 425. Example: MPC with two ADCs

64.3.4.5 Example: MPC with three ADCs

The following figure shows the example of MPC with three ADCs.

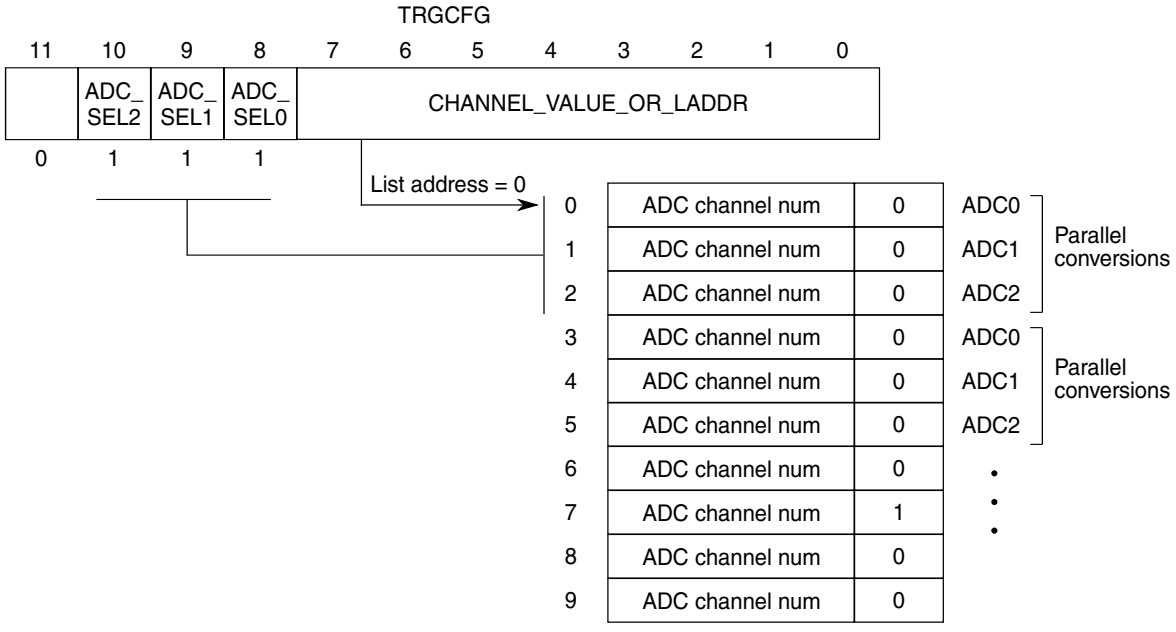


Figure 426. Example: MPC with three ADCs

64.3.4.6 MPC priority rules

MPC follows the same priority rules as for single conversions, which is based on the trigger input number: the lower the trigger, the higher the priority. However, MPC cannot start until all ADCs selected for the CL are available; that is, they are not currently

engaged in conversion. For example, if a trigger input asserts for a CL using ADC0 and ADC1, BCTU does not initiate the CL until ADC0 and ADC1 are both available.

Also, if ADC0 is available but there is a higher priority trigger for ADC1, the MPC does not start. If trigger inputs assert for two MPCs that have at least one ADC in common, the lower trigger number has higher priority. A priority conflict occurs only when separate requested CLs have at least one ADC in common. If the MPCs use different ADCs, there is no conflict and the MPCs execute at the same time.

64.3.5 Modes

64.3.5.1 Module Disable (Low Power state)

Module disable (MCR[MDIS]) stops the BCTU clock, resulting in reduced power consumption.

When you disable BCTU (write 1 to MDIS), it:

- Waits for the completion of any in-progress conversions before stopping the clock.
- Ignores all trigger inputs.
- Does not trigger any ADC conversion requests.
- Maintains any asserted trigger inputs, which you can clear if necessary.

When you re-enable BCTU (write 0 to MDIS) and global triggers are enabled (MCR[GTRGEN]), BCTU processes all active asserted trigger inputs and sends conversion requests to ADCs according to the priority scheme.

64.3.6 Clocking

This module has two clock ports.

1. ipg_clk_bctu - is the main clock of complete BCTU IP.
2. ipg_clk_s - is the gated IPG clock to be used in BCTU registers only.

64.3.7 Software reset

You can reinitialize all BCTU registers to their reset values with software reset (MCR[Software_Reset]).

Software reset does not clear any active trigger inputs, but it does put the ADC interface into the Reset state. Therefore, to avoid data incoherency, you must terminate any BCTU-triggered conversions or wait until they are complete before asserting software reset.

64.3.8 Interrupts and DMA requests

Table 363. Interrupts and DMA requests

Event	Enable interrupt	Enable DMA request	Description
Trigger Flag	MCR[TRGEN]	—	Interrupt request on assertion of trigger flag (MSR[TRGF])
ADC Data Ready	MCR[IEN*n*]	MCR[DMA*n*]	Interrupt or DMA request when ADC result data is available (ADC*n*DR)
CL Last	MCR[LIST_IEN]	—	Interrupt request when the last conversion of any CL executes
FIFO Watermark	FIFOCR[IEN_FIFO*n*]	FIFOCR[DMA_EN_FIFO*n*]	Interrupt or DMA request when the number of valid FIFO entries exceeds the FIFO

64.4 BCTU register descriptions

All BCTU registers are 32 bits wide. 8-bit write operations are allowed. The BCTU module does not include any coherence mechanism, so application software must ensure coherency.

NOTE

- You must always write 0 to reserved writable registers and fields. Read accesses of reserved registers and fields do not return meaningful data.
- For registers with write protection, if protection is active and you attempt to write to those registers, register content is unaffected and BCTU issues a transfer error.

64.4.1 BCTU memory map

BCTU base address: 4008_4000h

BCTU_1 base address: 406C_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration (MCR)	32	RW	0000_0000h
8h	Module Status (MSR)	32	RW	0000_0000h
18h - C8h	Trigger Configuration (TRGCFG_0 - TRGCFG_44)	32	RW	0000_0000h
228h	Write Protection (WRPROT)	32	RW	0000_0000h
22Ch	Software Trigger 1 (SFTRGR1)	32	RW	0000_0000h
230h	Software Trigger 2 (SFTRGR2)	32	RW	0000_0000h
23Ch - 248h	ADCn Result Data (ADC0DR - ADC3DR)	32	R	See section
24Ch	CL Size Status (LISTSTAR)	32	R	0000_0020h
250h - 28Ch	CL Channel Address (LISTCHR_0 - LISTCHR_15)	32	RW	0000_0000h
450h - 458h	FIFO Result Data (FIFO1DR - FIFO3DR)	32	R	0000_0000h
460h	FIFO Control (FIFOCR)	32	RW	0000_0000h
464h	FIFO Watermark Configuration (FIFOWM)	32	RW	0000_0000h
468h	FIFO Error/Status (FIFOERR)	32	RW	0000_0000h
46Ch	FIFO Status (FIFOSR)	32	R	0000_0000h
470h	FIFO Counter (FIFOCNTR)	32	R	0000_0000h

64.4.2 Module Configuration (MCR)

Offset

Register	Offset
MCR	0h

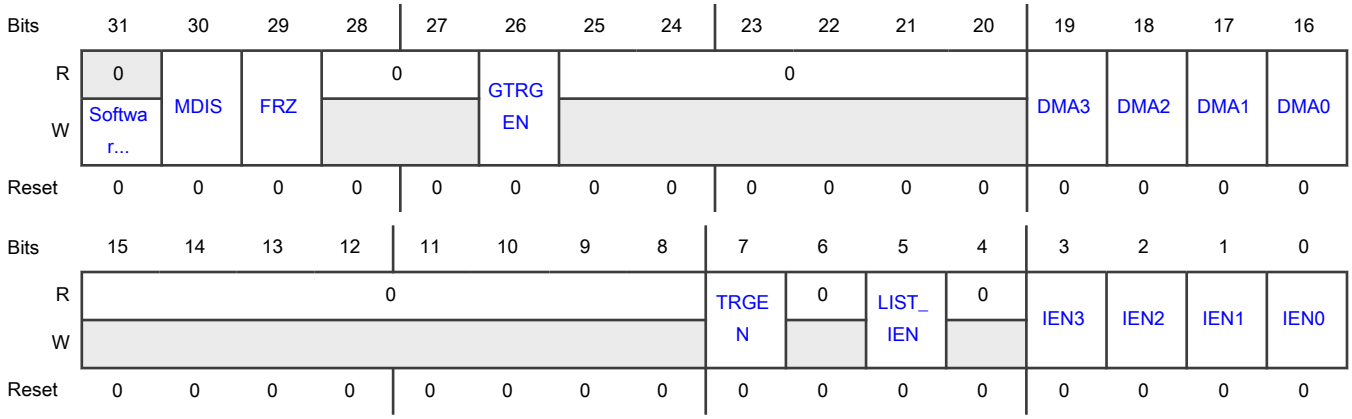
Function

Configures the following aspects of BCTU behavior:

- Low power
- Debug
- Trigger control
- DMA control
- Interrupt control

Access: User read/write

Diagram



Fields

Field	Function
31 Software_Reset	Software Reset Asserts soft reset, which initializes all BCTU registers and internal state machines to their reset values. 0b - Deasserts 1b - Asserts
30 MDIS	Module Disable Disables BCTU by putting it in Low Power state (see Module Disable (Low Power state)). 0b - Enable (normal operation) 1b - Disable (low-power operation)
29 FRZ	Debug Freeze Disables all hardware trigger inputs but leaves the software trigger enabled. Debug Freeze isolates BCTU from external triggers and allows you to manually trigger a conversion and read the conversion result. 0b - Disables 1b - Enables

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>28-27
—</td><td>Reserved</td></tr>
<tr><td>26
GTRGEN</td><td>Global Trigger Enable
Enables all individually enabled trigger inputs at the same time. For any given input trigger to be active, you must both enable the individual trigger (TRGCFG_n[TRIGEN]) and Global Trigger Enable.
See Configure all triggers.
0b - Disable
1b - Enable</td></tr>
<tr><td>25-20
—</td><td>Reserved</td></tr>
<tr><td>19
DMA3</td><td>Enable ADC3DR DMA
Enables DMA operation when new data is available in ADCnDR.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>BCTU</td><td>—</td><td>MCR</td></tr><tr><td>BCTU_1</td><td>MCR</td><td>—</td></tr></table>
0b - Disable
1b - Enable</td></tr>
<tr><td>18
DMA2</td><td>Enable ADC2DR DMA
Enables DMA operation when new data is available in ADCnDR.
0b - Disable
1b - Enable</td></tr>
<tr><td>17
DMA1</td><td>Enable ADC1DR DMA
Enables DMA operation when new data is available in ADCnDR.
0b - Disable
1b - Enable</td></tr>
<tr><td>16
DMA0</td><td>Enable ADC0DR DMA
Enables DMA operation when new data is available in ADCnDR.</td></tr>
</table>

Table continues on the next page...

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Field	Function
	0b - Disable 1b - Enable
15-8 —	Reserved
7 TRGEN	Trigger Interrupt Request Enable Enables an interrupt request on a Trigger Flag (MSR[TRGF]). 0b - Disable 1b - Enable
6 —	Reserved
5 LIST_IEN	CL Interrupt Enable Enables an interrupt request for the last conversion in a CL (both ADC*n*DR[LIST] and ADC*n*DR[LAST] are 1). 0b - Disable 1b - Enable
4 —	Reserved
3 IEN3	Interrupt Enable For ADC3DR Enables an interrupt request when BCTU writes a new conversion result to ADC Data (ADC*n*DR). Also enables an interrupt request on an overrun in ADC*n*DR, which indicates the previous data has been overwritten by a new conversion result. See also MSR[NDATA*n*] and MSR[DATAOVR*n*]]. Enabling ADC*n*DR DMA (DMA*n* field) disables the interrupt for new data in ADC*n*DR, but the interrupt for ADC*n*DR data overrun remains enabled. **NOTE** This field is not supported in every instance. The following table includes only supported registers. 0b - Disable 1b - Enable

Instance	Field supported in	Field not supported in
BCTU	—	MCR
BCTU_1	MCR	—

Table continues on the next page...

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Field	Function
2 IEN2	Interrupt Enable For ADC2DR Enables an interrupt request when BCTU writes a new conversion result to ADC Data (ADC*n*DR). Also enables an interrupt request on an overrun in ADC*n*DR, which indicates the previous data has been overwritten by a new conversion result. See also MSR[NDATA*n*] and MSR[DATAOVR*n*]]. Enabling ADC*n*DR DMA (DMA*n* field) disables the interrupt for new data in ADC*n*DR, but the interrupt for ADC*n*DR data overrun remains enabled. 0b - Disable 1b - Enable
1 IEN1	Interrupt Enable For ADC1DR Enables an interrupt request when BCTU writes a new conversion result to ADC Data (ADC*n*DR). Also enables an interrupt request on an overrun in ADC*n*DR, which indicates the previous data has been overwritten by a new conversion result. See also MSR[NDATA*n*] and MSR[DATAOVR*n*]]. Enabling ADC*n*DR DMA (DMA*n* field) disables the interrupt for new data in ADC*n*DR, but the interrupt for ADC*n*DR data overrun remains enabled. 0b - Disable 1b - Enable
0 IEN0	Interrupt Enable For ADC0DR Enables an interrupt request when BCTU writes a new conversion result to ADC Data (ADC*n*DR). Also enables an interrupt request on an overrun in ADC*n*DR, which indicates the previous data has been overwritten by a new conversion result. See also MSR[NDATA*n*] and MSR[DATAOVR*n*]]. Enabling ADC*n*DR DMA (DMA*n* field) disables the interrupt for new data in ADC*n*DR, but the interrupt for ADC*n*DR data overrun remains enabled. 0b - Disable 1b - Enable

64.4.3 Module Status (MSR)

Offset

Register	Offset
MSR	8h

Function

Indicates the status of various BCTU functions, including:

- Whether conversion data is available for each ADC
- CL operation, such as the last conversion command executed in a CL
- Whether BCTU triggered any of the ADCs

All flag fields become 0 upon assertion of a low-power (software) or clock-stop (hardware) request. You can turn off individual flags by writing 1 to the field.

Access: User read/write

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	0			0	0	0	0	0	0	0	0	0	0	0	0
W	TRGF_CLR				LIST3_L...	LIST2_L...	LIST1_L...	LIST0_L...	DATAOVR...	DATAOVR...	DATAOVR...	DATAOVR...	NDATA3_...	NDATA2_...	NDATA1_...	NDATA0_...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TRGF	0			LIST3_L...	LIST2_L...	LIST1_L...	LIST0_L...	DATAOVR3	DATAOVR2	DATAOVR1	DATAOVR0	NDATA3	NDATA2	NDATA1	NDATA0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 TRGF_CLR	TRGF Clear Changes Trigger Flag (TRGF) to 0. 0b - No action 1b - Changes to 0
30-28 —	Reserved
27 LIST3_Last_CLR	CL 3 Last Clear Changes CL *3* Last (LIST*n*_Last) to 0. **NOTE** This field is not supported in every instance. The following table includes only supported registers. Instance / Field supported in / Field not supported in: BCTU — MSR BCTU_1 MSR — 0b - No action 1b - Changes to 0
26	CL 2 Last Clear

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>LIST2_Last_CLR</td><td>Changes CL 2 Last (LISTn_Last) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>25
LIST1_Last_CLR</td><td>CL 1 Last Clear
Changes CL 1 Last (LISTn_Last) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>24
LIST0_Last_CLR</td><td>CL 0 Last Clear
Changes CL 0 Last (LISTn_Last) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>23
DATAOVR3_CLR</td><td>DATAOVR3 Clear
Changes Data Overrun 3 (DATAOVRn) to 0.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>BCTU</td><td>—</td><td>MSR</td></tr><tr><td>BCTU_1</td><td>MSR</td><td>—</td></tr></table>0b - No action
1b - Changes to 0</td></tr>
<tr><td>22
DATAOVR2_CLR</td><td>DATAOVR2 Clear
Changes Data Overrun 2 (DATAOVRn) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>21
DATAOVR1_CLR</td><td>DATAOVR1 Clear
Changes Data Overrun 1 (DATAOVRn) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>20</td><td>DATAOVR0 Clear</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>DATAOVR0_CLR</td><td>Changes Data Overrun 0 (DATAOVRn) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>19
NDATA3_CLR</td><td>New Data Clear
Changes New Data 3 (NDATAn) to 0.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>BCTU</td><td>—</td><td>MSR</td></tr><tr><td>BCTU_1</td><td>MSR</td><td>—</td></tr></table>
0b - No action
1b - Changes to 0</td></tr>
<tr><td>18
NDATA2_CLR</td><td>New Data Clear
Changes New Data 2 (NDATAn) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>17
NDATA1_CLR</td><td>New Data Clear
Changes New Data 1 (NDATAn) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>16
NDATA0_CLR</td><td>New Data Clear
Changes New Data 0 (NDATAn) to 0.
0b - No action
1b - Changes to 0</td></tr>
<tr><td>15
TRGF</td><td>Trigger Flag
Indicates at least one ADC was triggered.
0b - No ADC triggered
1b - An ADC was triggered</td></tr>
<tr><td>14-12</td><td>Reserved</td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>—</td><td></td></tr>
<tr><td>11
LIST3_Last</td><td>CL 3 Last Conversion
Indicates that ADC3 has executed the last conversion in a CL.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>BCTU</td><td>—</td><td>MSR</td></tr><tr><td>BCTU_1</td><td>MSR</td><td>—</td></tr></table>
0b - Last conversion not complete
1b - Last conversion complete</td></tr>
<tr><td>10
LIST2_Last</td><td>CL 2 Last Conversion
Indicates that ADC2 has executed the last conversion in a CL.
0b - Last conversion not complete
1b - Last conversion complete</td></tr>
<tr><td>9
LIST1_Last</td><td>CL 1 Last Conversion
Indicates that ADC1 has executed the last conversion in a CL.
0b - Last conversion not complete
1b - Last conversion complete</td></tr>
<tr><td>8
LIST0_Last</td><td>CL 0 Last Conversion
Indicates that ADC0 has executed the last conversion in a CL.
0b - Last conversion not complete
1b - Last conversion complete</td></tr>
<tr><td>7
DATAOVR3</td><td>Data Overrun 3
Indicates that the data in ADC3 has been overwritten with new data.
NOTE
This field is not supported in every instance. The following table includes only supported registers.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>BCTU</td><td>—</td><td>MSR</td></tr>
<tr><td>BCTU_1</td><td>MSR</td><td>—</td></tr>
</table>
0b - Data not overwritten
1b - Data overwritten
</td></tr>
<tr><td>6
DATAOVR2</td><td>Data Overrun 2
Indicates that the data in ADC2 has been overwritten with new data.
0b - Data not overwritten
1b - Data overwritten</td></tr>
<tr><td>5
DATAOVR1</td><td>Data Overrun 1
Indicates that the data in ADC1 has been overwritten with new data.
0b - Data not overwritten
1b - Data overwritten</td></tr>
<tr><td>4
DATAOVR0</td><td>Data Overrun 0
Indicates that the data in ADC0 has been overwritten with new data.
0b - Data not overwritten
1b - Data overwritten</td></tr>
<tr><td>3
NDATA3</td><td>New Data 3
Indicates that new conversion data is available for ADC3.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>BCTU</td><td>—</td><td>MSR</td></tr>
<tr><td>BCTU_1</td><td>MSR</td><td>—</td></tr>
</table>
0b - Not available
1b - Available
</td></tr>
<tr><td>2</td><td>New Data 2</td></tr>
</table>

Table continues on the next page...

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Field	Function
NDATA2	Indicates that new conversion data is available for ADC2. 0b - Not available 1b - Available
1 NDATA1	New Data 1 Indicates that new conversion data is available for ADC1. 0b - Not available 1b - Available
0 NDATA0	New Data 0 Indicates that new conversion data is available for ADC0. 0b - Not available 1b - Available

64.4.4 Trigger Configuration (TRGCFG_0 - TRGCFG_44)

Offset

For a = 0 to 44:

Register	Offset
TRGCFG_a	18h + (a × 4h)

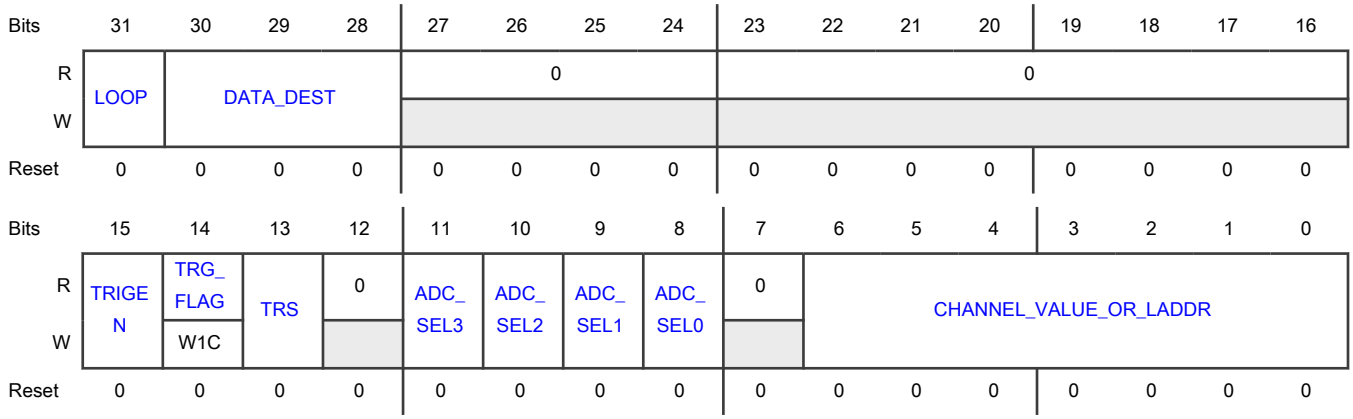
Function

Configures the corresponding trigger:

- Specifies the target ADC and ADC channel to use for conversion.
- Specifies whether to use a CL or a single ADC conversion command.

Access: User read/write

Diagram



Fields

Field	Function
31 LOOP	Loop Specifies that the current trigger executes in a loop; that is, the triggered conversion repeats until you disable Loop. Each loop-triggered conversion wins the priority evaluation among all pending triggers, and executes only if it is the highest-priority triggered conversion at the moment the conversion starts. 0b - Disable 1b - Enable
30-28 DATA_DEST	Data Destination Specifies the destination for storing the conversion results. You can route each ADC's conversion result to either of the following: • ADC-specific data registers • One of the available FIFOs BCTU routes conversion results to different destinations based on the trigger index that requested the conversion. You cannot duplicate the same data in more than one destination. 000b - ADC-specific data registers 001b - FIFO1 010b - FIFO2 011b - FIFO3 All other values are reserved.
27-24 —	Reserved
23-16 —	Reserved
15	Trigger Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
TRIGEN	Enables hardware input triggers to initiate ADC conversions. This field does not affect software triggers. 0b - Disable 1b - Enable
14 TRG_FLAG	Trigger Flag Indicates the trigger input is asserted and an ADC conversion is in progress. When the conversion completes, BCTU changes this field to 0. Writing 1 to this field causes the input trigger event to clear when the in-progress conversion completes, and prevents this trigger from initiating a new ADC conversion until the input trigger is asserted again. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No ongoing ADC conversion initiated 1b - Ongoing ADC conversion initiated When writing 0b - No action 1b - Changes to 0
13 TRS	Trigger Resolution Selects single conversion or CL conversions. 0b - Single conversion 1b - CL conversions
12 —	Reserved
11 ADC_SEL3	ADC Select 3 Selects ADC *3* for conversion. **NOTE** This field is not supported in every instance. The following table includes only supported registers. 0b - Deselects

Instance	Field supported in	Field not supported in
BCTU	—	TRGCFG_0–TRGCFG_44
BCTU_1	TRGCFG_0–TRGCFG_44	—

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Selects
10 ADC_SEL2	ADC Select 2 Selects ADC *2* for conversion. 0b - Deselects 1b - Selects
9 ADC_SEL1	ADC Select 1 Selects ADC *1* for conversion. 0b - Deselects 1b - Selects
8 ADC_SEL0	ADC Select 0 Selects ADC *0* for conversion. 0b - Deselects 1b - Selects
7 —	Reserved
6-0 CHANNEL_VALUE_OR_LADDR	Channel or CL Address Depending on the value of TRS: • 0: Specifies the ADC channel for conversion • 1: Specifies the address of the first CL position to execute

64.4.5 Write Protection (WRPROT)

Offset

Register	Offset
WRPROT	228h

Function

Enables write protection at reset exit. To allow writes to protected registers, you must write a special code into PROTEC_CODE. There are two codes to remove protection: one that permanently disables the protection; one that disables protection during one write cycle to a protected register, after which the protection code returns to the initial (protected) value of 0000b.

Access: User read/write

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												PROTEC_CODE			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved
3-0 PROTEC_CODE	Protection Code Controls the protection of write-protected registers. **NOTE** You can write this field only in Normal mode (MCR[MDIS] is 0). 0000b - Enable protection 1001b - Disable protection for one write cycle 1010b - Disable protection permanently

64.4.6 Software Trigger 1 (SFTRGR1)

Offset

Register	Offset
SFTRGR1	22Ch

Function

Allows you to trigger conversions on the associated triggers.

To use a software trigger, you must first disable the corresponding hardware trigger (TRGCFG_x[TRIGEN]).

BCTU writes 0 to a software trigger field on completion of the triggered conversion.

Access: User read/write; this register is write protected by Write Protection (WRPROT). If protection is enabled, writes to this register generate a transfer error and do not modify its content.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SFTRG31	SFTRG30	SFTRG29	SFTRG28	SFTRG27	SFTRG26	SFTRG25	SFTRG24	SFTRG23	SFTRG22	SFTRG21	SFTRG20	SFTRG19	SFTRG18	SFTRG17	SFTRG16
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SFTRG15	SFTRG14	SFTRG13	SFTRG12	SFTRG11	SFTRG10	SFTRG9	SFTRG8	SFTRG7	SFTRG6	SFTRG5	SFTRG4	SFTRG3	SFTRG2	SFTRG1	SFTRG0
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SFTRGm	Software Trigger m Starts an ADC conversion. 0b - No effect 1b - Trigger conversion

64.4.7 Software Trigger 2 (SFTRGR2)

Offset

Register	Offset
SFTRGR2	230h

Function

Allows you to trigger conversions on the associated triggers.

To use a software trigger, you must first disable the corresponding hardware trigger (TRGCFG_*n*[TRIGEN]).

BCTU writes 0 to a software trigger field on completion of the triggered conversion.

Access: User read/write; this register is write protected by Write Protection (WRPROT). If protection is enabled, writes to this register generate a transfer error and do not modify its content.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0			SFTRG44	SFTRG43	SFTRG42	SFTRG41	SFTRG40	SFTRG39	SFTRG38	SFTRG37	SFTRG36	SFTRG35	SFTRG34	SFTRG33	SFTRG32
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-13 —	Reserved
12-0 SFTRGm	Software Trigger m Starts an ADC conversion. 0b - No effect 1b - Trigger conversion

64.4.8 ADCn Result Data (ADC0DR - ADC3DR)

Offset

Register	Offset
ADC0DR	23Ch
ADC1DR	240h
ADC2DR	244h
ADC3DR	248h

Function

Provides ADC conversion result data. Also indicates the ADC channel used in that conversion, the trigger source that initiated it, and whether conversion was initiated from a CL.

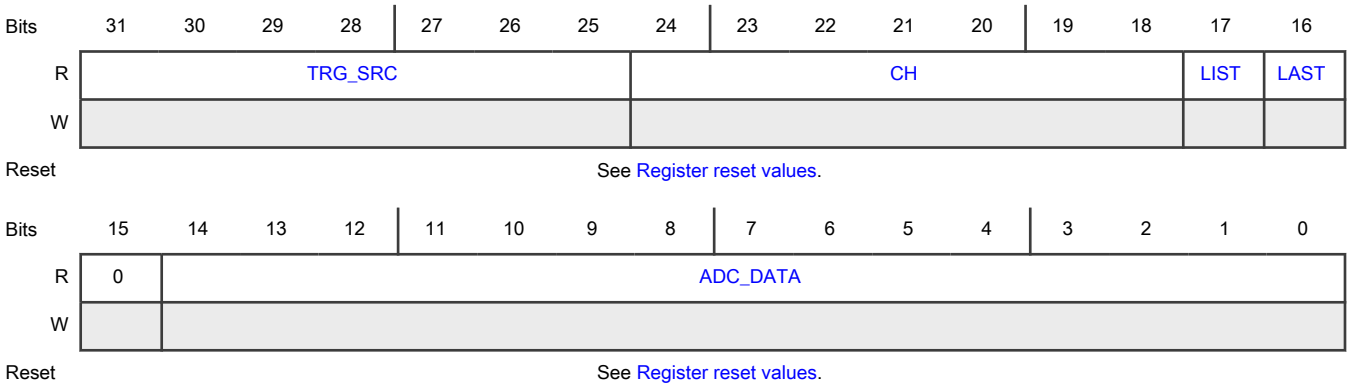
Access: User read

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
BCTU	ADC0DR–ADC2DR	ADC3DR
BCTU_1	ADC0DR–ADC3DR	—

Diagram



Register reset values

Register	Reset value
ADC0DR–ADC2DR	BCTU,BCTU_1: 0000_0000h
ADC3DR	0000_0000h

Fields

Field	Function
31-25 TRG_SRC	Trigger Source Contains the trigger number used to trigger the conversion.
24-18 CH	Channel Contains the ADC channel used for the conversion.
17 LIST	List Indicates whether the conversion was part of a CL or a single conversion trigger. 0b - Single conversion 1b - CL
16 LAST	Last For CL conversions, indicates this conversion result is the last conversion of the CL. 0b - Not the last conversion of a CL, or not a CL conversion

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Last conversion of a CL
15 —	Reserved
14-0 ADC_DATA	ADC Data Contains the data from the conversion.

64.4.9 CL Size Status (LISTSTAR)

Offset

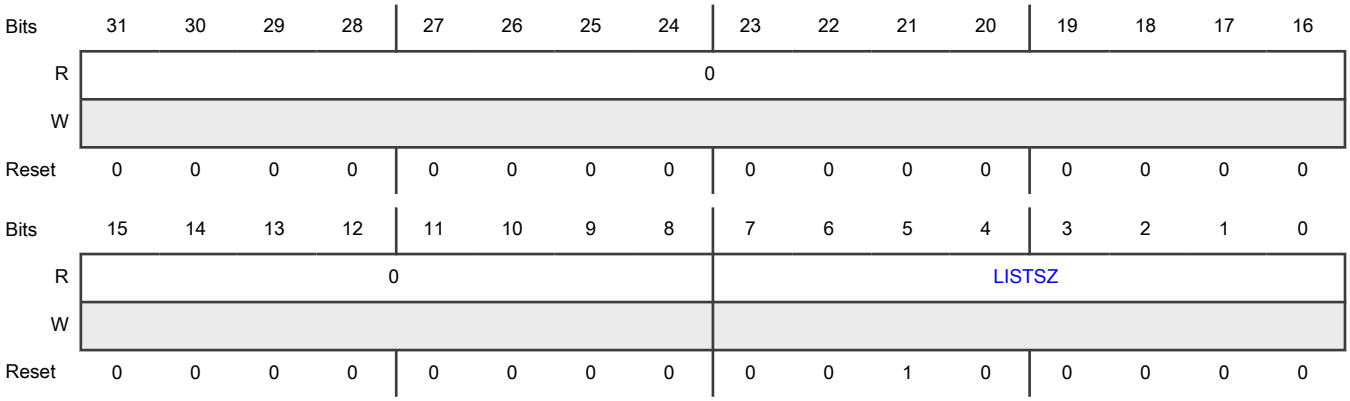
Register	Offset
LISTSTAR	24Ch

Function

Indicates the size of the CL. Each element of the CL contains the channel number used in one conversion.

Access: User read

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 LISTSZ	CL Size Indicates the size of the CL in number of elements.

64.4.10 CL Channel Address (LISTCHR_0 - LISTCHR_15)

Offset

For m = 0 to 15:

Register	Offset
LISTCHR_m	250h + (m × 4h)

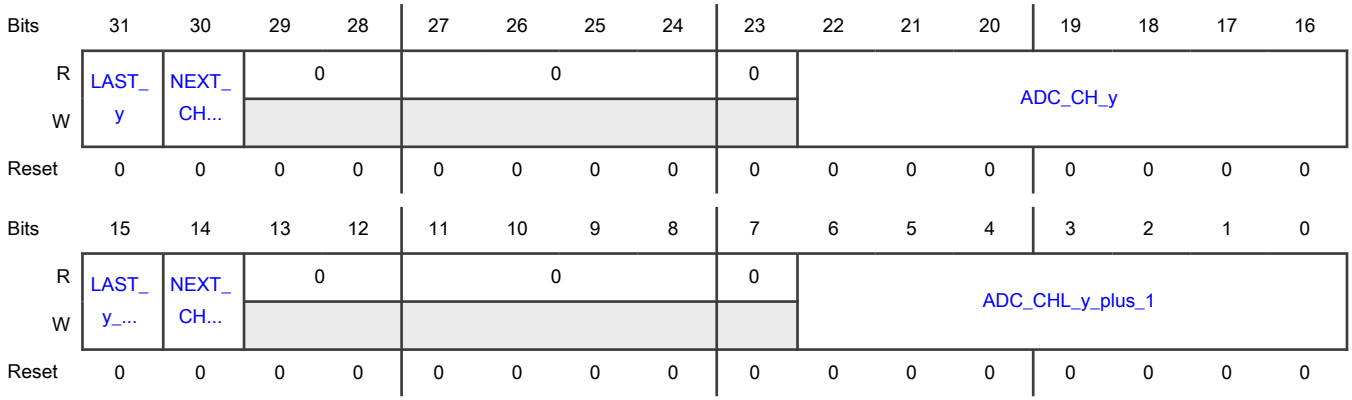
Function

Configures these attributes for two CL elements:

- ADC channel number to use for conversion
- Whether the element is the last element of a CL

Access: User read/write

Diagram



Fields

Field	Function
31 LAST_y	Last Channel Specifies this element as the last channel in the CL. 0b - Not last 1b - Last channel in CL
30 NEXT_CH_WAIT_ON_TRIG_y	Next Channel Wait For Trigger Instructs CL execution to stop after executing the current ADC channel. Execution begins again when the same trigger, which started the CL, reoccurs. **NOTE** If this is the last channel in the CL (LAST_y), you must write 0 to this field. 0b - CL executes continuously

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - CL stops executing
29-28 —	Reserved
27-24 —	Reserved
23 —	Reserved
22-16 ADC_CH_y	ADC Channel Selection Specifies the ADC channel to use for the *y* element of the CL, where *y* equals (2 x *m*).
15 LAST_y_plus_1	Last Channel Plus 1 Specifies this element as the next-to-last channel in the CL. 0b - Not next-to-last 1b - Next-to-last channel in CL
14 NEXT_CH_WAIT_ON_TRIG_y_plus_1	Next Channel Wait For Trigger Plus 1 Instructs CL execution to stop after executing the current ADC channel. Execution begins again when the same trigger, which started the CL, reoccurs. **NOTE** If this is the last channel in the CL (LAST_y_plus_1), you must write 0 to this field. 0b - CL executes continuously 1b - CL stops executing
13-12 —	Reserved
11-8 —	Reserved
7 —	Reserved
6-0 ADC_CHL_y_plus_1	ADC Channel Selection Plus 1 Specifies the ADC channel to use for the (*y* + 1) element of the CL, where *y* equals (2 x *m*).

64.4.11 FIFO Result Data (FIFO1DR - FIFO3DR)

Offset

Register	Offset
FIFO1DR	450h
FIFO2DR	454h
FIFO3DR	458h

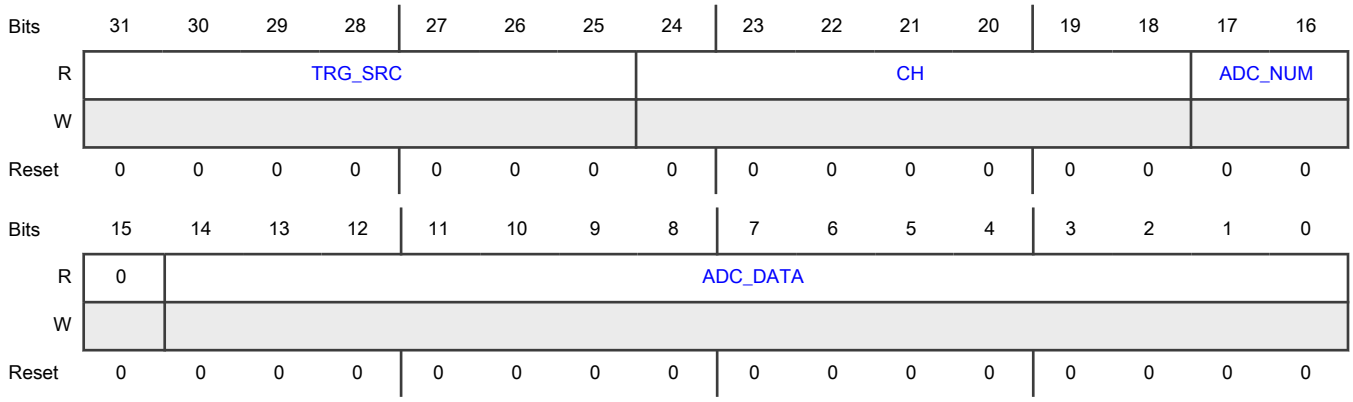
Function

Contains the ADC conversion result and information about the conversion:

- ADC channel
- Trigger source
- ADC number

Access: User read

Diagram



Fields

Field	Function
31-25 TRG_SRC	Trigger Source Indicates the trigger number used to trigger the conversion.
24-18 CH	Channel Indicates the ADC channel used for the conversion.
17-16 ADC_NUM	ADC Number Indicates the ADC used for conversion. 00b - ADC 0

Table continues on the next page...

Table continued from the previous page...

Field	Function
	01b - ADC 1 10b - ADC 2 11b - ADC 3
15 —	Reserved
14-0 ADC_DATA	ADC Data Contains the conversion data.

64.4.12 FIFO Control (FIFOCR)

Offset

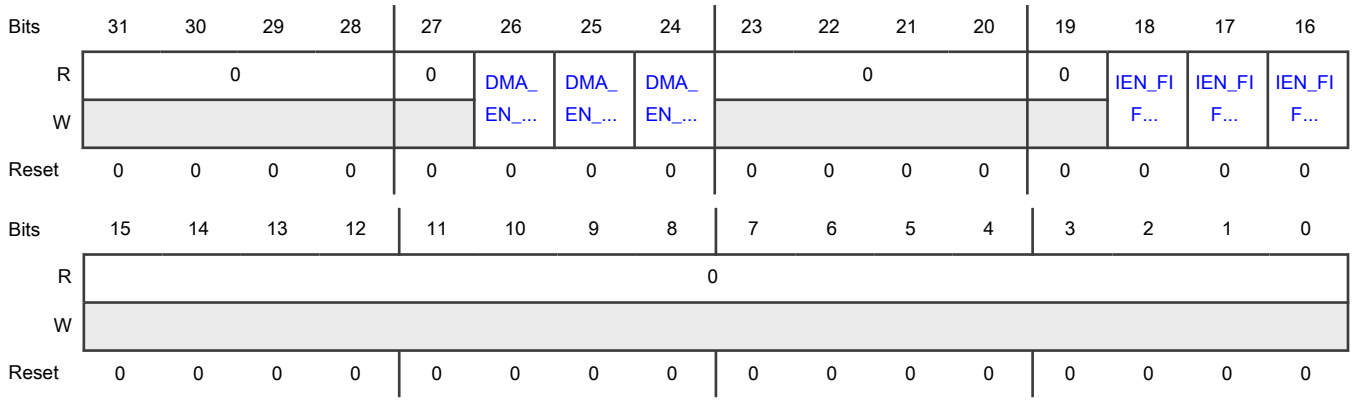
Register	Offset
FIFOCR	460h

Function

Provides control of FIFO-specific DMA, interrupts, and error interrupts.

Access: User read/write

Diagram



Fields

Field	Function
31-28 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
27 —	Reserved
26-24 DMA_EN_FIFOn	FIFOn DMA Enable Enables a DMA request when the number of valid FIFO entries is greater than the watermark level for that FIFO. 0b - Disable 1b - Enable
23-20 —	Reserved
19 —	Reserved
18-16 IEN_FIFOn	FIFOn Interrupt Enable Enables an interrupt request if the number of valid FIFO entries is greater than the watermark level for the FIFO. 0b - Disable 1b - Enable
15-0 —	Reserved

64.4.13 FIFO Watermark Configuration (FIFOWM)

Offset

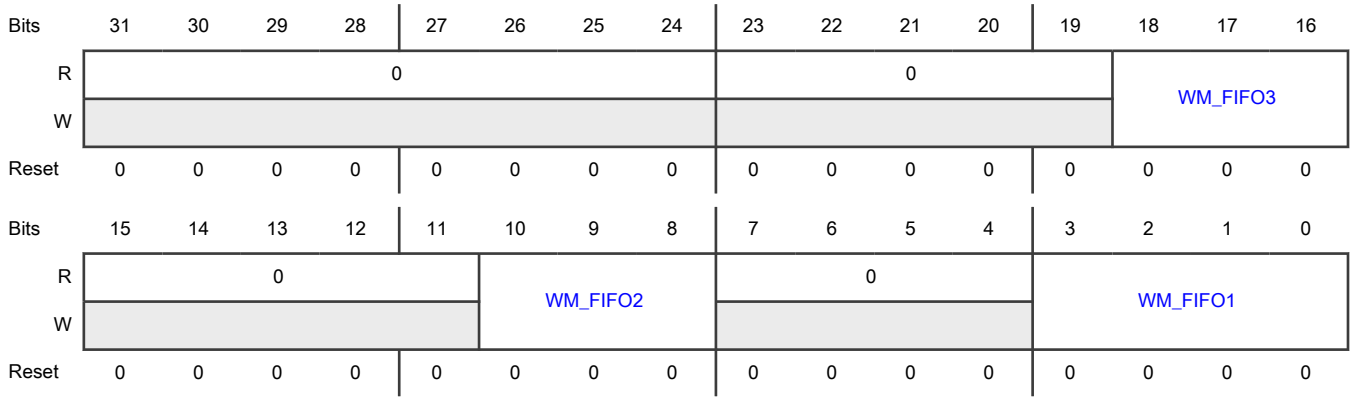
Register	Offset
FIFOWM	464h

Function

Specifies the FIFO watermark levels. If the number of active FIFO entries exceeds the watermark level, a DMA or interrupt request can be generated. See FIFO Control (FIFOCR).

Access: User read/write

Diagram



Fields

Field	Function
31-24 —	Reserved
23-19 —	Reserved
18-16 WM_FIFO3	FIFO3 Watermark Level Specifies the watermark level for FIFO3.
15-11 —	Reserved
10-8 WM_FIFO2	FIFO2 Watermark Level Specifies the watermark level for FIFO2.
7-4 —	Reserved
3-0 WM_FIFO1	FIFO1 Watermark Level Specifies the watermark level for FIFO1.

64.4.14 FIFO Error/Status (FIFOERR)

Offset

Register	Offset
FIFOERR	468h

Function

Allows you to clear FIFO error and status flags. Each FIFO has its own error and status flags that can be configured to generate an interrupt. FIFO Status (FIFOSR) maintains the status of these flags. BCTU writes a 1 to these flags, and you must then clear them using FIFOERR.

Access: User read/write

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		UNDR_ER...	OVR_ERR...	UNDR_ER...	OVR_ERR...	UNDR_ER...	OVR_ERR...	0				0	WM_INT_...	WM_INT_...	WM_INT_...
W			W1C	W1C	W1C	W1C	W1C	W1C						W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29 UNDR_ERR_FIFO3	Underrun Error Flag Indicates you have attempted to read from an empty FIFO. 0b - No underrun 1b - Underrun
28 OVR_ERR_FIFO3	Overrun Error Flag Indicates you have attempted to write to a full FIFO. 0b - No overrun 1b - Overrun
27 UNDR_ERR_FIFO2	Underrun Error Flag Indicates you have attempted to read from an empty FIFO. 0b - No underrun 1b - Underrun
26 OVR_ERR_FIFO2	Overrun Error Flag Indicates you have attempted to write to a full FIFO.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No overrun 1b - Overrun
25 UNDR_ERR_FIFO1	Underrun Error Flag Indicates you have attempted to read from an empty FIFO. 0b - No underrun 1b - Underrun
24 OVR_ERR_FIFO1	Overrun Error Flag Indicates you have attempted to write to a full FIFO. 0b - No overrun 1b - Overrun
23-20 —	Reserved
19 —	Reserved
18-16 WM_INT_FIFOn	FIFO Watermark Interrupt Status Indicates the number of active entries in FIFOn exceeds the watermark level. 0b - Does not exceed watermark 1b - Exceeds watermark
15-0 —	Reserved

64.4.15 FIFO Status (FIFOSR)

Offset

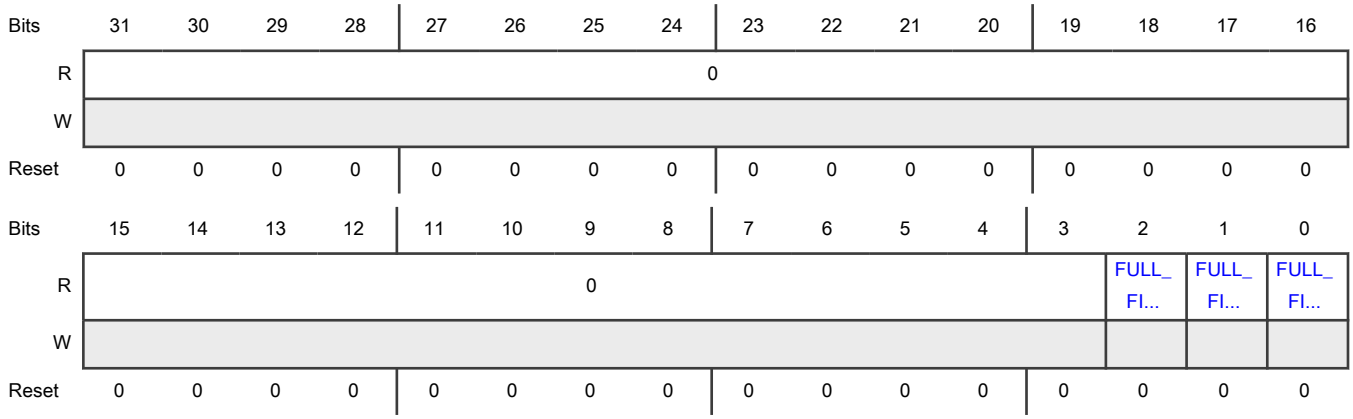
Register	Offset
FIFOSR	46Ch

Function

Contains the FIFO-full flags.

Access: User read

Diagram



Fields

Field	Function
31-3 —	Reserved
2-0 FULL_FIFOn	FIFO Full Indicates the FIFO is full. 0b - Not full 1b - Full

64.4.16 FIFO Counter (FIFOCNTR)

Offset

Register	Offset
FIFOCNTR	470h

Function

Indicates the number of active entries in each FIFO.

Access: User read

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								0				CNTR_FIFO3			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				CNTR_FIFO2				0				CNTR_FIFO1			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-20 —	Reserved
19-16 CNTR_FIFO3	Indicates the number of active entries in FIFO3.
15-12 —	Reserved
11-8 CNTR_FIFO2	FIFO2 Counter Indicates the number of active entries in FIFO2. See the chip-specific BCTU information for BCTU configuration.
7-5 —	Reserved
4-0 CNTR_FIFO1	FIFO1 Counter Indicates the number of active entries in FIFO1. See the chip-specific BCTU information for BCTU configuration.

64.5 Glossary

CL Conversion list. The set of ADC channels, configured through the CL Channel Address (LISTCHR_0 - LISTCHR_15) registers, used for performing multiple sequential conversions initiated by a single trigger.

MPC Multiple parallel conversions

PSI Parallel side interface

RWB Read/write bus

WDATA Write Data bus

Chapter 65
Trigger MUX (TRGMUX)

65.1 Chip-specific TRGMUX information

65.1.1 TRGMUX input output configuration and instances

This chip has 2 instance of TRGMUX module.

- TRGMUX_APP
- TRGMUX_MSC

The device supports the triggering scheme between peripherals. For the supported trigger sources and destination, see the TRGMUX connectivity file attached to this document.

NOTE

eTPU is supported for S32K396 only.

This device has 8 pads (SIUL2) mapped from TRGMUX inputs and TRGMUX outputs are mapped to the eMIOS channels, hence two timers channels can use a single pin of the device to do input capture.

While using TRGMUX, below points need to be taken care:

- Pulses which are visible on pads depends on the pad type. Different pad supports different frequencies. For more details on pad types and their respective bandwidth, see section "IO signal table" in "Signal Multiplexing" chapter.
- End of conversion (EOC) signals of SDADC modules are mapped on TRGMUX inputs as trigger sources. The EOC signal is asserted after ADC conversion regardless whether conversion is signaled by polling flags, interrupt or DMA transfer. The signal shall not be used to start injected conversion on same SDADC channel as it will overwrite current result register.
- The minimum pulse length requirement is 1.5X of destination clock, so that it gets properly sampled at the destination IP connected to TRGMUX outputs, otherwise there are chances of missing the triggers generated from source. For example, the trigger generated from PAD for ADC conversion should be kept high/low for at least 1.5X of ADC clock so that it gets sampled in ADC clock domain. To ensure this, pulse stretchers have been placed before some of the hardware modules mapped on TRGMUX outputs.
- Some PADS are being shared by both ADC and TRGMUX. It is recommended that trigger initiated from such PADS should not be used to trigger a conversion on the ADC channel mapped on same PAD. Failing to do this will cause congestion on same PAD.
- Out of all the pads mapped on TRGMUX, first four pads have glitch filters. For details, see the TRGMUX connectivity file attached to this document. The trigger pulse width should honour the pulse width requirement as per Glitch Filter specifications. The same signal can be observed at output pin if the pulse width of the input data signal is more than 400ns and no output signal should be observed if the pulse width of the input data signal is less than 20ns. A signal with a pulse width that is between 20ns and 400 ns should not be applied as the behavior is not guaranteed.
- Trigger outputs are grouped peripheral-wise and have a common lock bit based on TRGMUX REGx. For instance, normal_trigger, injected_trigger and external_sync of ADC_0 are grouped onto TRGMUX_REG0 and have a common lock bit.
- The other instance, TRGMUX_MSC, includes both instances of eTPU and the TRGMUX connection at its input. The output of trgmux_msc goes to DSPI_MSC and TRGMUX.

65.1.2 Pulse stretchers in TRGMUX

TRGMUX has some hardware modules on its input side running at faster clock than some of the IPs present on output side. For instance, eMIOS reload outputs running at 160 MHz can trigger LPI2C trigger input clocked at 40 MHz, in that case there is a high chance that trigger from eMIOS will be missed. Following Pulse stretchers are added for the IPs on output side of TRGMUX.

Table 364. Pulse stretchers in TRGMUX

Evaluation Parameter	ADC_0/1/2/3/4/5/6 external trigger to sync the start pulse	SD_0/1/2/3 Hardware trigger	BCTU_0 trigger 39/40/41	BCTU_1 trigger 39/40/41	FlexIO trigger input_0/1/2/3	LPI2C_0 Trigger input	LPSPI_0/1/2 Trigger input	CM7_0/1/2_RXEV
IP expects	synchronized single cycle pulse	Async Pulse	Synchronized pulse	Synchronized pulse	IP requirement is to have 2 cycle pulse of flexio_clk	IP requirement is to have 2 cycle pulse of lpi2c_clk	IP requirement is to have 2 cycle pulse of lpspi_clk	single cycle pulse
Frequency	CORE_CLK	PLAT_AIPS_CLK	CORE_CLK	CORE_CLK	CORE_CLK	AIPS_SLOW_CLK	LPSPI_0 PLAT_AIPS_CLK LPSPI_1/2-AIPS_SLOW _CLK	CORE_CLK
Inside IP	Used as combo signal	Synchronized inside IP	flopped inside IP and clear after ADC conversion completed	flopped inside IP and clear after ADC conversion completed	synchronized inside IP	synchronized inside IP	synchronized inside IP	-
At SoC	Since it an ASYNC signal and IP required synchronized single cycle pulse, so a pulse stretcher is added to convert pulse from any frequency domain into a single cycle pulse of CORE_CLK	Pulse stretcher is added to convert any pulse into a two cycle pulse of scan_clk	Since slow IP such as LPCMP or from PAD can also trigger BCTU and BCTU wants that trigger should clear after the ADC conversion. So a pulse stretcher is added which convert any size of pulse to a single cycle pulse of BCTU clock (CORE_CLK)	Since slow IP such as LPCMP or from PAD can also trigger BCTU and BCTU wants that trigger should clear after the ADC conversion. So a pulse stretcher is added which convert any size of pulse to a single cycle pulse of BCTU clock (CORE_CLK)	Pulse stretcher is added to convert any pulse into a two cycle pulse of flexio_clk	Pulse stretcher is added to convert any pulse into a two cycle pulse of lpi2c_clk	Pulse stretcher is added to convert any pulse into a two cycle pulse of lpspi_clk	Pulse stretcher is added to convert any pulse into a single cycle pulse of CORE_CLK

Table continues on the next page...

Table 364. Pulse stretchers in TRGMUX (continued)

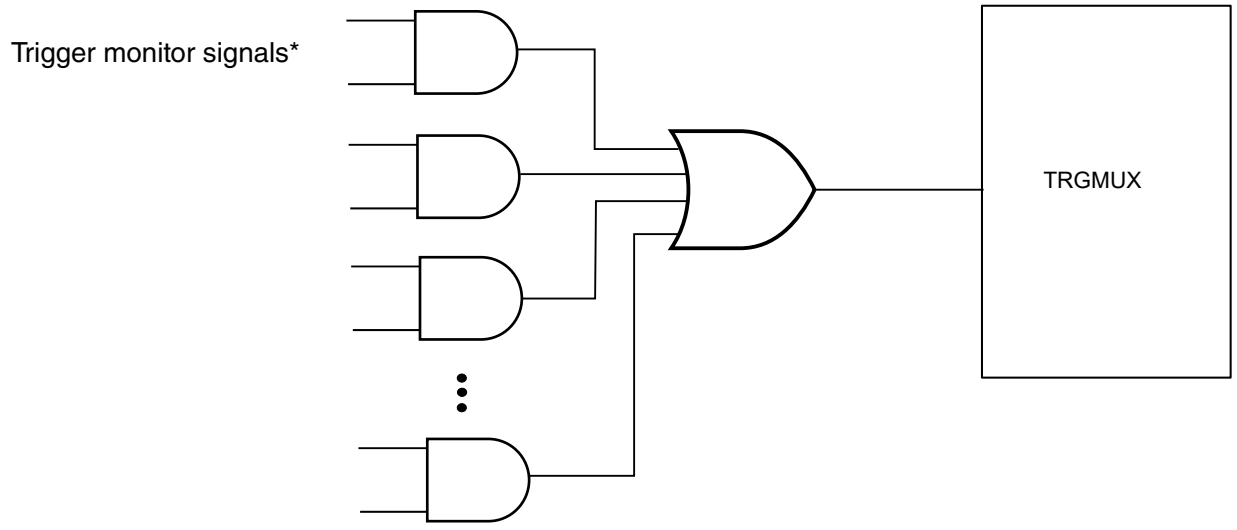
Evaluation Parameter	ADC_0/1/2/3/4/5/6 external trigger to sync the start pulse	SD_0/1/2/3 Hardware trigger	BCTU_0 trigger 39/40/41	BCTU_1 trigger 39/40/41	FlexIO trigger input_0/1/2/3	LPI2C_0 Trigger input	LPSPI_0/1/2 Trigger input	CM7_0/1/2_RXEV
Output slot at which pulse stretcher is added	2, 6, 10,14,18,22,26	28, 32, 36, 40	52, 53, 54	56, 57, 58	124, 125, 126, 127	244	144, 148, 152	232, 233, 234

NOTE

The trigger outputs which have pulse stretcher before them, there should be at least a gap of 5 cycle of destination clock for back to back trigger.

65.1.3 Trigger monitor

A trigger monitor is added before the TRGMUX inputs. You can configure the UDR registers in SIUL2 named as MUX* registers with offset from 0x100 to 0x11C to select which trigger needs to propagate to the above TRGMUX inputs. By default after coming out of reset, all the enables are 0. Hence no trigger will be coming to these 3 TRGMUX inputs.



*See the TRGMUX connectivity sheet attached to this document for the details of trigger monitor signals.

Figure 427. Trigger monitor

65.2 Overview

TRGMUX allows you to configure the trigger inputs for various peripherals.

65.2.1 Block diagram

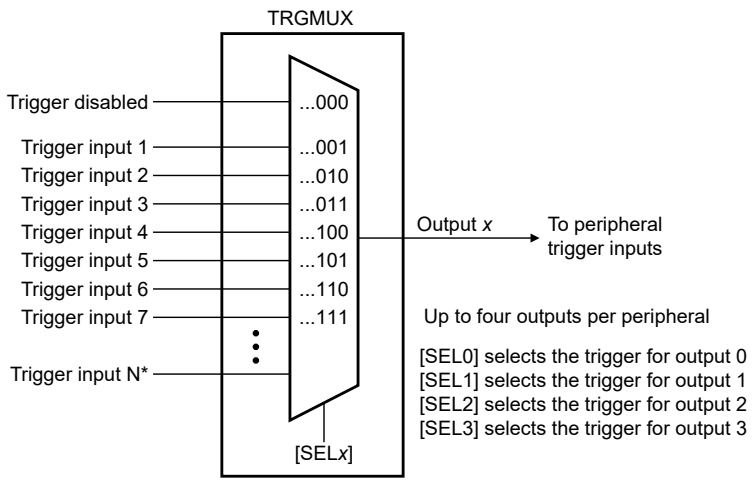


Figure 428. Block diagram

65.2.2 Features

- Configurable trigger sources for peripherals
- Dedicated TRGMUX register for each peripheral

65.3 Functional description

65.3.1 Clocking

This module has no clocking considerations.

65.3.2 Interrupts

This module has no interrupts.

65.4 External signals

This module has no external signals.

65.5 Initialization

This module does not require initialization.

65.6 TRGMUX register descriptions

65.6.1 TRGMUX memory map

You can only write to TRGMUX registers in Supervisor mode.

Table 365. Select bit fields

Field	Description
SEL*x*	Specifies the MUX select for the peripheral trigger inputs. Use this field to select the trigger sources for peripheral modules. 0h - LOGIC 0 (VSS) 1h - LOGIC 1 (VDD) 2h - Trigger_monitor_mux0 3h - Trigger_monitor_mux1 4h - Trigger_monitor_mux2 5h - SD_End of conversion_01 6h - SD_End of conversion_23 7h - SD_SW_TRG_OUT_01 8h - SD_SW_TRG_OUT_23 9h - LPCMP_0_COUT output Ah - LPCMP_1_COUT output Bh - eDMA_0_eDMA0 DONE Ch - eDMA_0_eDMA16 DONE Dh - eDMA_1_eDMA0 DONE Eh - eDMA_1_eDMA16 DONE Fh - eMIOS_0_RELOAD_OUT_CH[23] 10h - eMIOS_0_RELOAD_OUT_CH[22] 11h - eMIOS_0_RELOAD_OUT_CH[8] 12h - eMIOS_0_RELOAD_OUT_CH[0] 13h - eMIOS_0_IPP_DO_eMIOS_CH[0] 14h - eMIOS_0_IPP_DO_eMIOS_CH[1] 15h - eMIOS_0_IPP_DO_eMIOS_CH[2] 16h - eMIOS_0_IPP_DO_eMIOS_CH[3] 17h - eMIOS_0_IPP_DO_eMIOS_CH[4] 18h - eMIOS_0_IPP_DO_eMIOS_CH[5] 19h - eMIOS_0_IPP_DO_eMIOS_CH[6] 1Ah - eMIOS_0_IPP_DO_eMIOS_CH[7] 1Bh - eMIOS_0_IPP_DO_eMIOS_CH[8] 1Ch - eMIOS_0_IPP_DO_eMIOS_CH[9] 1Dh - eMIOS_0_IPP_DO_eMIOS_CH[10] 1Eh - eMIOS_0_IPP_DO_eMIOS_CH[11] 1Fh - eMIOS_0_IPP_DO_eMIOS_CH[12] 20h - eMIOS_0_IPP_DO_eMIOS_CH[13]

Table continues on the next page...

Table 365. Select bit fields

Field	Description
	21h - eMIOS_0_IPP_DO_eMIOS_CH[14] 22h - eMIOS_0_IPP_DO_eMIOS_CH[15] 23h - eMIOS_0_IPP_DO_eMIOS_CH[22] 24h - eMIOS_0_IPP_DO_eMIOS_CH[23] 25h - PWM_0_OUT_TRIG 26h - PWM_1_OUT_TRIG 27h - PWM_0_0_MUX_TRIG0 28h - PWM_0_0_MUX_TRIG1 29h - PWM_0_1_MUX_TRIG0 2Ah - PWM_0_1_MUX_TRIG1 2Bh - PWM_0_2_MUX_TRIG0 2Ch - PWM_0_2_MUX_TRIG1 2Dh - PWM_0_3_MUX_TRIG0 2Eh - PWM_0_3_MUX_TRIG1 2Fh - PWM_1_0_MUX_TRIG0 30h - PWM_1_0_MUX_TRIG1 31h - PWM_1_1_MUX_TRIG0 32h - PWM_1_1_MUX_TRIG1 33h - PWM_1_2_MUX_TRIG0 34h - PWM_1_2_MUX_TRIG1 35h - PWM_1_3_MUX_TRIG0 36h - PWM_1_3_MUX_TRIG1 37h - PWM_0_MST_RELOAD 38h - FlexIO_External Output Trigger 0 39h - FlexIO_External Output Trigger 1 3Ah - FlexIO_External Output Trigger 2 3Bh - FlexIO_External Output Trigger 3 3Ch - SIUL_TRGMUX_IN0 3Dh - SIUL_TRGMUX_IN1 3Eh - SIUL_TRGMUX_IN2 3Fh - SIUL_TRGMUX_IN3 40h - SIUL_TRGMUX_IN4 41h - SIUL_TRGMUX_IN5 42h - SIUL_TRGMUX_IN6

Table continues on the next page...

Table 365. Select bit fields

Field	Description
	43h - SIUL_TRGMUX_IN7 44h - LPSPI_0_End of frame trigger 45h - LPSPI_0_Receive data trigger 46h - LPSPI_1_End of frame trigger 47h - LPSPI_1_Receive data trigger 48h - LPSPI_2_End of frame trigger 49h - LPSPI_2_Receive data trigger 4Ah - LPUART_0_trg_txword 4Bh - LPUART_0_trg_rxword 4Ch - LPUART_0_trg_rxidle 4Dh - LPUART_1_trg_txword 4Eh - LPUART_1_trg_rxword 4Fh - LPUART_1_trg_rxidle 50h - LPUART_2_trg_txword 51h - LPUART_2_trg_rxword 52h - LPUART_2_trg_rxidle 53h - LCU_0_LC1_out_i1 54h - LCU_0_LC1_out_i2 55h - LCU_0_LC1_out_i3 56h - LCU_0_LC1_out_i4 57h - LCU_0_LC2_out_i1 58h - LCU_0_LC2_out_i2 59h - LCU_0_LC2_out_i3 5Ah - LCU_0_LC2_out_i4 5Bh - LCU_0_LC3_out_i1 5Ch - LCU_0_LC3_out_i2 5Dh - LCU_0_LC3_out_i3 5Eh - LCU_0_LC3_out_i4 5Fh - LCU_1_LC1_out_i1 60h - LCU_1_LC1_out_i2 61h - LCU_1_LC1_out_i3 62h - LCU_1_LC1_out_i4 63h - LCU_1_LC2_out_i1 64h - LCU_1_LC2_out_i2

Table continues on the next page...

Table 365. Select bit fields

Field	Description
	65h - LCU_1_LC2_out_i3 66h - LCU_1_LC2_out_i4 67h - LCU_1_LC3_out_i1 68h - LCU_1_LC3_out_i2 69h - LCU_1_LC3_out_i3 6Ah - LCU_1_LC3_out_i4 6Bh - PIT0_PIT0 CH0 6Ch - PIT0_PIT0 CH1 6Dh - PIT0_PIT0 CH2 6Eh - PIT0_PIT0 CH3 6Fh - TRGMUX_MSC_TRGMUX_IN0 70h - TRGMUX_MSC_TRGMUX_IN1 71h - TRGMUX_MSC_TRGMUX_IN2 72h - TRGMUX_MSC_TRGMUX_IN3 73h - TRGMUX_MSC_TRGMUX_IN4 74h - TRGMUX_MSC_TRGMUX_IN5 75h - TRGMUX_MSC_TRGMUX_IN6 76h - TRGMUX_MSC_TRGMUX_IN7 77h - TRGMUX_MSC_TRGMUX_IN8 78h - TRGMUX_MSC_TRGMUX_IN9 79h - COOLFLUX_TRGMUX_IN0 7Ah - COOLFLUX_TRGMUX_IN1 7Bh - COOLFLUX_TRGMUX_IN2 7Ch - COOLFLUX_TRGMUX_IN3 7Dh - CM7_0_1_TXEV 7Eh - CM7_2_TXEV 7Fh - Reserved

TRGMUX_APP base address: 4008_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	TRGMUX ADC12_0 (ADC12_0)	32	RW	0000_0000h
4h	TRGMUX ADC12_1 (ADC12_1)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
8h	TRGMUX ADC12_2 (ADC12_2)	32	RW	0000_0000h
Ch	TRGMUX ADC12_3 (ADC12_3)	32	RW	0000_0000h
10h	TRGMUX ADC12_4 (ADC12_4)	32	RW	0000_0000h
14h	TRGMUX ADC12_5 (ADC12_5)	32	RW	0000_0000h
18h	TRGMUX ADC12_6 (ADC12_6)	32	RW	0000_0000h
1Ch	TRGMUX SD_0 (SD_0)	32	RW	0000_0000h
20h	TRGMUX SD_1 (SD_1)	32	RW	0000_0000h
24h	TRGMUX SD_2 (SD_2)	32	RW	0000_0000h
28h	TRGMUX SD_3 (SD_3)	32	RW	0000_0000h
2Ch	TRGMUX LPCMP_0 (LPCMP_0)	32	RW	0000_0000h
30h	TRGMUX LPCMP_1 (LPCMP_1)	32	RW	0000_0000h
34h	TRGMUX BCTU_0 (BCTU_0)	32	RW	0000_0000h
38h	TRGMUX BCTU_1 (BCTU_1)	32	RW	0000_0000h
3Ch	TRGMUX SWG_0 (SWG_0)	32	RW	0000_0000h
40h	TRGMUX SWG_1 (SWG_1)	32	RW	0000_0000h
44h	TRGMUX eMIOS012_ODIS (eMIOS012_ODIS)	32	RW	0000_0000h
48h	TRGMUX eMIOS0_ipp_0 (eMIOS0_ipp_0)	32	RW	0000_0000h
4Ch	TRGMUX eMIOS0_ipp_1 (eMIOS0_ipp_1)	32	RW	0000_0000h
50h	TRGMUX eMIOS0_ipp_2 (eMIOS0_ipp_2)	32	RW	0000_0000h
54h	TRGMUX eMIOS0_ipp_3 (eMIOS0_ipp_3)	32	RW	0000_0000h
58h	TRGMUX eTPU_A_input (eTPU_A_input)	32	RW	0000_0000h
5Ch	TRGMUX eTPU_AB_input (eTPU_AB_input)	32	RW	0000_0000h
60h	TRGMUX eTPU_B_input (eTPU_B_input)	32	RW	0000_0000h
64h	TRGMUX PWM0_fault (PWM0_fault)	32	RW	0000_0000h
68h	TRGMUX PWM1_fault (PWM1_fault)	32	RW	0000_0000h
6Ch	TRGMUX PWM_EXT_SYNC (PWM_EXT_SYNC)	32	RW	0000_0000h
70h	TRGMUX PWM_EXT_AB_0 (PWM_EXT_AB_0)	32	RW	0000_0000h
74h	TRGMUX PWM_EXT_AB_1 (PWM_EXT_AB_1)	32	RW	0000_0000h
78h	TRGMUX PWM_EXT_CLK_FORCE (PWM_EXT_CLK_FORCE)	32	RW	0000_0000h
7Ch	TRGMUX FlexIO (FlexIO)	32	RW	0000_0000h
80h	TRGMUX SIUL_OUT_0 (SIUL_OUT_0)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
84h	TRGMUX SIUL_OUT_1 (SIUL_OUT_1)	32	RW	0000_0000h
88h	TRGMUX SIUL_OUT_2 (SIUL_OUT_2)	32	RW	0000_0000h
8Ch	TRGMUX SIUL_OUT_3 (SIUL_OUT_3)	32	RW	0000_0000h
90h	TRGMUX LPSPI_0 (LPSPI_0)	32	RW	0000_0000h
94h	TRGMUX LPSPI_1 (LPSPI_1)	32	RW	0000_0000h
98h	TRGMUX LPSPI_2 (LPSPI_2)	32	RW	0000_0000h
9Ch	TRGMUX LPUART_0 (LPUART_0)	32	RW	0000_0000h
A0h	TRGMUX LPUART_1 (LPUART_1)	32	RW	0000_0000h
A4h	TRGMUX LPUART_2 (LPUART_2)	32	RW	0000_0000h
A8h	TRGMUX LPUART_3 (LPUART_3)	32	RW	0000_0000h
ACh	TRGMUX DSPI_MSC (DSPI_MSC)	32	RW	0000_0000h
B0h	TRGMUX LCU0_sync (LCU0_sync)	32	RW	0000_0000h
B4h	TRGMUX LCU0_force (LCU0_force)	32	RW	0000_0000h
B8h	TRGMUX LCU0_0 (LCU0_0)	32	RW	0000_0000h
BCh	TRGMUX LCU0_1 (LCU0_1)	32	RW	0000_0000h
C0h	TRGMUX LCU0_2 (LCU0_2)	32	RW	0000_0000h
C4h	TRGMUX LCU1_sync (LCU1_sync)	32	RW	0000_0000h
C8h	TRGMUX LCU1_force (LCU1_force)	32	RW	0000_0000h
CCh	TRGMUX LCU1_0 (LCU1_0)	32	RW	0000_0000h
D0h	TRGMUX LCU1_1 (LCU1_1)	32	RW	0000_0000h
D4h	TRGMUX LCU1_2 (LCU1_2)	32	RW	0000_0000h
D8h	TRGMUX TRGMUX_MSC_OUT_0 (TRGMUX_MSC_OUT_0)	32	RW	0000_0000h
DCh	TRGMUX TRGMUX_MSC_OUT_1 (TRGMUX_MSC_OUT_1)	32	RW	0000_0000h
E0h	TRGMUX TRGMUX_MSC_OUT_2 (TRGMUX_MSC_OUT_2)	32	RW	0000_0000h
E4h	TRGMUX COOLFLUX_OUT (COOLFLUX_OUT)	32	RW	0000_0000h
E8h	TRGMUX CM7_RXEV (CM7_RXEV)	32	RW	0000_0000h
ECh	TRGMUX eTPU1_odis (eTPU1_odis)	32	RW	0000_0000h
F0h	TRGMUX eTPU2_odis (eTPU2_odis)	32	RW	0000_0000h
F4h	TRGMUX LPI2C_0_Triggered (LPI2C_0_Triggered)	32	RW	0000_0000h

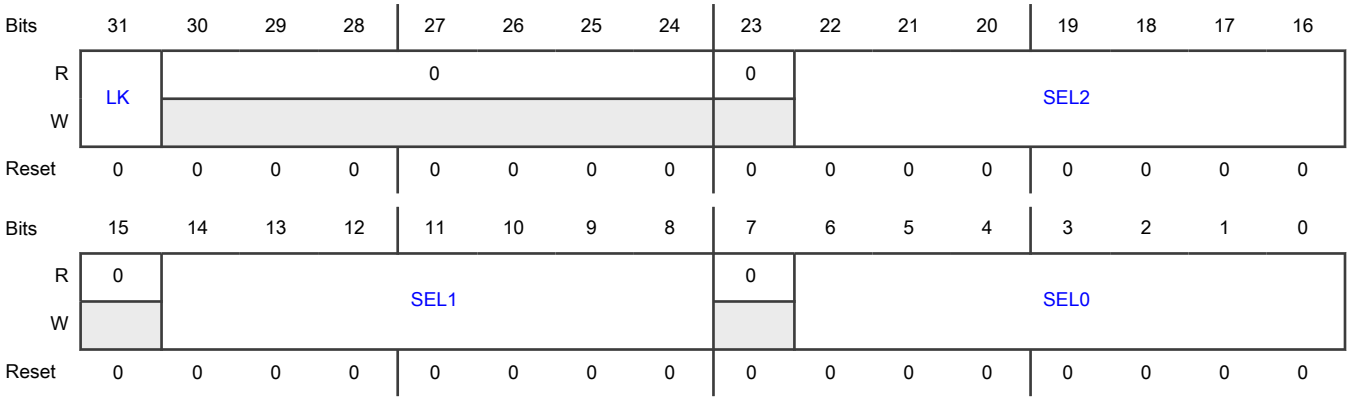
65.6.2 TRGMUX ADC12_0 (ADC12_0)

Offset

Register	Offset
ADC12_0	0h

Function
Configures the ADC12_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.3 TRGMUX ADC12_1 (ADC12_1)

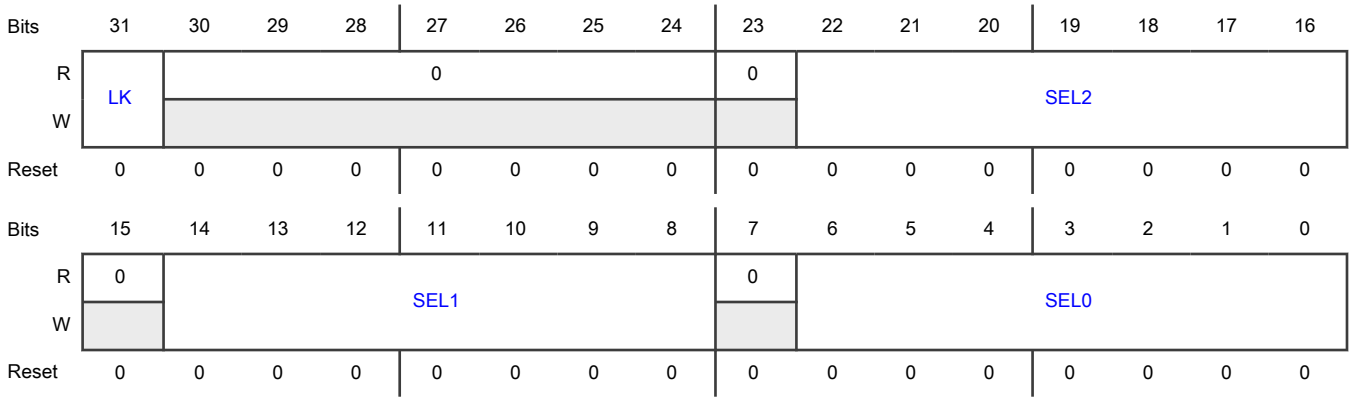
Offset

Register	Offset
ADC12_1	4h

Function

Configures the ADC12_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

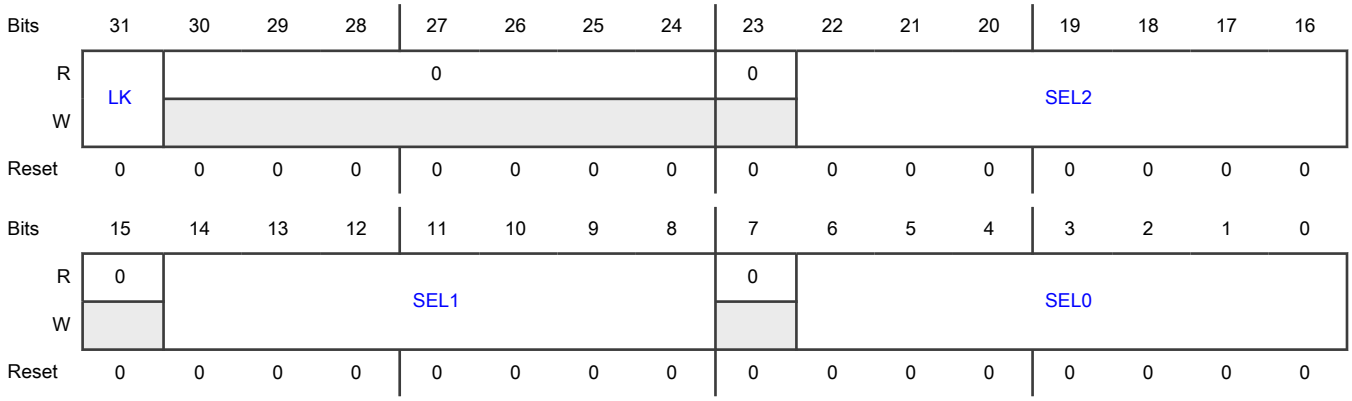
65.6.4 TRGMUX ADC12_2 (ADC12_2)

Offset

Register	Offset
ADC12_2	8h

Function
Configures the ADC12_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

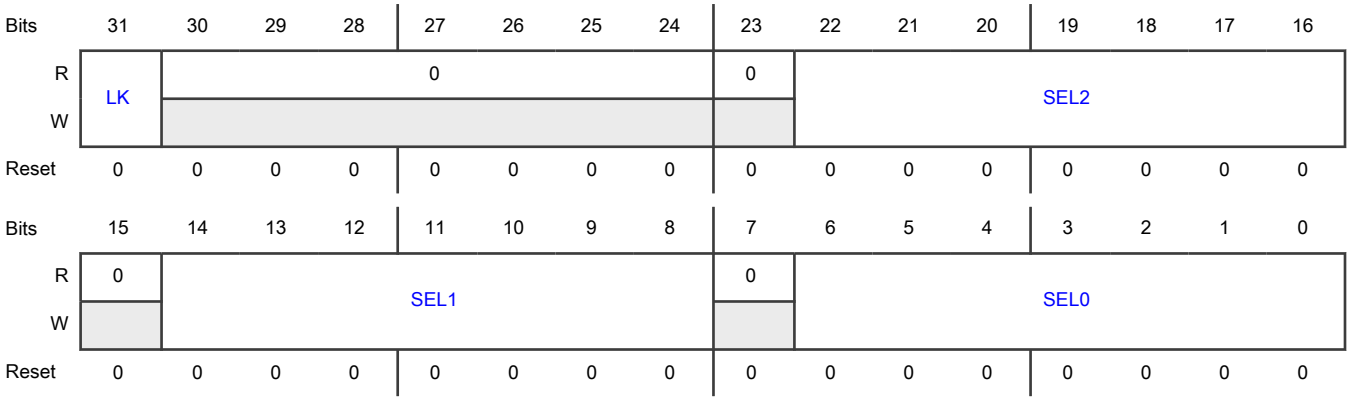
65.6.5 TRGMUX ADC12_3 (ADC12_3)

Offset

Register	Offset
ADC12_3	Ch

Function
Configures the ADC12_3 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

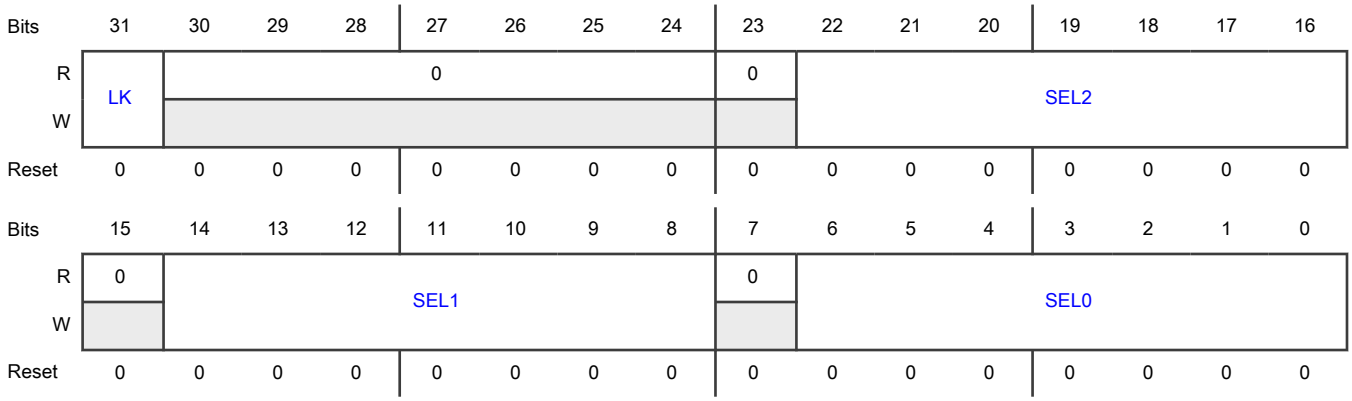
65.6.6 TRGMUX ADC12_4 (ADC12_4)

Offset

Register	Offset
ADC12_4	10h

Function
Configures the ADC12_4 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

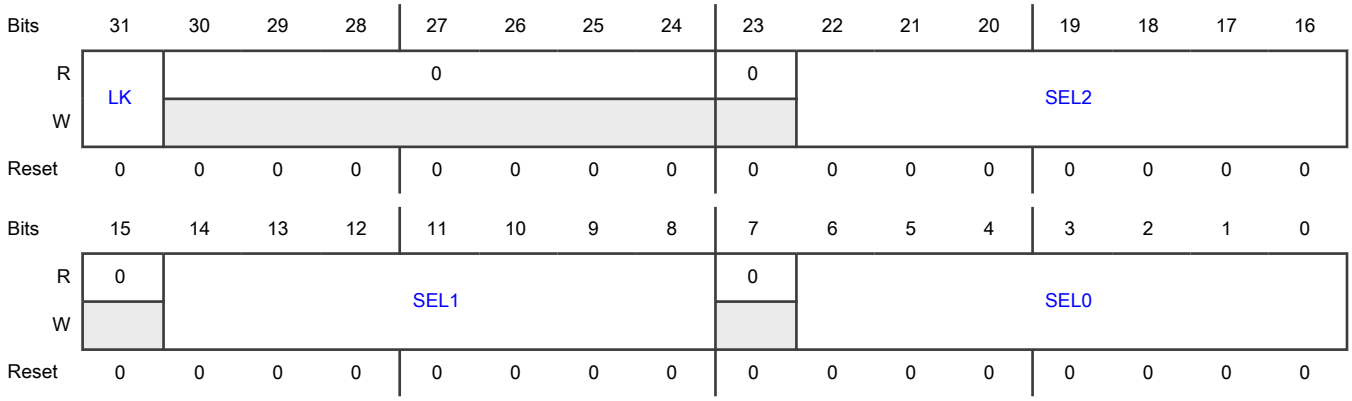
65.6.7 TRGMUX ADC12_5 (ADC12_5)

Offset

Register	Offset
ADC12_5	14h

Function
Configures the ADC12_5 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

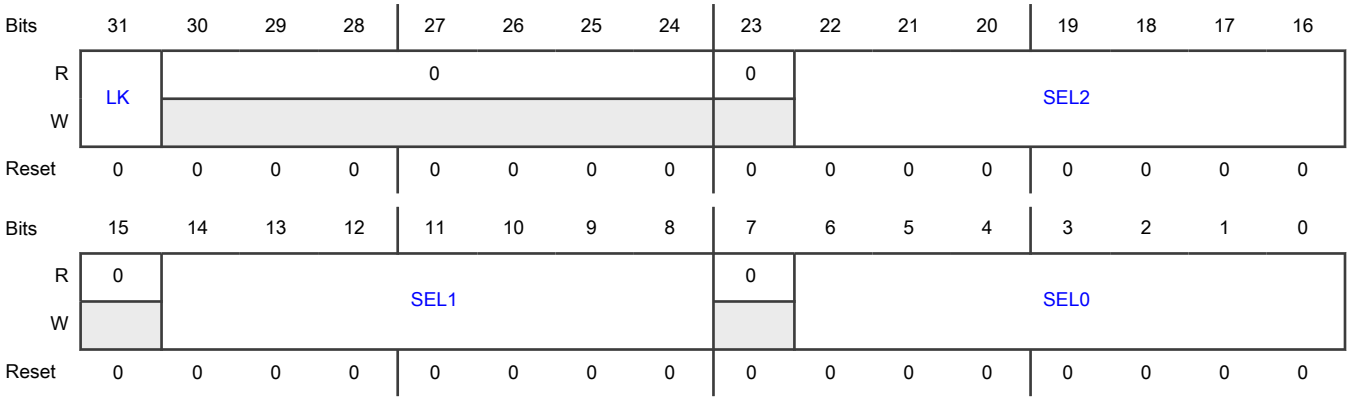
65.6.8 TRGMUX ADC12_6 (ADC12_6)

Offset

Register	Offset
ADC12_6	18h

Function
Configures the ADC12_6 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.9 TRGMUX SD_0 (SD_0)

Offset

Register	Offset
SD_0	1Ch

Function
Configures the SD_0 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	0							0	0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.10 TRGMUX SD_1 (SD_1)

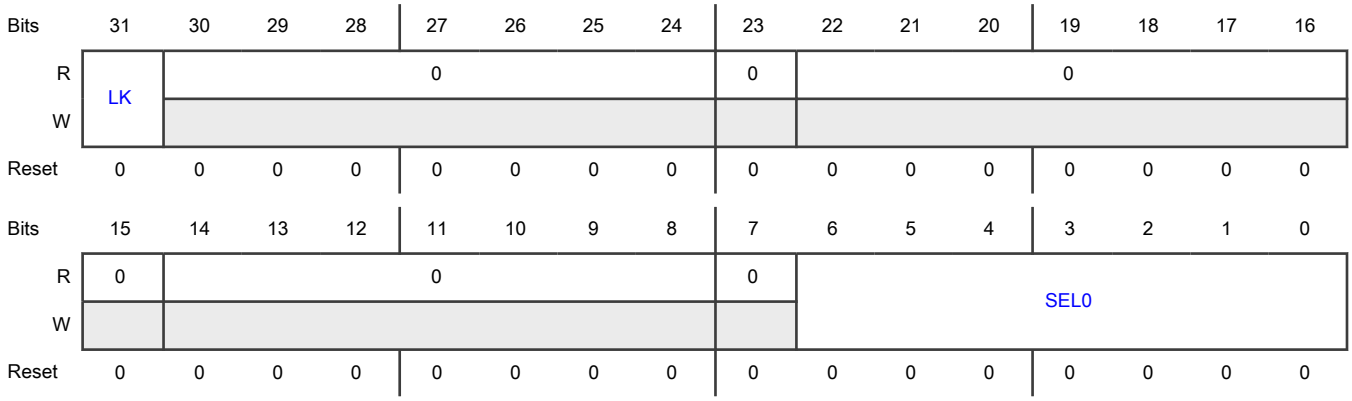
Offset

Register	Offset
SD_1	20h

Function

Configures the SD_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

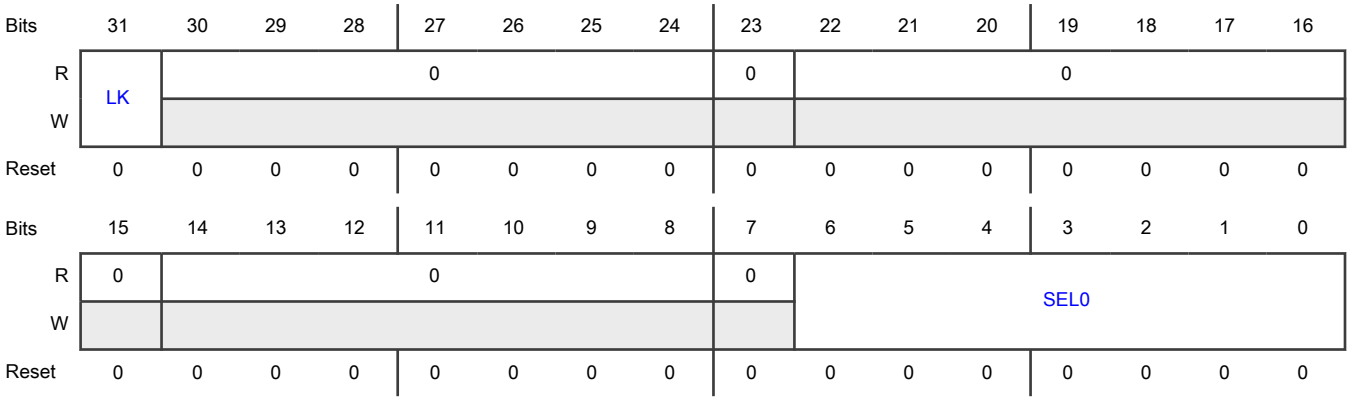
65.6.11 TRGMUX SD_2 (SD_2)

Offset

Register	Offset
SD_2	24h

Function
Configures the SD_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.12 TRGMUX SD_3 (SD_3)

Offset

Register	Offset
SD_3	28h

Function

Configures the SD_3 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	0							0	0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.13 TRGMUX LPCMP_0 (LPCMP_0)

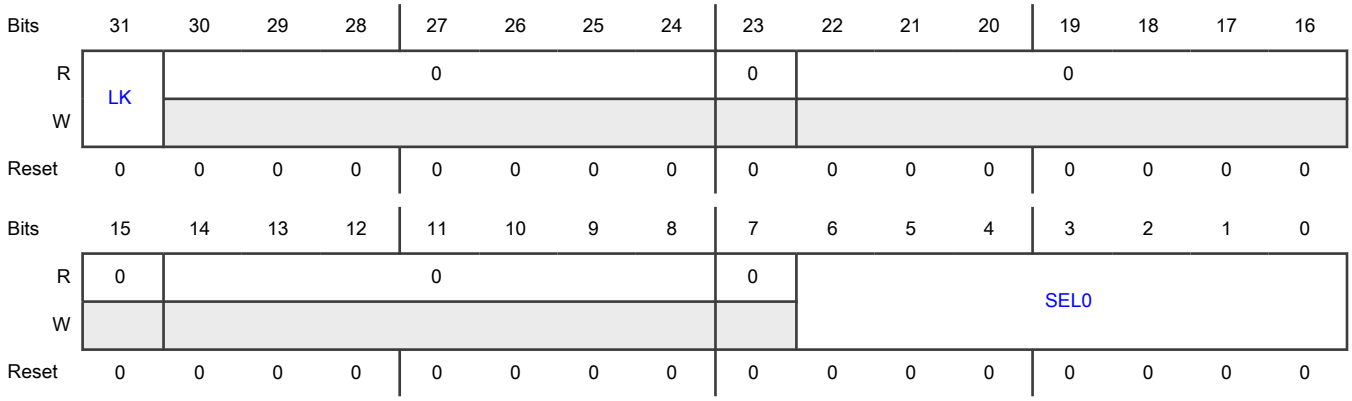
Offset

Register	Offset
LPCMP_0	2Ch

Function

Configures the LPCMP_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

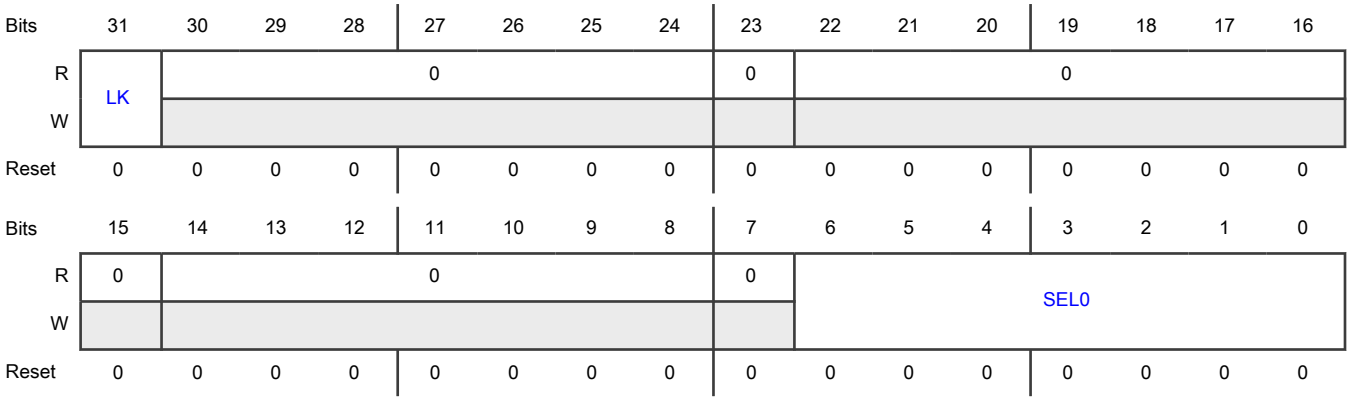
65.6.14 TRGMUX LPCMP_1 (LPCMP_1)

Offset

Register	Offset
LPCMP_1	30h

Function
Configures the LPCMP_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.15 TRGMUX BCTU_0 (BCTU_0)

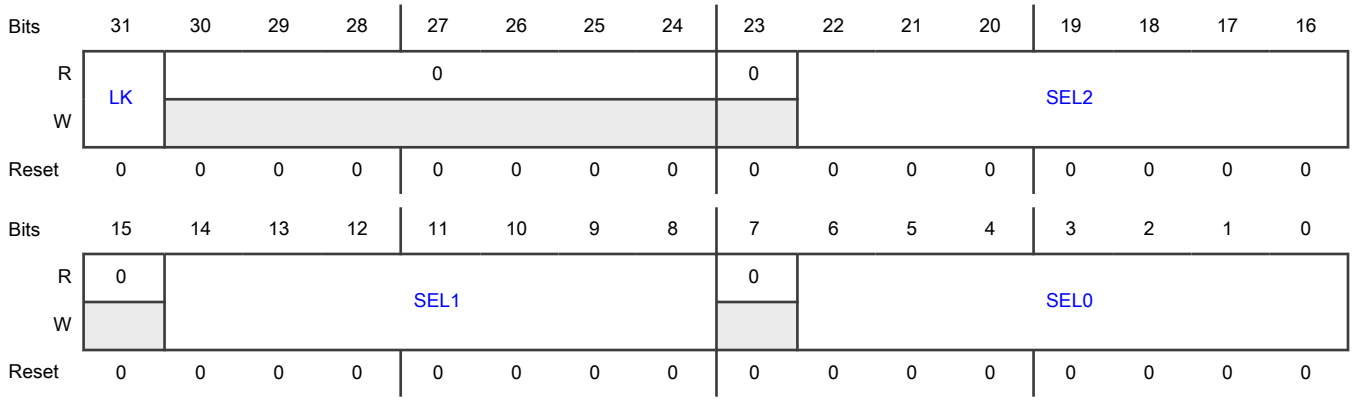
Offset

Register	Offset
BCTU_0	34h

Function

Configures the BCTU_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

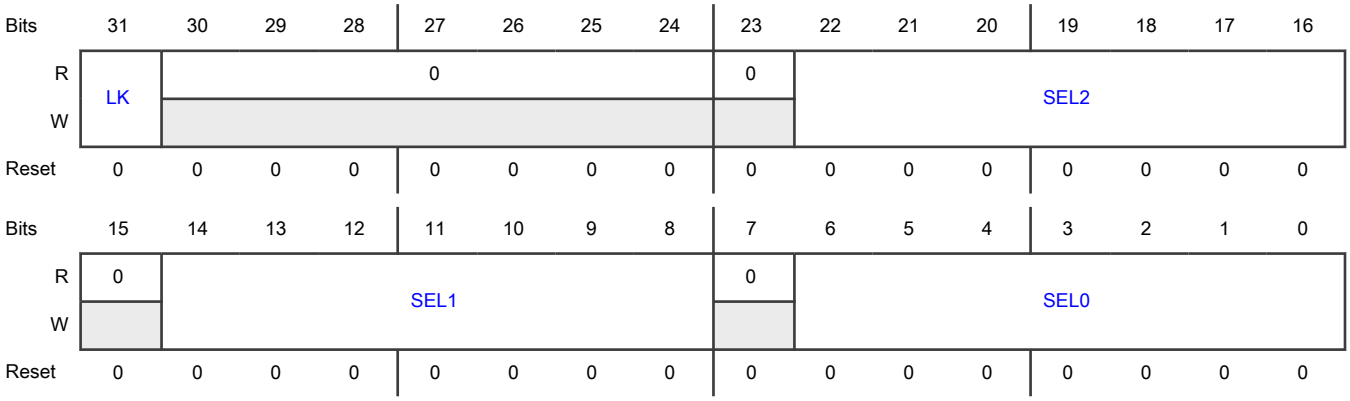
65.6.16 TRGMUX BCTU_1 (BCTU_1)

Offset

Register	Offset
BCTU_1	38h

Function
Configures the BCTU_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

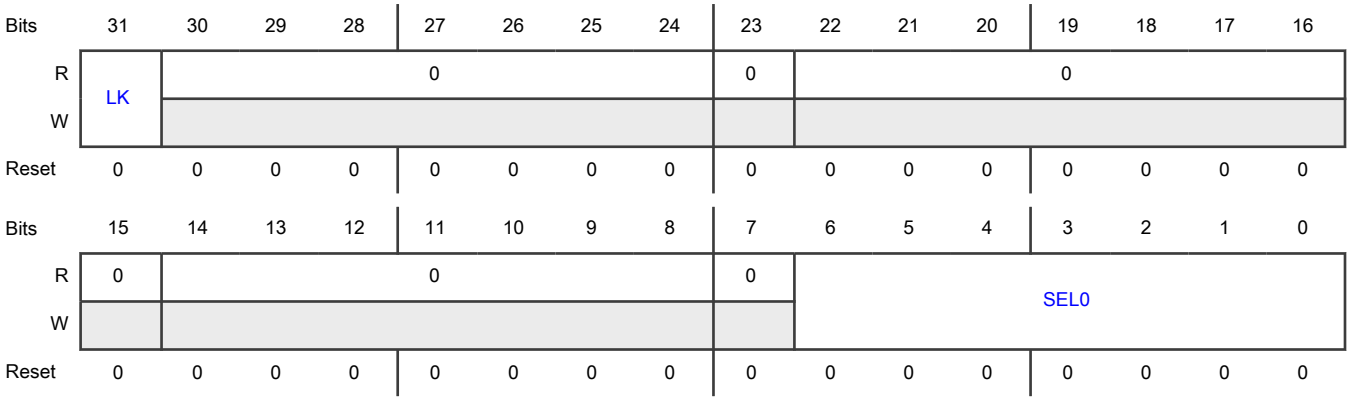
65.6.17 TRGMUX SWG_0 (SWG_0)

Offset

Register	Offset
SWG_0	3Ch

Function
Configures the SWG_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.18 TRGMUX SWG_1 (SWG_1)

Offset

Register	Offset
SWG_1	40h

Function

Configures the SWG_1 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	0							0	0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.19 TRGMUX eMIOS012_ODIS (eMIOS012_ODIS)

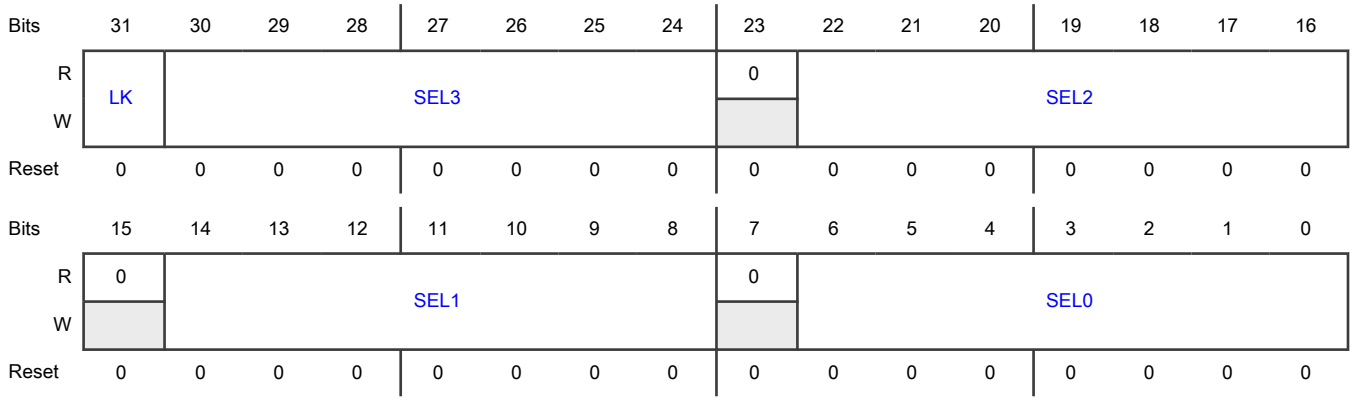
Offset

Register	Offset
eMIOS012_ODIS	44h

Function

Configures the eMIOS012_ODIS module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

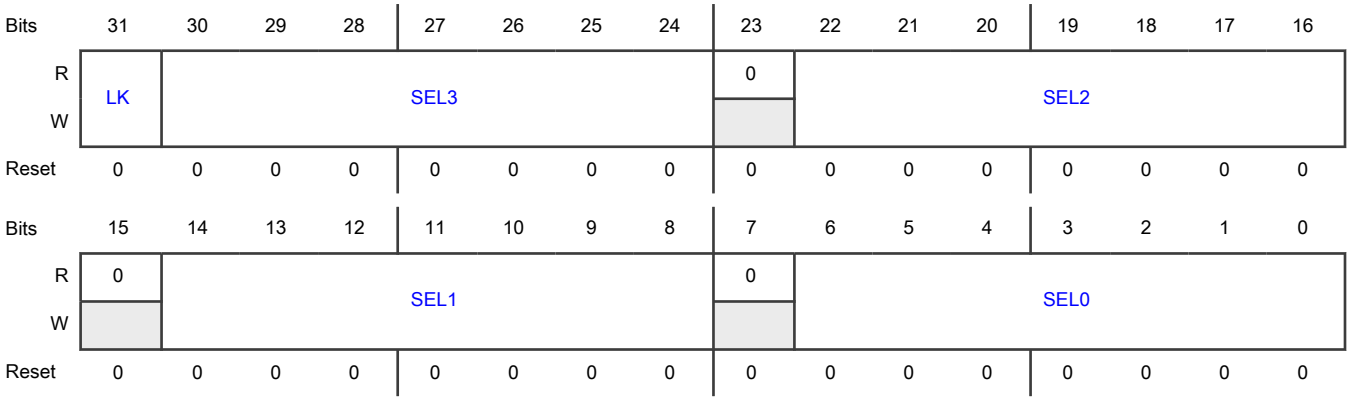
65.6.20 TRGMUX eMIOS0_ipp_0 (eMIOS0_ipp_0)

Offset

Register	Offset
eMIOS0_ipp_0	48h

Function
Configures the eMIOS0_ipp_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.21 TRGMUX eMIOS0_ipp_1 (eMIOS0_ipp_1)

Offset

Register	Offset
eMIOS0_ipp_1	4Ch

Function
Configures the eMIOS0_ipp_1 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	SEL3							0	SEL2						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	SEL1							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.22 TRGMUX eMIOS0_ipp_2 (eMIOS0_ipp_2)

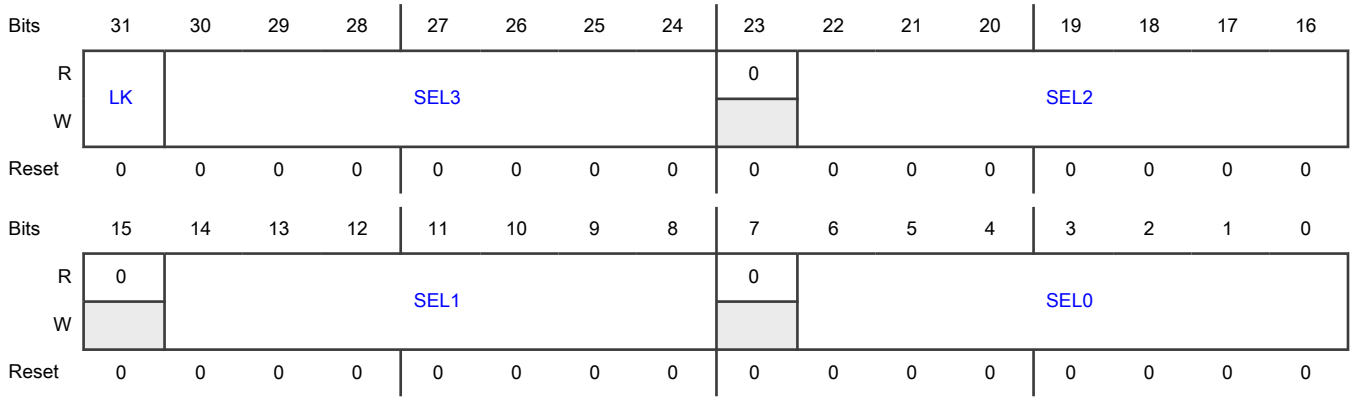
Offset

Register	Offset
eMIOS0_ipp_2	50h

Function

Configures the eMIOS0_ipp_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

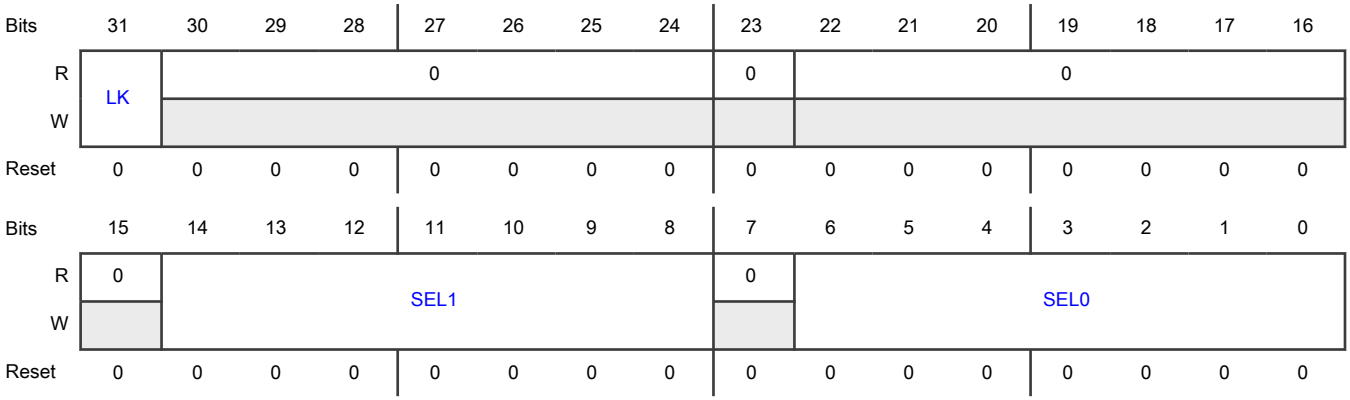
65.6.23 TRGMUX eMIOS0_ipp_3 (eMIOS0_ipp_3)

Offset

Register	Offset
eMIOS0_ipp_3	54h

Function
Configures the eMIOS0_ipp_3 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

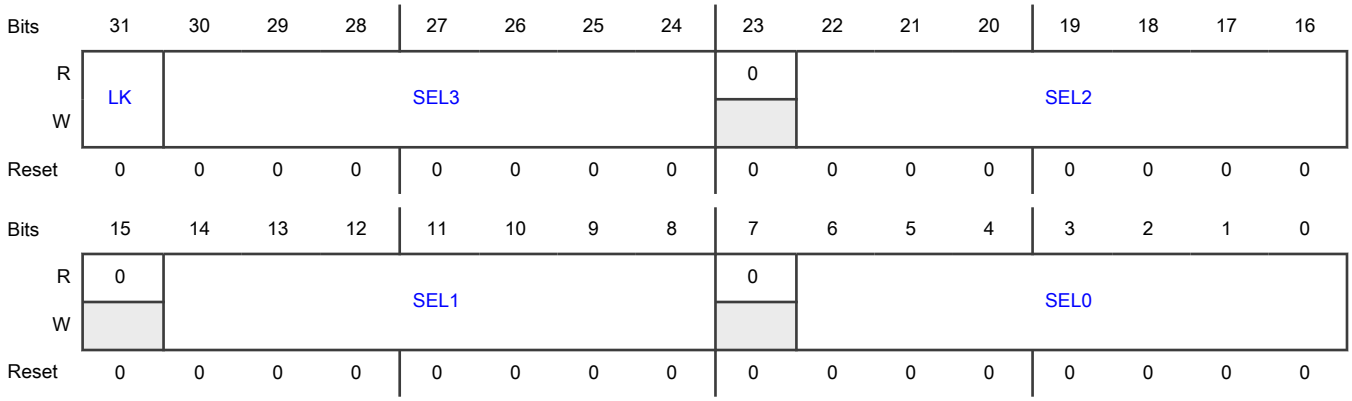
65.6.24 TRGMUX eTPU_A_input (eTPU_A_input)

Offset

Register	Offset
eTPU_A_input	58h

Function
Configures the eTPU_A_input module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

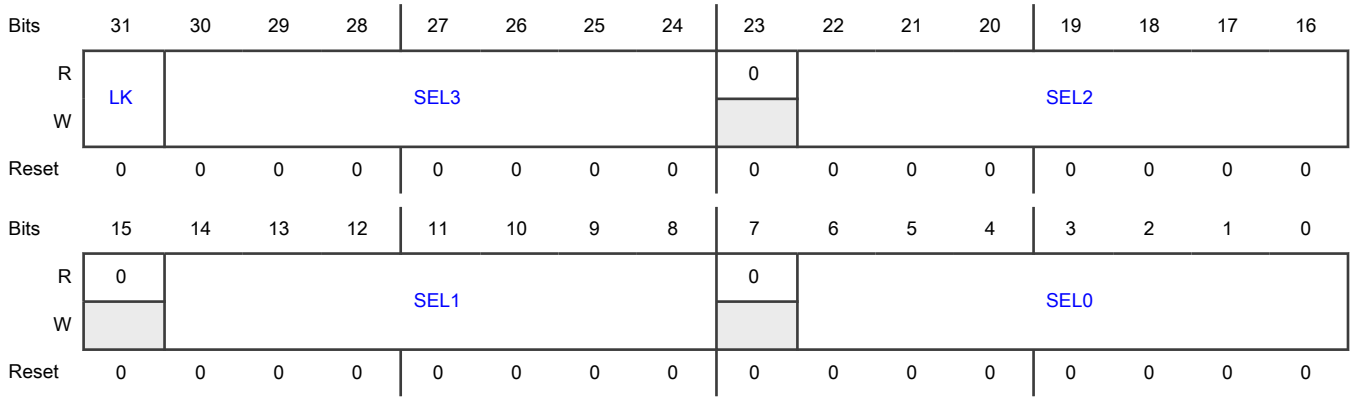
65.6.25 TRGMUX eTPU_AB_input (eTPU_AB_input)

Offset

Register	Offset
eTPU_AB_input	5Ch

Function
Configures the eTPU_AB_input module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

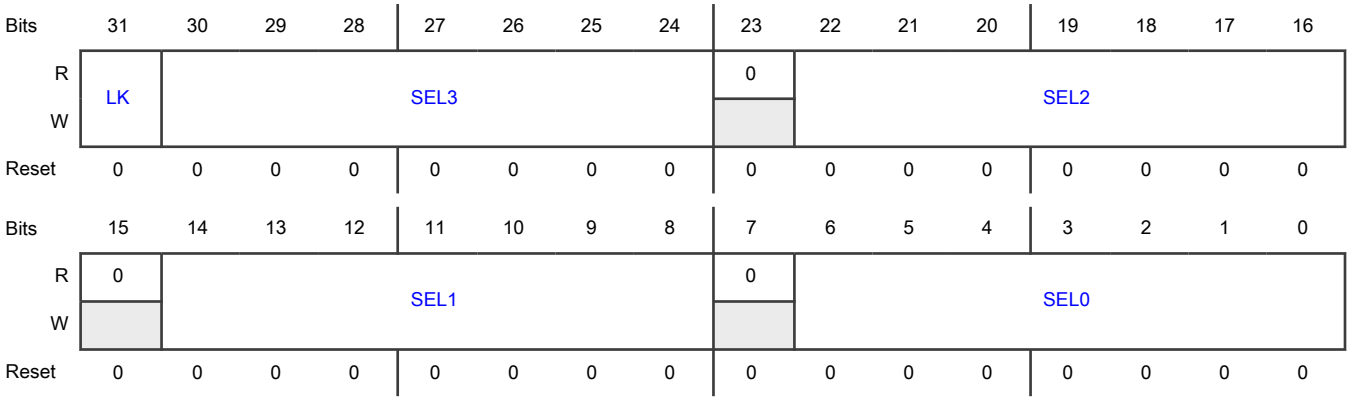
65.6.26 TRGMUX eTPU_B_input (eTPU_B_input)

Offset

Register	Offset
eTPU_B_input	60h

Function
Configures the eTPU_B_input module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

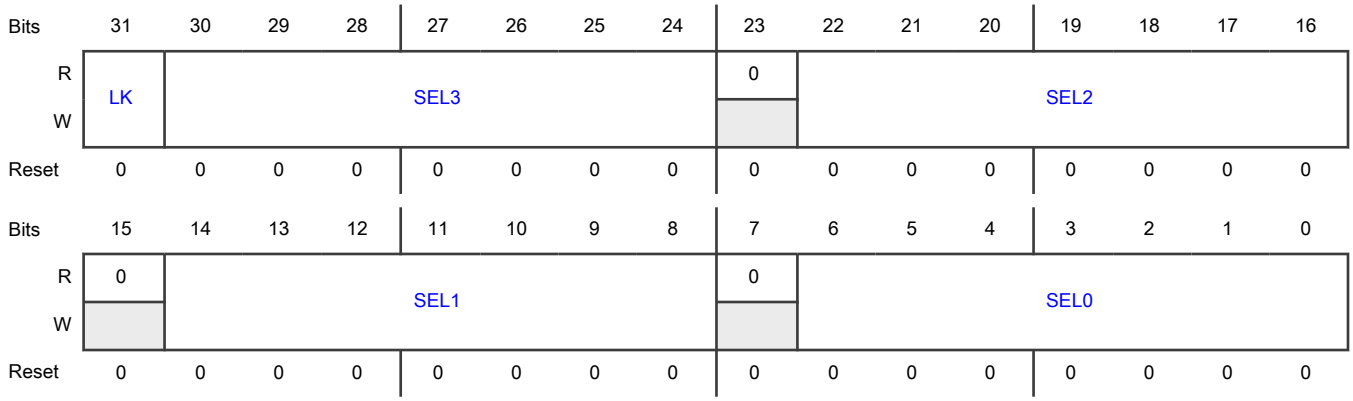
65.6.27 TRGMUX PWM0_fault (PWM0_fault)

Offset

Register	Offset
PWM0_fault	64h

Function
Configures the PWM0_fault module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

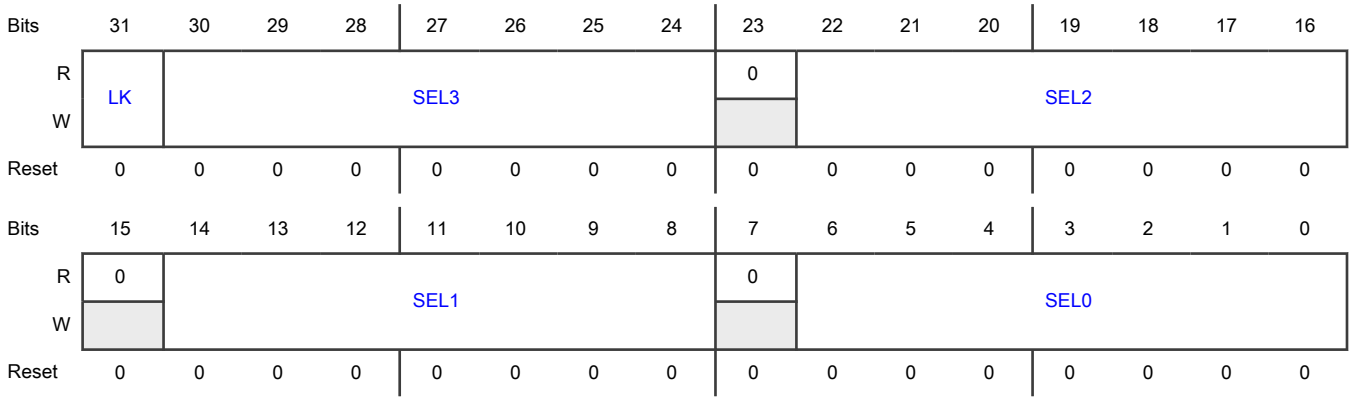
65.6.28 TRGMUX PWM1_fault (PWM1_fault)

Offset

Register	Offset
PWM1_fault	68h

Function
Configures the PWM1_fault module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.29 TRGMUX PWM_EXT_SYNC (PWM_EXT_SYNC)

Offset

Register	Offset
PWM_EXT_SYNC	6Ch

Function
Configures the PWM_EXT_SYNC module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	SEL3							0	SEL2						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	SEL1							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.30 TRGMUX PWM_EXT_AB_0 (PWM_EXT_AB_0)

Offset

Register	Offset
PWM_EXT_AB_0	70h

Function
Configures the PWM_EXT_AB_0 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	SEL3							0	SEL2						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	SEL1							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.31 TRGMUX PWM_EXT_AB_1 (PWM_EXT_AB_1)

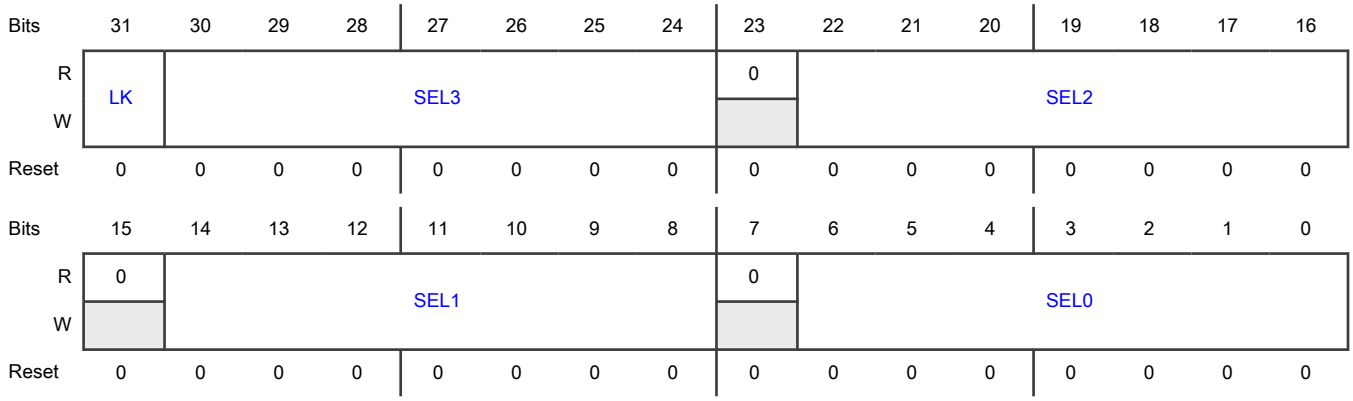
Offset

Register	Offset
PWM_EXT_AB_1	74h

Function

Configures the PWM_EXT_AB_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.32 TRGMUX PWM_EXT_CLK_FORCE (PWM_EXT_CLK_FORCE)

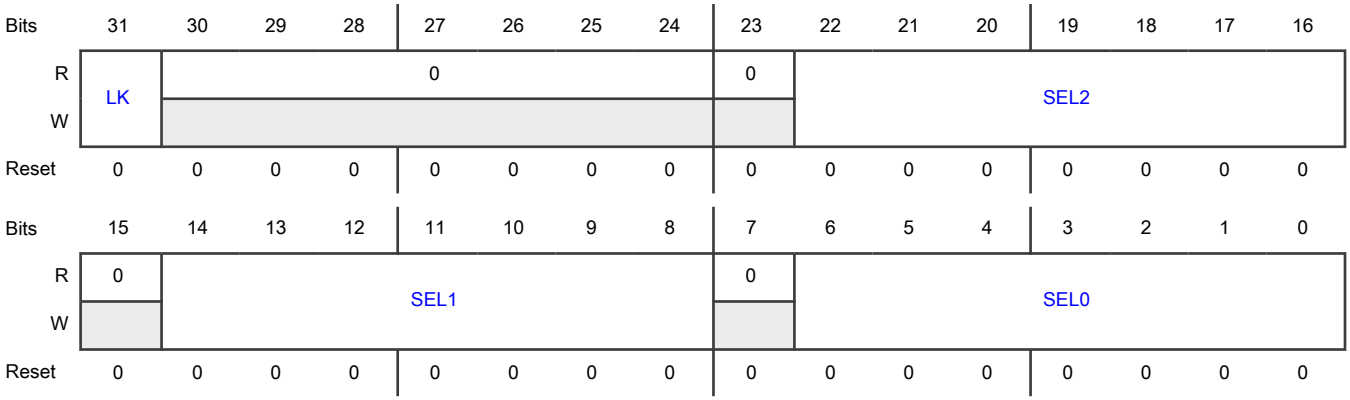
Offset

Register	Offset
PWM_EXT_CLK_FORCE	78h

Function

Configures the PWM_EXT_CLK_FORCE module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

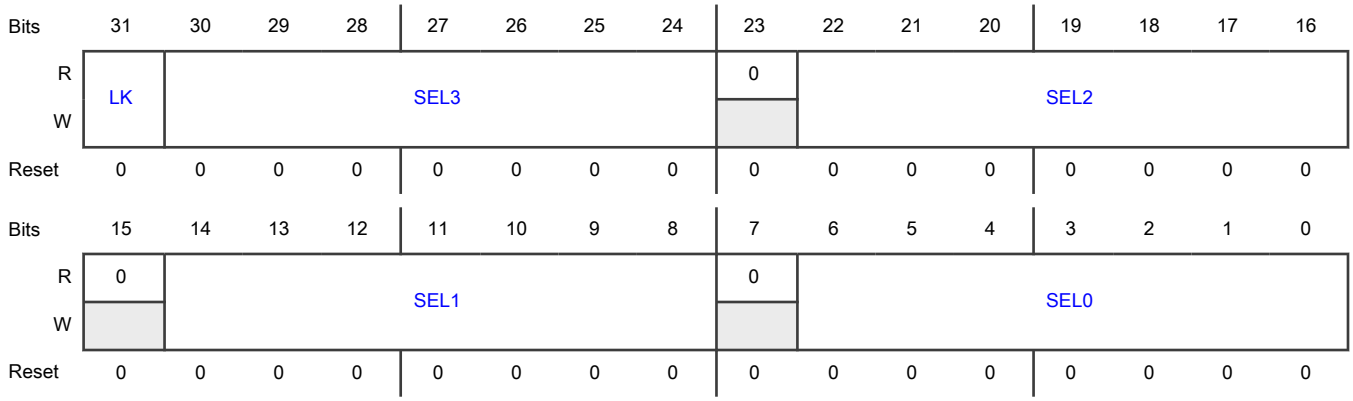
65.6.33 TRGMUX FlexIO (FlexIO)

Offset

Register	Offset
FlexIO	7Ch

Function
Configures the FlexIO module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

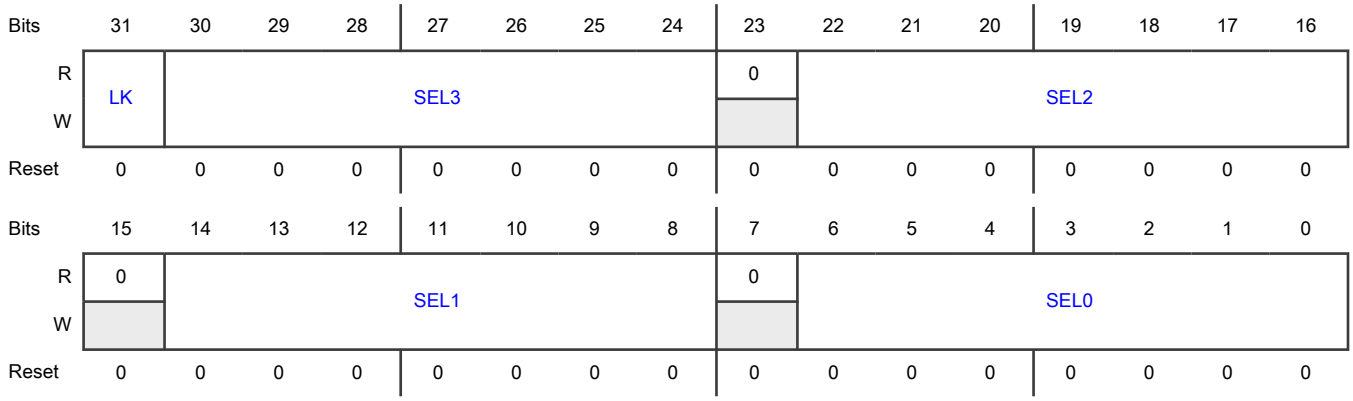
65.6.34 TRGMUX SIUL_OUT_0 (SIUL_OUT_0)

Offset

Register	Offset
SIUL_OUT_0	80h

Function
Configures the SIUL_OUT_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.35 TRGMUX SIUL_OUT_1 (SIUL_OUT_1)

Offset

Register	Offset
SIUL_OUT_1	84h

Function
Configures the SIUL_OUT_1 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	SEL3							0	SEL2						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	SEL1							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.36 TRGMUX SIUL_OUT_2 (SIUL_OUT_2)

Offset

Register	Offset
SIUL_OUT_2	88h

Function
Configures the SIUL_OUT_2 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	SEL3							0	SEL2						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	SEL1							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.37 TRGMUX SIUL_OUT_3 (SIUL_OUT_3)

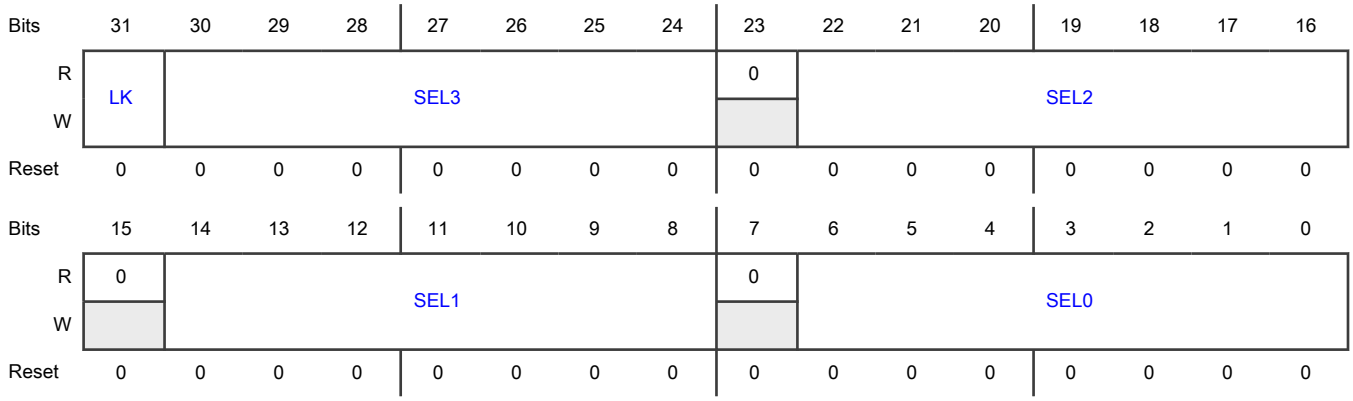
Offset

Register	Offset
SIUL_OUT_3	8Ch

Function

Configures the SIUL_OUT_3 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

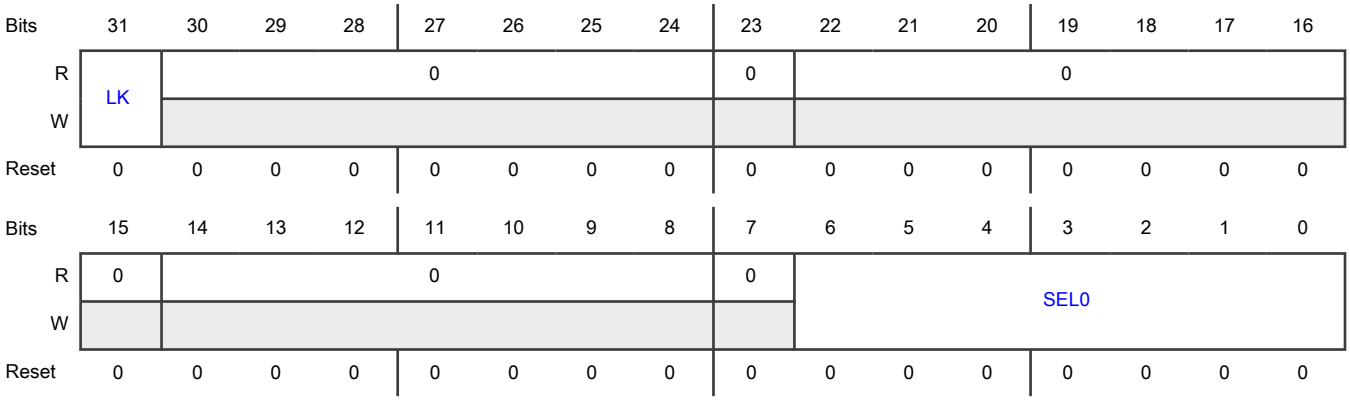
65.6.38 TRGMUX LPSPI_0 (LPSPI_0)

Offset

Register	Offset
LPSPI_0	90h

Function
Configures the LPSPI_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.39 TRGMUX LPSPI_1 (LPSPI_1)

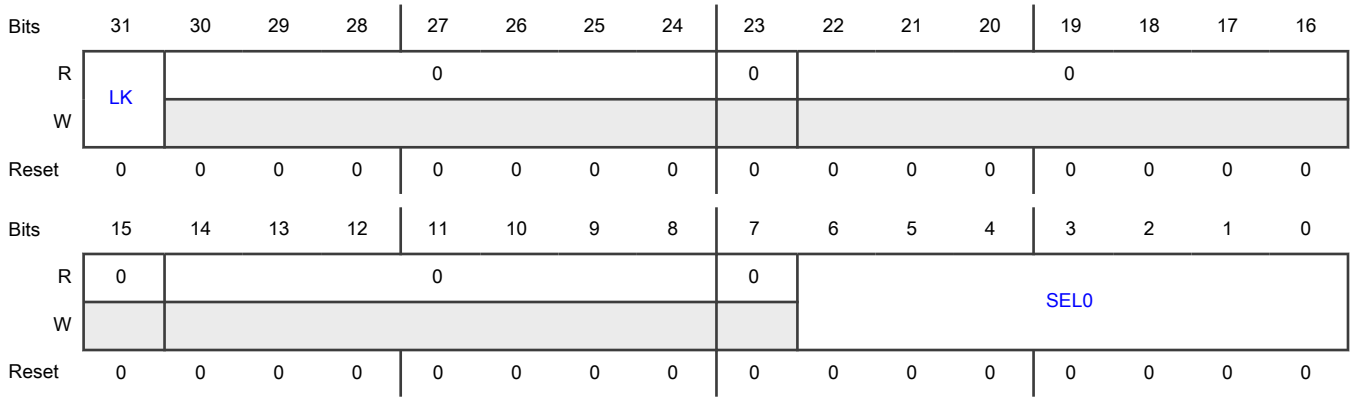
Offset

Register	Offset
LPSPI_1	94h

Function

Configures the LPSPI_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.40 TRGMUX LPSPI_2 (LPSPI_2)

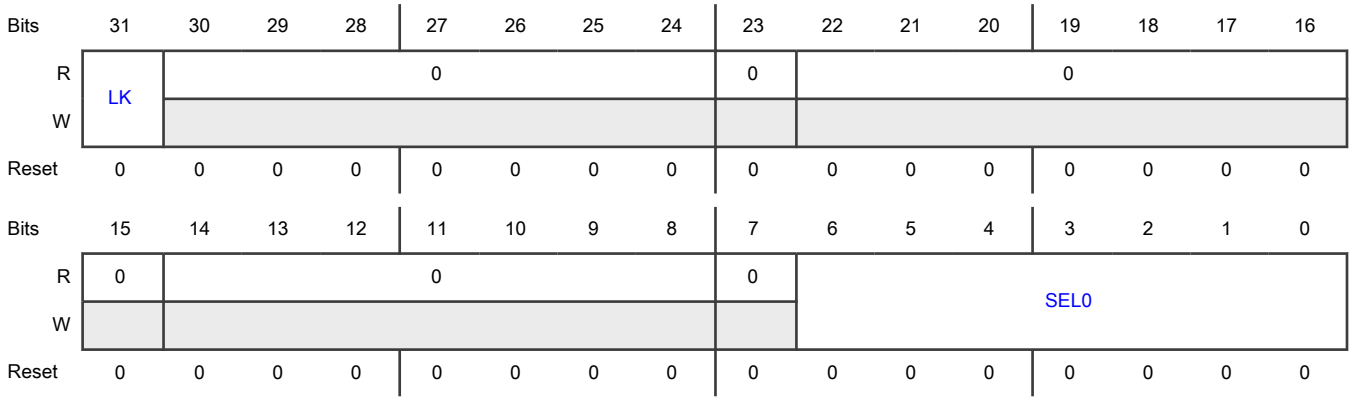
Offset

Register	Offset
LPSPI_2	98h

Function

Configures the LPSPI_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

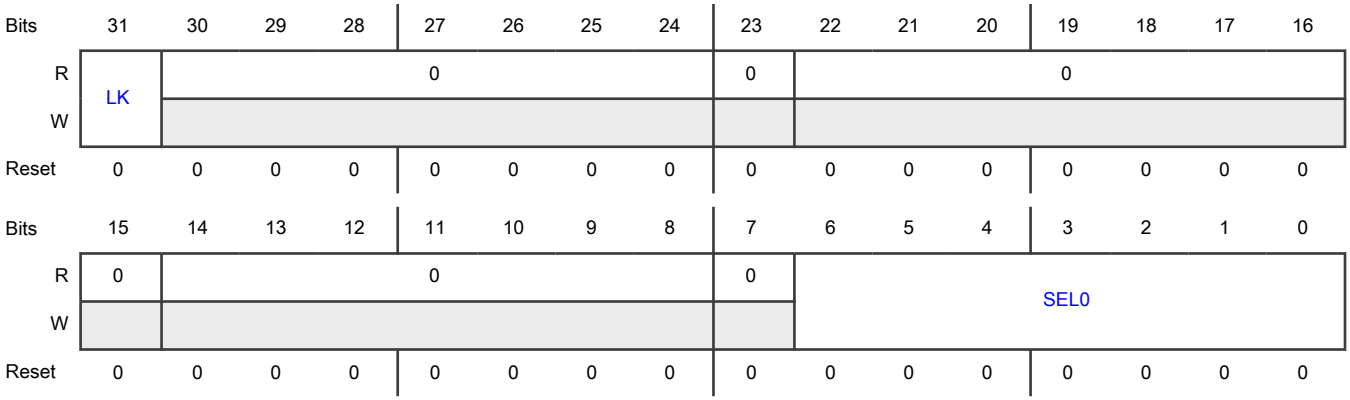
65.6.41 TRGMUX LPUART_0 (LPUART_0)

Offset

Register	Offset
LPUART_0	9Ch

Function
Configures the LPUART_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

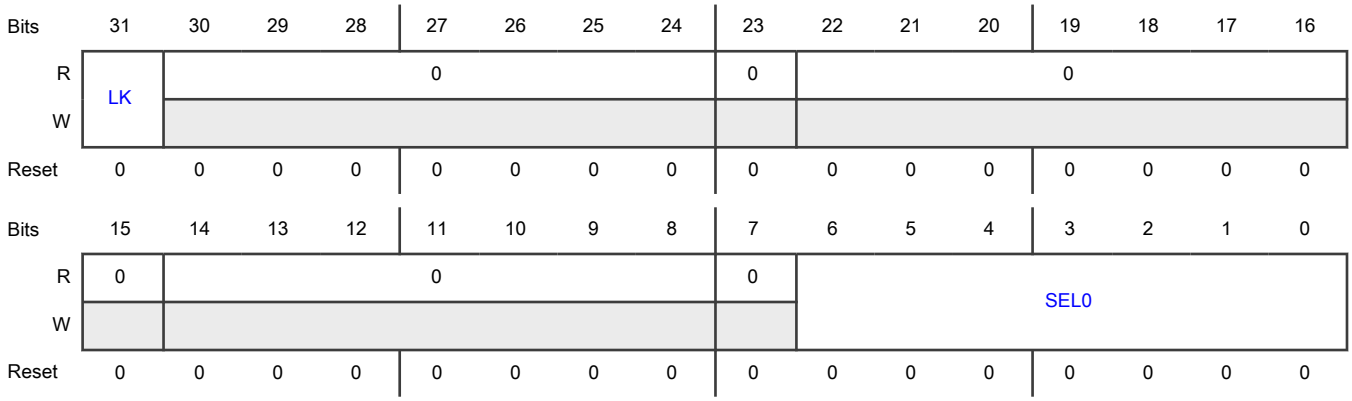
65.6.42 TRGMUX LPUART_1 (LPUART_1)

Offset

Register	Offset
LPUART_1	A0h

Function
Configures the LPUART_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.43 TRGMUX LPUART_2 (LPUART_2)

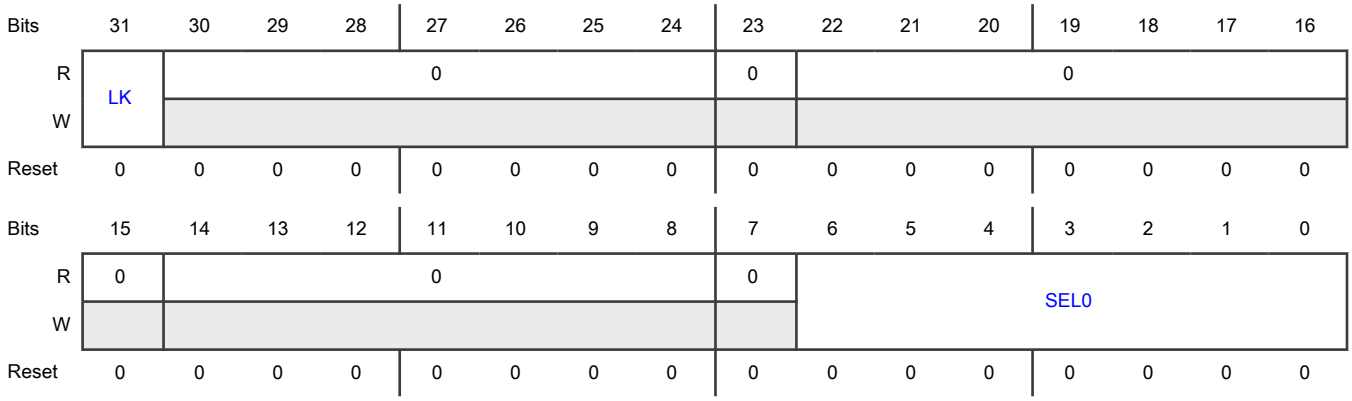
Offset

Register	Offset
LPUART_2	A4h

Function

Configures the LPUART_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

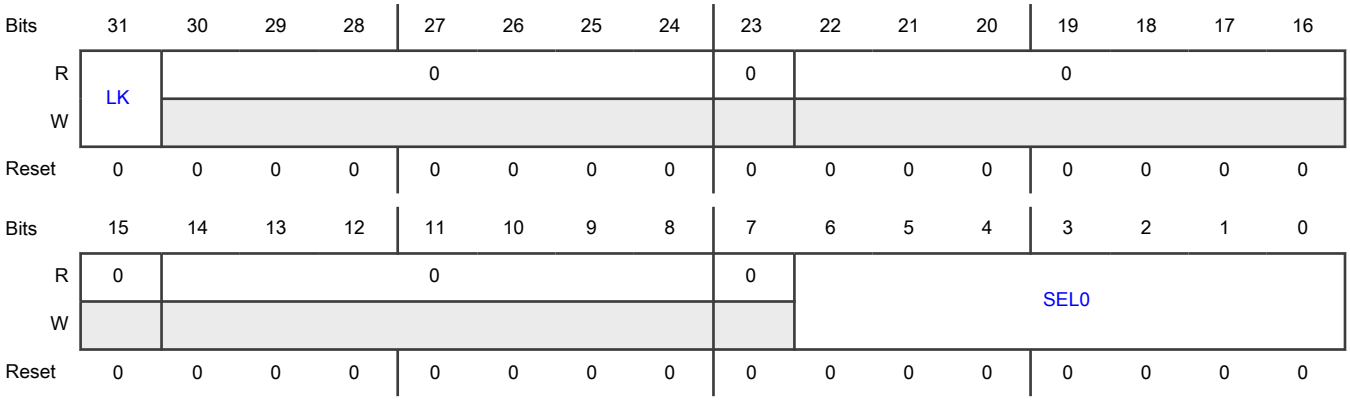
65.6.44 TRGMUX LPUART_3 (LPUART_3)

Offset

Register	Offset
LPUART_3	A8h

Function
Configures the LPUART_3 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.45 TRGMUX DSPI_MSC (DSPI_MSC)

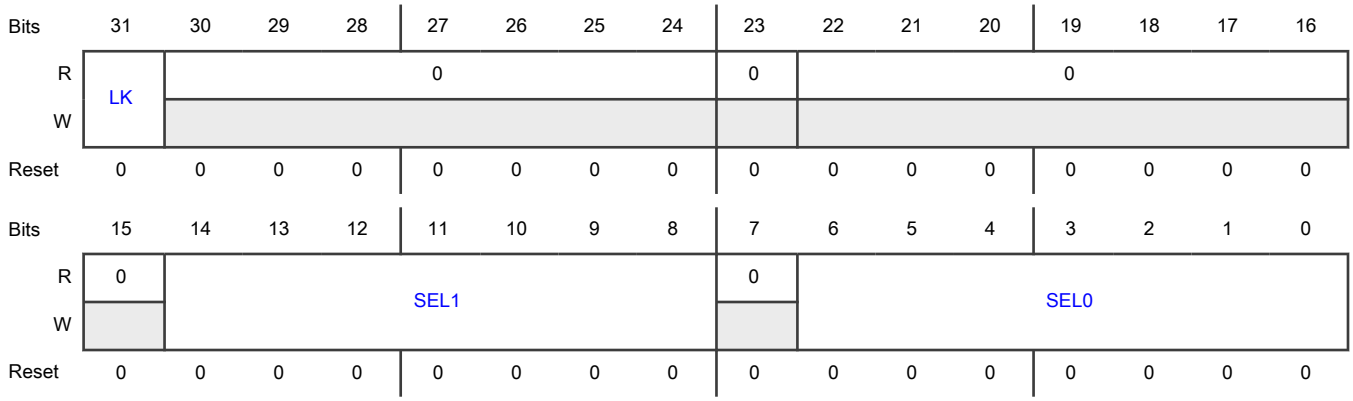
Offset

Register	Offset
DSPI_MSC	ACh

Function

Configures the DSPI_MSC module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.46 TRGMUX LCU0_sync (LCU0_sync)

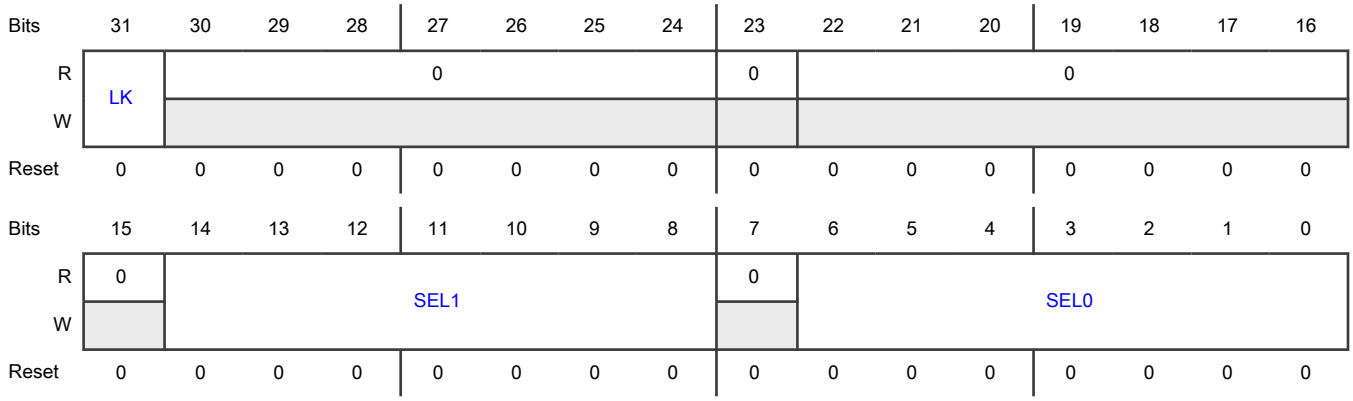
Offset

Register	Offset
LCU0_sync	B0h

Function

Configures the LCU0_sync module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

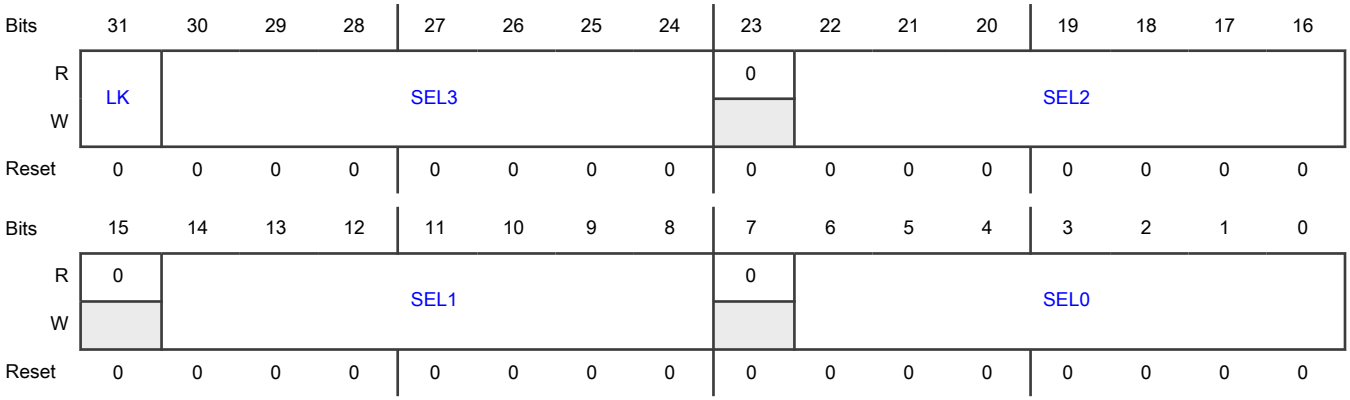
65.6.47 TRGMUX LCU0_force (LCU0_force)

Offset

Register	Offset
LCU0_force	B4h

Function
Configures the LCU0_force module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

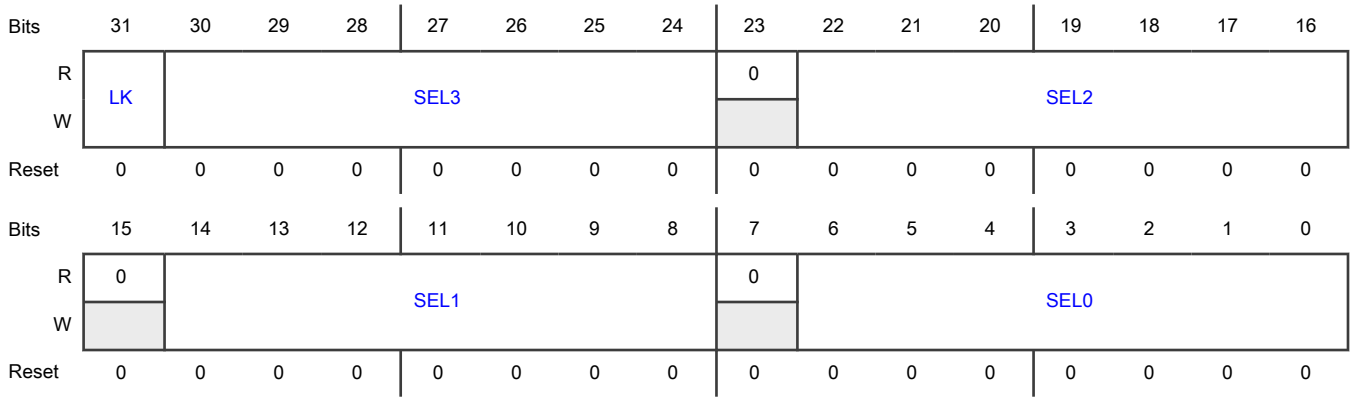
65.6.48 TRGMUX LCU0_0 (LCU0_0)

Offset

Register	Offset
LCU0_0	B8h

Function
Configures the LCU0_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.49 TRGMUX LCU0_1 (LCU0_1)

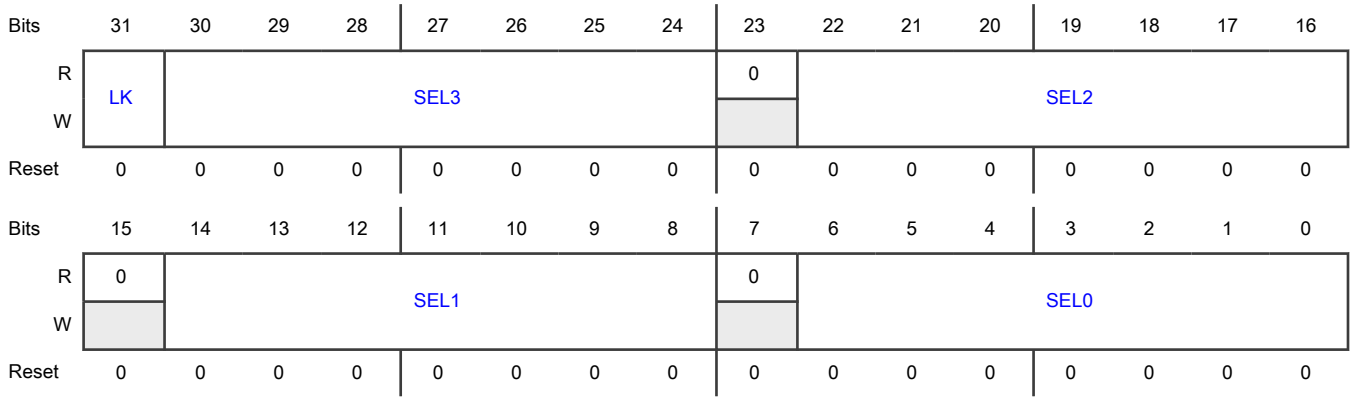
Offset

Register	Offset
LCU0_1	BCh

Function

Configures the LCU0_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

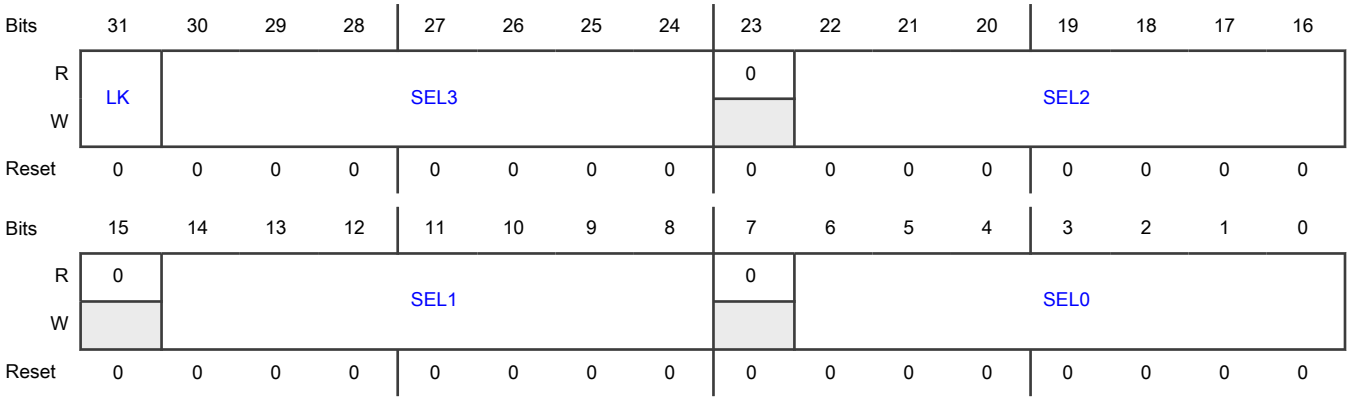
65.6.50 TRGMUX LCU0_2 (LCU0_2)

Offset

Register	Offset
LCU0_2	C0h

Function
Configures the LCU0_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

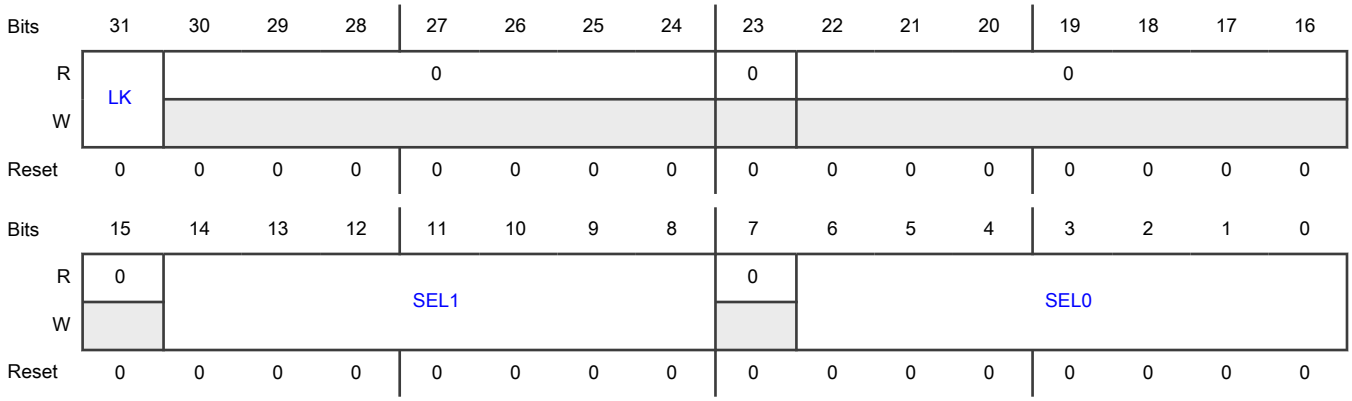
65.6.51 TRGMUX LCU1_sync (LCU1_sync)

Offset

Register	Offset
LCU1_sync	C4h

Function
Configures the LCU1_sync module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.52 TRGMUX LCU1_force (LCU1_force)

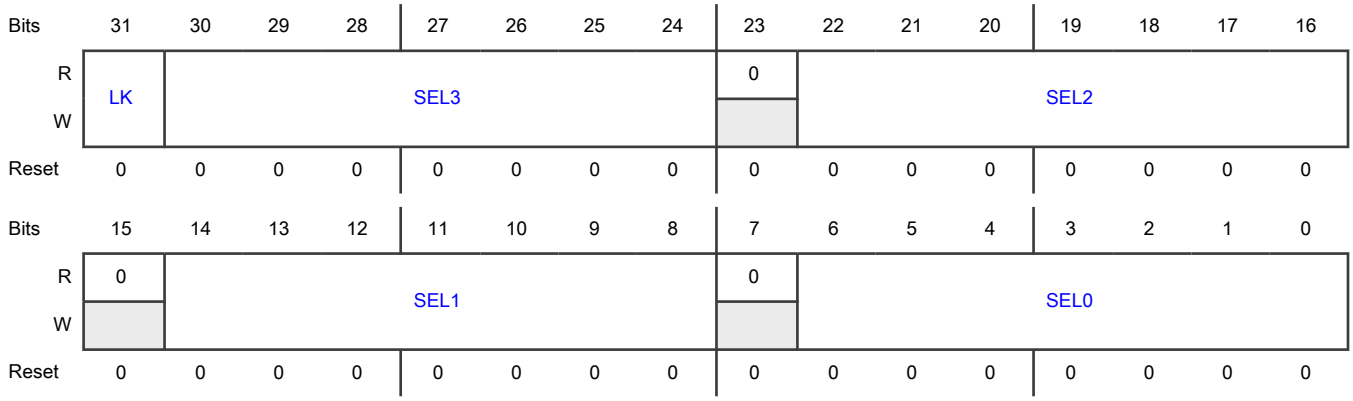
Offset

Register	Offset
LCU1_force	C8h

Function

Configures the LCU1_force module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

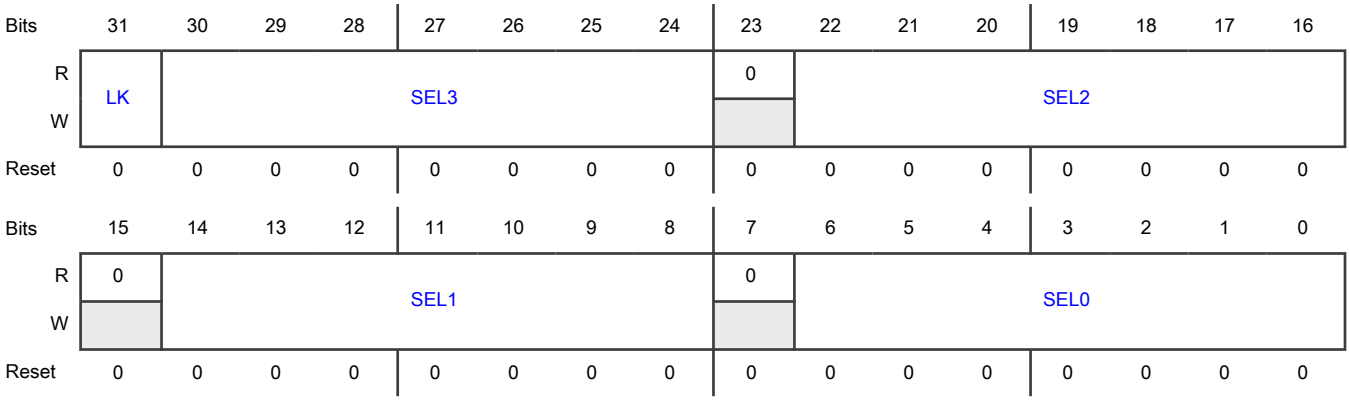
65.6.53 TRGMUX LCU1_0 (LCU1_0)

Offset

Register	Offset
LCU1_0	CCh

Function
Configures the LCU1_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

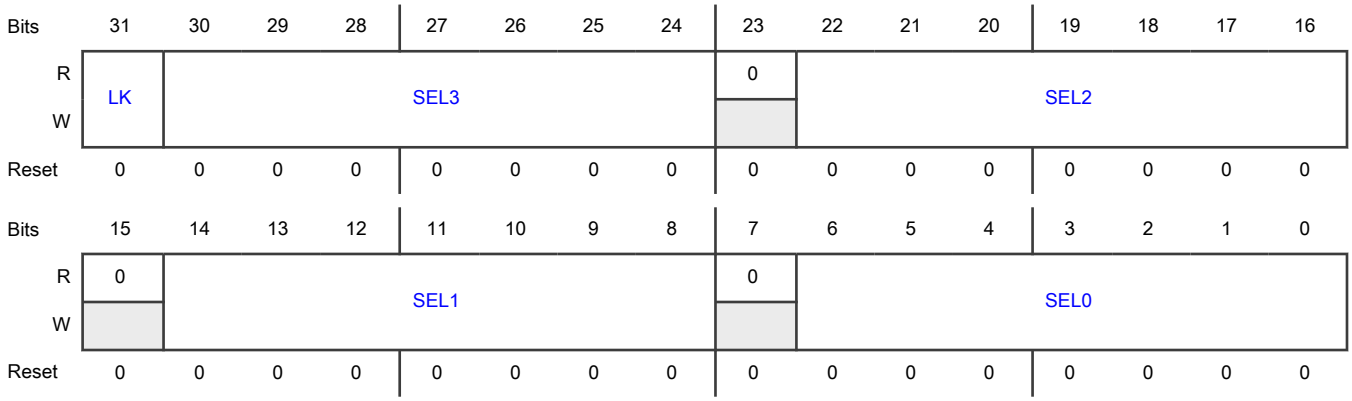
65.6.54 TRGMUX LCU1_1 (LCU1_1)

Offset

Register	Offset
LCU1_1	D0h

Function
Configures the LCU1_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.55 TRGMUX LCU1_2 (LCU1_2)

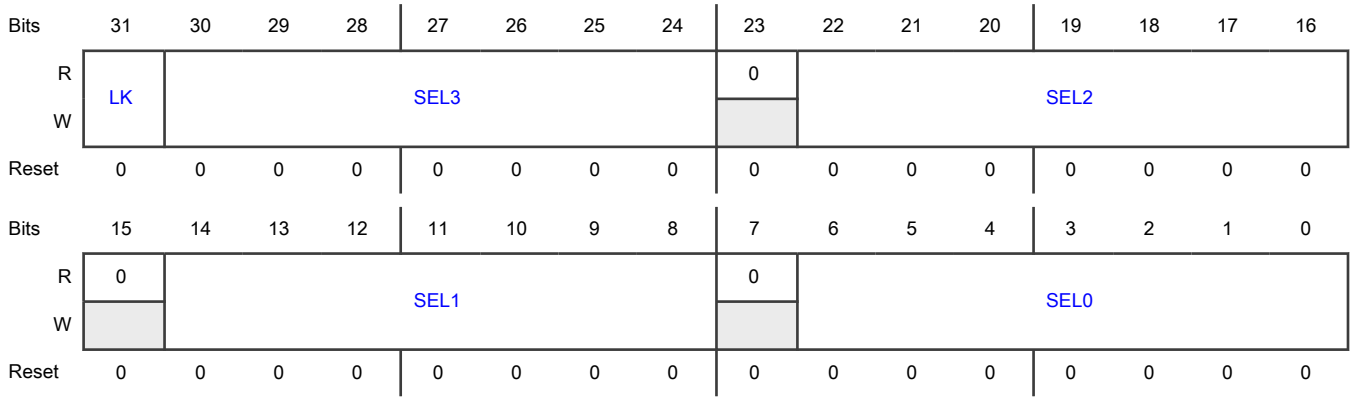
Offset

Register	Offset
LCU1_2	D4h

Function

Configures the LCU1_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.56 TRGMUX TRGMUX_MSC_OUT_0 (TRGMUX_MSC_OUT_0)

Offset

Register	Offset
TRGMUX_MSC_OUT_0	D8h

Function

Configures the TRGMUX_MSC_OUT_0 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	SEL3							0	SEL2						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	SEL1							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

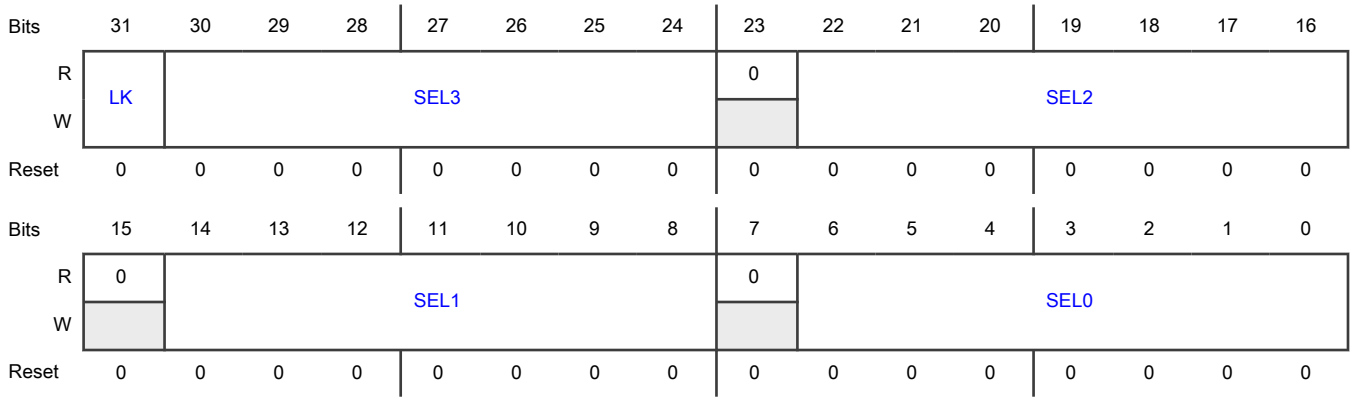
65.6.57 TRGMUX TRGMUX_MSC_OUT_1 (TRGMUX_MSC_OUT_1)

Offset

Register	Offset
TRGMUX_MSC_OUT_1	DCh

Function
Configures the TRGMUX_MSC_OUT_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.58 TRGMUX TRGMUX_MSC_OUT_2 (TRGMUX_MSC_OUT_2)

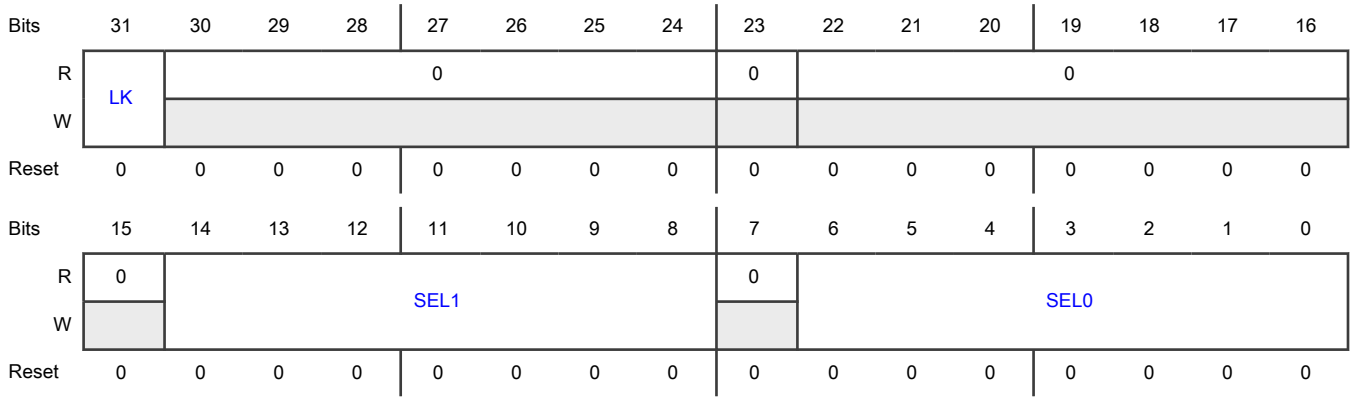
Offset

Register	Offset
TRGMUX_MSC_OUT_2	E0h

Function

Configures the TRGMUX_MSC_OUT_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

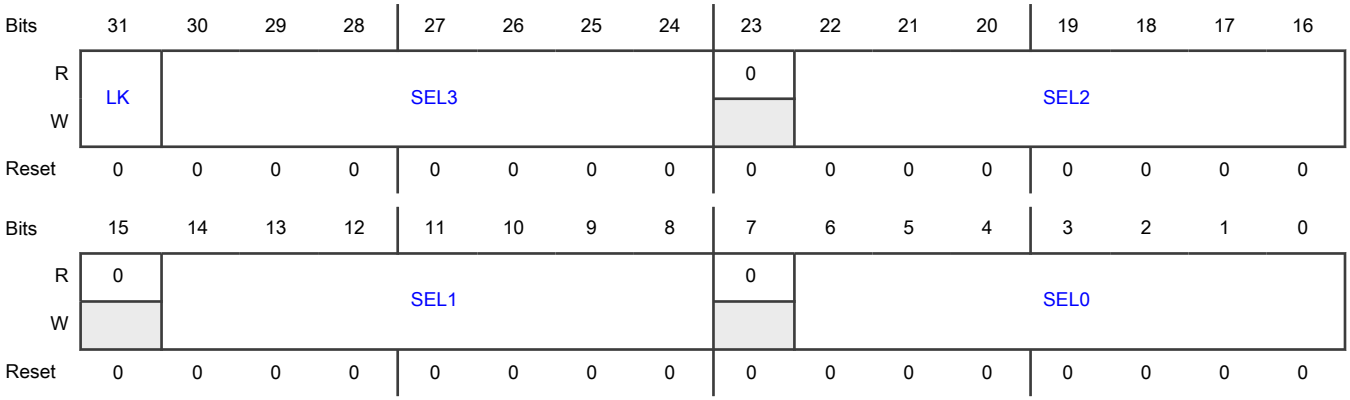
65.6.59 TRGMUX COOLFLUX_OUT (COOLFLUX_OUT)

Offset

Register	Offset
COOLFLUX_OUT	E4h

Function
Configures the COOLFLUX_OUT module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

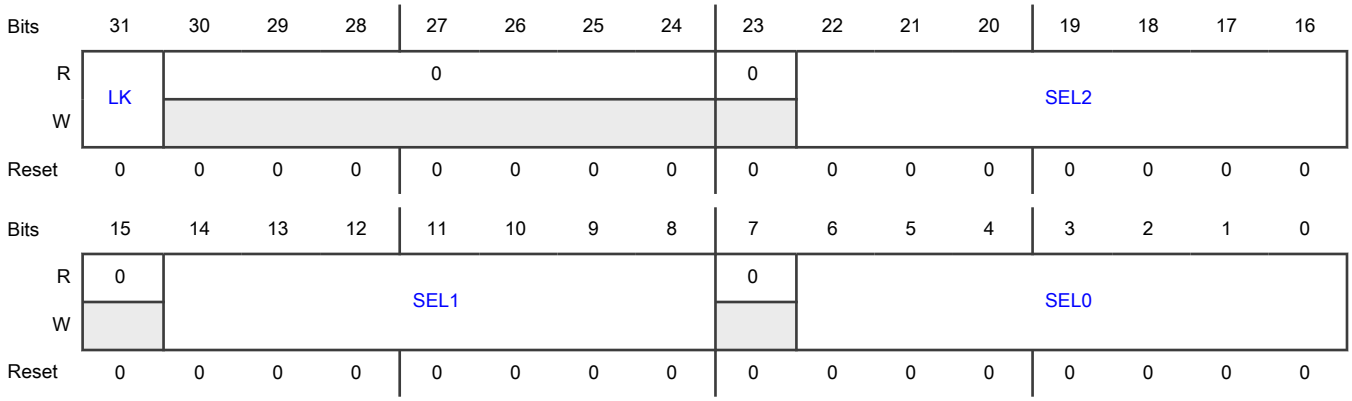
65.6.60 TRGMUX CM7_RXEV (CM7_RXEV)

Offset

Register	Offset
CM7_RXEV	E8h

Function
Configures the CM7_RXEV module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

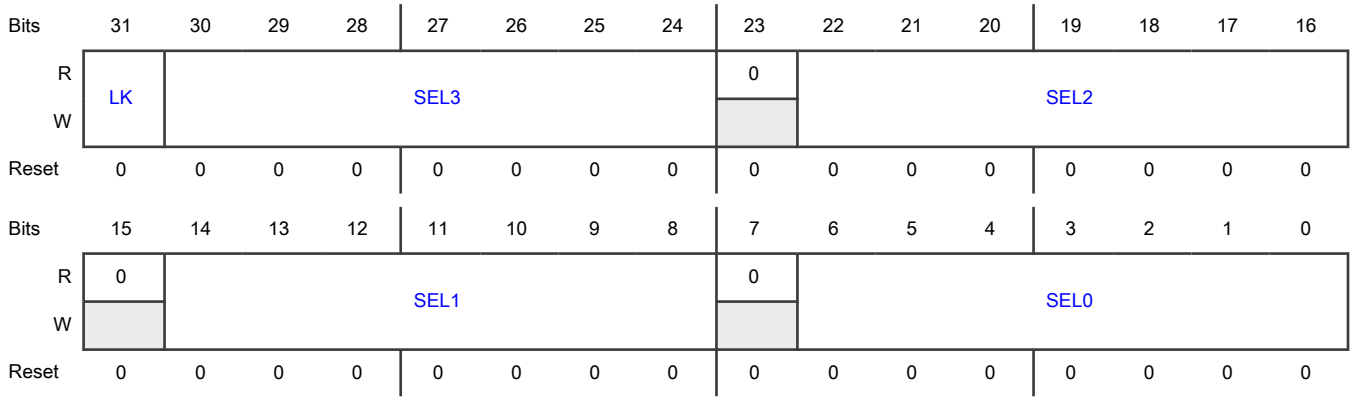
65.6.61 TRGMUX eTPU1_odis (eTPU1_odis)

Offset

Register	Offset
eTPU1_odis	ECh

Function
Configures the eTPU1_odis module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

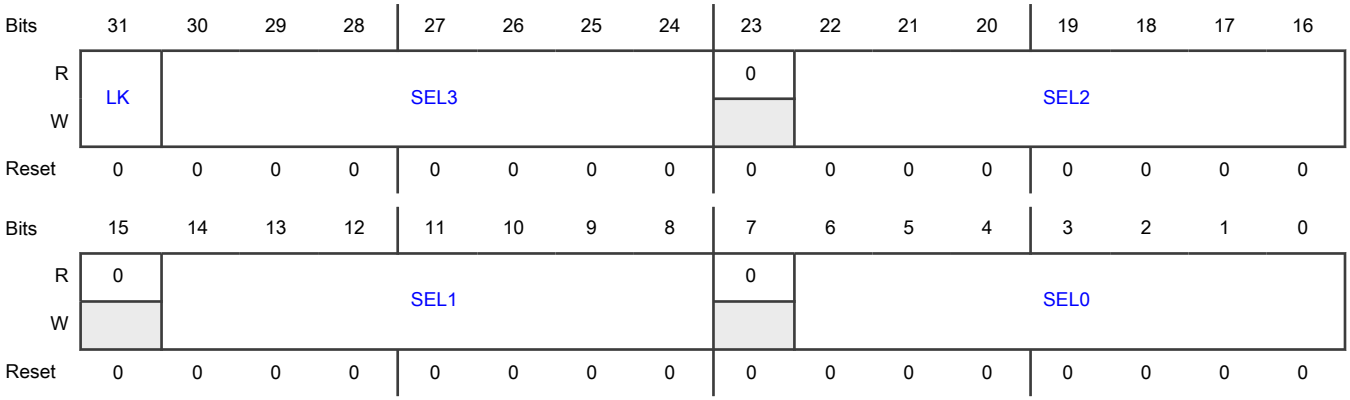
65.6.62 TRGMUX eTPU2_odis (eTPU2_odis)

Offset

Register	Offset
eTPU2_odis	F0h

Function
Configures the eTPU2_odis module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 365 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 365 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 365 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.6.63 TRGMUX LPI2C_0_Triggered (LPI2C_0_Triggered)

Offset

Register	Offset
LPI2C_0_Triggered	F4h

Function
Configures the LPI2C_0_Triggered module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	0							0	0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	0							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 —	Reserved
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 365 for field values.

65.7 TRGMUX register descriptions

65.7.1 TRGMUX memory map

You can only write to TRGMUX registers in Supervisor mode.

Table 366. Select bit fields

Field	Description
SEL*x*	Specifies the MUX select for the peripheral trigger inputs. Use this field to select the trigger sources for peripheral modules. 0h - LOGIC 0 (VSS) 1h - LOGIC 1 (VDD) 2h - eTPU_A_output[0] 3h - eTPU_A_output[1] 4h - eTPU_A_output[2] 5h - eTPU_A_output[3] 6h - eTPU_A_output[4]

Table continues on the next page...

Table 366. Select bit fields

Field	Description
	7h - eTPU_A_output[5] 8h - eTPU_A_output[6] 9h - eTPU_A_output[7] Ah - eTPU_A_output[8] Bh - eTPU_A_output[9] Ch - eTPU_A_output[10] Dh - eTPU_A_output[11] Eh - eTPU_A_output[12] Fh - eTPU_A_output[13] 10h - eTPU_A_output[14] 11h - eTPU_A_output[15] 12h - eTPU_A_output[16] 13h - eTPU_A_output[17] 14h - eTPU_A_output[18] 15h - eTPU_A_output[19] 16h - eTPU_A_output[20] 17h - eTPU_A_output[21] 18h - eTPU_A_output[22] 19h - eTPU_A_output[23] 1Ah - eTPU_A_output[24] 1Bh - eTPU_A_output[25] 1Ch - eTPU_A_output[26] 1Dh - eTPU_A_output[27] 1Eh - eTPU_A_output[28] 1Fh - eTPU_A_output[29] 20h - eTPU_A_output[30] 21h - eTPU_A_output[31] 22h - eTPU_B_output[0] 23h - eTPU_B_output[1] 24h - eTPU_B_output[2] 25h - eTPU_B_output[3] 26h - eTPU_B_output[4] 27h - eTPU_B_output[5] 28h - eTPU_B_output[6]

Table continues on the next page...

Table 366. Select bit fields

Field	Description
	29h - eTPU_B_output[7] 2Ah - eTPU_B_output[8] 2Bh - eTPU_B_output[9] 2Ch - eTPU_B_output[10] 2Dh - eTPU_B_output[11] 2Eh - eTPU_B_output[12] 2Fh - eTPU_B_output[13] 30h - eTPU_B_output[14] 31h - eTPU_B_output[15] 32h - eTPU_B_output[16] 33h - eTPU_B_output[17] 34h - eTPU_B_output[18] 35h - eTPU_B_output[19] 36h - eTPU_B_output[20] 37h - eTPU_B_output[21] 38h - eTPU_B_output[22] 39h - eTPU_B_output[23] 3Ah - eTPU_B_output[24] 3Bh - eTPU_B_output[25] 3Ch - eTPU_B_output[26] 3Dh - eTPU_B_output[27] 3Eh - eTPU_B_output[28] 3Fh - eTPU_B_output[29] 40h - eTPU_B_output[30] 41h - eTPU_B_output[31] 42h - TRGMUX_APP_TRGMUX_IN0 43h - TRGMUX_APP_TRGMUX_IN1 44h - TRGMUX_APP_TRGMUX_IN2 45h - TRGMUX_APP_TRGMUX_IN3 46h - TRGMUX_APP_TRGMUX_IN4 47h - TRGMUX_APP_TRGMUX_IN5 48h - TRGMUX_APP_TRGMUX_IN6 49h - TRGMUX_APP_TRGMUX_IN7 4Ah - TRGMUX_APP_TRGMUX_IN8

Table continues on the next page...

Table 366. Select bit fields

Field	Description
	4Bh - TRGMUX_APP_TRGMUX_IN9 4Ch - Unused 4Dh - Unused 4Eh - Unused 4Fh - Unused 50h - Unused 51h - Unused 52h - Unused 53h - Unused 54h - Unused 55h - Unused 56h - Unused 57h - Unused 58h - Unused 59h - Unused 5Ah - Unused 5Bh - Unused 5Ch - Unused 5Dh - Unused 5Eh - Unused 5Fh - Unused 60h - Unused 61h - Unused 62h - Unused 63h - Unused 64h - Unused 65h - Unused 66h - Unused 67h - Unused 68h - Unused 69h - Unused 6Ah - Unused 6Bh - Unused 6Ch - Unused

Table continues on the next page...

Table 366. Select bit fields

Field	Description
	6Dh - Unused 6Eh - Unused 6Fh - Unused 70h - Unused 71h - Unused 72h - Unused 73h - Unused 74h - Unused 75h - Unused 76h - Unused 77h - Unused 78h - Unused 79h - Unused 7Ah - Unused 7Bh - Unused 7Ch - Unused 7Dh - Unused 7Eh - Unused 7Fh - Unused

TRGMUX_MSC base address: 406C_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	TRGMUX DSPI_MSC_Input_0 (DSPI_MSC_Input_0)	32	RW	0000_0000h
4h	TRGMUX DSPI_MSC_Input_1 (DSPI_MSC_Input_1)	32	RW	0000_0000h
8h	TRGMUX DSPI_MSC_Input_2 (DSPI_MSC_Input_2)	32	RW	0000_0000h
Ch	TRGMUX DSPI_MSC_Input_3 (DSPI_MSC_Input_3)	32	RW	0000_0000h
10h	TRGMUX DSPI_MSC_Input_4 (DSPI_MSC_Input_4)	32	RW	0000_0000h
14h	TRGMUX DSPI_MSC_Input_5 (DSPI_MSC_Input_5)	32	RW	0000_0000h
18h	TRGMUX DSPI_MSC_Input_6 (DSPI_MSC_Input_6)	32	RW	0000_0000h
1Ch	TRGMUX DSPI_MSC_Input_7 (DSPI_MSC_Input_7)	32	RW	0000_0000h
20h	TRGMUX DSPI_MSC_Input_8 (DSPI_MSC_Input_8)	32	RW	0000_0000h
24h	TRGMUX DSPI_MSC_Input_9 (DSPI_MSC_Input_9)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
28h	TRGMUX DSPI_MSC_Input_10 (DSPI_MSC_Input_10)	32	RW	0000_0000h
2Ch	TRGMUX DSPI_MSC_Input_11 (DSPI_MSC_Input_11)	32	RW	0000_0000h
30h	TRGMUX DSPI_MSC_Input_12 (DSPI_MSC_Input_12)	32	RW	0000_0000h
34h	TRGMUX DSPI_MSC_Input_13 (DSPI_MSC_Input_13)	32	RW	0000_0000h
38h	TRGMUX DSPI_MSC_Input_14 (DSPI_MSC_Input_14)	32	RW	0000_0000h
3Ch	TRGMUX DSPI_MSC_Input_15 (DSPI_MSC_Input_15)	32	RW	0000_0000h
40h	TRGMUX TRGMUX_APP_TRGMUX_OUT_0 (TRGMUX_APP_TRGMUX_OUT_0)	32	RW	0000_0000h
44h	TRGMUX TRGMUX_APP_TRGMUX_OUT_1 (TRGMUX_APP_TRGMUX_OUT_1)	32	RW	0000_0000h
48h	TRGMUX TRGMUX_APP_TRGMUX_OUT_2 (TRGMUX_APP_TRGMUX_OUT_2)	32	RW	0000_0000h

65.7.2 TRGMUX DSPI_MSC_Input_0 (DSPI_MSC_Input_0)

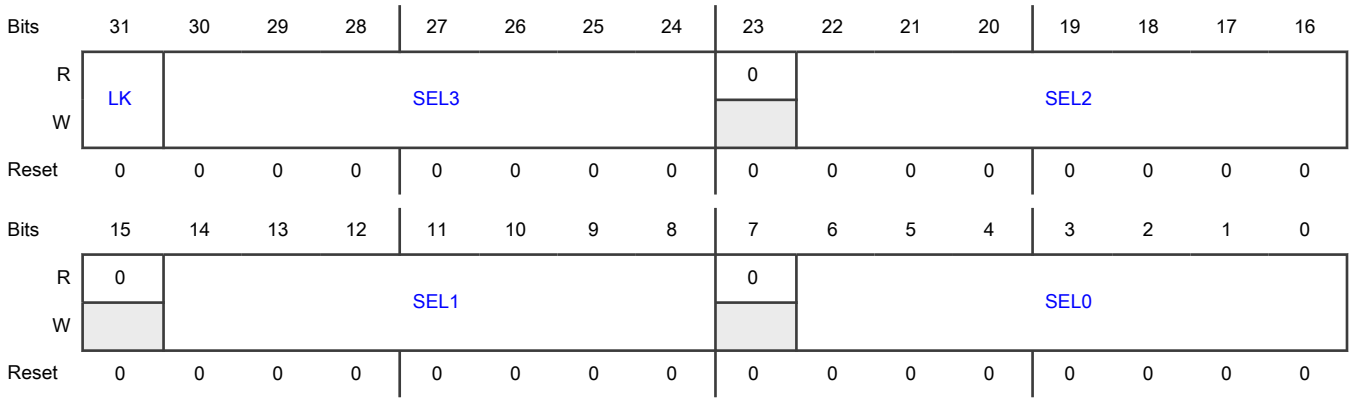
Offset

Register	Offset
DSPI_MSC_Input_0	0h

Function

Configures the DSPI_MSC_Input_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

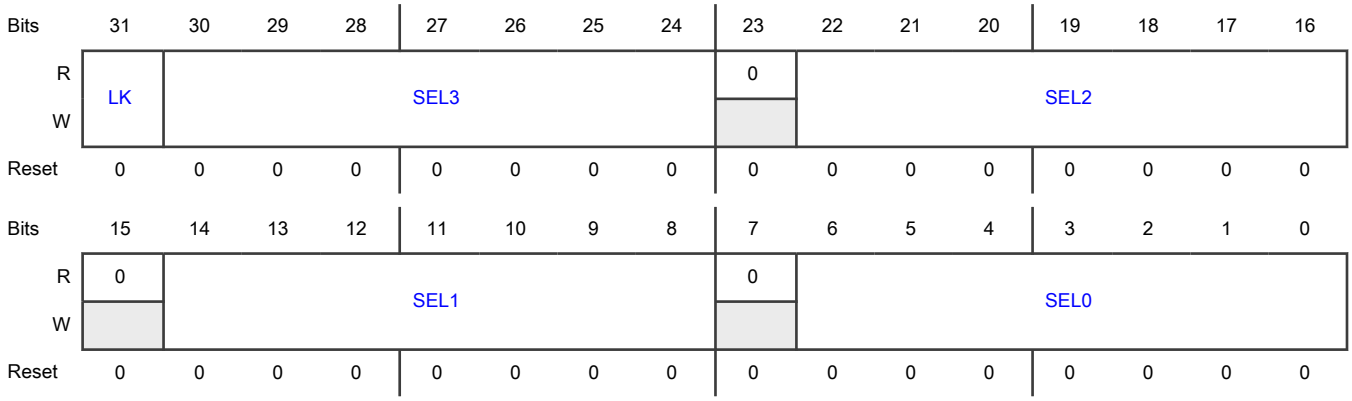
65.7.3 TRGMUX DSPI_MSC_Input_1 (DSPI_MSC_Input_1)

Offset

Register	Offset
DSPI_MSC_Input_1	4h

Function
Configures the DSPI_MSC_Input_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

65.7.4 TRGMUX DSPI_MSC_Input_2 (DSPI_MSC_Input_2)

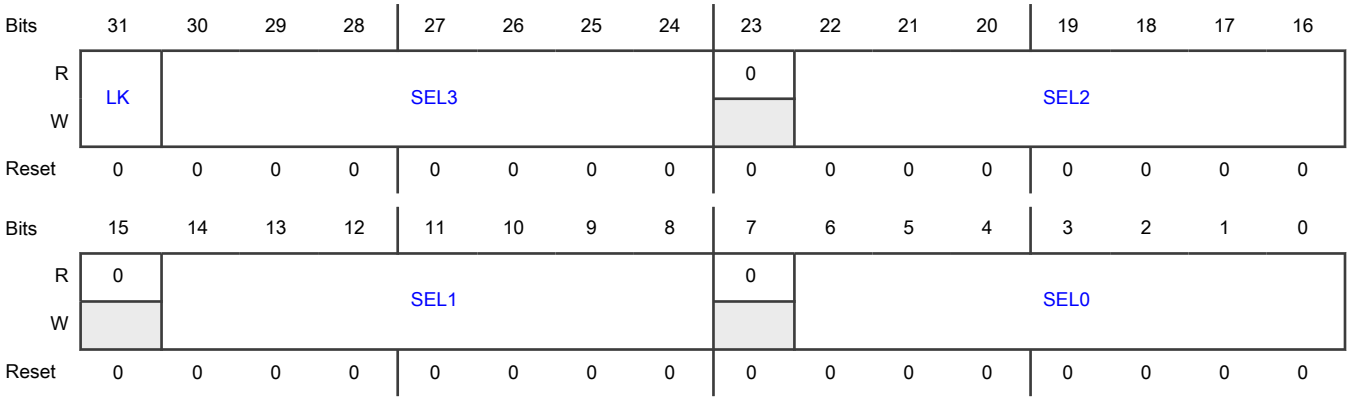
Offset

Register	Offset
DSPI_MSC_Input_2	8h

Function

Configures the DSPI_MSC_Input_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

65.7.5 TRGMUX DSPI_MSC_Input_3 (DSPI_MSC_Input_3)

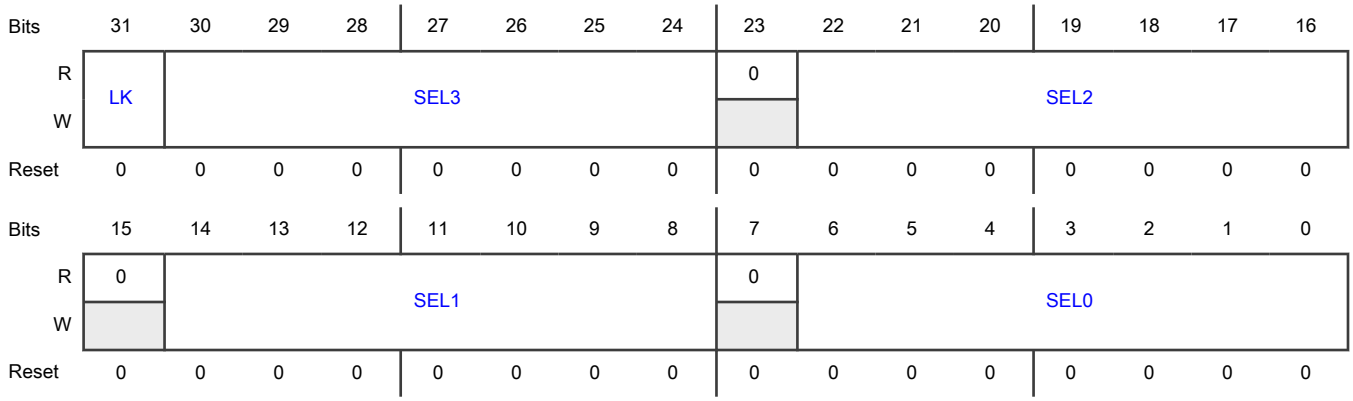
Offset

Register	Offset
DSPI_MSC_Input_3	Ch

Function

Configures the DSPI_MSC_Input_3 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

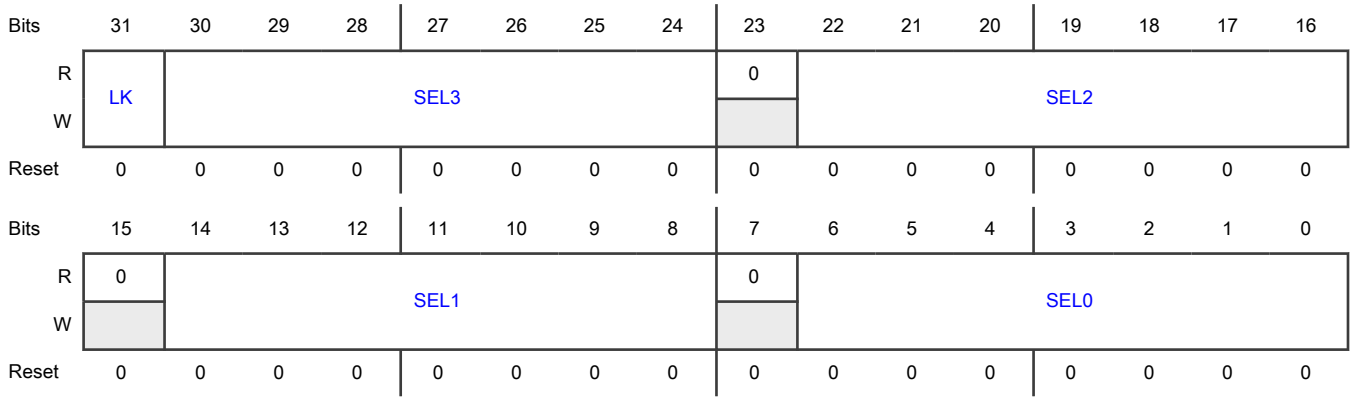
65.7.6 TRGMUX DSPI_MSC_Input_4 (DSPI_MSC_Input_4)

Offset

Register	Offset
DSPI_MSC_Input_4	10h

Function
Configures the DSPI_MSC_Input_4 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

65.7.7 TRGMUX DSPI_MSC_Input_5 (DSPI_MSC_Input_5)

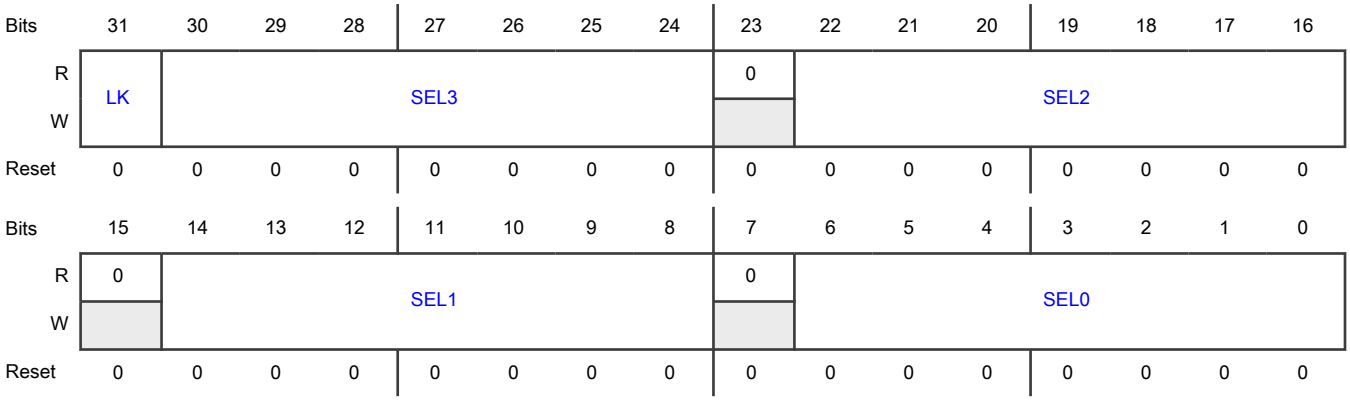
Offset

Register	Offset
DSPI_MSC_Input_5	14h

Function

Configures the DSPI_MSC_Input_5 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

65.7.8 TRGMUX DSPI_MSC_Input_6 (DSPI_MSC_Input_6)

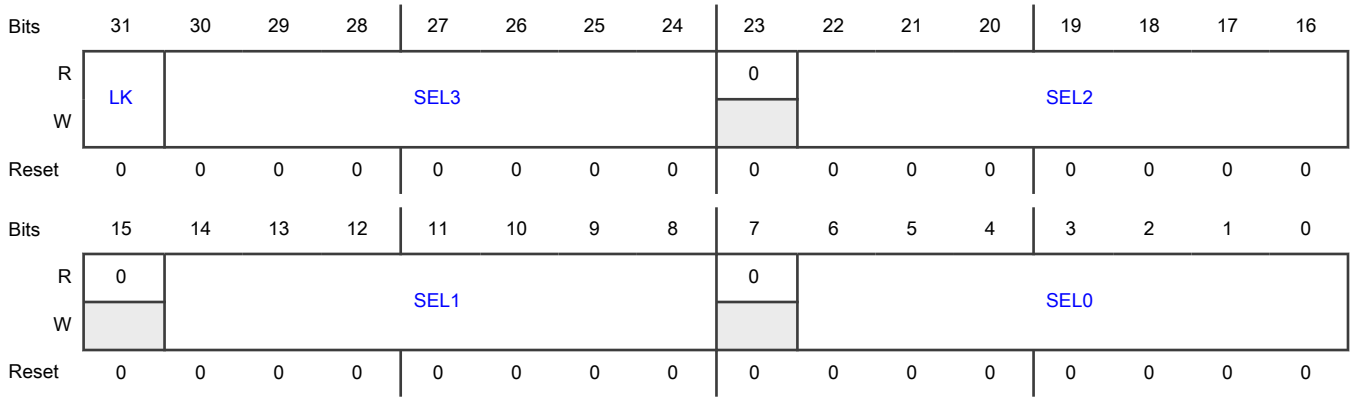
Offset

Register	Offset
DSPI_MSC_Input_6	18h

Function

Configures the DSPI_MSC_Input_6 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

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Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

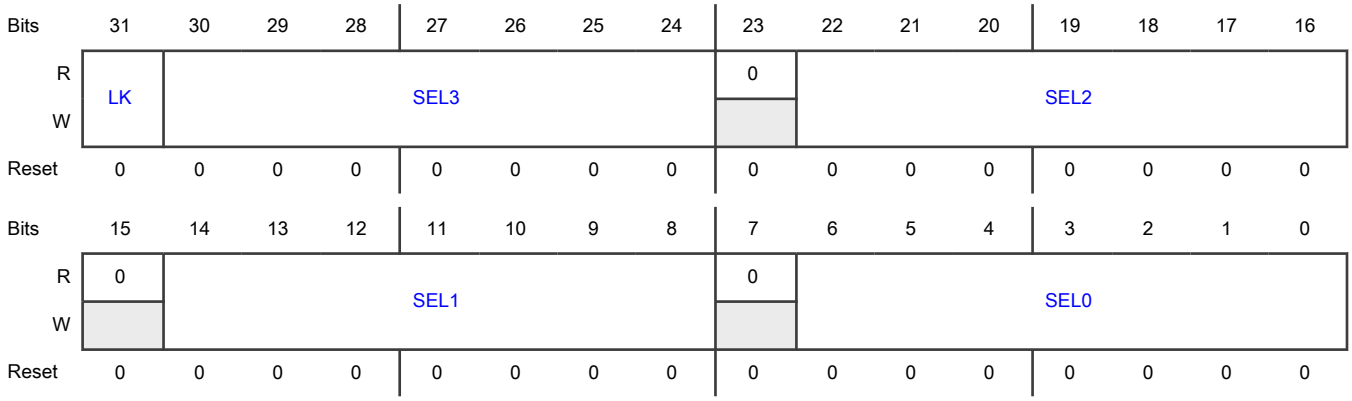
65.7.9 TRGMUX DSPI_MSC_Input_7 (DSPI_MSC_Input_7)

Offset

Register	Offset
DSPI_MSC_Input_7	1Ch

Function
Configures the DSPI_MSC_Input_7 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

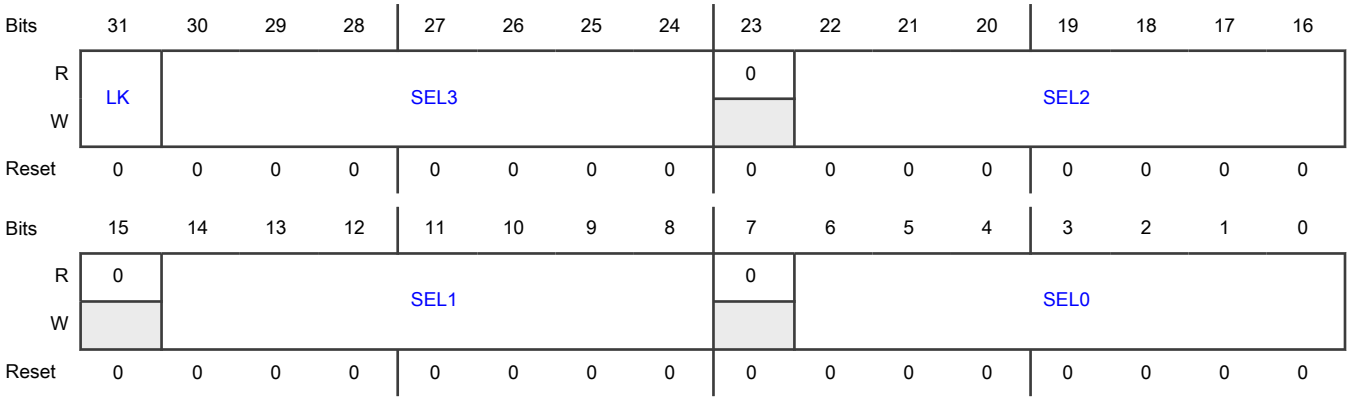
65.7.10 TRGMUX DSPI_MSC_Input_8 (DSPI_MSC_Input_8)

Offset

Register	Offset
DSPI_MSC_Input_8	20h

Function
Configures the DSPI_MSC_Input_8 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

65.7.11 TRGMUX DSPI_MSC_Input_9 (DSPI_MSC_Input_9)

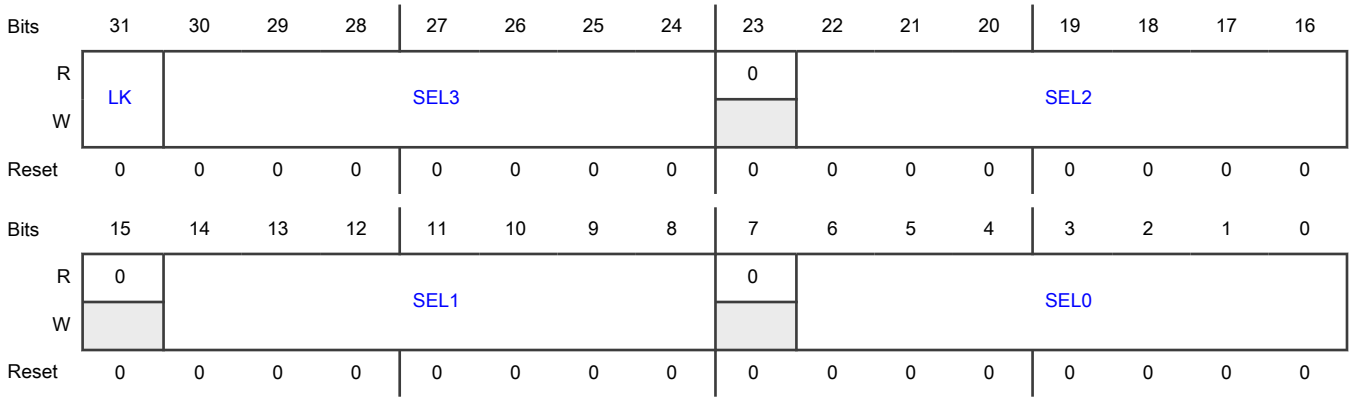
Offset

Register	Offset
DSPI_MSC_Input_9	24h

Function

Configures the DSPI_MSC_Input_9 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

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Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

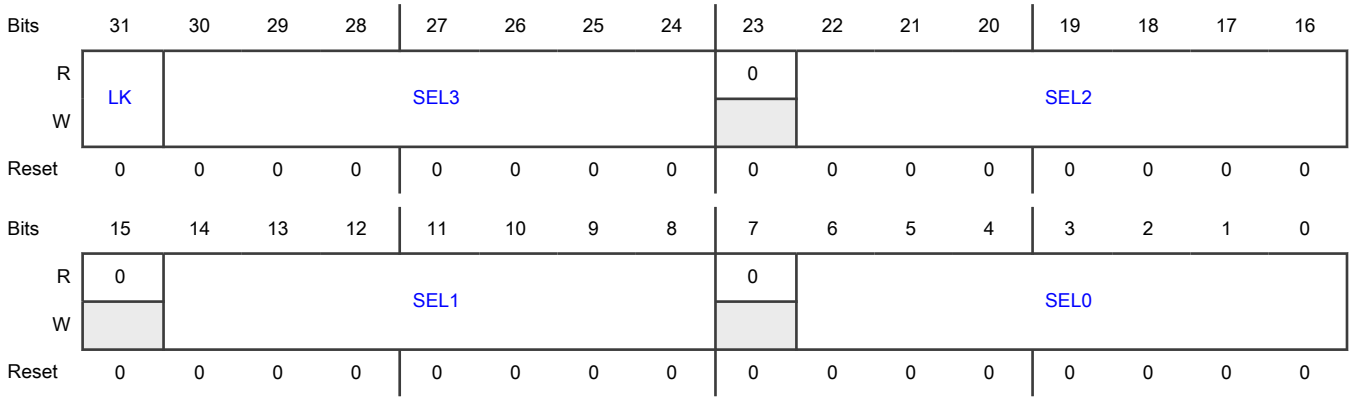
65.7.12 TRGMUX DSPI_MSC_Input_10 (DSPI_MSC_Input_10)

Offset

Register	Offset
DSPI_MSC_Input_10	28h

Function
Configures the DSPI_MSC_Input_10 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

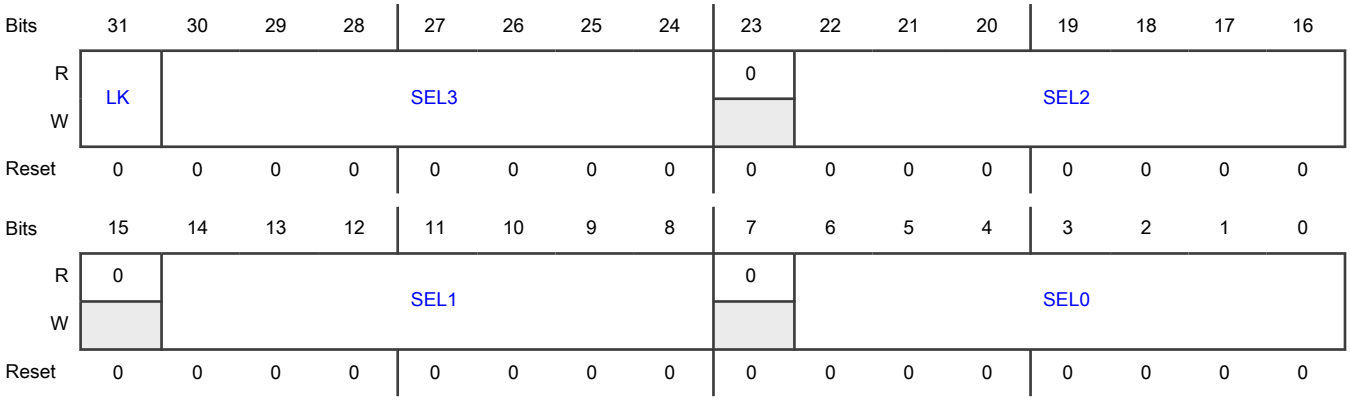
65.7.13 TRGMUX DSPI_MSC_Input_11 (DSPI_MSC_Input_11)

Offset

Register	Offset
DSPI_MSC_Input_11	2Ch

Function
Configures the DSPI_MSC_Input_11 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

65.7.14 TRGMUX DSPI_MSC_Input_12 (DSPI_MSC_Input_12)

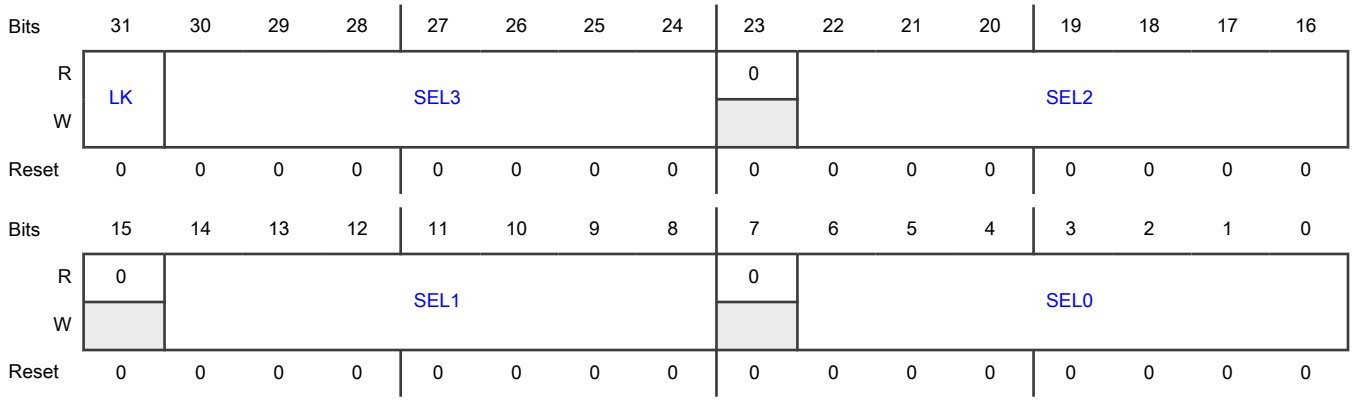
Offset

Register	Offset
DSPI_MSC_Input_12	30h

Function

Configures the DSPI_MSC_Input_12 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

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Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

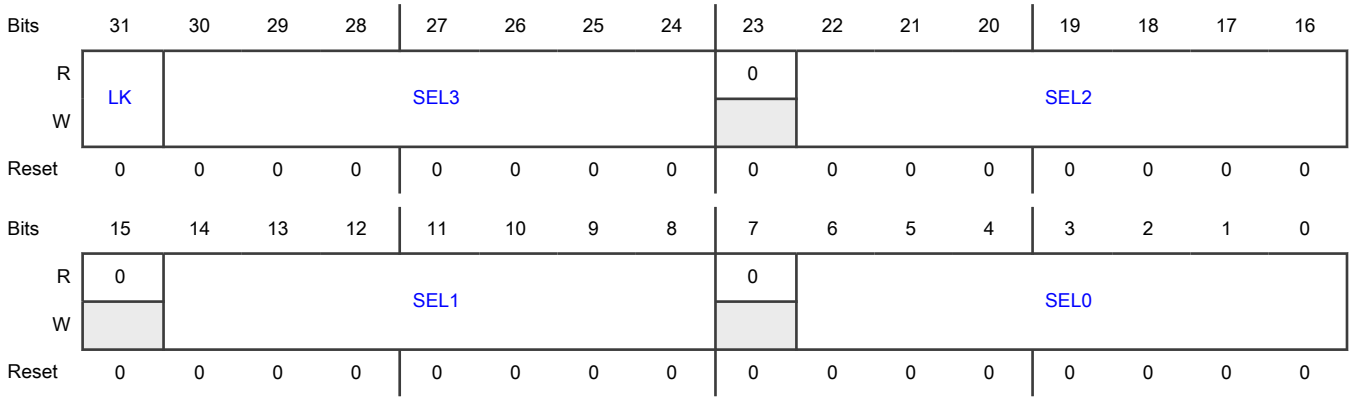
65.7.15 TRGMUX DSPI_MSC_Input_13 (DSPI_MSC_Input_13)

Offset

Register	Offset
DSPI_MSC_Input_13	34h

Function
Configures the DSPI_MSC_Input_13 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

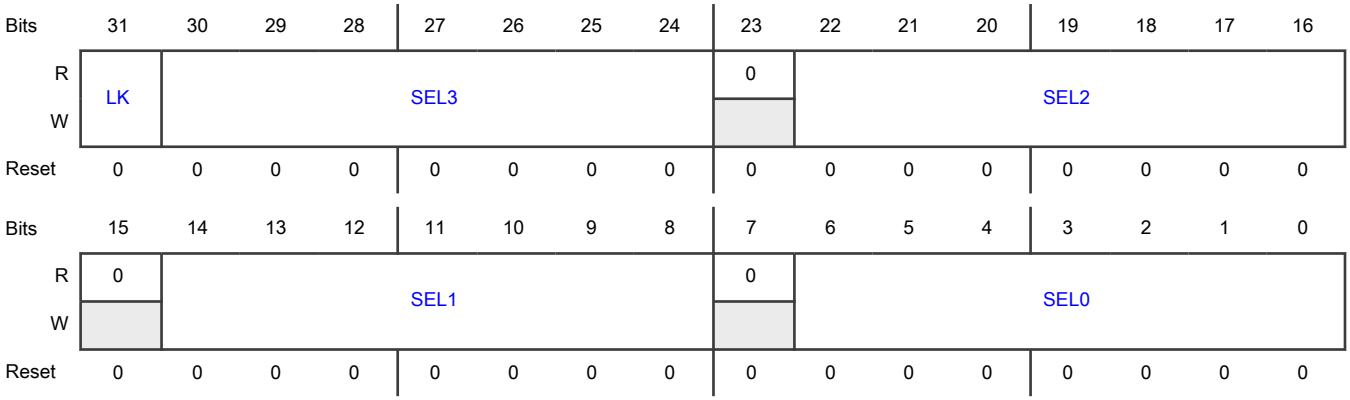
65.7.16 TRGMUX DSPI_MSC_Input_14 (DSPI_MSC_Input_14)

Offset

Register	Offset
DSPI_MSC_Input_14	38h

Function
Configures the DSPI_MSC_Input_14 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

65.7.17 TRGMUX DSPI_MSC_Input_15 (DSPI_MSC_Input_15)

Offset

Register	Offset
DSPI_MSC_Input_15	3Ch

Function

Configures the DSPI_MSC_Input_15 module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LK	SEL3							0	SEL2						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	SEL1							0	SEL0						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

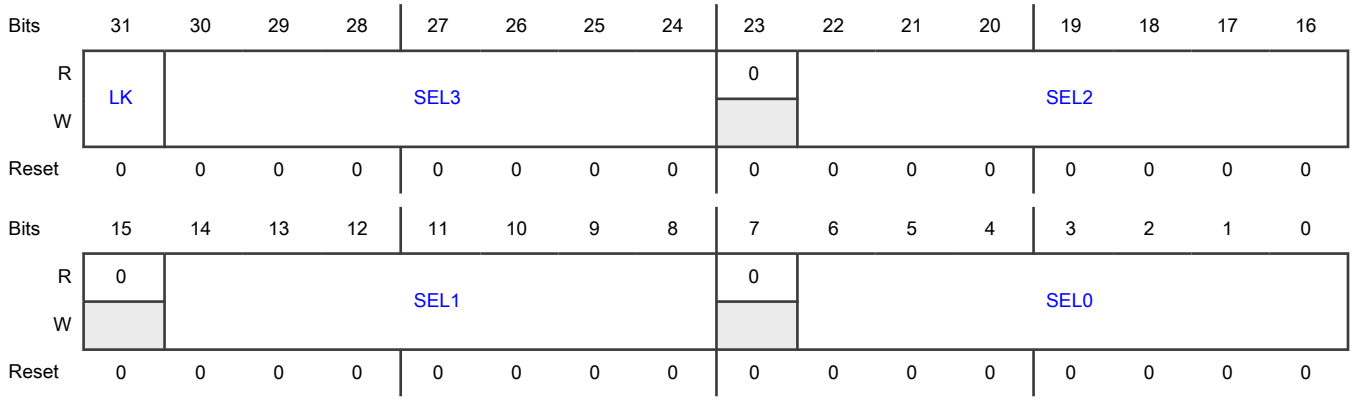
65.7.18 TRGMUX TRGMUX_APP_TRGMUX_OUT_0 (TRGMUX_APP_TRGMUX_OUT_0)

Offset

Register	Offset
TRGMUX_APP_TRGMUX_OUT_0	40h

Function
Configures the TRGMUX_APP_TRGMUX_OUT_0 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

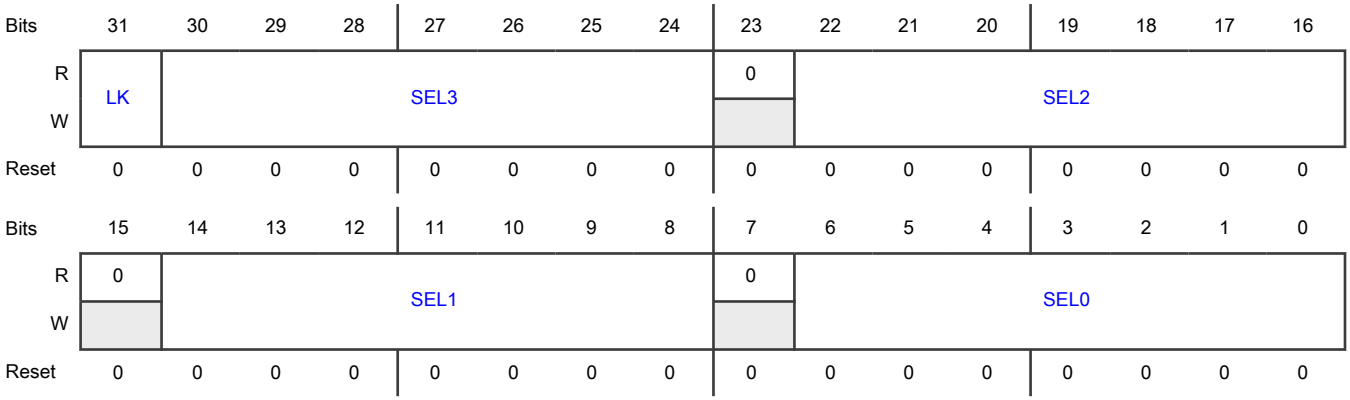
65.7.19 TRGMUX TRGMUX_APP_TRGMUX_OUT_1 (TRGMUX_APP_TRGMUX_OUT_1)

Offset

Register	Offset
TRGMUX_APP_TRGMUX_OUT_1	44h

Function
Configures the TRGMUX_APP_TRGMUX_OUT_1 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset. 0b - Register is writable 1b - Register is not writable until the next system reset
30-24 SEL3	TRGMUX Source Select 3 Specifies the source select for output 3. See Table 366 for field values.
23 —	Reserved
22-16 SEL2	TRGMUX Source Select 2 Specifies the source select for output 2. See Table 366 for field values.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

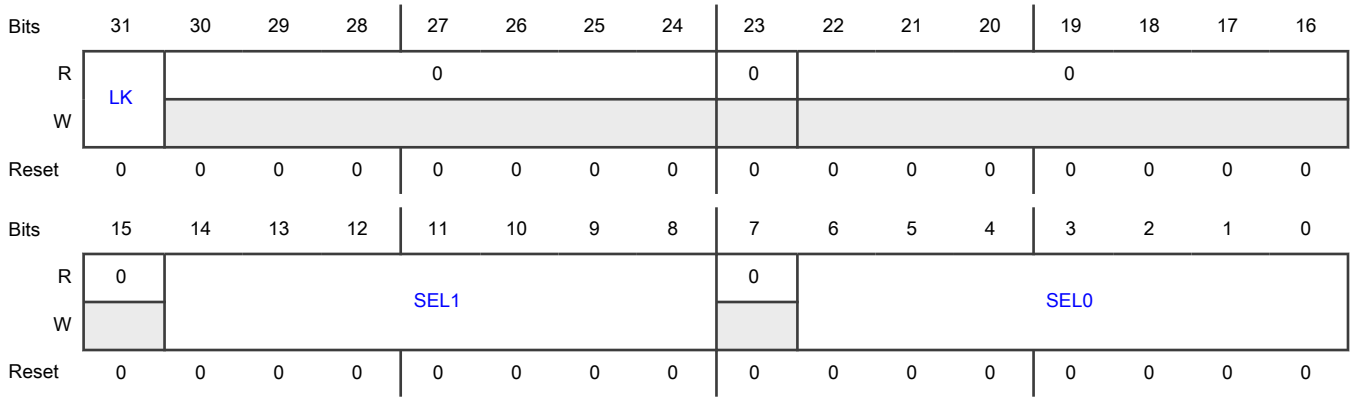
65.7.20 TRGMUX TRGMUX_APP_TRGMUX_OUT_2 (TRGMUX_APP_TRGMUX_OUT_2)

Offset

Register	Offset
TRGMUX_APP_TRGMUX_OUT_2	48h

Function
Configures the TRGMUX_APP_TRGMUX_OUT_2 module.

Diagram



Fields

Field	Function
31 LK	TRGMUX Register Lock Disables writing to the register. You can write to this field once after system reset. When this field is 1, you cannot write to SEL*x* until the next system reset. This field becomes 0 after system reset.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Register is writable 1b - Register is not writable until the next system reset
30-24 —	Reserved
23 —	Reserved
22-16 —	Reserved
15 —	Reserved
14-8 SEL1	TRGMUX Source Select 1 Specifies the source select for output 1. See Table 366 for field values.
7 —	Reserved
6-0 SEL0	TRGMUX Source Select 0 Specifies the source select for output 0. See Table 366 for field values.

Chapter 66
CoolFlux DSP Subsystem (DSPSS)

66.1 Chip-specific DSPSS information

66.1.1 CoolFlux configuration

NOTE

Pulse type triggers are not supported.
Please configure DSPSS_DSP0_CFG[dspss_dsp0_core_trigger_safety_cfg] and DSPSS_DSP0_CFG[dspss_dsp0_core_trigger_cfg] bits accordingly.

NOTE

Only threads 1 and 2 are available on S32K36x.

66.1.2 CoolFlux debug interface

The following sections describe the usage of the debug interface.

66.1.2.1 CoolFlux Arm Cortex-M7 co-debugging

Four external conditions can generate a break by using the break_in[3:0] signals. Of these four signals, one can be selected to generate break events. When the selected signal is sampled as low, then high, on successive clk's, a break is generated.

The selection is done with the instructions listed in the below table. apb_dbg_bic[3:0] select the corresponding break_in[3:0] signal to be the break signal. This means that all other break_in signals will be disabled. apb_dbg_bids disables all break_in[3:0] signals.

Table 367. Instructions for setting hardware breakpoints

Instruction	Opcode	Description
apb_dbg_bids	<ID>10 0011 1000	Disables the external breakpoint function. None of the break_in signals will cause a break.
apb_dbg_bic0	<ID>10 0011 1001	A rising edge on break_in(0) will cause a break.
apb_dbg_bic1	<ID>10 0011 1010	A rising edge on break_in(1) will cause a break.
apb_dbg_bic2	<ID>10 0011 1011	A rising edge on break_in(2) will cause a break.
apb_dbg_bic3	<ID>10 0011 1100	A rising edge on break_in(3) will cause a break.

The break_out signal can be used to output the halted, the debug_mode signal or a breakpoint hit event:

- The debug_mode signal is active while the CoolFlux DSP16LC is in debug mode.
- The halted signal is active when the CoolFlux DSP16LC has been halted by an eopi instruction, an eopci instruction or by an eopc instruction.
- An internal breakpoint is hit.

The selection is done with the instructions listed in the table below.

Table 368. Break_out signal selection

Instruction	Opcode	Description
apb_dbg_bods	<ID>10 0011 0000	break_out is low
apb_dbg_both	<ID>10 0011 0001	break_out means halted
apb_dbg_bodm	<ID>10 0011 0010	break_out means debug mode
apb_dbg_bpox	<ID>10 0011 0011	break_out means breakpoint hit

66.1.2.2 Cross break interface

This chapter describes the usage of the cross break interface.

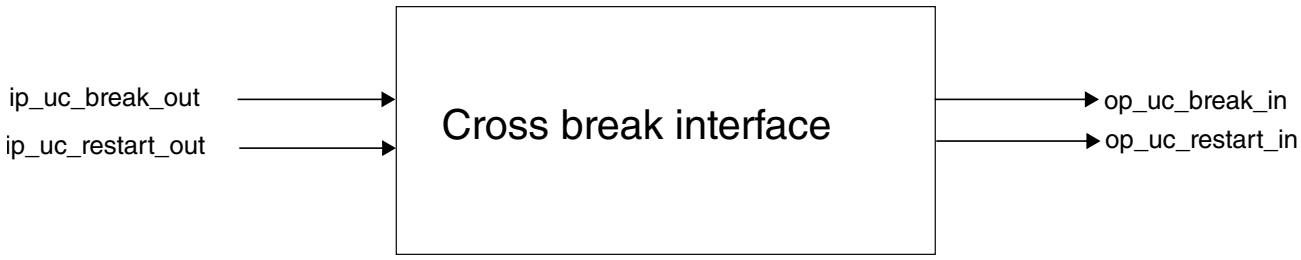


Figure 429. Cross break interface

The design has a cross break module that makes it possible to put the micro-controller and DSP into debug mode at the same time. It also allows the micro-controller to restart when the DSP restarts at the same time. The architecture is shown in the figure below.

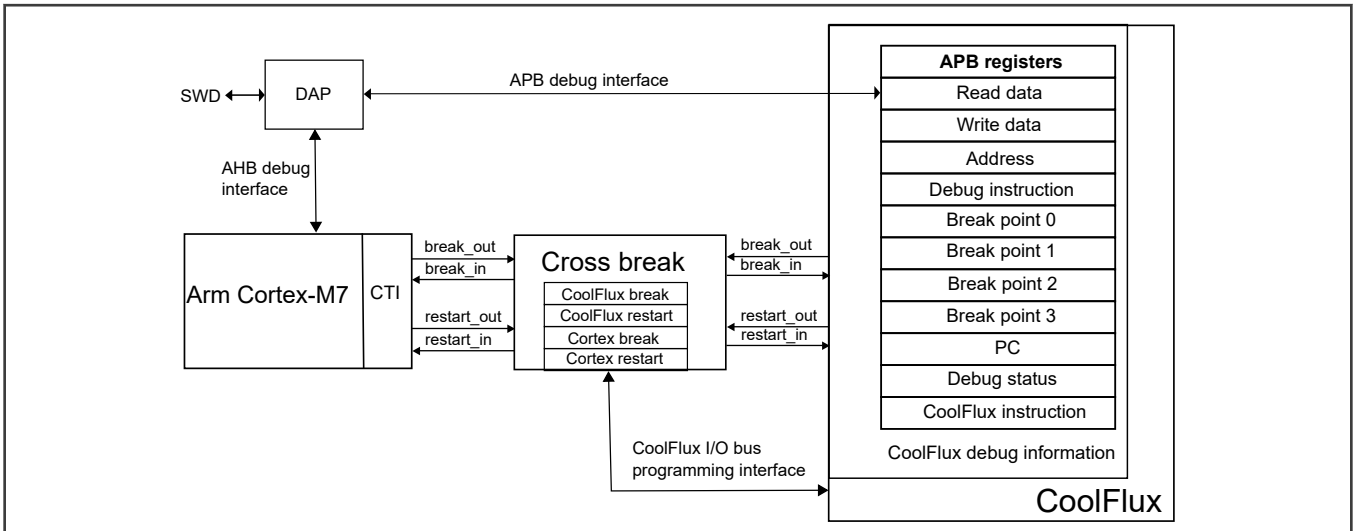


Figure 430. Cross break interface architecture

The cross break module connects the debug signals between the micro controller and the DSP. It allows both processors to enter debug mode at the same time. It also allows to restart the micro-controller at the moment the DSP leaves debug mode. For the purpose four configuration bits are provided. All four bits are disabled by default. In order to use them, they independently need to be enabled explicitly.

Enabling the DSP break configuration allows the CoolFlux to enter debug mode when the micro-controller enters debug mode, using the ip_uc_break_out from the micro-controller.

Enabling the UC break configuration allows the micro-controller to enter debug mode when the CoolFlux BSP32 enters debug mode, using the op_uc_break_in towards the micro-controller.

Enabling the DSP restart configuration allows the micro-controller to restart from debug mode when the micro-controller goes out of debug mode, using the ip_uc_restart_out towards the micro-controller.

Enabling the UC restart configuration allows the micro-controller to restart from debug mode when the CoolFlux goes out of debug mode, using the op_uc_restart_in towards the micro-controller.

66.2 Introduction

DSPSS is a signal processing block. It is built to implement FIR filtering capability for motor resolver application. CoolFlux DSP is the main processing block of this subsystem which provides multi-threaded processing capability (up to 4 threads). The subsystem has dedicated program and data memories for parallel access. This block processes samples obtained from SDADC interface and then keeps the processed data in local SRAM, which is then accessed by core or DMA.

66.2.1 Block diagram

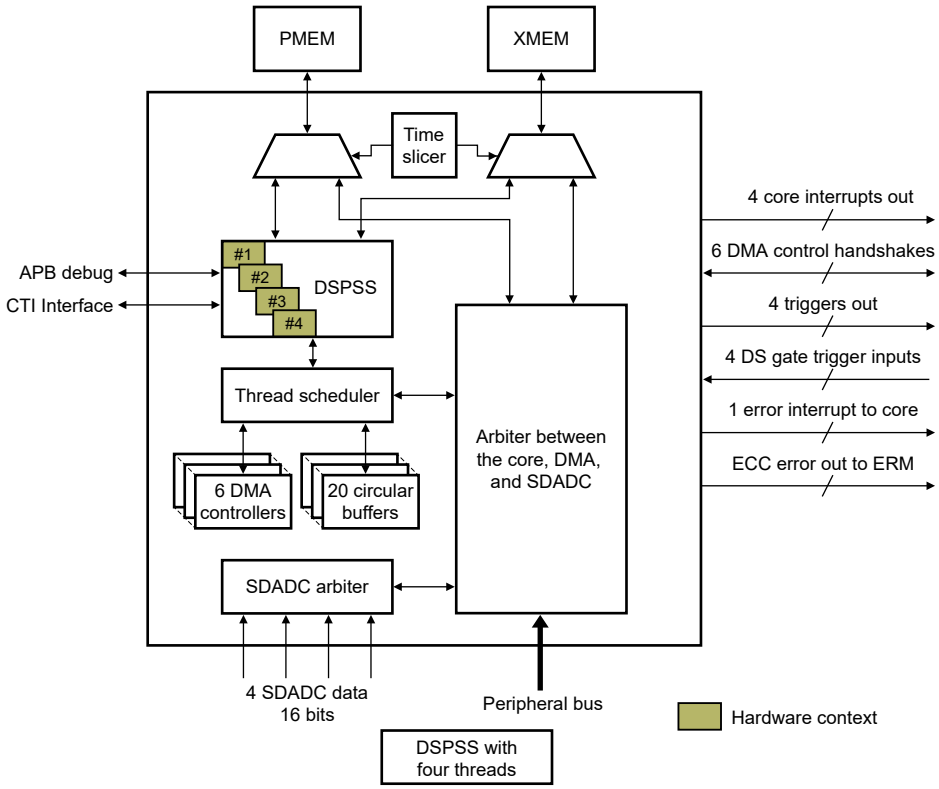


Figure 431. DSPSS block diagram

66.2.2 Features

- One instance of DSPSS with four-thread hardware multi-threading support.
- Memories
  - Single-port program memory (PMEM) and data memory with ECC (XMEM) interfaces running at twice the frequency of DSP and host core interface frequency.
  - 32 KB of program memory.
  - 24 KB of data memory.
  - XMEM and PMEM ECC error run status to ERM and FCCU.
  - Two virtual ports for two masters (DSP and peripheral bus master) on PMEM and XMEM interfaces.

- ECC algorithm for PMEM and XMEM is Single Error Correction with Double Error Detection (SECDED).
- In PMEM, only 32-bit data RW accesses are allowed.
- In XMEM, 32-bit and 16-bit aligned data RW accesses are allowed from the peripheral bus interface.
- In XMEM, 16-bit data RW accesses are allowed from DSP.

- DMA
  - Six DSP firmware-controlled DMA request channels and hardware control response handling.
- Buffer management
  - Circular buffer support for DSP and HOST core. This buffer is aligned at 4-byte address boundary in XMEM.
  - Circular buffer support for DSP and DMA. This buffer is aligned at 4-byte address boundary in XMEM.
  - Circular buffer support for DSP and SDADC. This buffer is aligned at 4-byte address boundary in XMEM.
  - No two circular buffers can point to the same region in XMEM.
- Thread Scheduling
  - Hardware scheduling of threads based on sample and clock threshold.
  - No hardware scheduling of threads. In this mode, DSP firmware can switch context via an instruction. Hardware scheduler will not schedule any thread in this mode.
  - Per thread suspension and re-enable support through software.
  - Thread re-enabling flow controlled through software.
  - The default thread that DSP starts to execute after reset de-assertion is Thread-0.
- Triggers and Interrupts
  - DSP trigger to host core per thread.
  - Four triggers to TRIGMUX. DSP firmware controls these triggers. Write a 1 to set the trigger and write a 0 to reset the trigger.
  - DSP error interrupt to host.
  - Supports multiple trigger inputs, like DS gate.
- SDADC Interface
  - 16-bit aligned accesses from SDADC interface to XMEM.
  - ECC is calculated for 32-bit data in PMEM and 16-bit data in XMEM.
- Miscellaneous
  - Digital Stream (DS) gate status register for DSP firmware to control result gate.
  - Debug and CTI interface for DSPSS debug support.

66.3 Functional description

The following sections describe functional details of DSPSS.

66.3.1 DSPSS components

This table describes the functions of the main components of DSPSS.

Table 369. DSPSS components

Component	Function
cf16L	DSP multi-thread core for processing (for example, FIR, FFT) incoming SDADC data.
Scheduler	This is the hardware scheduler block inside DSPSS. Schedules the thread on the DSP core for data processing depending on the scheduling mode.
Software configuration registers	Block for configuring DSPSS for various applications.
Time division multiplexer (time slicer)	Time division multiplexer or arbiter for accessing XMEM and PMEM through various masters (DSP and Cortex-M7 core).
DMA-read buffer monitor	DMA read buffer pointers are monitored. If there is an address mismatch between the IPS interface and internally-maintained pointer, an error interrupt is generated.
DMA-write buffer monitor	DMA write buffer pointers are monitored. If there is an address mismatch between the IPS interface and internally-maintained pointer, an error interrupt is generated.
DSP core buffer region	Scratch pad area between the Cortex-M7 core and DSP core. Read and write pointers are maintained inside the monitor and underflow and overflow errors are generated. Cortex-M7 core is notified through the interrupt.

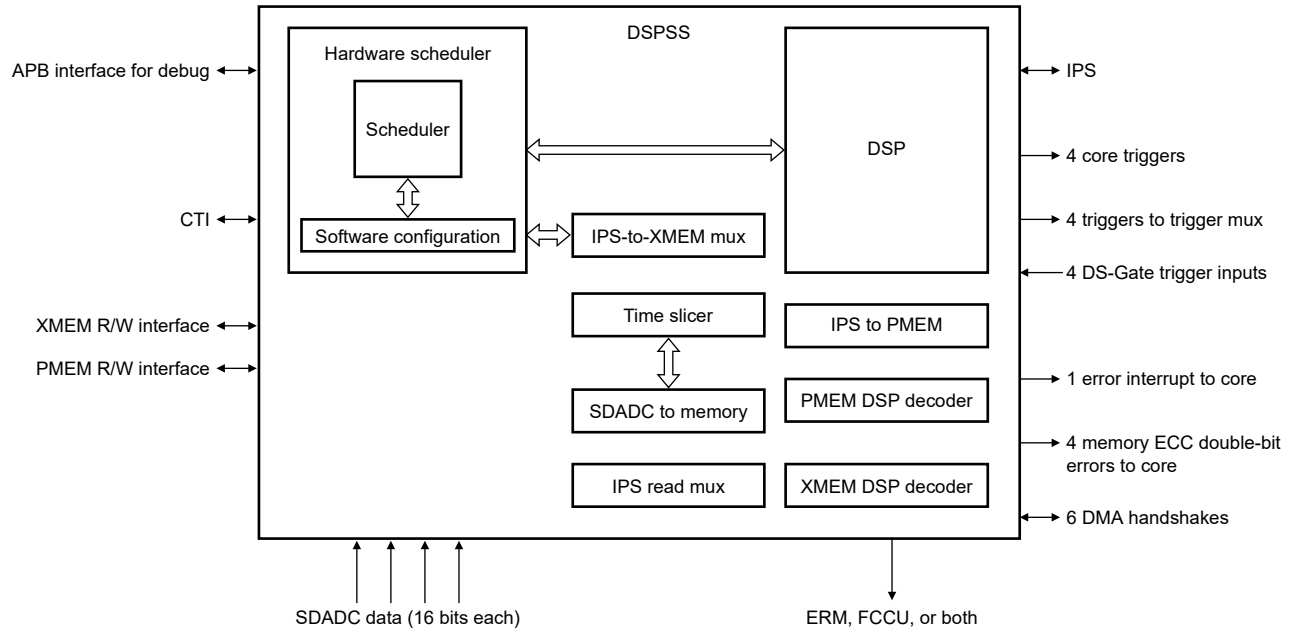


Figure 432. DSPSS components

66.3.2 SDADC interface

The SDADC pushes data through the SDADC interface shown in the system diagram. Every ADC sample is 16 bits and is received using SDADC clock. The sample path to XMEM goes through two levels of arbitration. SDADC data is written into XMEM only if you enable the thread; otherwise, the hardware scheduler drops the data. The write path to PMEM is not supported.

1. Level 1 arbitration is round-robin across four SDADC inputs.
2. Arbitration of SDADC flow:
    a. On reset deassertion, the grant is parked with ADC0.
    b. When a request is made from one or more masters at a time, grant is first given to the master where the grant vector is currently parked (if there is a request from the current master); otherwise, masters are given grants in round-robin.
    c. If there is no request, the grant vector is parked with the last requester.
3. Level 2 arbitration is between the SDADC arbitration winner and access from CORE or DMA.
4. Level 2 arbitration has default high priority for access via CORE or DMA. SDADC data can be given higher priority over the core when you write 1 to DSPSS_DSP0_CFG[XMEM_CTRL_PRIORITY].

66.3.2.1 SDADC input buffer

SDADC data is written into the core-allocated SDADC buffer in XMEM. Because DSP firmware is managing the read pointer of this region, only DSP firmware manages overflow and underflow errors.

66.3.3 Scheduling modes

DSPSS is software-programmable. You should program one of these scheduling modes:

1. Sample Threshold mode
2. Clock Threshold mode
3. Software mode

All threads will be scheduled based on one type of mode.

Changing scheduling modes is possible only after DSPSS is reset.

66.3.3.1 Sample Threshold mode

1. This is the default mode and is active when SCHEDULER_MODE_CFG[SCHEDULER_MODE] is 00b.
2. SCHEDULER_MODE_CFG[SCHD_SEQ_1] has no meaning in Sample Threshold mode.
3. In this mode, the thread that first reaches the respective sample threshold that you programmed is scheduled first (if only that thread is enabled).
4. The thread switching is requested as soon as the sample threshold is reached. After the DSP processes the requested thread, the next thread in the pipeline is scheduled next. The process then repeats.
5. Software has access to thread configuration registers to enable scheduler scheduling the threads on DSPSS. The configuration involves the following attributes in scheduler configuration register space:
    - Per-thread buffer configuration registers
    - Per-thread sample threshold register
    - Per-thread enable registers
    - Soft reset register to control the initialization of DSPSS
6. Hardware scheduler maintains the SDADC input buffer write pointer. The DSP firmware manages the corresponding read pointer and maintains the input buffer overflow and underrun.

66.3.3.2 Clock Threshold mode

1. Active when you or the chip writes 01b to SCHEDULER_MODE_CFG[SCHEDULER_MODE].

2. In this mode, you program the scheduling sequence using SCHEDULER_MODE_CFG[SCHD_SEQ_1], SCHEDULER_MODE_CFG[SCHD_SEQ_2], SCHEDULER_MODE_CFG[SCHD_SEQ_3], and SCHEDULER_MODE_CFG[SCHD_SEQ_4].
3. Threads are scheduled in the order SCHEDULER_MODE_CFG[SCHD_SEQ_1] first and SCHEDULER_MODE_CFG[SCHD_SEQ_4] last. Default sequence is thread 0 first and thread 3 last.
4. When the thread is enabled and is part of the scheduling sequence, scheduler sends a context request to DSPSS. DSP processes the requested thread for the number of clock cycles programmed in the threshold register for that thread.
5. Thread switching is requested after the clocking threshold of the current thread is reached.
6. The figure below shows the sequence of threads scheduled by the hardware scheduler:

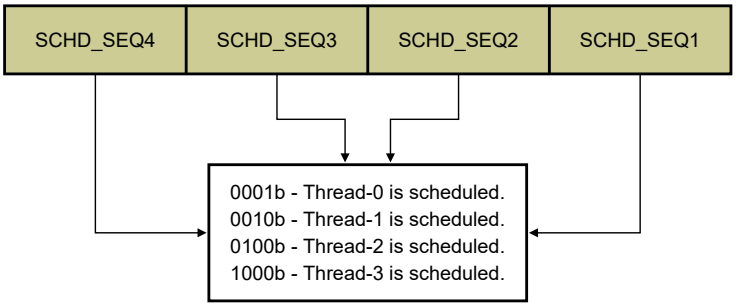


Figure 433. Clock Threshold mode thread sequencing

7. Hardware scheduler maintains the SDADC input buffer write pointer. DSP firmware manages the corresponding read pointer and maintains the input buffer overflow and underrun.

66.3.3.3 Software Scheduling mode

1. Active when you write 10b to SCHEDULER_MODE_CFG[SCHEDULER_MODE].
2. Hardware scheduling is not used in this mode, and you switch context using the switch context instruction in firmware.
3. Hardware scheduler maintains the SDADC input buffer write pointer. DSP firmware manages the corresponding read pointer and maintains the input buffer overflow and underrun.
4. You can write 1 to SCHEDULER_THRD_EN to enable, or write 0 to disable, data streams for a specific thread.
5. You should not use software suspension through DSPSS using THREAD_SUSPEND_REQ*n*[SUSPEND_REQ].
6. You are responsible for disabling the threads.

66.3.4 Using DSPSS in Sample Threshold mode

In Sample Threshold mode (the default mode), you must specify the following parameters at boot time:

1. Program execution code start pointer for each thread in PMEM.
2. The default thread that executes the reset routine is thread 0. The reset routine is used to program internal register space for DSP threads.
3. Memory allocation for input buffer and output buffer in XMEM for every thread.
4. The stack space of each DSP instance.
5. The relation between the threshold for a thread and buffer size is **THREAD_THRESHOLD × N = THREAD_END_ADDR[15:1] - THREAD_START_ADDR[15:1]**.
6. The value of N should be an integer > 1.

NOTE

DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_TH] signifies the number of samples to be processed in an active thread. It can be Block length in the FIR filter use case or it can be number of samples in the FFT use case (64, 256, or 512 sample points).

7. After the block of data or threshold in the example FIR case above is processed, the DSP suspends the thread by incrementing the XMEM data pointer to the next DSPSS_SCHEDULER_XMEM_ADDR_TH*n*[SCHEDULER_THRD_START_ADDR] + DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_TH] and the program counter (PMEM pointer) to call the block processing function or start the block processing code.
8. This process repeats indefinitely.

The process for FFT processing is similar.

66.3.4.1 DSPSS boot flow in Sample Threshold mode

1. Load the four threads program code in PMEM.
2. Load the reset routine for DSP in PMEM.
3. You need to initialize PMEM and XMEM with 0h at boot time.
4. Program the DSPSS_SCHEDULER_DSP_CFG_TH*n*[DSPSS_SCHEDULER_DSP_PCINIT] values for every thread in Hardware scheduler of DSPSS. The PCINIT value for each thread should be in multiples of 8 PMEM locations (DSP programming guideline).
5. The default thread that DSP starts to execute after reset is deasserted is thread-0. If thread-0 is not enabled, DSP should be loaded with a sleep instruction.
6. If any thread is not enabled in the beginning but is expected to be enabled at a later point in time, it is recommended to program the PCINIT for those threads also.
7. Program the thread start and end addresses using DSPSS_SCHEDULER_XMEM_ADDR_TH*n*[SCHEDULER_THRD_START_ADDR] and DSPSS_SCHEDULER_XMEM_ADDR_TH*n*[SCHEDULER_THRD_END_ADDR] in the DSPSS hardware scheduler.
8. Program the sample threshold value for every enabled thread using DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_TH].
9. Program SCHEDULER_MODE_CFG[NEXT_REQ_HALT_ACK_WAIT_CTRL], if threads are to be scheduled as soon as they are ready to schedule. In this case, whenever the number of samples from a particular thread reaches the threshold value, the thread is scheduled without waiting for the halt acknowledge for the currently running thread (sleep state).
10. Deassert the DSP reset using DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] in DSPSS.
11. Reset deassertion of DSP should be chosen based on the application requirement.
12. Whenever there is a reset routine to be executed inside DSP after reset deassertion, you must write 0 to DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] and you must write 1 to DSPSS_DSP0_CFG[dspss_scheduler_dsp0_reset].
    - When you write 0 to DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN], DSP exits reset and executes the reset routine with default thread 0.
    - DSP samples the PC_INIT value for each thread.
    - Program the thread enable using DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_EN]. ADC streams should be enabled after threads are enabled.

NOTE

If DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] is written to 0 in the above steps, then the threads should be enabled after the reset routine is executed. The status of completion of the reset routine can be managed in multiple ways; for example, DSP triggering the Cortex-M7 core or the Cortex-M7 core polling the sleep status of thread 0 (when a sleep instruction is executed at the end of the reset routine).

13. When there is no reset routine to be executed inside DSP after reset deassertion, you can write 1 to DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] (after this, you must also write 1 to DSPSS_DSP0_CFG[dspss_scheduler_dsp0_reset]). In this case, the module deasserts the DSP reset along with the first context request.
    - Program the thread enable using DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_EN]. ADC streams should be enabled after threads are enabled.
    - The module deasserts reset to the DSP along with the first context request.
    - DSP samples the PC_INIT value for each thread.
    - DSP starts to execute the thread that was scheduled by Hardware scheduler.
14. Hardware scheduler schedules DSP contexts based on the corresponding threshold values.
15. After DSP processes the data block of a thread, DSP should write to DSP_TO_DMA_REQUEST_STATUS*n*[DSP_TO_DMA_REQUEST_STATUS] to initiate a trigger to DMA. This allows DMA to start the processed data transfer to eTPU memory. The request remains asserted until the last DMA write performed through the DMA interface is completed. DSP can also use the Hardware scheduler to program HW_CTRL_DMA_REQ_RESPONSE*n*[START] and HW_CTRL_DMA_REQ_RESPONSE*n*[NUM_OF_DMA_REQ] to send back-to-back triggers to DMA for the programmed number of requests.
16. After DMA acknowledges the DSP request, DSP can poll DSP_TO_DMA_REQUEST_STATUS*n*[DMA_TO_DSP_ACK_STATUS] for the status of that acknowledge.
17. DSP should execute a sleep instruction in the corresponding thread to notify DSPSS of processing completion.

66.3.5 Using DSPSS in Clock Threshold mode

In Clock Threshold mode, you must specify the following parameters at boot time:

1. Program execution code start pointer for each thread in PMEM.
2. The default thread executing the reset routine for the threads programming is thread-0. The reset routine is the default library function for programming the internal register space of DSP threads.
3. Memory allocation for input buffer and output buffer in XMEM for every thread.
4. The stack space of each DSP instance.

66.3.5.1 DSPSS boot flow in Clock Threshold mode

1. Load the 4 threads program code in PMEM.
2. Load the reset routine for DSP in PMEM.
3. You need to initialize PMEM and XMEM at boot time.
4. Write 01b to SCHEDULER_MODE_CFG[SCHEDULER_MODE].
5. In this mode, program the scheduling sequence in SCHEDULER_MODE_CFG[SCHD_SEQ_1], SCHEDULER_MODE_CFG[SCHD_SEQ_2], SCHEDULER_MODE_CFG[SCHD_SEQ_3], SCHEDULER_MODE_CFG[SCHD_SEQ_4].
6. Threads are scheduled in the order SCHEDULER_MODE_CFG[SCHD_SEQ_1] first and SCHEDULER_MODE_CFG[SCHD_SEQ_4] last. Default sequence is thread-0 first and thread-3 last, then the sequence repeats itself.

7. Program the DSPSS_SCHEDULER_DSP_CFG_TH*n*[DSPSS_SCHEDULER_DSP_PCINIT] values for every thread in the Hardware scheduler of DSPSS. The PCINIT value for each thread should be in multiples of eight PMEM locations (DSP programming guideline).
8. The default thread that DSP starts to execute after reset is deasserted is thread-0. If the thread-0 is not enabled, DSP should be loaded with a sleep instruction.
9. If any thread is not enabled in the beginning but is expected to be enabled at a later point in time, it is recommended to program the PCINIT for those threads also.
10. Program the thread start and end address using DSPSS_SCHEDULER_XMEM_ADDR_TH*n*[SCHEDULER_THRD_START_ADDR] and DSPSS_SCHEDULER_XMEM_ADDR_TH*n*[SCHEDULER_THRD_END_ADDR] in the Hardware scheduler of DSPSS.
11. Program the clock threshold value for every enabled thread using DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_TH]. This field represents the number of DSP clock cycles the Hardware scheduler waits before scheduling the next thread. Minimum value of this field should be 12h because acknowledgement of any context request may take up to eight cycles of DSP clock.
12. Deassert the DSP reset using DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] in DSPSS.
13. You should choose the DSP reset deassertion based on the application requirement.
14. Whenever there is a reset routine to be executed inside DSP after reset deassertion, DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] should be set to 0 and DSPSS_DSP0_CFG[dspss_scheduler_dsp0_reset] should be set to 1.
    - When you write 0 to DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN], DSP exits reset and executes the reset routine with default thread 0.
    - DSP samples the PC_INIT value for each thread.
    - Program the thread enable using DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_EN]. You should enable the ADC streams after enabling the threads.

    NOTE

    If DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] is 0 in the above steps, you should enable the threads after the reset routine is executed. The status of completion of the reset routine can be managed in multiple ways; for example, DSP triggering the Cortex-M7 core or the Cortex-M7 core polling the sleep status of thread 0 (when a sleep instruction is executed at the end of the reset routine).
15. When there is no reset routine to be executed inside DSP after reset deassertion, DSPSS_DSP0_CFG[SCHED_DSP_RST_CTRL_EN] can be written to 1 (after this, you should also write DSPSS_DSP0_CFG[dspss_scheduler_dsp0_reset] to 1). In this case, reset to DSP is deasserted along with the first context request.
    - Program the thread enable using DSPSS_SCHEDULER_XMEM_TH*n*[SCHEDULER_THRD_EN]. ADC streams should be enabled after threads are enabled.
    - Reset to DSP is deasserted along with the first context request.
    - DSP samples the PC_INIT value for each thread.
    - DSP starts to execute the thread that was scheduled by Hardware scheduler.
16. When enabled, a thread is scheduled as per the sequence defined in the scheduling sequence. The clock count timer begins counting for the time the thread is required to be active. When the timer expires, a new thread request is scheduled as defined in SCHEDULER_MODE_CFG[SCHD_SEQ_1].
17. After DSP processes the data block of a thread, DSP should write 1 to DSP_TO_DMA_REQUEST_STATUS*n*[DSP_TO_DMA_REQUEST_STATUS] to initiate a trigger to DMA. This allows DMA to start the processed data transfer to eTPU memory. The request remains asserted until the last DMA write performed through the DMA interface is completed. DSP can also use the Hardware scheduler to program

HW_CTRL_DMA_REQ_RESPONSE*n*[START] and HW_CTRL_DMA_REQ_RESPONSE*n*[NUM_OF_DMA_REQ] to send back-to-back triggers to DMA for the programmed number of requests.

18. After DMA acknowledges the DSP request, DSP can poll DSP_TO_DMA_REQUEST_STATUS*n*[DMA_TO_DSP_ACK_STATUS] for the status of that acknowledge.
19. DSP should execute a sleep instruction in the corresponding thread to notify DSPSS of processing completion.
20. If threads are required to be scheduled as per the sequence defined in SCHEDULER_MODE_CFG[SCHD_SEQ_1], SCHEDULER_MODE_CFG[SCHD_SEQ_2], SCHEDULER_MODE_CFG[SCHD_SEQ_3], and SCHEDULER_MODE_CFG[SCHD_SEQ_4], then you must write to SCHEDULER_MODE_CFG[NEXT_REQ_HALT_ACK_WAIT_CTRL] before enabling the thread. In this case, a thread remains active for the time until DSP executes the sleep instruction. After that, the next active thread defined in scheduling sequence is scheduled.

66.3.6 Hardware scheduler flow

Hardware scheduler flow (for Sample Threshold mode) is shown in Figure 434.

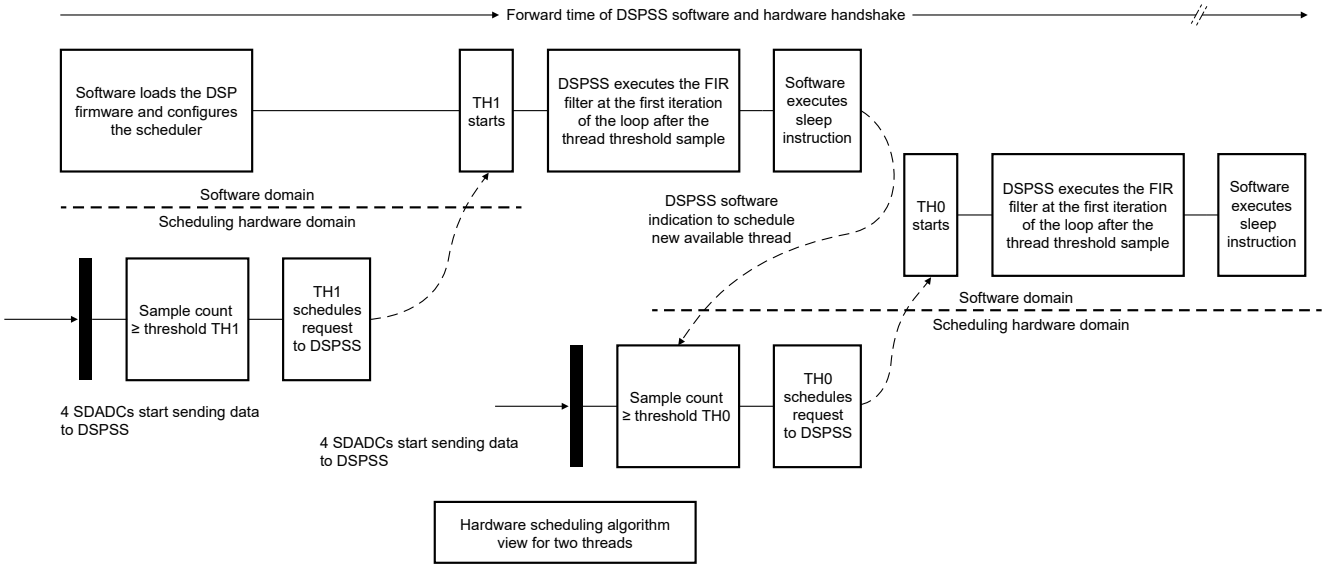


Figure 434. Hardware scheduler flow

Data and Task scheduling flow is shown in Figure 435.

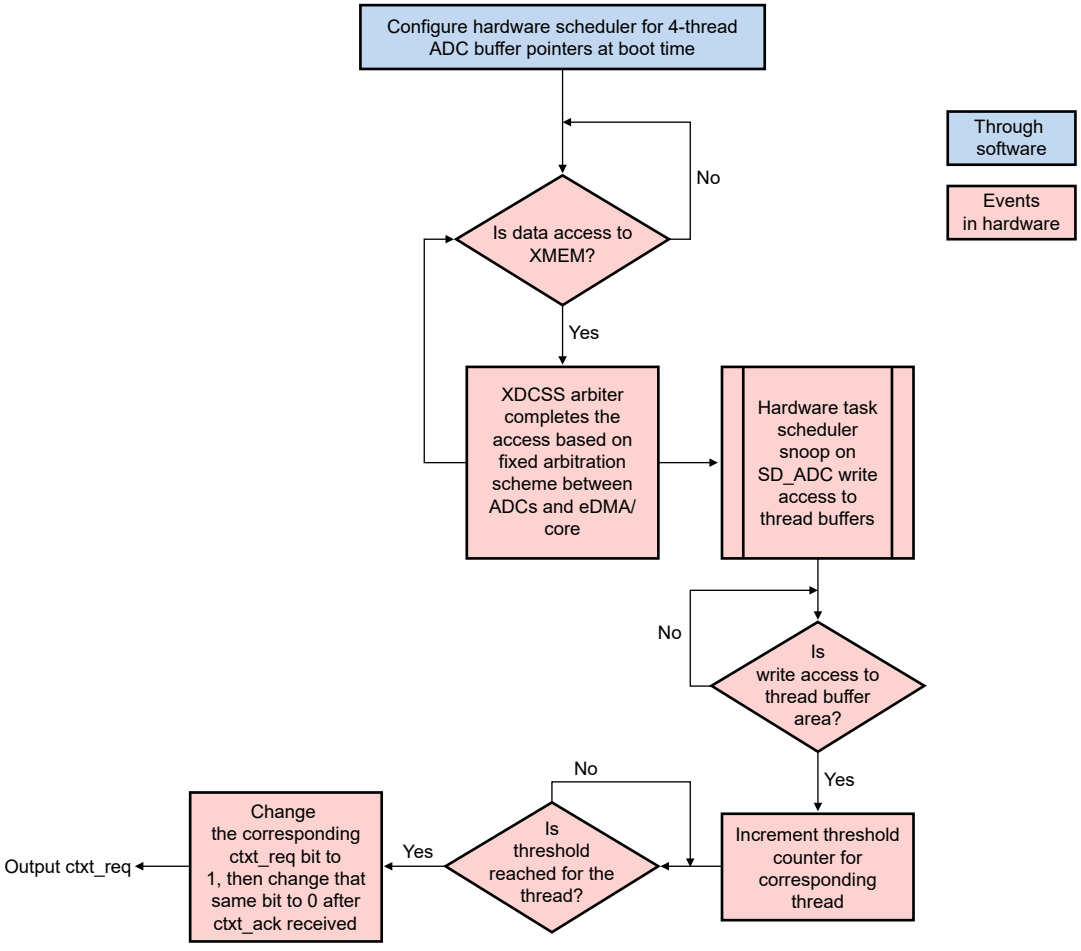


Figure 435. Data and task scheduling flow

66.3.7 DMA interface

DSPSS supports six DMA channels controlled through the DSP firmware. The DSP firmware triggers the DMA request through Single Request mode, or Hardware-Assisted DMA Request mode for multiple requests.

- Single Request Mode: DSP triggers a DMA request using DSP_TO_DMA_REQUEST_STATUS*n*[DSP_TO_DMA_REQUEST_STATUS]. This allows DMA to start the processed data transfer to the destination. The request remains asserted until the last DMA write performed through the DMA interface is completed.
- Hardware-Assisted DMA Request mode: DSP can use the hardware scheduler to send back-to-back triggers to DMA for the programmed number of requests if you program HW_CTRL_DMA_REQ_RESPONSE*n*[START] and HW_CTRL_DMA_REQ_RESPONSE*n*[NUM_OF_DMA_REQ]. If host or DSP is required to halt this mode, write 1 to HW_CTRL_DMA_REQ_STOP*n*[STOP].

66.3.7.1 DMA buffer space

DMA_READ_BUFFER: DSP writes the processed data in this buffer. After DSP processes the data block, DSP triggers the DMA through IO to transfer the processed data in this buffer into eTPU memory.

- Configure the buffer address in XMEM by programming the start and end addresses using registers DMA_READ_ADDR*n*[DMA_READ_START_ADDR] and DMA_READ_ADDR*n*[DMA_READ_END_ADDR].

- If DSP processed data is to be written at a different address than the buffer start address, DSP should update DMA_CURR_RD_PTR*n*[DMA_CURR_READ_PTR]. Cortex-M7 core should program DMA to start reading from the same address.
- Enable DMA_READ_BUFFER monitoring by writing 1 to DMA_BUFFER_CFG[DMA_READ_EN].
- The write pointer of DSP in the DMA-READ buffer is maintained inside the DSP firmware.
- When DMA monitoring logic is enabled, DMA should not read the same location twice or perform a random access on the DMA region. If you do this, the monitoring logic generates an address mismatch error.
- Only DSP firmware manages overflow and underflow errors in this buffer.
- DSP and Cortex-M7 core can access the current read pointer by reading DMA_CURR_RD_PTR*n*[DMA_CURR_READ_PTR]. You can also access the wrap status of the read pointer by reading DMA_CURR_RD_PTR*n*[DMA_READ_PTR_WRAP].
- DSPSS resets DMA_CURR_RD_PTR*n*[DMA_CURR_READ_PTR] to the buffer start address on the positive edge of DMA_BUFFER_CFG[DMA_READ_EN].
- DSPSS monitors the corresponding peripheral bus address and the internally maintained read pointer and generates an error if there is a mismatch.
- DSPSS supports a status field, DMA_ERROR_STATUS*n*[DMA_ADDR_MISMATCH_RD_BUFFER], for every DMA read buffer for the address mismatch error.
- DSPSS supports a status field, DMA_ERROR_STATUS*n*[DMA_XFR_ERR_READ], for every DMA read buffer if DMA initiates any read access other than half-word or word size in the DMA read buffer.
- If interrupts are enabled through INTERRUPT_ENABLE_REGISTER[DMA_READ_BUFFER_ERR_INTR_EN] and INTERRUPT_ENABLE_REGISTER[DMA_READ_BUFFER_XFR_ERR_INTR_EN], DSPSS reports address mismatch errors and transfer errors to Cortex-M7 core through the interrupt.
- If mismatch errors are reported, you should write 0 to DMA_BUFFER_CFG[DMA_READ_EN]. You should take the corrective action and then you should re-enable the buffer monitoring logic.

Table 370. DMA CURR READ POINTER

Event	Effect on pointer
Write 1 to DMA_BUFFER_CFG[DMA_READ_EN]	DSPSS updates DMA_CURR_RD_PTR*n*[DMA_CURR_READ_PTR] to DMA_READ_ADDR*n*[DMA_READ_START_ADDR]
DSP IO interface updates DMA_CURR_RD_PTR*n*[DMA_CURR_READ_PTR]	DSP IO should update the pointer before you enable the monitoring logic. When you enable buffer monitoring, pointer does not reset to DMA_READ_ADDR*n*[DMA_READ_START_ADDR] when you enable DMA_BUFFER_CFG[DMA_READ_EN].
Last location of DMA write buffer is reached	Pointer wraps to DMA_READ_ADDR*n*[DMA_READ_START_ADDR]
Last location of XMEM is reached	Pointer wraps to the first location of memory

DMA_WRITE_BUFFER: XMEM space where DMA writes data that DSP can use during operation. Read pointer of DSP in the DMA write buffer is maintained inside DSP firmware. Only DSP firmware manages overflow and underflow errors.

- Configure the buffer address in XMEM by programming the start and end addresses using registers DMA_WRITE_ADDR*n*[DMA_WRITE_START_ADDR] and DMA_WRITE_ADDR*n*[DMA_WRITE_END_ADDR]. This can also be done through the DSP IO interface.
- If DMA write data is to be written at a different address than the buffer start address, then DSP should update the DMA_CURR_WR_PTR*n*[DMA_CURR_WRITE_PTR]. Cortex-M7 core should program DMA to start writing from the same address.
- Enable the DMA_WRITE_BUFFER monitoring by writing 1 to DMA_BUFFER_CFG[DMA_WRITE_EN].
- DSP read pointer for DMA write buffer is maintained inside DSP firmware.

- When DMA monitoring logic is enabled, DMA should not write the same location twice or perform a random access on the DMA region. If you do this, the monitoring logic generates an address mismatch error.
- Last and first location accesses of read and write masters should be aligned to avoid address mismatch errors.
- Only DSP firmware manages overflow and underflow errors in this buffer.
- DSP core can access the current write pointer by reading DMA_CURR_WR_PTR*n*[DMA_CURR_WRITE_PTR]. You can also access the wrap status of the write pointer by reading DMA_CURR_WR_PTR*n*[DMA_WRITE_PTR_WRAP].
- DMA_CURR_WR_PTR*n*[DMA_CURR_WRITE_PTR] is reset to buffer start address on the positive edge of DMA_BUFFER_CFG[DMA_WRITE_EN].
- DSPSS monitors the corresponding peripheral bus address and the internally-maintained write pointer and generates an error if there is a mismatch.
- DSPSS supports a status register DMA_ERROR_STATUS*n*[DMA_ADDR_MISMATCH_WR_BUFFER] for every DMA write buffer, for the address mismatch error.
- DSPSS supports a status register DMA_ERROR_STATUS*n*[DMA_XFR_ERR_WRITE] for every DMA write buffer, if DMA initiates any write access other than half-word or word size in the DMA write buffer.
- If interrupts are enabled through INTERRUPT_ENABLE_REGISTER[DMA_WRITE_BUFFER_ERR_INTR_EN] and INTERRUPT_ENABLE_REGISTER[DMA_WRITE_BUFFER_XFR_ERR_INTR_EN], DSPSS reports an address mismatch error and transfer error to Cortex-M7 core through the interrupt.
- If mismatch errors are reported, you should write 0 to DMA_BUFFER_CFG[DMA_WRITE_EN]. You should take the corrective action and then you should re-enable the buffer monitoring logic.

Table 371. DMA CURR WRITE POINTER

Event	Effect on pointer
Write 1 to DMA_BUFFER_CFG[DMA_WRITE_EN]	DSPSS updates DMA_CURR_WR_PTR*n*[DMA_CURR_WRITE_PTR] to DMA_WRITE_ADDR*n*[DMA_WRITE_START_ADDR]
DSP IO interface updates DMA_CURR_WR_PTR*n*[DMA_CURR_WRITE_PTR]	DSP IO should update the pointer before enabling the monitoring logic. When you enable buffer monitoring, pointer does not reset to DMA_WRITE_ADDR*n*[DMA_WRITE_START_ADDR] when you enable DMA_BUFFER_CFG[DMA_WRITE_EN].
Last location of DMA write buffer is reached	Pointer wraps to DMA_WRITE_ADDR*n*[DMA_WRITE_START_ADDR]
Last location of XMEM is reached	Pointer wraps to the first location of memory

66.3.8 DSP core buffer

DSPSS supports a per-thread circular buffer shared between Cortex-M7 core and DSP. The control configuration determines the read and write pointer owners. Programmable hardware support is available to monitor the state of the read and write pointers updated by the respective DSP core to generate the overflow and underflow status of the buffer. Perform the steps below to enable the DSP core buffer:

1. Configure the buffer address in XMEM by programming the start and end addresses using DSP_CORE_BUF_ADDR*n*[DSP_CORE_BUF_START_ADDR] and DSP_CORE_BUF_ADDR*n*[DSP_CORE_BUF_END_ADDR].
2. Configure the read and write owners of the buffers by programming DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_MASTER].
3. Enable the DSP_CORE buffer by writing 1 into DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_EN].
4. When DSP and Cortex-M7 core interact with each other in this scratch pad area, the current read and write pointers are updated in DSPSS to reflect the accesses of the respective owners.

5. DSP core can access the current read pointer by reading DSP_CORE_CURR_RD_PTR*n*[DSP_CORE_CURR_RD_PTR]. Wrap status of the read pointer can also be accessed by reading through the same register.
6. DSP core can access the current write pointer by reading DSP_CORE_CURR_WR_PTR*n*[DSP_CORE_CURR_WR_PTR]. Wrap status of the write pointer can also be accessed by reading through the same register.
7. DSPSS supports a status register DSP_CORE_BUFFER_STATUS*n*i>[DSP_CORE_BUFFER_OVF] for every DSP core buffer, for the underflow and overflow errors of this buffer.
8. If interrupts are enabled through INTERRUPT_ENABLE_REGISTER2[DSP_CORE_BUFFER_OVERFLOW_IE] and INTERRUPT_ENABLE_REGISTER2[DSP_CORE_BUFFER_UNDERRUN_IE], overflow and underflow errors of the buffer are reported to Cortex-M7 core through the interrupt.

Table 372. DSP core current read/write pointer

Event	Effect on pointer
Write 1 to DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_EN]	DSPSS updates DSP_CORE_CURR_RD_PTR*n*[DSP_CORE_CURR_RD_PTR] and DSP_CORE_CURR_WR_PTR*n*[DSP_CORE_CURR_WR_PTR] to DSP_CORE_BUF_ADDR*n*[DSP_CORE_BUF_START_ADDR]
DSP updates DSP_CORE_CURR_RD_PTR*n*[DSP_CORE_CURR_RD_PTR] and DSP_CORE_CURR_WR_PTR*n*[DSP_CORE_CURR_WR_PTR] through IO	DSP IO should update the pointer before enabling the monitoring logic. When buffer monitoring is enabled, pointer does not reset to DSP_CORE_BUF_ADDR*n*[DSP_CORE_BUF_START_ADDR] when DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_EN] is enabled.
Last location of DSP core buffer is reached	Pointers wrap to the DSP_CORE_BUF_ADDR*n*[DSP_CORE_BUF_START_ADDR]
Last location of XMEM is reached	Pointers wrap to the first location of memory

66.3.9 Clocking

The table below lists the clocking frequency requirements. Except for Debug clock, all the clocks are synchronous to each other. System bus clock and DSP clock are inverted with respect to each other.

Table 373. Clock description

Clock name	Description	Frequency requirement(MHz)
DSP clock	DSP core and hardware scheduler clock	160 MHz
System bus clock	Software Configuration clock	160 MHz
RAM clock	XMEM,PMEM and time-slicer clock	320 MHz; should be twice the DSP clock or System bus clock frequency
SDADC clock	Clock for SDADC data received at DSPSS	80 MHz
Debug clock	APB interface clock for DSPSS debug	160 MHz

66.3.10 DSPSS triggers

66.3.10.1 Triggers

DSPSS supports different triggers to host core (Cortex-M7 core). DSP can use these triggers for signaling Cortex-M7 core, or for trigger mux functionality.

66.3.10.1.1 Triggers to host core

There is support for a per-thread trigger interface to Cortex-M7 core that can be used to trigger the core. DSP firmware controls these triggers. All triggers are generated on host clock (peripheral clock). DSPSS clears the status when you write 1 to the field.

O_CORE_TRIGGER: There is support for a per-thread trigger output interface. DSP firmware controls the trigger by writing 1 into DSPSS_DSP_IO_INTF0[DSP_TRIGGER_CORE_TH1 to start any DSPSS function outside the DSPSS subsystem. These triggers have level and pulse support from DSPSS, and Cortex-M7 core can configure them through DSPSS_DSP0_CFG[dspss_dsp0_core_trigger_cfg].

O_CORE_TRIGGER_SAFETY: There is support for trigger-to-core for the safety threads on the output interface. DSP firmware controls the trigger by writing 1 into DSPSS_DSP_CORE_TRIGGER_SAFETY[DSP_TRIGGER_SAFETY_1] to start any hardware function outside DSPSS. These triggers have level and pulse support from DSPSS, and Cortex-M7 core can configure them through DSPSS_DSP0_CFG[dspss_dsp0_core_trigger_safety_cfg]

O_TRIGMUX_TRIGGER: There is support for trigger-to-trigger mux for gasoline engine applications. Implementation of DSPSS actions is defined in upper level of hierarchy. DSP firmware controls the trigger by writing 1 into DS_GATE_TRIGMUX_REGISTER*n*[DS_GATE_TRIGMUX_TRIGGER] to start any hardware function outside DSPSS. DSP firmware clears this by writing 0 back to the same register field.

66.3.11 DSPSS interrupts

66.3.11.1 Understanding DSPSS error levels

There are multiple possible error sources within DSPSS. This table describes the levels at which different errors can occur. These errors can generate an interrupt to the host core if the corresponding interrupt is enabled.

Table 374. DSPSS error levels

DSPSS errors at different levels	Description
DSP	If firmware detects any error resulting inside DSP during the operation, this can be signaled to Cortex-M7 core. DSP acknowledge, corresponding to a context change request timeout, could indicate a DSP pipeline in a hung state and should be communicated to Cortex-M7 core.
Errors in SDADC input buffer	Errors resulting from the SDADC input buffer inside XMEM. For example, request FIFO overflow error, SDADC FIFO overflow or underrun error.
Errors in DMA read buffer	An error resulting from the pointer mismatch between DMA and the internally-maintained current read pointer triggers an error notification to core. If any unaligned access from DMA is received, error notification to Cortex-M7 core is asserted. **NOTE** If Cortex-M7 core asserts DMA_BUFFER_CFG[MAP_XFR_DMA_ERR_ON_IPS], then DMA address mismatch errors are reported as transfer errors.
Errors in DMA write buffer	An error resulting from the pointer mismatch between DMA and the internally-maintained current write pointer triggers an error notification to core. If any unaligned access from DMA is received, error notification to Cortex-M7 core is asserted. **NOTE** If Cortex-M7 core asserts DMA_BUFFER_CFG[MAP_XFR_DMA_ERR_ON_IPS], then DMA address mismatch errors are reported as transfer errors.

Table continues on the next page...

Table 374. DSPSS error levels (continued)

DSPSS errors at different levels	Description
Errors in DSP Cortex-M7 core buffer	An error resulting from an overflow or underrun inside this buffer triggers an error notification to core.

66.3.11.1.1 Error and interrupts

ERM Interface: ERM interface is the output interface of DSPSS for ERM and FCCU. Multi-bit ECC errors and single-bit ECC errors inside XMEM and PMEM are reported for the DSP and Cortex-M7 core accesses separately. If a single-bit error is detected, error position is also provided at the ERM interface.

TRIG_ERR: There is support for an error interrupt to the CORE through the output trigger error signal. DSP firmware, as well as through programmable enables for different hardware error status scenarios listed below, triggers this interrupt. Error Map Association is defined in the following table:

Table 375. Decipher error sources

Source of error	Details	Error level	Associated field
DSP ACK TIMEOUT_ERROR	DSPSS asserts a non-recoverable error when it does not receive an acknowledgement against the context request within the maximum time for DSP acknowledgement. This could be the result of DSP pipeline in a hung state, and therefore you must reset DSPSS and restart everything again.	DSP	DSP_ACK_TIMEOUT_CFG_AND_ERR_CTRL[DSP_ACK_TIMEOUT_ERR]
DSP initialization error	DSPSS asserts a non-recoverable error when the initialization completion status of DSP is deasserted because of an issue internal to the DSP core. You must reset DSPSS and restart everything again.	DSP	CURR_ACTIVE_THRD[DSP_INIT_COMP]
DSP firmware detects internal DSP ERROR	DSPSS asserts a non-recoverable error when DSP firmware detects any issue inside the DSP core. An example of this is SDADC buffer overflow or underrun errors through the pointers it is managing inside the firmware. Host core determines the action in this case.	DSP	DSP_TO_CORE_TRIG_ERR_STATUS*n*[DSP_TO_CORE_TRIG_ERR_STATUS]
Request FIFO threshold crossing	When the total number of requests inside the DSP thread accumulator FIFO reaches the programmed threshold, an interrupt is reported to Cortex-M7 core. Host core determines the action in this case; for example, the system can be restarted, or one or more threads can be disabled by suspending them.	DSPSS	DSP_ACK_TIMEOUT_CFG_AND_ERR_CTRL[REQ_ACC_FIFO_INTR]
Request FIFO overflow error	Asserted when the internally-maintained request FIFO overflows. Request FIFO can maintain 16 requests at a time. A DSP processing rate slower than the supported SDADC data rate would cause this error. Software must reset DSPSS, check the SDADC data rate or the DSP processing rate, then restart everything.	SDADC input buffer	SDADC_SYNC_FIFO_ERROR_STATUS[REQ_FIFO_OVERFLOW]

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Table 375. Decipher error sources (continued)

Source of error	Details	Error level	Associated field
SDADC async FIFO overflow error	Asserted when the SDADC asynchronous FIFO overflows. This could be the result of SDADC data not getting a slot over the peripheral bus to be written into XMEM. Host core must suspend the corresponding thread or reset DSPSS.	SDADC input buffer	SDADC_SYNC_FIFO_ERROR_STATUS[OVERFLOW]
Address mismatch error in DMA read buffer	Asserted when there is a pointer mismatch between DMA and the internally-maintained current read pointer. Host core must reconfigure DMA or take any associated action.	DMA read buffer	DMA_ERROR_STATUS*n*[DMA_ADDR_MISMATCH_RD_BUFFER]
Address mismatch error in DMA write buffer	Asserted when there is a pointer mismatch between DMA and the internally-maintained current write pointer. Host core must reconfigure DMA or take any associated action.	DMA write buffer	DMA_ERROR_STATUS*n*[DMA_ADDR_MISMATCH_WR_BUFFER]
Unaligned DMA access error in DMA write buffer	Asserted when there is a DMA unaligned write access on DMA interface. You must correct the access types.	DMA write buffer	DMA_ERROR_STATUS*n*[DMA_XFR_ERR_WRITE]
Unaligned DMA access error in DMA read buffer	Asserted when there is a DMA unaligned read access on DMA interface in DMA read buffer. You must correct the access types.	DMA read buffer	DMA_ERROR_STATUS*n*[DMA_XFR_ERR_READ]
Overflow in DSP-Cortex-M7 core buffer	Asserted when the write pointer of the write master overflows in the buffer. You must reconfigure the DSP core CBUF and restart the monitoring logic.	DSP core shared buffer	DSP_CORE_BUFFER_STATUS*n*[DSP_CORE_BUFFER_OVF]
Underrun in DSP-Cortex-M7 core buffer	Asserted when the read pointer of read master is ahead of the write pointer of write master. You must reconfigure the DSP core CBUF and restart the monitoring logic.	DSP core shared buffer	DSP_CORE_BUFFER_STATUS*n*[DSP_CORE_BUFFER_UNDF]

66.3.12 Thread re-enabling

When you or DSPSS suspends or disables an active thread, you might be required to re-enable the same thread at a later point time during DSPSS operation. Whenever a thread is suspended, DSP executes a goto-PCINIT instruction corresponding to that thread and returns to the start of the program. Threads can be suspended or disabled for the following reasons:

- Multi-bit Errors on Memory Access: Whenever there is a multi-bit error in data or program memory, an error is reported over the ERM interface. You should reset DSPSS to re-enable the threads and the subsystem. See .
- Suspension request from Cortex-M7 core (host): If there is an issue in the system pipeline or for other reasons, Cortex-M7 core can assert the suspension request using THREAD_SUSPEND_REQ*n*[SUSPEND_REQ]. After the request is asserted, hardware scheduler suspends the thread on priority, but waits for the currently executing thread to complete. Before sending a suspend request, it first sends a dummy context request followed by suspend request to change the context to the thread for which Cortex-M7 core set the suspension. After the thread is suspended, DSPSS schedules the other threads in the pipeline. Before initiating the thread suspension, you should ensure that there is no pending DMA request from the DSPSS interface. If there is any pending request, it needs to be completed to avoid the possibility of the DMA interface becoming hung. See DMA interface.
- Thread PCINIT change during DSPSS operation: To do this, the new PCINIT value is first programmed into DSPSS_SCHEDULER_DSP_CFG_TH*n*[DSPSS_SCHEDULER_DSP_PCINIT], and then the thread is suspended by setting up a suspension request for that thread in THREAD_SUSPEND_REQ*n*[SUSPEND_REQ]. Before initiating the PCINIT

change flow, you should ensure that there is no pending DMA request from the DSPSS interface. If there is any pending request, it needs to be completed to avoid the possibility of the DMA interface becoming hung. See DMA interface.

66.3.12.1 Thread suspension on software request

You can suspend a running thread for one or more reasons; for example, a malfunction of other components in the system related to one of the ADC streams, or you wish to change the software DSP is currently executing on the ADC stream. Software suspension should not be performed in Software Scheduling mode. The thread re-enable flow consists of the following steps.

1. You assert the suspension request using THREAD_SUSPEND_REQ*n*[SUSPEND_REQ].
2. DSPSS automatically disables DSPSS_SCHEDULER_XMEM_TH*n*[THREAD_EN] corresponding to that thread.
3. After the request is asserted, the hardware scheduler suspends the thread on priority but waits for the currently executing thread to complete.
4. Before sending a suspend request, DSPSS first sends a dummy context request followed by a suspend request to change the context to the thread for which Cortex-M7 core asserts suspension after the context of the currently-active thread changes inside DSP.
5. DSP suspends the currently running thread and executes a goto-PCINIT instruction, and returns to the start of the program.
6. After the thread is suspended, hardware scheduler schedules the other threads in the pipeline.
7. When the suspension of thread is completed, DSP asserts the suspend acknowledgement signal to send acknowledgement for the thread that DSP suspended.
8. DSPSS deasserts the suspension request inside THREAD_SUSPEND_REQ*n*[SUSPEND_REQ], the register field for which you asserted the suspension request.
9. When suspend acknowledgement is received from DSP, the suspend status is asserted in DSPSS_DSP_TH_STATUS*n*[dspss_th_suspended].
10. Cortex-M7 core can again enable the thread using DSPSS_SCHEDULER_XMEM_TH*n*[THREAD_EN] after DSPSS_DSP_TH_STATUS*n*[dspss_th_suspended] is asserted. Cortex-M7 core should write 1 to clear this field. DSP firmware can also be requested to clear this field as part of the program.

To change the PCINIT value of a thread, first program the new PCINIT value into DSPSS_SCHEDULER_DSP_CFG_THn[DSPSS_SCHEDULER_DSP_PCINIT], then the above steps can be performed.

66.4 DSPSS register descriptions

This section presents the DSPSS registers that are available to the Cortex-M7 core. Not all of these are available, or available in the same way, to the DSP core; see DSPSS_IO register descriptions.

DSPSS registers are word-accessible. Transfer errors are generated for the holes in the register space. A transfer error is also generated if any access is not aligned to word-access, or if XMEM is accessed beyond the 24 KB space. Transfer error is not generated for write accesses on read-only registers.

66.4.1 DSPSS memory map

dspss_0 base address: 406D_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Thread Start And End Address Location Configuration (DSPSS_SCHEDULER_XMEM_ADDR_TH0)	32	RW	0000_0000h
4h	Thread Threshold And Enable (DSPSS_SCHEDULER_XMEM_TH0)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
8h	PC Initial Value (DSPSS_SCHEDULER_DSP_CFG_TH0)	32	RW	0000_0000h
Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0)	32	R	0000_0000h
14h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR0)	32	R	0000_0000h
1Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR0)	32	RW	0000_0000h
28h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR0)	32	RW	0000_0000h
2Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR0)	32	RW	0000_0000h
30h	Reference DMA Read Region (DMA_READ_ADDR0)	32	RW	0000_0000h
38h	DMA Error Status (DMA_ERROR_STATUS0)	32	RW	0000_0000h
40h	Reference DMA Write Region (DMA_WRITE_ADDR0)	32	RW	0000_0000h
44h	DMA Current Write Pointer (DMA_CURR_WR_PTR0)	32	RW	0000_0000h
48h	DMA Current Read Pointer (DMA_CURR_RD_PTR0)	32	RW	0000_0000h
50h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS0)	32	R	0000_0000h
54h	Thread Suspend Request For Thread Disabling/PCINIT Change (THREAD_SUSPEND_REQ0)	32	RW	0000_0000h
5Ch	Thread Status (DSPSS_DSP_TH_STATUS0)	32	RW	0000_0000h
7Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS0)	32	RW	0000_0000h
80h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS0)	32	RW	0000_0000h
84h	DSP Output Control (DS_GATE_STATUS_REGISTER0)	32	R	0000_0000h
88h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER0)	32	R	0000_0000h
8Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP0)	32	RW	0000_0000h
90h	DMA Error Control (DMA_ERROR_CTRL0)	32	RW	0000_0000h
94h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0)	32	R	0000_0400h
300h	Thread Start And End Address Location Configuration (DSPSS_SCHEDULER_XMEM_ADDR_TH1)	32	RW	0000_0000h
304h	Thread Threshold And Enable (DSPSS_SCHEDULER_XMEM_TH1)	32	RW	0000_0000h
308h	PC Initial Value (DSPSS_SCHEDULER_DSP_CFG_TH1)	32	RW	0000_0000h
30Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH1)	32	R	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
314h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR1)	32	R	0000_0000h
31Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR1)	32	RW	0000_0000h
328h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR1)	32	RW	0000_0000h
32Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR1)	32	RW	0000_0000h
330h	Reference DMA Read Region (DMA_READ_ADDR1)	32	RW	0000_0000h
338h	DMA Error Status (DMA_ERROR_STATUS1)	32	RW	0000_0000h
340h	Reference DMA Write Region (DMA_WRITE_ADDR1)	32	RW	0000_0000h
344h	DMA Current Write Pointer (DMA_CURR_WR_PTR1)	32	RW	0000_0000h
348h	DMA Current Read Pointer (DMA_CURR_RD_PTR1)	32	RW	0000_0000h
350h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS1)	32	R	0000_0000h
354h	Thread Suspend Request For Thread Disabling/PCINIT Change (THREAD_SUSPEND_REQ1)	32	RW	0000_0000h
35Ch	Thread Status (DSPSS_DSP_TH_STATUS1)	32	RW	0000_0000h
37Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS1)	32	RW	0000_0000h
380h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS1)	32	RW	0000_0000h
384h	DSP Output Control (DS_GATE_STATUS_REGISTER1)	32	R	0000_0000h
388h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER1)	32	R	0000_0000h
38Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP1)	32	RW	0000_0000h
390h	DMA Error Control (DMA_ERROR_CTRL1)	32	RW	0000_0000h
394h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE1)	32	R	0000_0400h
600h	Thread Start And End Address Location Configuration (DSPSS_SCHEDULER_XMEM_ADDR_TH2)	32	RW	0000_0000h
604h	Thread Threshold And Enable (DSPSS_SCHEDULER_XMEM_TH2)	32	RW	0000_0000h
608h	PC Initial Value (DSPSS_SCHEDULER_DSP_CFG_TH2)	32	RW	0000_0000h
60Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH2)	32	R	0000_0000h
614h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR2)	32	R	0000_0000h
61Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR2)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
628h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR2)	32	RW	0000_0000h
62Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR2)	32	RW	0000_0000h
630h	Reference DMA Read Region (DMA_READ_ADDR2)	32	RW	0000_0000h
638h	DMA Error Status (DMA_ERROR_STATUS2)	32	RW	0000_0000h
640h	Reference DMA Write Region (DMA_WRITE_ADDR2)	32	RW	0000_0000h
644h	DMA Current Write Pointer (DMA_CURR_WR_PTR2)	32	RW	0000_0000h
648h	DMA Current Read Pointer (DMA_CURR_RD_PTR2)	32	RW	0000_0000h
650h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS2)	32	R	0000_0000h
654h	Thread Suspend Request For Thread Disabling/PCINIT Change (THREAD_SUSPEND_REQ2)	32	RW	0000_0000h
65Ch	Thread Status (DSPSS_DSP_TH_STATUS2)	32	RW	0000_0000h
67Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS2)	32	RW	0000_0000h
680h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS2)	32	RW	0000_0000h
684h	DSP Output Control (DS_GATE_STATUS_REGISTER2)	32	R	0000_0000h
688h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER2)	32	R	0000_0000h
68Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP2)	32	RW	0000_0000h
690h	DMA Error Control (DMA_ERROR_CTRL2)	32	RW	0000_0000h
694h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE2)	32	R	0000_0400h
900h	Thread Start And End Address Location Configuration (DSPSS_SCHEDULER_XMEM_ADDR_TH3)	32	RW	0000_0000h
904h	Thread Threshold And Enable (DSPSS_SCHEDULER_XMEM_TH3)	32	RW	0000_0000h
908h	PC Initial Value (DSPSS_SCHEDULER_DSP_CFG_TH3)	32	RW	0000_0000h
90Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3)	32	R	0000_0000h
914h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR3)	32	R	0000_0000h
91Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR3)	32	RW	0000_0000h
928h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR3)	32	RW	0000_0000h
92Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR3)	32	RW	0000_0000h
930h	Reference DMA Read Region (DMA_READ_ADDR3)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
938h	DMA Error Status (DMA_ERROR_STATUS3)	32	RW	0000_0000h
940h	Reference DMA Write Region (DMA_WRITE_ADDR3)	32	RW	0000_0000h
944h	DMA Current Write Pointer (DMA_CURR_WR_PTR3)	32	RW	0000_0000h
948h	DMA Current Read Pointer (DMA_CURR_RD_PTR3)	32	RW	0000_0000h
950h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS3)	32	R	0000_0000h
954h	Thread Suspend Request For Thread Disabling/PCINIT Change (THREAD_SUSPEND_REQ3)	32	RW	0000_0000h
95Ch	Thread Status (DSPSS_DSP_TH_STATUS3)	32	RW	0000_0000h
97Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS3)	32	RW	0000_0000h
980h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS3)	32	RW	0000_0000h
984h	DSP Output Control (DS_GATE_STATUS_REGISTER3)	32	R	0000_0000h
988h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER3)	32	R	0000_0000h
98Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP3)	32	RW	0000_0000h
990h	DMA Error Control (DMA_ERROR_CTRL3)	32	RW	0000_0000h
994h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE3)	32	R	0000_0400h
BE4h	DSPSS Soft Reset (DSPSS_SOFT_RESET_REGISTER)	32	RW	0000_0000h
BE8h	DSP ACK Timeout Configuration And Error Control (DSP_ACK_TIMEOUT_CFG_AND_ERR_CTRL)	32	RW	0000_1008h
BECh	Disable Monitoring of ECC Errors In XMEM And PMEM (ECC_ERROR_MONITOR_THREAD_SUSPEND_CTRL)	32	RW	0000_0038h
BF0h	Interrupt Enable (INTERRUPT_ENABLE_REGISTER2)	32	RW	0000_0000h
BF4h	FIFO Overflow Status (SDADC_SYNC_FIFO_ERROR_STATUS)	32	RW	0000_0000h
BFCh	Configuration For DSP-Core Buffer (DSP_CORE_BUFFER_CFG)	32	RW	0000_0000h
C00h	DMA Buffer Configuration (DMA_BUFFER_CFG)	32	RW	0000_0000h
C04h	Thread Scheduling Mode Selection (SCHEDULER_MODE_CFG)	32	RW	0002_1084h
C08h	DSP0 Reset And Core Trigger Configuration (DSPSS_DSP0_CFG)	32	RW	0000_0000h
C10h	Interrupt Enable (INTERRUPT_ENABLE_REGISTER)	32	RW	0000_0000h
C14h	DSP Trigger to Core (DSPSS_DSP_IO_INTF0)	32	RW	0000_0000h
C1Ch	DSP Core Status (CURR_ACTIVE_THRD)	32	RW	0000_0001h
C24h	DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
C30h	Reference DMA Read Region (DMA_READ_ADDR4)	32	RW	0000_0000h
C38h	DMA Error Status (DMA_ERROR_STATUS4)	32	RW	0000_0000h
C40h	Reference DMA Write Region (DMA_WRITE_ADDR4)	32	RW	0000_0000h
C44h	DMA Current Write Pointer (DMA_CURR_WR_PTR4)	32	RW	0000_0000h
C48h	DMA Current Read Pointer (DMA_CURR_RD_PTR4)	32	RW	0000_0000h
C50h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS4)	32	R	0000_0000h
C8Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP4)	32	RW	0000_0000h
C90h	DMA Error Control (DMA_ERROR_CTRL4)	32	RW	0000_0000h
C94h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE4)	32	R	0000_0400h
F30h	Reference DMA Read Region (DMA_READ_ADDR5)	32	RW	0000_0000h
F38h	DMA Error Status (DMA_ERROR_STATUS5)	32	RW	0000_0000h
F40h	Reference DMA Write Region (DMA_WRITE_ADDR5)	32	RW	0000_0000h
F44h	DMA Current Write Pointer (DMA_CURR_WR_PTR5)	32	RW	0000_0000h
F48h	DMA Current Read Pointer (DMA_CURR_RD_PTR5)	32	RW	0000_0000h
F50h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS5)	32	R	0000_0000h
F8Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP5)	32	RW	0000_0000h
F90h	DMA Error Control (DMA_ERROR_CTRL5)	32	RW	0000_0000h
F94h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE5)	32	R	0000_0400h

66.4.2 Thread Start And End Address Location Configuration (DSPSS_SCHEDULER_XMEM_ADDR_TH0 - DSPSS_SCHEDULER_XMEM_ADDR_TH3)

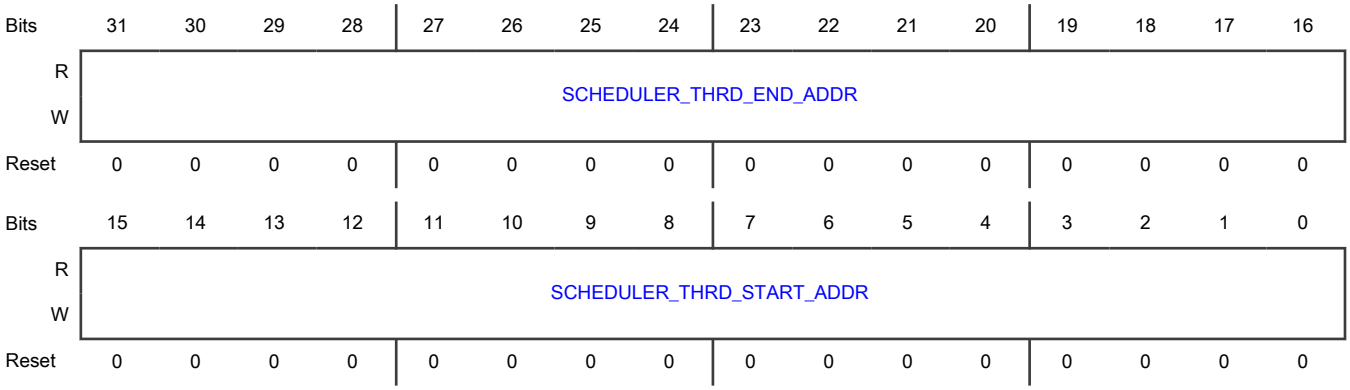
Offset

Register	Offset
DSPSS_SCHEDULER_XMEM_ADDR_TH0	0h
DSPSS_SCHEDULER_XMEM_ADDR_TH1	300h
DSPSS_SCHEDULER_XMEM_ADDR_TH2	600h
DSPSS_SCHEDULER_XMEM_ADDR_TH3	900h

Function

Contains the start and end address memory location for respective threads in memory.

Diagram



Fields

Field	Function
31-16 SCHEDULER_THRD_END_ADDR	End Address Specifies the end address of the SDADC input buffer to write the SDADC data in the XMEM. The end address is byte-address-aligned.
15-0 SCHEDULER_THRD_START_ADDR	Start Address Specifies the start address to write the SDADC data in the XMEM. The start address must be a multiple of 4. This field is byte-aligned, but the programming must be word-aligned (4 bytes). This is due to the fact that all the buffers in XMEM are aligned at 4-byte boundaries.

66.4.3 Thread Threshold And Enable (DSPSS_SCHEDULER_XMEM_TH0 - DSPSS_SCHEDULER_XMEM_TH3)

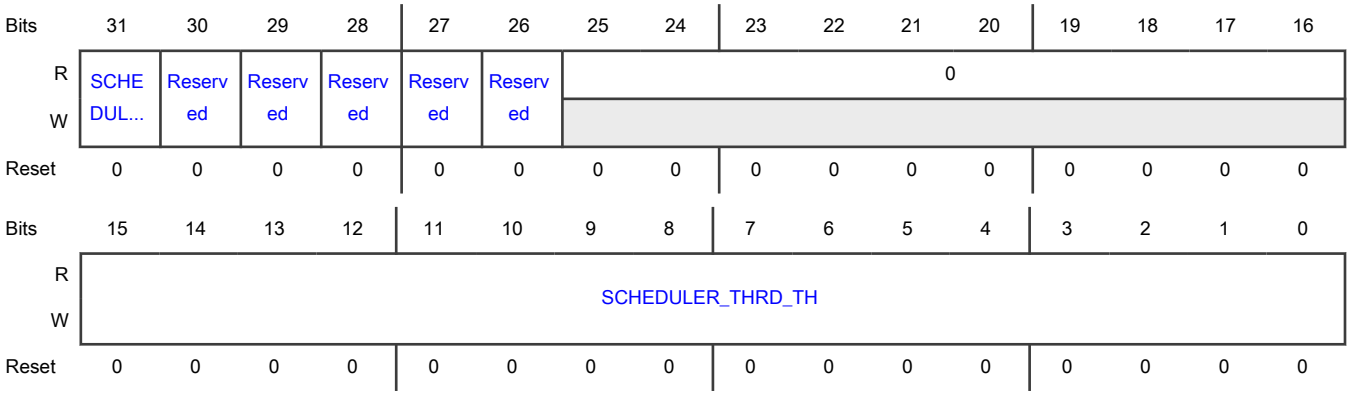
Offset

Register	Offset
DSPSS_SCHEDULER_XMEM_TH0	4h
DSPSS_SCHEDULER_XMEM_TH1	304h
DSPSS_SCHEDULER_XMEM_TH2	604h
DSPSS_SCHEDULER_XMEM_TH3	904h

Function

Programs the threshold for scheduling the respective thread for DSP operation.

Diagram



Fields

Field	Function
31 SCHEDULER_THRD_EN	Thread Enable Enables the thread. Use this field only in Software Scheduling mode. For other modes, disable threads using only the thread-suspension mechanism. If you write 0 to this field in the middle of an operation, the already-running thread is unaffected. The disabling affects only future thread scheduling. 0b - Disable 1b - Enable
30 —	Reserved
29 —	Reserved
28 —	Reserved
27 —	Reserved
26 —	Reserved
25-16 —	Reserved

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Field	Function
15-0 SCHEDULER_THRD_TH	Thread Threshold Specifies different parameters depending on SCHEDULER_MODE_CFG[SCHEDULER_MODE] as follows:

In this mode:	SCHEDULER_THRD_TH specifies:
Sample Threshold (SCHEDULER_MODE = 0)	Number of ADC samples for which a thread is scheduled
Clock Threshold (SCHEDULER_MODE = 1)	Number of clock cycles for which a thread is scheduled

66.4.4 PC Initial Value (DSPSS_SCHEDULER_DSP_CFG_TH0 - DSPSS_SCHEDULER_DSP_CFG_TH3)

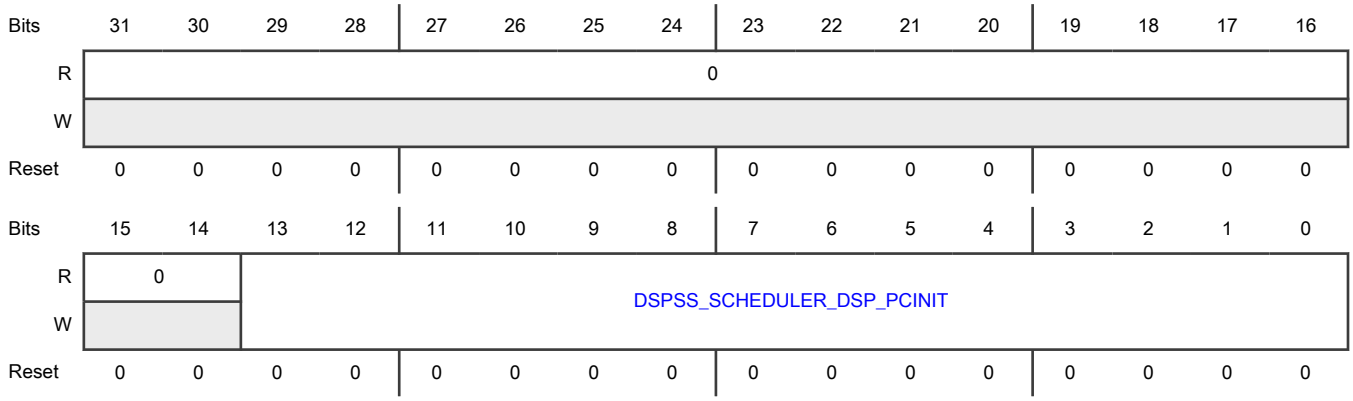
Offset

Register	Offset
DSPSS_SCHEDULER_DSP_CFG_TH0	8h
DSPSS_SCHEDULER_DSP_CFG_TH1	308h
DSPSS_SCHEDULER_DSP_CFG_TH2	608h
DSPSS_SCHEDULER_DSP_CFG_TH3	908h

Function

Specifies the PC initial value for the threads inside the DSP.

Diagram



Fields

Field	Function
31-14 —	Reserved
13-0 DSPSS_SCHEDULER_DSP_PCINIT	PC Initial Value Specifies the PC initial value for the thread inside the DSP. This field is aligned at word boundaries.

66.4.5 Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0 - DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3)

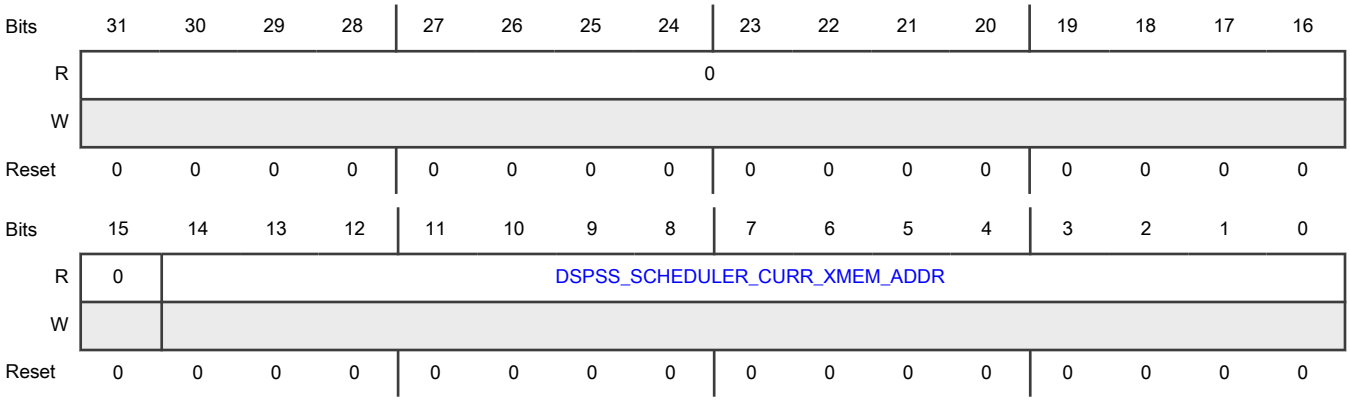
Offset

Register	Offset
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0	Ch
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH1	30Ch
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH2	60Ch
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3	90Ch

Function

This register gives the latest write-pointer value of SDADC input buffer (which resides in XMEM). The pointer is updated for each data write from SDADC interface to the buffer.

Diagram



Fields

Field	Function
31-15 —	Reserved
14-0 DSPSS_SCHEDULER_CURR_XMEM_ADDR	Current Write Pointer Location Indicates the current location of the write pointer in data memory for the thread. The MSB denotes wrap bit; it toggles after every wrap. The remaining bits denote the pointer value.

66.4.6 Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR0 - DSP_SDADC_CURR_READ_PTR3)

Offset

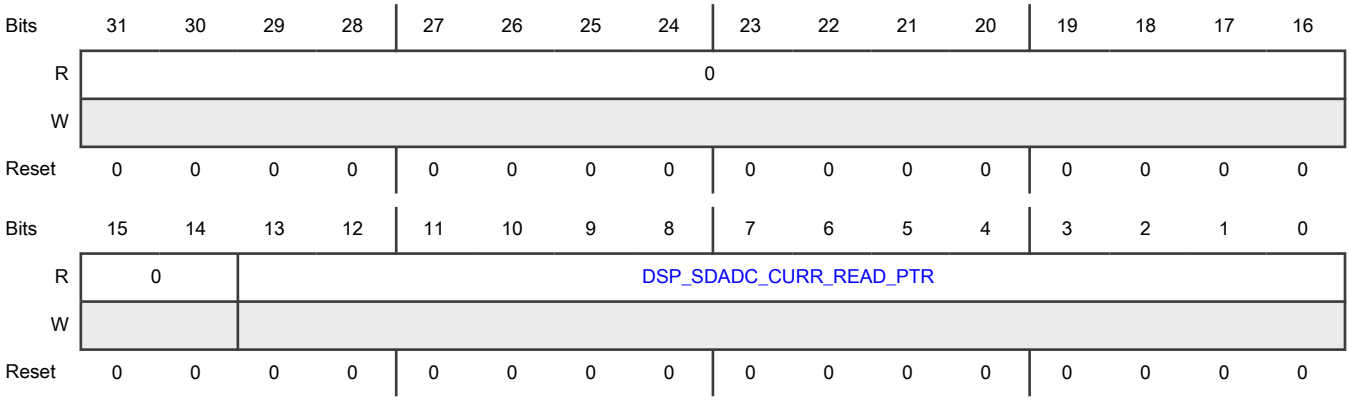
Register	Offset
DSP_SDADC_CURR_READ_PTR0	14h
DSP_SDADC_CURR_READ_PTR1	314h
DSP_SDADC_CURR_READ_PTR2	614h
DSP_SDADC_CURR_READ_PTR3	914h

Function

Indicates the last address for which a request was scheduled in Sample Threshold mode.

Both the Cortex-M7 core and the DSP core can access this register.

Diagram



Fields

Field	Function
31-14 —	Reserved
13-0 DSP_SDADC_CURR_READ_PTR	Address Pointer Indicates the address value for which the last request was scheduled in Sample Threshold mode.

66.4.7 Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR0 - DSP_CORE_BUF_ADDR3)

Offset

Register	Offset
DSP_CORE_BUF_ADDR0	1Ch
DSP_CORE_BUF_ADDR1	31Ch
DSP_CORE_BUF_ADDR2	61Ch
DSP_CORE_BUF_ADDR3	91Ch

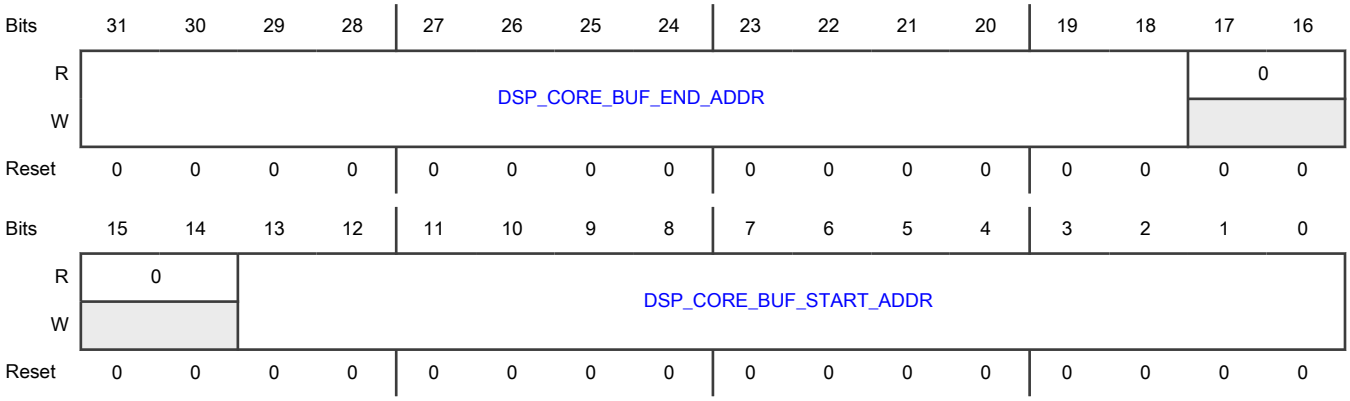
Function

Specifies the start and end pointers for the DSP and Cortex-M7 core scratch-pad area that the two cores share.

Both the Cortex-M7 core and the DSP core can access this register.

The fields in this register are half-word aligned.

Diagram



Fields

Field	Function
31-18 DSP_CORE_BUF_END_ADDR	End Pointer Specifies the end pointer for the circular buffer defined for the scratch pad between the two buffers. The address rolls back to the start address after reaching the last location.
17-14 —	Reserved
13-0 DSP_CORE_BUF_START_ADDR	Start Pointer Specifies the start pointer for the circular buffer defined for the scratch pad between the two buffers.

66.4.8 Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR0 - DSP_CORE_CURR_RD_PTR3)

Offset

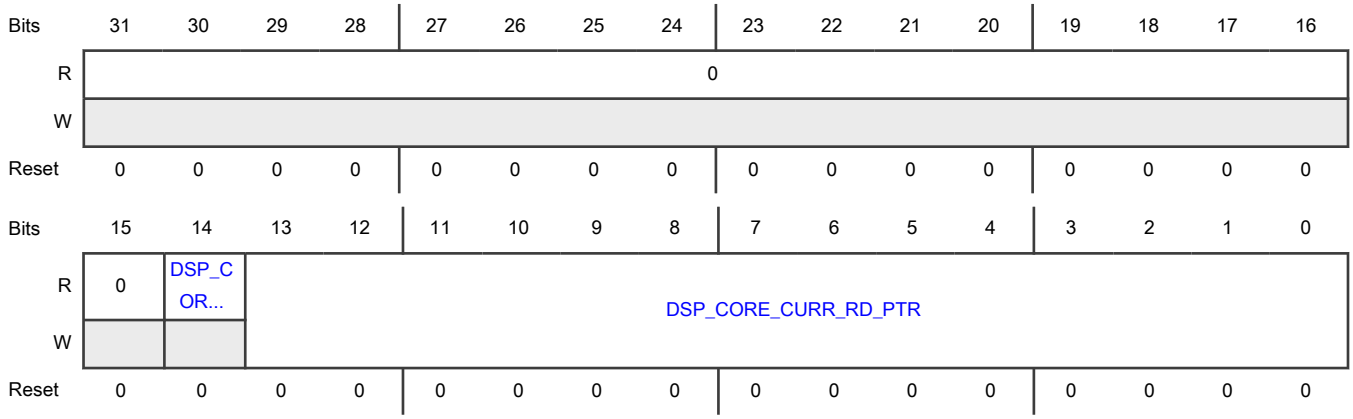
Register	Offset
DSP_CORE_CURR_RD_PTR0	28h
DSP_CORE_CURR_RD_PTR1	328h
DSP_CORE_CURR_RD_PTR2	628h
DSP_CORE_CURR_RD_PTR3	928h

Function

Specifies the current value of the DSP/core read pointer in the DSP buffer.

Both the Cortex-M7 core and the DSP core can access this register. DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_EN] enables this functionality.

Diagram



Fields

Field	Function
31-15 —	Reserved
14 DSP_CORE_CURR_RD_PTR_WRAP	Wrap Status Indicates the current read pointer wrap status of the DSP core buffer space inside XMEM. DSPSS changes DSP_CORE_CURR_RD_PTR_WRAP to 1 whenever DSP_CORE_CURR_RD_PTR exceeds the defined end address of this region. DSPSS changes DSP_CORE_CURR_RD_PTR_WRAP to 0 when the current write pointer also wraps around.
13-0 DSP_CORE_CURR_RD_PTR	Read Pointer Specifies the current read pointer value of the DSP core buffer space inside XMEM. The start address for the buffer space is DSP_CORE_BUF_ADDR*n*[DSP_CORE_BUF_START_ADDR] unless the master loads a new value. If an underflow or overflow error occurs in this buffer space, the Cortex-M7 core can update this pointer to restart the sharing of information with DSP in this space.

66.4.9 Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR0 - DSP_CORE_CURR_WR_PTR3)

Offset

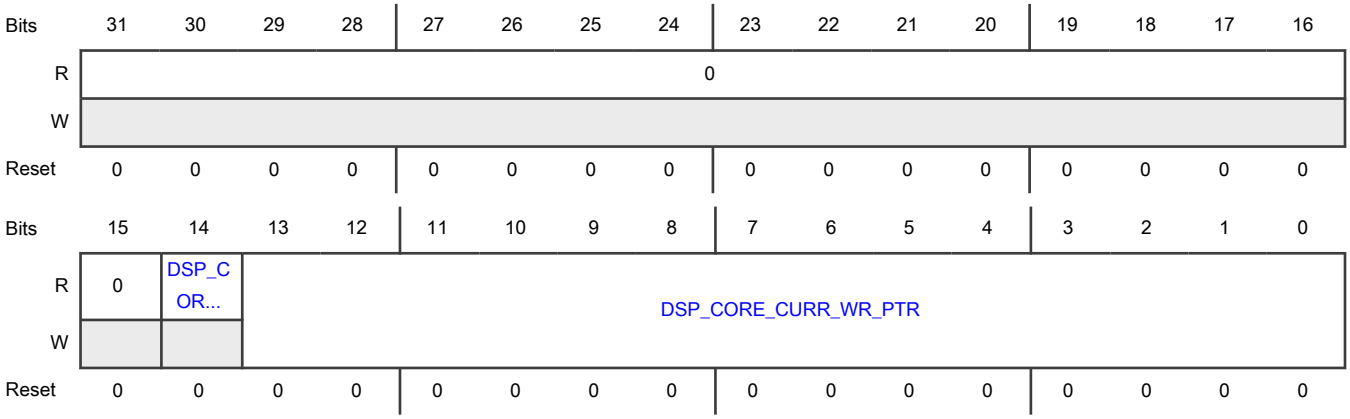
Register	Offset
DSP_CORE_CURR_WR_PTR0	2Ch
DSP_CORE_CURR_WR_PTR1	32Ch
DSP_CORE_CURR_WR_PTR2	62Ch
DSP_CORE_CURR_WR_PTR3	92Ch

Function

Specifies the current value of the DSP/core write pointer in the DSP buffer.

Both the Cortex-M7 core and the DSP core can access this register. DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_EN] enables this functionality.

Diagram



Fields

Field	Function
31-15 —	Reserved
14 DSP_CORE_CURR_WR_PTR_WRAP	Wrap Status Indicates the current write pointer wrap status of the DSP core buffer space inside XMEM. DSPSS changes DSP_CORE_CURR_WR_PTR_WRAP to 1 whenever DSP_CORE_CURR_WR_PTR exceeds the defined end address of this region.

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Field	Function
	DSPSS changes DSP_CORE_CURR_WR_PTR_WRAP to 0 when the current read pointer also wraps around.
13-0 DSP_CORE_CURR_WR_PTR	Write Pointer Specifies the current write pointer value of the DSP core buffer space inside XMEM. The start address for the buffer space is DSP_CORE_BUF_ADDR*n*[DSP_CORE_BUF_START_ADDR] unless the master loads a new value. If an underflow or overflow error occurs in this buffer space, the Cortex-M7 core can update this pointer to restart the sharing of information with DSP in this space.

66.4.10 Reference DMA Read Region (DMA_READ_ADDR0 - DMA_READ_ADDR5)

Offset

Register	Offset
DMA_READ_ADDR0	30h
DMA_READ_ADDR1	330h
DMA_READ_ADDR2	630h
DMA_READ_ADDR3	930h
DMA_READ_ADDR4	C30h
DMA_READ_ADDR5	F30h

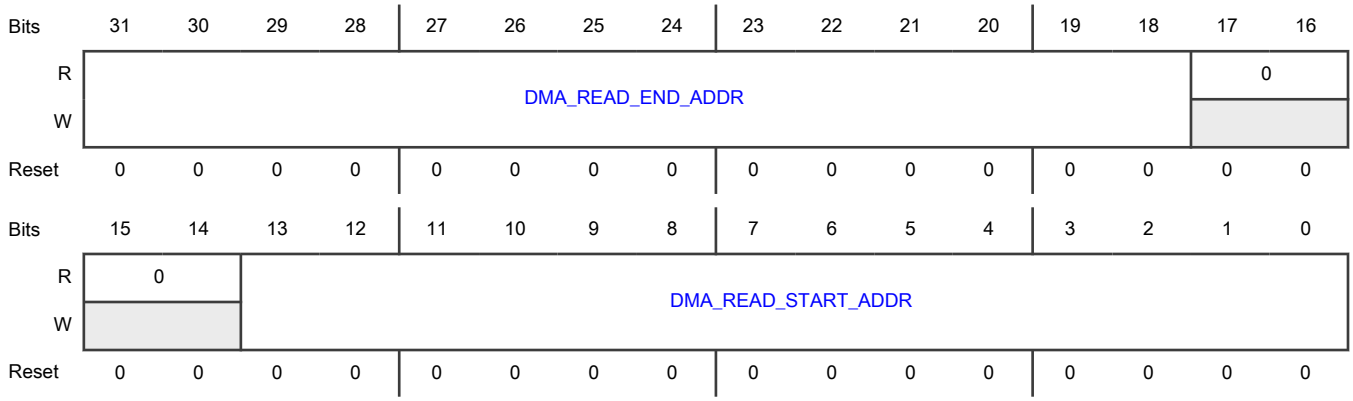
Function

Specifies the start and end addresses of the DMA_READ circular buffer.

DSP is the write master of this region. The address fields are half-word aligned.

Both the Cortex-M7 core and the DSP core can access this register.

Diagram



Fields

Field	Function
31-18 DMA_READ_END_ADDR	End Address
17-14 —	Reserved
13-0 DMA_READ_START_ADDR	Start Address

66.4.11 DMA Error Status (DMA_ERROR_STATUS0 - DMA_ERROR_STATUS5)

Offset

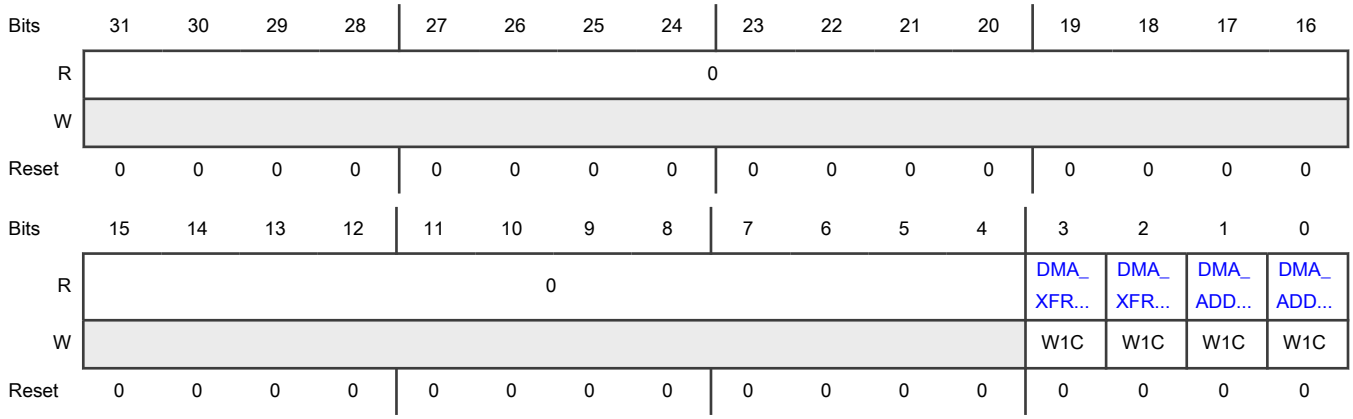
Register	Offset
DMA_ERROR_STATUS0	38h
DMA_ERROR_STATUS1	338h
DMA_ERROR_STATUS2	638h
DMA_ERROR_STATUS3	938h
DMA_ERROR_STATUS4	C38h
DMA_ERROR_STATUS5	F38h

Function

Contains flags that indicate the status of DMA errors.

Both the Cortex-M7 core and the DSP core can access this register.

Diagram



Fields

Field	Function
31-4 —	Reserved
3 DMA_XFR_ERR_READ	Transfer Error Read Flag Indicates when any access other than half-word or word is made in the DMA-READ buffer. Status of these bits are valid only when DMA_BUFFER_CFG[DMA_READ_EN] is set. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing 0b - No effect 1b - Clear the flag
2 DMA_XFR_ERR_WRITE	Transfer Error Write Flag Indicates when any access other than half-word or word is made in the DMA-WRITE buffer. Status of these bits are valid only when DMA_BUFFER_CFG[DMA_WRITE_EN] is set. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing

Table continues on the next page...

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Field	Function
	0b - No effect 1b - Clear the flag
1 DMA_ADDR_MISMATCH_RD_BUFFER	Address Mismatch Read Flag Indicates when a read-access address from DMA doesn't match the expected current read pointer and the address is within the address range of the DMA buffer, as specified in the DMA_READ_START_ADDR and DMA_READ_END_ADDR fields of Reference DMA Read Region (DMA_READ_ADDR0 - DMA_READ_ADDR5). **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing 0b - No effect 1b - Clear the flag
0 DMA_ADDR_MISMATCH_WR_BUFFER	Address Mismatch Write Flag Indicates when a write-access address from DMA doesn't match the expected current write pointer and the address is within the address range of the DMA buffer, as specified in the DMA_WRITE_START_ADDR and DMA_WRITE_END_ADDR fields of Reference DMA Write Region (DMA_WRITE_ADDR0 - DMA_WRITE_ADDR5). **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing 0b - No effect 1b - Clear the flag

66.4.12 Reference DMA Write Region (DMA_WRITE_ADDR0 - DMA_WRITE_ADDR5)

Offset

Register	Offset
DMA_WRITE_ADDR0	40h

Table continues on the next page...

Table continued from the previous page...

Register	Offset
DMA_WRITE_ADDR1	340h
DMA_WRITE_ADDR2	640h
DMA_WRITE_ADDR3	940h
DMA_WRITE_ADDR4	C40h
DMA_WRITE_ADDR5	F40h

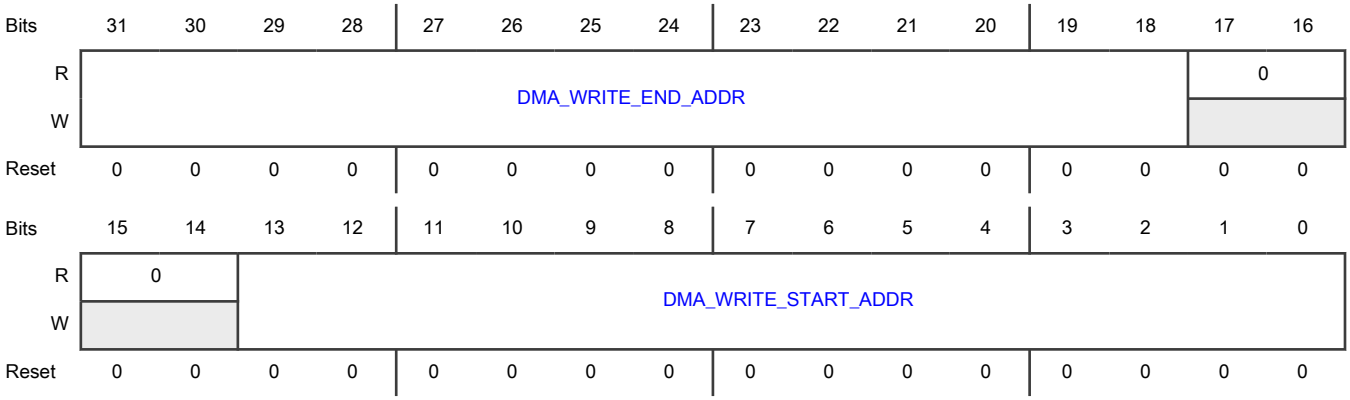
Function

Specifies the start and end addresses of the DMA_WRITE circular buffer.

DMA is the write master of this region. The address fields are half-word aligned.

Both the Cortex-M7 core and the DSP core can access this register.

Diagram



Fields

Field	Function
31-18 DMA_WRITE_END_ADDR	End Address
17-14 —	Reserved
13-0 DMA_WRITE_START_ADDR	Start Address

66.4.13 DMA Current Write Pointer (DMA_CURR_WR_PTR0 - DMA_CURR_WR_PTR5)

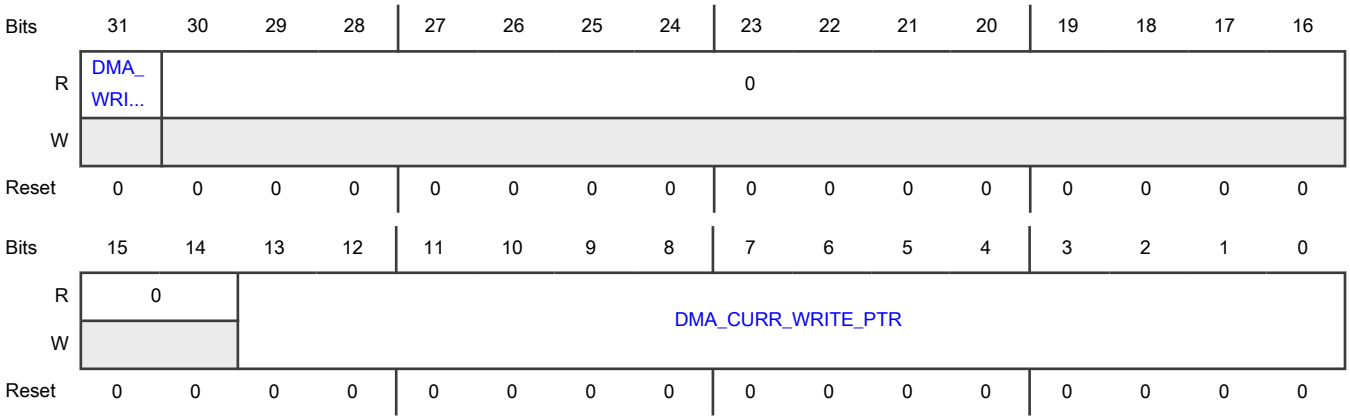
Offset

Register	Offset
DMA_CURR_WR_PTR0	44h
DMA_CURR_WR_PTR1	344h
DMA_CURR_WR_PTR2	644h
DMA_CURR_WR_PTR3	944h
DMA_CURR_WR_PTR4	C44h
DMA_CURR_WR_PTR5	F44h

Function

Specifies the current DMA write pointer inside the DMA buffer in XMEM.

Diagram



Fields

Field	Function
31 DMA_WRITE_PTR_WRAP	DMA-WRITE Buffer Wrap Toggles whenever the write pointer in the DMA-WRITE buffer wraps.
30-14 —	Reserved
13-0 DMA_CURR_WRITE_PTR	Write Pointer Specifies the current DMA write pointer in the DMA-WRITE region. When the Cortex-M7 core writes 1 to the corresponding bit in DMA_BUFFER_CFG[DMA_WRITE_EN], DMA_CURR_WRITE_PTR increments after every DMA write access in the defined DMA-WRITE region.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	DSP maintains the read pointer for this buffer in firmware. Both the Cortex-M7 and DSP cores can update this field before the start of monitoring logic. This is provided for the case where the master (Cortex-M7 core) overwrote the data in a location different from the last write location. This update can happen only when DMA_ERROR_STATUS*n*[DMA_XFR_ERR_WRITE] is not 0.

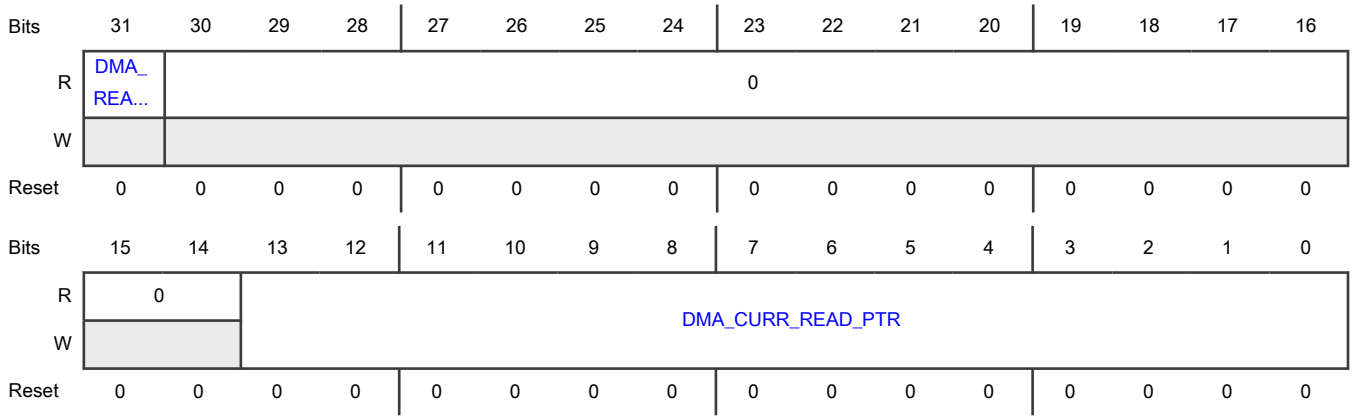
66.4.14 DMA Current Read Pointer (DMA_CURR_RD_PTR0 - DMA_CURR_RD_PTR5)

Offset

Register	Offset
DMA_CURR_RD_PTR0	48h
DMA_CURR_RD_PTR1	348h
DMA_CURR_RD_PTR2	648h
DMA_CURR_RD_PTR3	948h
DMA_CURR_RD_PTR4	C48h
DMA_CURR_RD_PTR5	F48h

Function
Specifies the current DMA read pointer inside the DMA buffer in XMEM.

Diagram



Fields

Field	Function
31	DMA-READ Buffer Wrap Toggles whenever the read pointer in the DMA-READ buffer wraps.

Table continues on the next page...

Table continued from the previous page...

Field	Function
DMA_READ_PTR_WRAP	This field returns to its reset value when you enable DMA buffer monitoring (write 1 to the corresponding bit in DMA_BUFFER_CFG[DMA_READ_EN]).
30-14 —	Reserved
13-0 DMA_CURR_READ_PTR	Read Pointer Specifies the current DMA read pointer in the DMA-READ region. DSP maintains the write pointer for this buffer in firmware, because DSP controls the DMA request. When the Cortex-M7 core writes 1 to the corresponding bit in DMA_BUFFER_CFG[DMA_READ_EN], DMA_CURR_READ_PTR increments after every DMA read access in the defined DMA-READ region. Both the Cortex-M7 and DSP cores can update this field before the start of monitoring logic. This is provided for the case where the master (Cortex-M7 core) overwrote the data in a location different from the last write location. This update can happen only when DMA_ERROR_STATUS*n*[DMA_XFR_ERR_READ] is not 0.

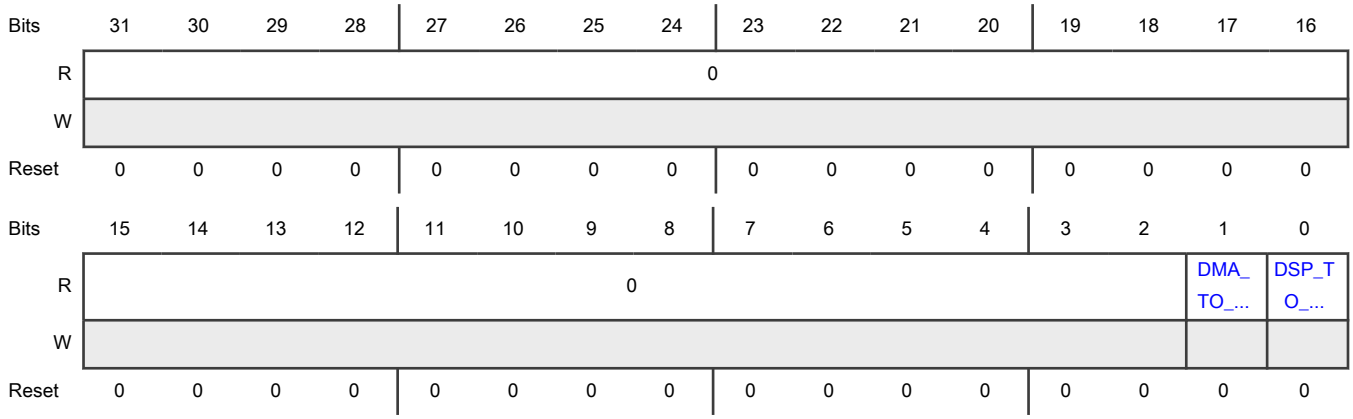
66.4.15 DMA Request Status (DSP_TO_DMA_REQUEST_STATUS0 - DSP_TO_DMA_REQUEST_STATUS5)

Offset

Register	Offset
DSP_TO_DMA_REQUEST_STATUS0	50h
DSP_TO_DMA_REQUEST_STATUS1	350h
DSP_TO_DMA_REQUEST_STATUS2	650h
DSP_TO_DMA_REQUEST_STATUS3	950h
DSP_TO_DMA_REQUEST_STATUS4	C50h
DSP_TO_DMA_REQUEST_STATUS5	F50h

Function

Diagram



Fields

Field	Function
31-2 —	Reserved
1 DMA_TO_DSP_ACK_STATUS	DMA Acknowledgment Status 0b - Acknowledgment for current DMA request is pending 1b - DMA acknowledges the current DMA request
0 DSP_TO_DMA_REQUEST_STATUS	DMA Request Status DMA Request Status The DSP core changes this field to 1 to initiate DMA on XMEM. DSPSS changes this field to 0 after the DMA request completes. 0b - DMA request is complete 1b - Initiate DMA request

66.4.16 Thread Suspend Request For Thread Disabling/PCINIT Change (THREAD_SUSPEND_REQ0 - THREAD_SUSPEND_REQ3)

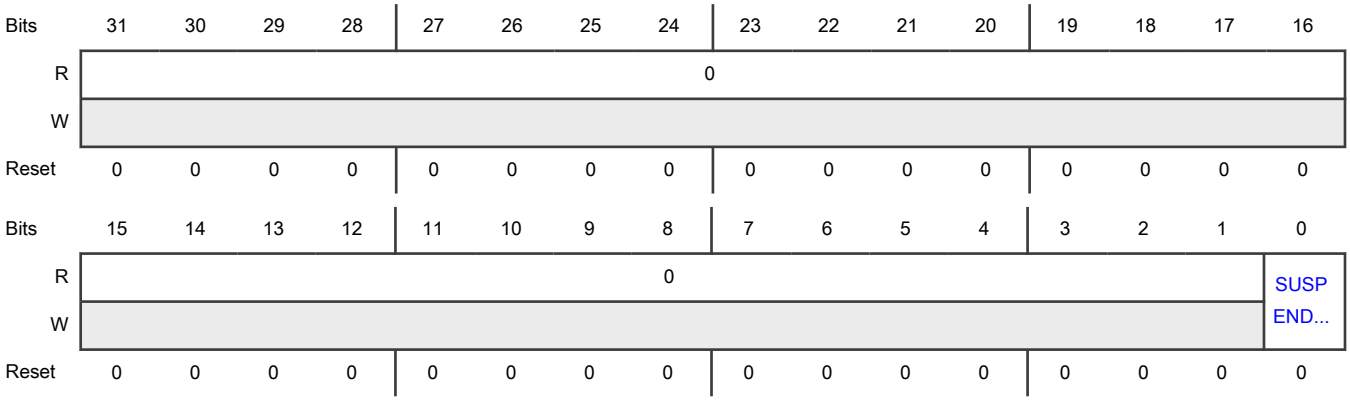
Offset

Register	Offset
THREAD_SUSPEND_REQ0	54h
THREAD_SUSPEND_REQ1	354h
THREAD_SUSPEND_REQ2	654h
THREAD_SUSPEND_REQ3	954h

Function

Requests a thread suspension.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 SUSPEND_REQ	Suspend Request Specifies whether to initiate a suspend request. 0b - Do not initiate 1b - Initiate

66.4.17 Thread Status (DSPSS_DSP_TH_STATUS0 - DSPSS_DSP_TH_STATUS3)

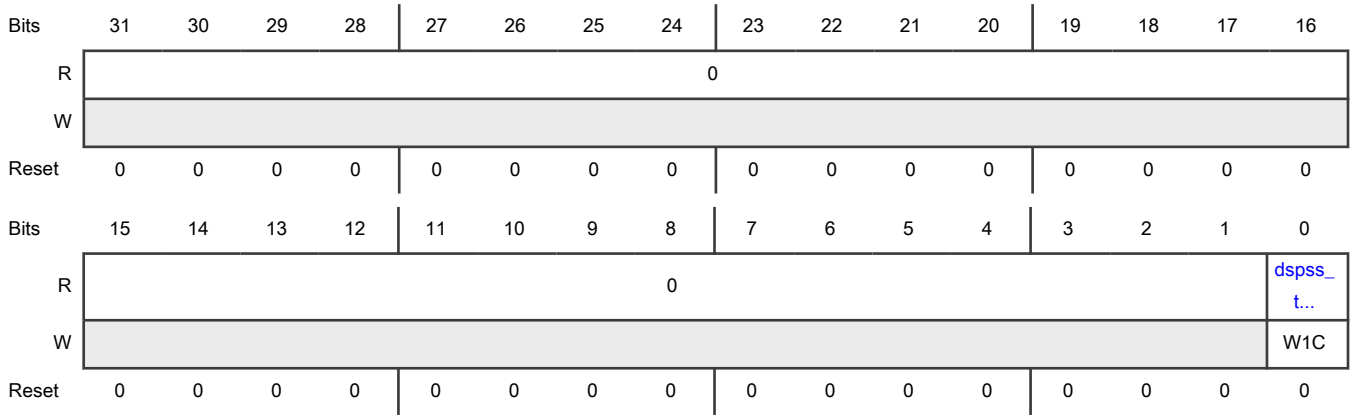
Offset

Register	Offset
DSPSS_DSP_TH_STATUS0	5Ch
DSPSS_DSP_TH_STATUS1	35Ch
DSPSS_DSP_TH_STATUS2	65Ch
DSPSS_DSP_TH_STATUS3	95Ch

Function

Indicates the status of DSP0 for thread *n*.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 dspss_th_suspended	Thread Status Indicates whether the thread is suspended or not. 0b - Not suspended 1b - Suspended

66.4.18 DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS0 - DSP_CORE_BUFFER_STATUS3)

Offset

Register	Offset
DSP_CORE_BUFFER_STATUS0	7Ch
DSP_CORE_BUFFER_STATUS1	37Ch
DSP_CORE_BUFFER_STATUS2	67Ch
DSP_CORE_BUFFER_STATUS3	97Ch

Function

Indicates the status of the DSP core buffer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0													DSP_COR...	DSP_COR...	Reserved
W														W1C	W1C	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-3 —	Reserved
2 DSP_CORE_BUFFER_UNDF	Buffer Underflow Flag When DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_EN] = 1, indicates that the DSP core buffer space underflowed. You must disable the buffer before the Cortex-M7 core or DSP core clears this flag. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No underflow 1b - Underflow occurred When writing 0b - No effect 1b - Clear the flag
1 DSP_CORE_BUFFER_OVF	Buffer Overflow Flag When DSP_CORE_BUFFER_CFG[DSP_CORE_BUFFER_EN] = 1, indicates that the write pointer inside the DSP core buffer overflowed. You must disable the buffer before the Cortex-M7 core or DSP core clears this flag. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No overflow

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Overflow occurred When writing 0b - No effect 1b - Clear the flag
0 —	Reserved

66.4.19 DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS0 - DSP_TO_CORE_TRIG_ERR_STATUS3)

Offset

Register	Offset
DSP_TO_CORE_TRIG_ERR_STATUS0	80h
DSP_TO_CORE_TRIG_ERR_STATUS1	380h
DSP_TO_CORE_TRIG_ERR_STATUS2	680h
DSP_TO_CORE_TRIG_ERR_STATUS3	980h

Function

Indicates an error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															DSP_TO_...
W																W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved
0 DSP_TO_CORE_TRIG_ERR_STATUS	Error Status Indicates an error. DSP sets this flag whenever DSP encounters an error. The Cortex-M7 core clears this flag. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Error did not occur 1b - Error occurred When writing 0b - No effect 1b - Clear the flag

66.4.20 DSP Output Control (DS_GATE_STATUS_REGISTER0 - DS_GATE_STATUS_REGISTER3)

Offset

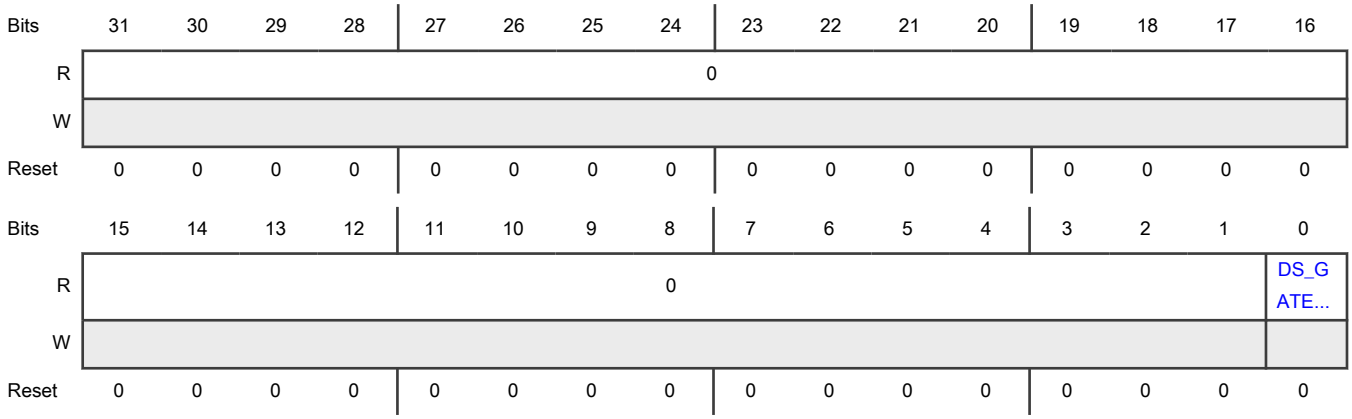
Register	Offset
DS_GATE_STATUS_REGISTER0	84h
DS_GATE_STATUS_REGISTER1	384h
DS_GATE_STATUS_REGISTER2	684h
DS_GATE_STATUS_REGISTER3	984h

Function

Exchanges information between DSPSS and the rest of the chip.

This is a general-purpose register for which the DSP software defines the action. DSP reads this register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 DS_GATE_STATUS_REGISTER	General-Purpose Data Exchange Exchanges general-purpose information according to the DSP software. The Cortex-M7 core and DSP read this field.

66.4.21 DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER0 - DS_GATE_TRIGMUX_REGISTER3)

Offset

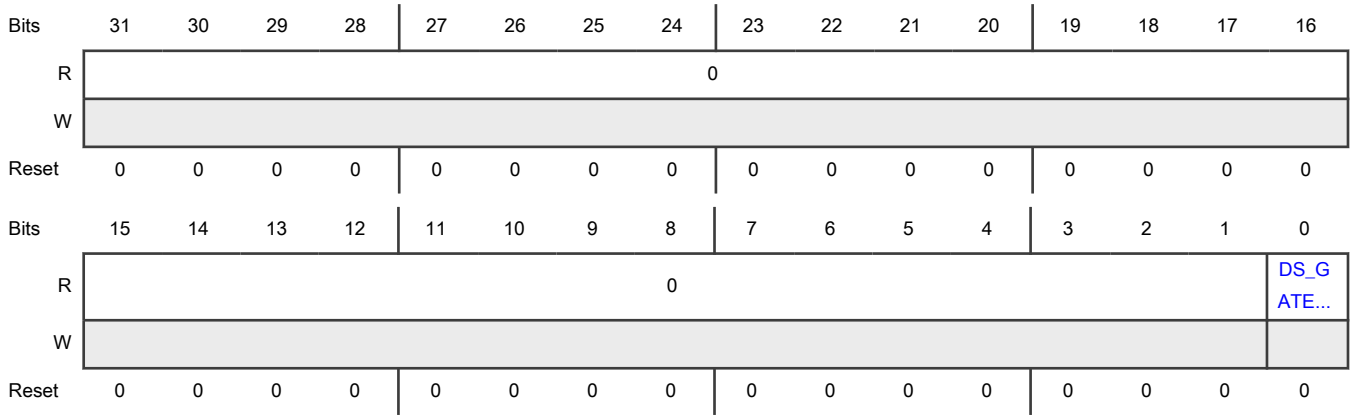
Register	Offset
DS_GATE_TRIGMUX_REGISTER0	88h
DS_GATE_TRIGMUX_REGISTER1	388h
DS_GATE_TRIGMUX_REGISTER2	688h
DS_GATE_TRIGMUX_REGISTER3	988h

Function

Sends a trigger to TRIGMUX for the respective thread.

The DSP core reads and writes to this register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 DS_GATE_TRIGMUX_TRIGGER	Trigger To TRIGMUX Sends a trigger. The DSP firmware writes 1 to this field. The DSP DW writes 0 to this field. 0b - Do not send a trigger 1b - Send a trigger

66.4.22 Stop DMA Request (HW_CTRL_DMA_REQ_STOP0 - HW_CTRL_DMA_REQ_STOP5)

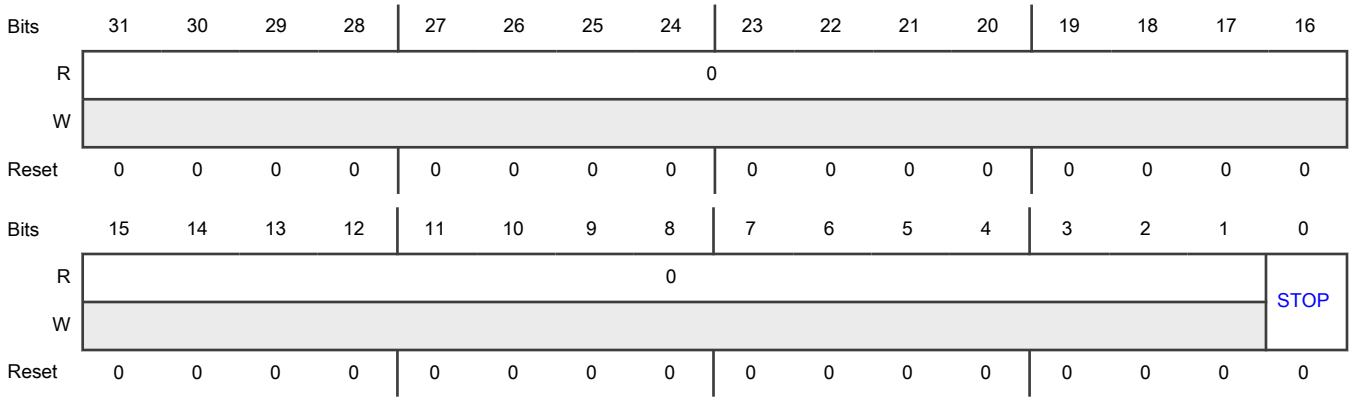
Offset

Register	Offset
HW_CTRL_DMA_REQ_STOP0	8Ch
HW_CTRL_DMA_REQ_STOP1	38Ch
HW_CTRL_DMA_REQ_STOP2	68Ch
HW_CTRL_DMA_REQ_STOP3	98Ch
HW_CTRL_DMA_REQ_STOP4	C8Ch
HW_CTRL_DMA_REQ_STOP5	F8Ch

Function

Stops the assertion of a new request at the DMA interface.

Diagram



Fields

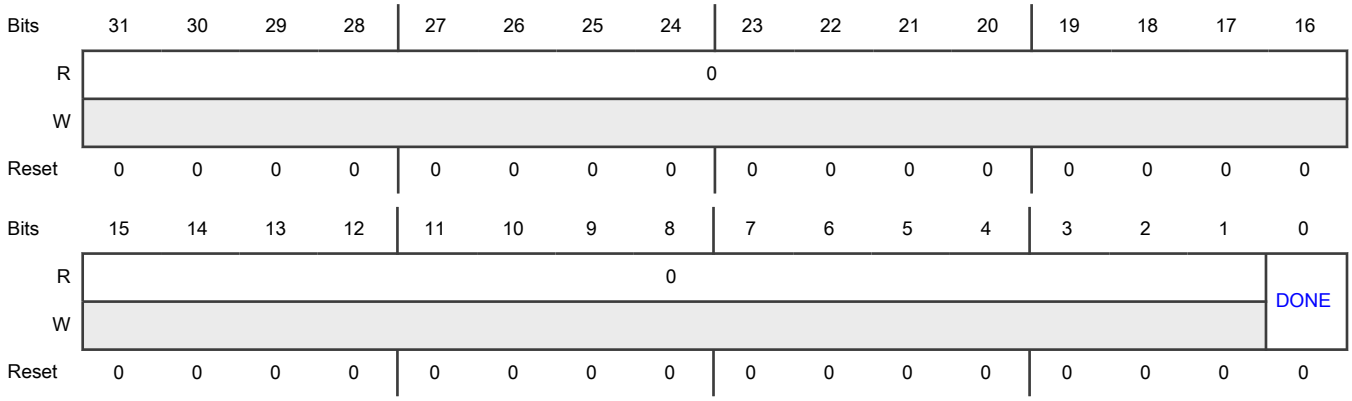
Field	Function
31-1 —	Reserved
0 STOP	Stop Request Works with HW_CTRL_DMA_REQ_RESPONSE*n*[START] to stop the assertion of another DMA request. The Cortex-M7 and DSP cores write 1 to this field. DSPSS changes this field to 0 when DMA asserts ipd_dma_done_lw or when DMA_ERR_CTRL*n*[DONE] = 1. 0b - Do not stop 1b - Stop

66.4.23 DMA Error Control (DMA_ERROR_CTRL0 - DMA_ERROR_CTRL5)

Offset

Register	Offset
DMA_ERROR_CTRL0	90h
DMA_ERROR_CTRL1	390h
DMA_ERROR_CTRL2	690h
DMA_ERROR_CTRL3	990h
DMA_ERROR_CTRL4	C90h
DMA_ERROR_CTRL5	F90h

Diagram



Fields

Field	Function
31-1 —	Reserved
0 DONE	Dummy Done The Cortex-M7 core should write 1 to this field when an error or hang occurs during a DMA transfer. DSPSS changes this field back to 0 after one peripheral-bus clock cycle. If the DSP core used Hardware-Assisted DMA mode, use this field only after writing 1 to HW_CTRL_DMA_REQ_STOP*n*[STOP].

66.4.24 Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0 - HW_CTRL_DMA_REQ_RESPONSE5)

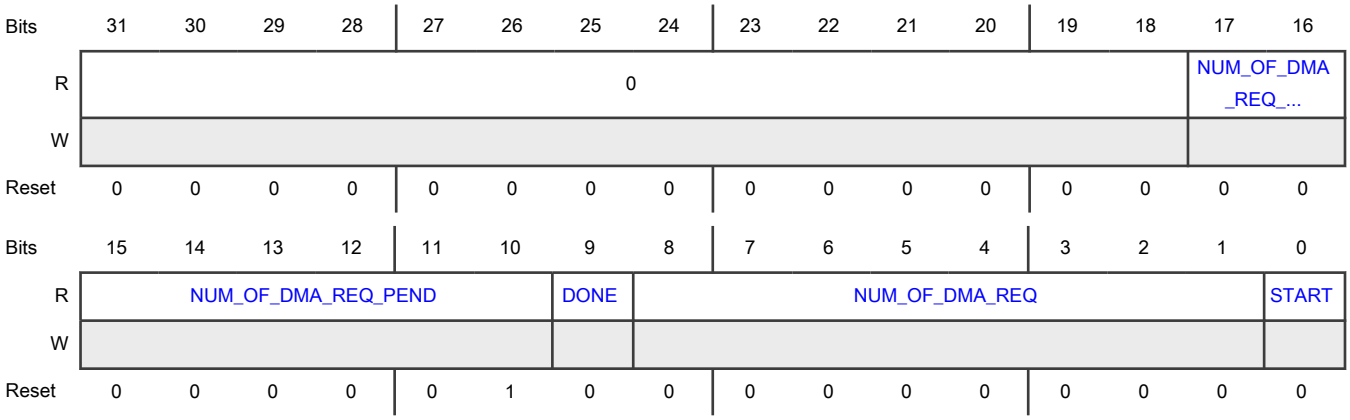
Offset

Register	Offset
HW_CTRL_DMA_REQ_RESPONSE0	94h
HW_CTRL_DMA_REQ_RESPONSE1	394h
HW_CTRL_DMA_REQ_RESPONSE2	694h
HW_CTRL_DMA_REQ_RESPONSE3	994h
HW_CTRL_DMA_REQ_RESPONSE4	C94h
HW_CTRL_DMA_REQ_RESPONSE5	F94h

Function

HW generates request as soon DSP FW programs the count and sets the start bit. These configurations are common for all the threads across the DSP.

Diagram



Fields

Field	Function
31-18 —	Reserved
17-10 NUM_OF_DMA_REQ_PEND	Number of Pending DMA Requests Indicates the number of DMA requests that are remaining at a given time. This is the real-time status. After all the requests are serviced, this field becomes 0. If HW_CTRL_DMA_REQ_STOP*n*[STOP] = 1, no new requests are sent to DMA and therefore NUM_OF_DMA_REQ_PEND gives information about the number of requests that are pending.
9 DONE	Done Generating DMA Requests Indicates whether DMA request generation is finished. DSPSS changes this field to 1 after either of the following occurs: • DSPSS finishes generating the expected number of DMA requests (as you specified in HW_CTRL_DMA_REQ_RESPONSE*n*[NUM_OF_DMA_REQ]). • You write 1 to DMA_ERROR_CTRL*n*[DONE]. The DSP firmware must write 0 to this field before launching new hardware-assisted DMA requests. 0b - Not finished 1b - Finished
8-1 NUM_OF_DMA_REQ	Number of DMA Requests Indicates the number of requests to generate when HW_CTRL_DMA_REQ_RESPONSE*n*[START] = 1. This field must not be updated dynamically during the ongoing DMA transfer. Your DSP firmware can update NUM_OF_DMA_REQ only when HW_CTRL_DMA_REQ_RESPONSE*n*[DONE] = 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 START	Start Request Indicates the start of a hardware request. After every DMA-done event, DSPSS asserts a new request until the total number of request reaches HW_CTRL_DMA_REQ_RESPONSE*n*[NUM_OF_DMA_REQ]. Your DSP firmware must program this again if it must use this feature. Ongoing DMA operation does not stop when the thread is suspended through an mbit error. If you require DMA operation to be halted, the Cortex-M7 core must write 1 to HW_CTRL_DMA_REQ_STOP*n*[STOP].

66.4.25 DSPSS Soft Reset (DSPSS_SOFT_RESET_REGISTER)

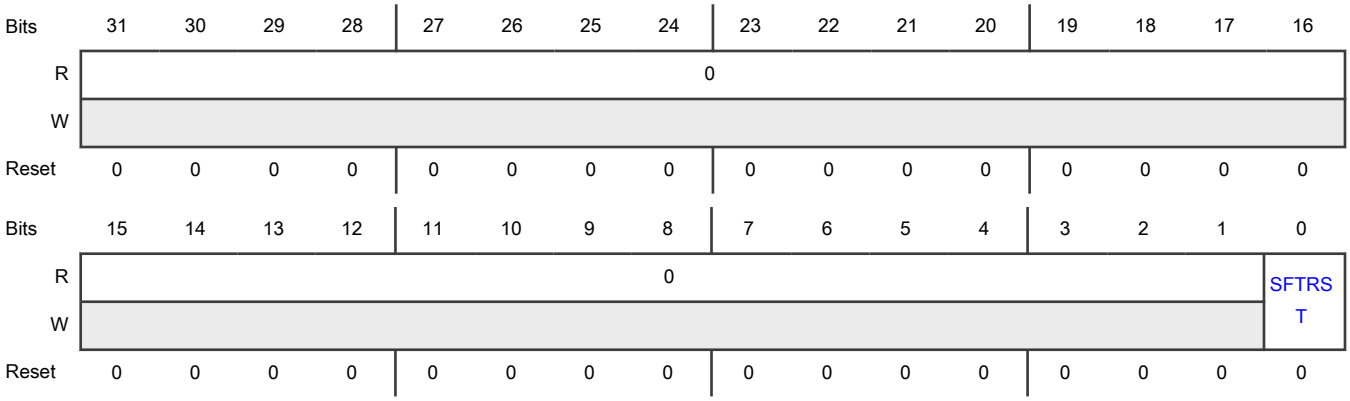
Offset

Register	Offset
DSPSS_SOFT_RESET_REGISTER	BE4h

Function

Performs a soft reset.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 SFTRST	Soft Reset Performs a soft reset.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Writing 1 to this field resets everything inside DSPSS except the DSP core. Before writing 1 to this field, ensure that DSP threads are either not running or in Sleep mode. 0b - Do not reset 1b - Reset

66.4.26 DSP ACK Timeout Configuration And Error Control (DSP_ACK_TIMEOUT_CFG_AND_ERR_CTRL)

Offset

Register	Offset
DSP_ACK_TIMEOUT_CFG_AND_ERR_CTRL	BE8h

Function

Configures the DSP to acknowledge a context-request timer, and controls the required actions after a timeout.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								DSP_ACK...	DSP_ACK...	DSP_ACK...	DSP_ACK...	REQ_COUNT_ACC_FIFO			
W									W1C	W1C	W1C	W1C				
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REQ_COU...	REQ_ACC...	REQ_ACC_FIFO_THRESHOLD_FOR_INTR					DSP_ACK...	Reserved	DSP_ACK...	DSP_ACK_TIMEOUT_TIMER					
W		W1C						W1C								
Reset	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0

Fields

Field	Function
31-24 —	Reserved
23	DSP ACK Timeout Error Flag For Thread 3 Indicates a acknowledgment timeout error for thread 3.

Table continues on the next page...

Table continued from the previous page...

Field	Function
DSP_ACK_TIMEOUT_ERR_TH3	DSPSS sets this flag when DSP_ACK_TIMEOUT_EN = 1 and the DSP core fails to acknowledge the context request change within DSP_ACK_TIMEOUT_TIMER cycles. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing 0b - No effect 1b - Clear the flag
22 DSP_ACK_TIMEOUT_ERR_TH2	DSP ACK Timeout Error Flag For Thread 2 Indicates a acknowledgment timeout error for thread 2. DSPSS sets this flag when DSP_ACK_TIMEOUT_EN = 1 and the DSP core fails to acknowledge the context request change within DSP_ACK_TIMEOUT_TIMER cycles. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing 0b - No effect 1b - Clear the flag
21 DSP_ACK_TIMEOUT_ERR_TH1	DSP ACK Timeout Error Flag For Thread 1 Indicates a acknowledgment timeout error for thread 1. DSPSS sets this flag when DSP_ACK_TIMEOUT_EN = 1 and the DSP core fails to acknowledge the context request change within DSP_ACK_TIMEOUT_TIMER cycles. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing 0b - No effect

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Clear the flag
20 DSP_ACK_TIMEOUT_ERR_TH0	DSP ACK Timeout Error Flag For Thread 0 Indicates a acknowledgment timeout error for thread 0. DSPSS sets this flag when DDSP_ACK_TIMEOUT_EN = 1 and the DSP core fails to acknowledge the context request change within DSP_ACK_TIMEOUT_TIMER cycles. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred 1b - This error occurred When writing 0b - No effect 1b - Clear the flag
19-15 REQ_COUNT_ACC_FIFO	Context Requests In Request FIFO Indicates the real-time number of context requests inside the request FIFO.
14 REQ_ACC_FIFO_INTR	Interrupt Status On Request FIFO Threshold Cross
13-9 REQ_ACC_FIFO_THRESHOLD_FOR_INTR	Interrupt Threshold For Request FIFO Specifies the threshold value of the thread-accumulator FIFO. An interrupt occurs if the number of thread requests equals or exceeds this value. Do not write a value greater than 16d to this field. 0_0000b-1_0000b - Threshold as defined in the description All other values are reserved.
8 DSP_ACK_TIMEOUT_ERR	DSP ACK Timeout Error Flag Indicates a acknowledgment timeout error. DSPSS sets this flag when DSP_ACK_TIMEOUT_EN = 1 and the DSP core fails to acknowledge the context request change within DSP_ACK_TIMEOUT_TIMER cycles. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No such error occurred

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - This error occurred When writing 0b - No effect 1b - Clear the flag
7 —	Reserved
6 DSP_ACK_TIMEOUT_EN	DSP ACK Timeout Enable 0b - Disable 1b - Enable
5-0 DSP_ACK_TIMEOUT_TIMER	DSP ACK Timeout Timer Configuration Specifies the maximum number of DSP clock cycles for DSP to acknowledge the context-change request. If DSP does not respond during that time (for example, due to a DSP hardware problem), DSPSS sets the timeout-error flag (DSP_ACK_TIMEOUT_CFG_AND_ERR_CTRL[DSP_ACK_TIMEOUT_ERR]). You must write a value of 8d or greater to this field. 00_0000b-00_0111b - Reserved All other values - Clock cycles as defined in the description

66.4.27 Disable Monitoring of ECC Errors In XMEM And PMEM (ECC_ERROR_MONITOR_THREAD_SUSPEND_CTRL)

Offset

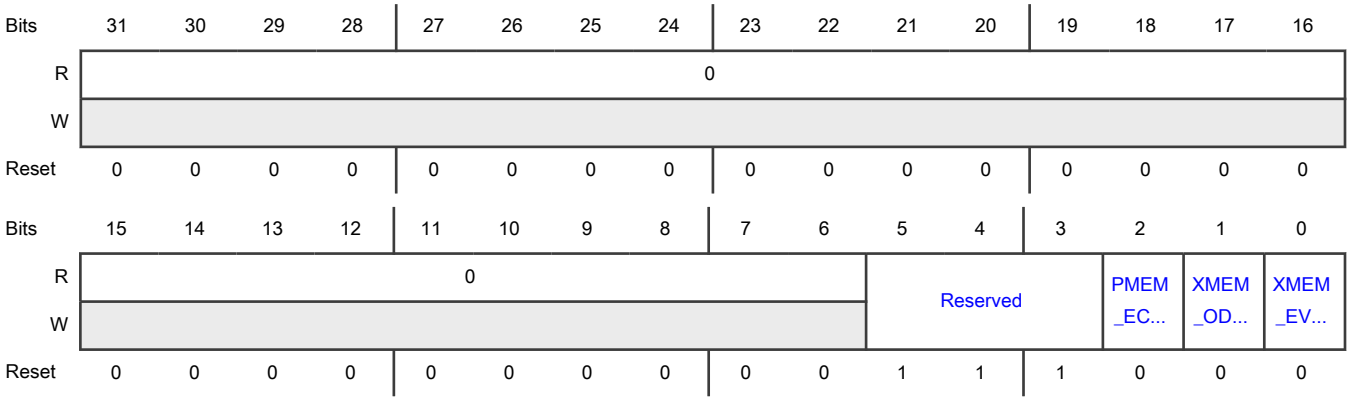
Register	Offset
ECC_ERROR_MONITOR_THREAD_SUSPEND_CTRL	BECh

Function

Disables ECC error monitoring for:

- PMEM.
- The odd instance of XMEM.
- The even instance of XMEM.

Diagram



Fields

Field	Function
31-6 —	Reserved
5-3 —	Reserved
2 PMEM_ECC_ERROR_DIS	Error Monitoring Disable For PMEM Disables the ECC error monitor for PMEM. 0b - Enable 1b - Disable
1 XMEM_ODD_ECC_ERROR_DIS	Error Monitoring Disable For Odd XMEM Disables the ECC error monitor for the odd instance of XMEM. 0b - Enable 1b - Disable
0 XMEM_EVEN_ECC_ERROR_DIS	Error Monitoring Disable For Even XMEM Disables the ECC error monitor for the even instance of XMEM. 0b - Enable 1b - Disable

66.4.28 Interrupt Enable (INTERRUPT_ENABLE_REGISTER2)

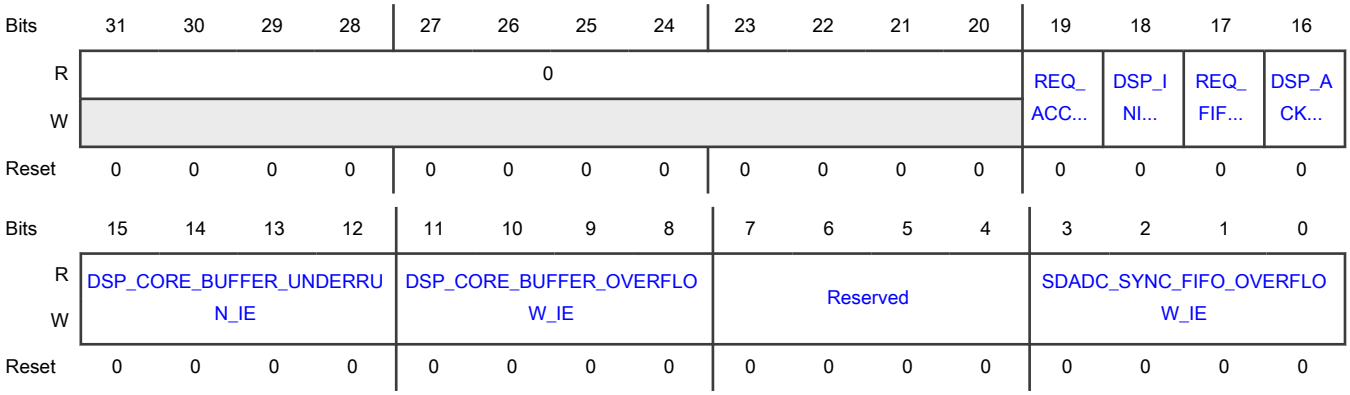
Offset

Register	Offset
INTERRUPT_ENABLE_REGISTER2	BF0h

Function

Enables various interrupts.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 REQ_ACC_FIFO_THRESHOLD_CROSS_INT_EN	Interrupt enable: Request accumulator FIFO Use this field if you need an interrupt whenever the thread-request accumulator FIFO crosses the programmed threshold. This tells you if a buildup exists in the request FIFO. 0b - Disable 1b - Enable
18 DSP_INIT_LOW_IE	Interrupt enable: DSP_INIT_LOW 0b - Disable 1b - Enable
17 REQ_FIFO_ERR_IE_EN	Interrupt enable: REQ_FIFO_ERR 0b - Disable 1b - Enable
16 DSP_ACK_TIMEOUT_ERR_IE	Interrupt enable: DSP_ACK_TIMEOUT Error 0b - Disable 1b - Enable
15-12 DSP_CORE_BUFFER_UNDERRUN_IE	Interrupt enable: DSP-CORE BUFFER Underrun Error Contains bits that enable the interrupts for individual threads. Within this field, bit *m* enables the interrupt for thread *m*. For example, bit 2 enables the interrupt for thread 2.
11-8	Interrupt enable: DSP-CORE BUFFER Overflow Error

Table continues on the next page...

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Field	Function
DSP_CORE_BUFFER_OVERFLOW_IE	Contains bits that enable the interrupts for individual threads. Within this field, bit *m* enables the interrupt for thread *m*. For example, bit 2 enables the interrupt for thread 2.
7-4 —	Reserved
3-0 SDADC_SYNC_FIFO_OVERFLOW_IE	Interrupt enable: SDADC_SYNC_FIFO_OVERFLOW Contains bits that enable the interrupts for individual threads. Within this field, bit *m* enables the interrupt for thread *m*. For example, bit 2 enables the interrupt for thread 2.

66.4.29 FIFO Overflow Status (SDADC_SYNC_FIFO_ERROR_STATUS)

Offset

Register	Offset
SDADC_SYNC_FIFO_ERROR_STATUS	BF4h

Function

Indicates the overflow status of the request FIFO and SDSDC sync FIFO.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0							REQ_FIF...	Reserved				OVERFLOW			
W								W1C	W1C				W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-9	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
8 REQ_FIFO_OVERFLOW	Request FIFO Overflow Flag DSPSS sets this flag when the request FIFO overflows. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No overflow occurred 1b - Overflow occurred When writing 0b - No effect 1b - Clear the flag
7-4 —	Reserved
3-0 OVERFLOW	SDADC Sync FIFO Overflow Flag Contains flags that enable the interrupts for individual threads. Within this field, bit *m* represents the flag for thread *m*. For example, bit 2 is the flag for thread 2. DSPSS sets a flag in this field when the respective SDADC sync FIFO overflows.

66.4.30 Configuration For DSP-Core Buffer (DSP_CORE_BUFFER_CFG)

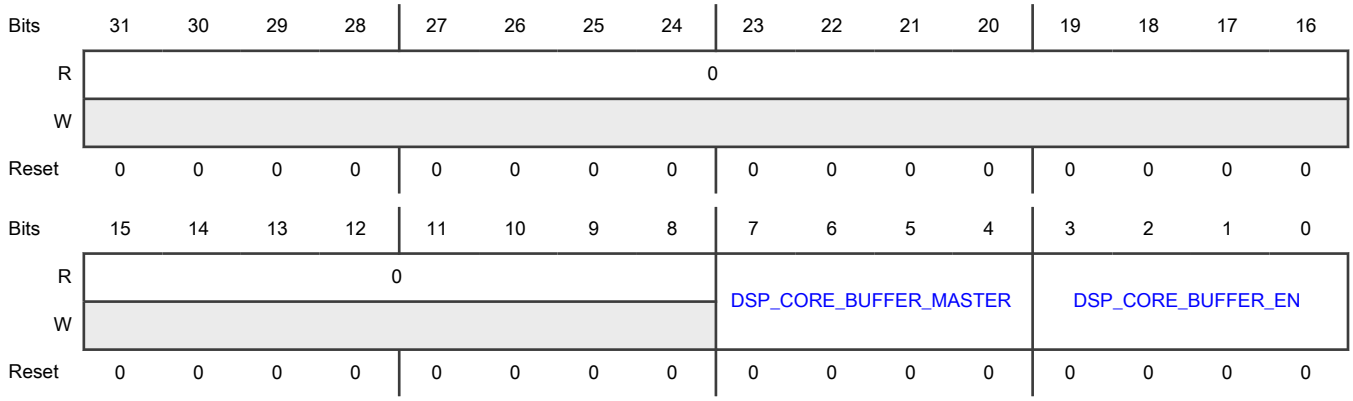
Offset

Register	Offset
DSP_CORE_BUFFER_CFG	BFCh

Function

Configures the DSP core buffer.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-4 DSP_CORE_BUFFER_MASTER	Programming the current read/write ownership inside the DSP_CORE buffer in XMEM. This register is provided for software use only. Hardware does not prohibit any access to any of the regions based on the value programmed in this field. Contains bits that control submodule access in the respective DSP-CORE buffer region for individual threads. Within this field, bit *m* controls access for thread *m*. For example, bit 2 controls the access for thread 2. For each bit: • A value of 0 means the Cortex-M7 core has only write access and DSP has only read access. • A value of 1 means the Cortex-M7 core has only read access and DSP has only write access.
3-0 DSP_CORE_BUFFER_EN	DSP Core Buffer Enable Enables the pointer monitoring logic in the buffer specified by the addresses inside DSP_CORE_READ_PTR and DSP_CORE_WRITE_PTR. This is one hot encoded. LSB is the buffer enable for TH-0 and MSB is for TH-3.

66.4.31 DMA Buffer Configuration (DMA_BUFFER_CFG)

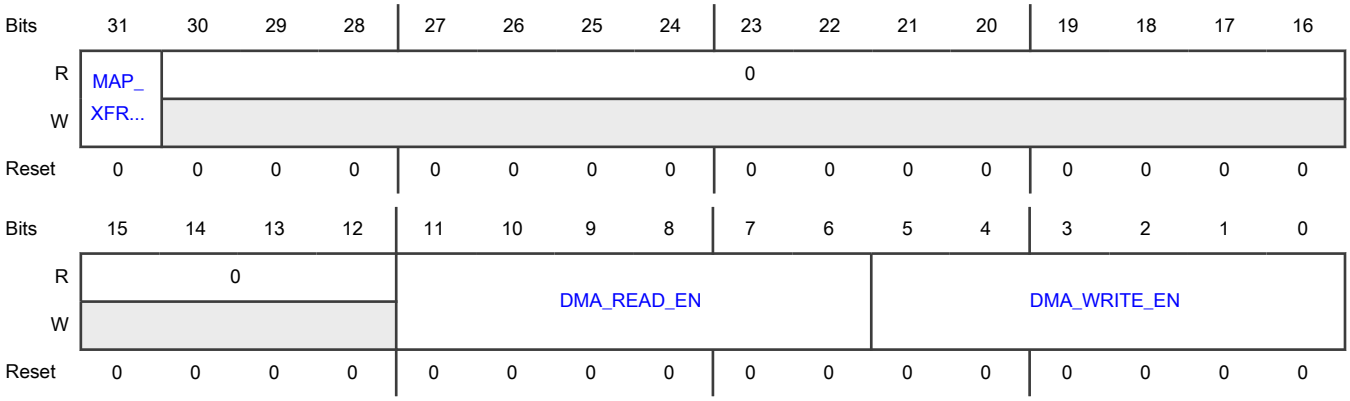
Offset

Register	Offset
DMA_BUFFER_CFG	C00h

Function

Configures the DMA-READ and DMA-WRITE buffers.

Diagram



Fields

Field	Function
31 MAP_XFR_DMA_ERR_ON_IPS	When set, the DMA_ADDR_MISMATCH_RD_BUFFER/DMA_ADDR_MISMATCH_RD_BUFFER errors are mapped on IPS_XFR_ERR.
30-12 —	Reserved
11-6 DMA_READ_EN	DMA-READ Buffer Monitor Enable Contains bits that enable the monitoring of the read pointer for individual buffers. Within this field, bit *m* enables the monitoring for DMA-*m*. For example, bit 2 enables the monitoring for DMA-2.
5-0 DMA_WRITE_EN	DMA-WRITE Buffer Monitor Enable Contains bits that enable the monitoring of the write pointer for individual buffers. Within this field, bit *m* enables the monitoring for DMA-*m*. For example, bit 2 enables the monitoring for DMA-2.

66.4.32 Thread Scheduling Mode Selection (SCHEDULER_MODE_CFG)

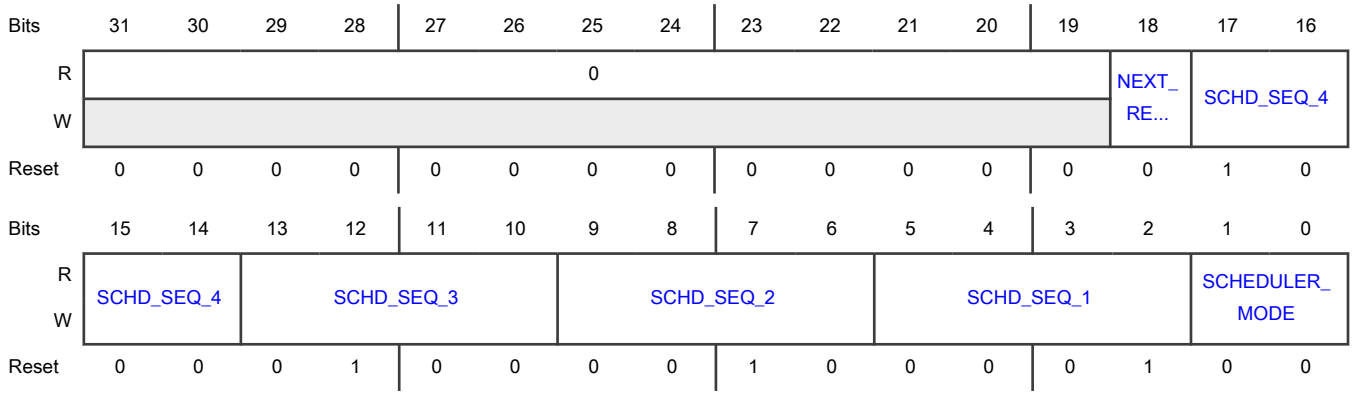
Offset

Register	Offset
SCHEDULER_MODE_CFG	C04h

Function

Configures DSP threads. These configurations are common for all the threads across the DSP.

Diagram



Fields

Field	Function
31-19 —	Reserved
18 NEXT_REQ_HALT_ACK_WAIT_CTRL	Thread Scheduling Control Specifies the relationship between the mode and the scheduling of the next thread, as follows:

Value	Next-thread scheduling in Sample Threshold mode	Next-thread scheduling in Clock Threshold mode
0	When halt_ack (the sleep instruction) from DSP is received for the current ongoing thread	When the threshold reaches the clock-threshold value for the last scheduled thread
1	As soon as the sample accumulation crosses the programmed threshold	When halt_ack is received for the last scheduled thread

17-14 SCHD_SEQ_4	Schedule For Fourth Thread Specifies the fourth thread to be scheduled in Clock Threshold mode. **NOTE** Threads are scheduled only if they are enabled. 0001b - Thread 0 0010b - Thread 1 0100b - Thread 2 1000b - Thread 3
13-10 SCHD_SEQ_3	Schedule For Third Thread Specifies the third thread to be scheduled in Clock Threshold mode.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE Threads are scheduled only if they are enabled. 0001b - Thread 0 0010b - Thread 1 0100b - Thread 2 1000b - Thread 3
9-6 SCHD_SEQ_2	Schedule For Second Thread Specifies the second thread to be scheduled in Clock Threshold mode. **NOTE** Threads are scheduled only if they are enabled. 0001b - Thread 0 0010b - Thread 1 0100b - Thread 2 1000b - Thread 3
5-2 SCHD_SEQ_1	Schedule For First Thread Specifies the first thread to be scheduled in Clock Threshold mode. **NOTE** Threads are scheduled only if they are enabled. 0001b - Thread 0 0010b - Thread 1 0100b - Thread 2 1000b - Thread 3
1-0 SCHEDULER_MODE	Scheduler Mode Selection Selects the mode for thread scheduling. You can change scheduling modes only after a DSPSS reset. 00b - Sample Threshold mode and hardware thread scheduling 01b - Clock Threshold scheduling mode; the SCHD_SEQ_n fields in this register establish the sequence of scheduling 10b - Software scheduling; no hardware scheduling 11b - Reserved

66.4.33 DSP0 Reset And Core Trigger Configuration (DSPSS_DSP0_CFG)

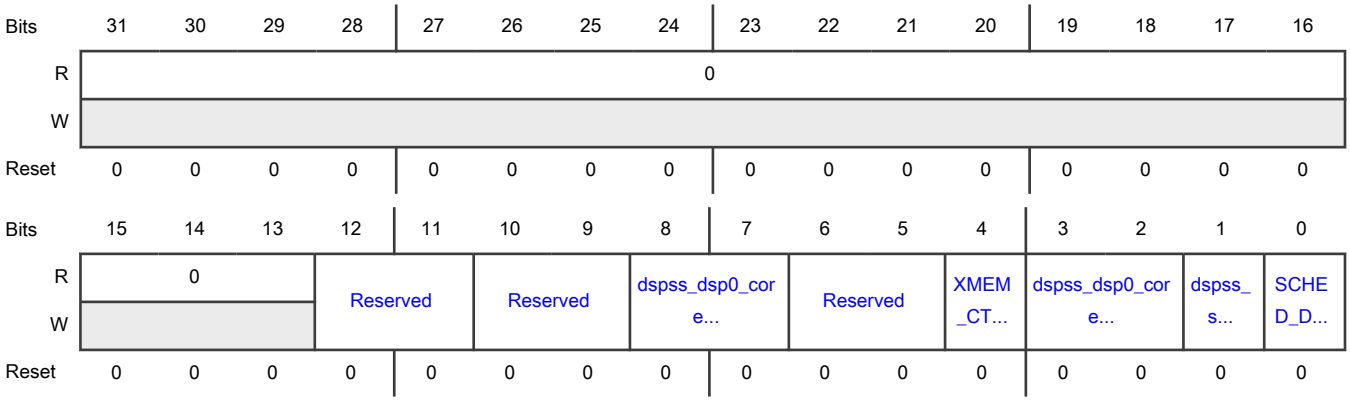
Offset

Register	Offset
DSPSS_DSP0_CFG	C08h

Function

Configures DSP reset and core-trigger options.

Diagram



Fields

Field	Function
31-13 —	Reserved
12-11 —	Reserved
10-9 —	Reserved
8-7 dspss_dsp0_core_trigger_safety_cfg	Core Trigger Configuration Controls whether a trigger to the core occurs, and if it does, what type of trigger it is. 00b,11b - No trigger 01b - Pulse trigger 10b - Level-signal trigger
6-5 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
4 XMEM_CTRL_PRIORITY	XMEM Priority Access Control Specifies what module has priority for XMEM access between SDADC and the Cortex-M7 core with DMA. 0b - Core with DMA 1b - SDADC
3-2 dspss_dsp0_core_trigger_cfg	Core Trigger Configuration Controls whether a trigger to the core occurs, and if it does, what type of trigger it is. 00b,11b - No trigger 01b - Pulse trigger 10b - Level-signal trigger
1 dspss_scheduler_dsp0_reset	Thread Reset Assertion Control Controls the reset assertion and deassertion for the thread inside DSP. When this field is 1 and SCHED_DSP_RST_CTRL_EN is 0, the DSP reset deasserts.
0 SCHED_DSP_RST_CTRL_EN	Reset Assertion Control Controls the reset assertion and deassertion of DSP. 0b - Reset deasserts whenever dspss_scheduler_dsp0_reset is 1. 1b - DSPSS releases the reset when the sample/clock threshold is achieved and scheduling request is sent.

66.4.34 Interrupt Enable (INTERRUPT_ENABLE_REGISTER)

Offset

Register	Offset
INTERRUPT_ENABLE_REGISTER	C10h

Function
Enables various interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved				DMA_READ_BUFFER_XFR_ERR_INTR_EN						DMA_WRITE_BUFFER_XFR_ERR_INTR_EN					
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DMA_READ_BUFFER_ERR_INTR_EN						DMA_WRITE_BUFFER_ERR_INTR_EN						DSP_ERROR_INTR_EN			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27-22 DMA_READ_BUFFER_XFR_ERR_INTR_EN	Interrupt Enable for DMA-READ Buffer XFR Errors Contains bits that enable the interrupts for individual DMAs. Within this field, bit *n* enables the interrupt for DMA *n*. For example, bit 2 enables the interrupt for DMA-2.
21-16 DMA_WRITE_BUFFER_XFR_ERR_INTR_EN	Interrupt Enable for DMA-WRITE Buffer XFR Errors Contains bits that enable the interrupts for individual DMAs. Within this field, bit *n* enables the interrupt for DMA *n*. For example, bit 2 enables the interrupt for DMA-2.
15-10 DMA_READ_BUFFER_ERR_INTR_EN	Interrupt Enable for DMA-READ Buffer Pointer Mismatch Errors Contains bits that enable the interrupts for individual DMAs. Within this field, bit *n* enables the interrupt for DMA *n*. For example, bit 2 enables the interrupt for DMA-2.
9-4 DMA_WRITE_BUFFER_ERR_INTR_EN	Interrupt Enable for DMA-WRITE Buffer Pointer Mismatch Errors Contains bits that enable the interrupts for individual DMAs. Within this field, bit *n* enables the interrupt for DMA *n*. For example, bit 2 enables the interrupt for DMA-2.
3-0 DSP_ERROR_INTR_EN	Interrupt Enable for DSP Errors Contains bits that enable the interrupts for individual threads. Within this field, bit *n* enables the interrupt for thread *n*. For example, bit 2 enables the interrupt for thread 2. The corresponding status field is DSP_TO_CORE_TRIG_ERR_STATUS*n*[DSP_TO_CORE_TRIG_ERR_STATUS].

66.4.35 DSP Trigger to Core (DSPSS_DSP_IO_INTF0)

Offset

Register	Offset
DSPSS_DSP_IO_INTF0	C14h

Function

Works with DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY) to send triggers to the host core.

DSP directly changes the fields in this register to 1 whenever DSP intends to send a trigger to the Cortex-M7 core. The Cortex-M7 core uses a write-1-to-clear operation to return the fields to 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												DSP_TRI...	DSP_TRI...	DSP_TRI...	DSP_TRI...
W													W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved
3 DSP_TRIGGER_CORE_TH3	Trigger for Thread 3
2 DSP_TRIGGER_CORE_TH2	Trigger for Thread 2
1 DSP_TRIGGER_CORE_TH1	Trigger for Thread 1
0	Trigger for Thread 0

Table continues on the next page...

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Field	Function
DSP_TRIGGER_CORE_TH0	

66.4.36 DSP Core Status (CURR_ACTIVE_THRD)

Offset

Register	Offset
CURR_ACTIVE_THRD	C1Ch

Function

Provides various status indicators relevant to the DSP core.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	DSP_COM...	LAST_CTXT_REQ				DSP_THRD_SLEEP_STATUS				Reserved	DSP_INI...	CURR_ACTIVE_THREAD			
W		W1C														
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-15 —	Reserved
14 DSP_COMP_LOW	DSP_COMP_LOW If during the DSPSS operation, stop_ack_n is de-asserted due to any instruction execution or any other reason inside DSP, this field is set. An interrupt for the same is given on trig_err in this case if interrupt is enabled. 0b - DSP is active. 1b - DSP is inactive.
13-10	Last Context Request

Table continues on the next page...

Table continued from the previous page...

Field	Function
LAST_CTXT_REQ	Indicates the last thread for which DSPSS gave a request in Software Scheduler mode. 0001b - Thread 0 0010b - Thread 1 0100b - Thread 2 1000b - Thread 3 All other values are reserved.
9-6 DSP_THRD_SLEEP_STATUS	Thread Sleep State Indicates which threads are in Sleep state. 0001b - Thread 0 0010b - Thread 1 0100b - Thread 2 1000b - Thread 3 All other values are reserved.
5 —	Reserved
4 DSP_INIT_COMP	Initialization Complete Indicates whether DSP completed initialization. This field directly reflects the status signal from the DSP core. 0b - Not complete 1b - Complete
3-0 CURR_ACTIVE_THREAD	Current Context Connected to DSP Execution Pipeline Indicates the current context that DSP is processing or currently available for execution. DSP executes thread 0 by default. Therefore, when DSP is in reset, thread 0 is the current active thread that is connected to the DSP execution pipeline. In that case, this field value is 0001b. **NOTE** When the current thread moves to Sleep state, this does not change the status of this field. For update latency of this field, see the CoolFlux Interface Manual section 9.2. Contact your NXP marketing representative to obtain this manual. 0001b - Thread 0 0010b - Thread 1 0100b - Thread 2 1000b - Thread 3 All other values are reserved.

66.4.37 DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY)

Offset

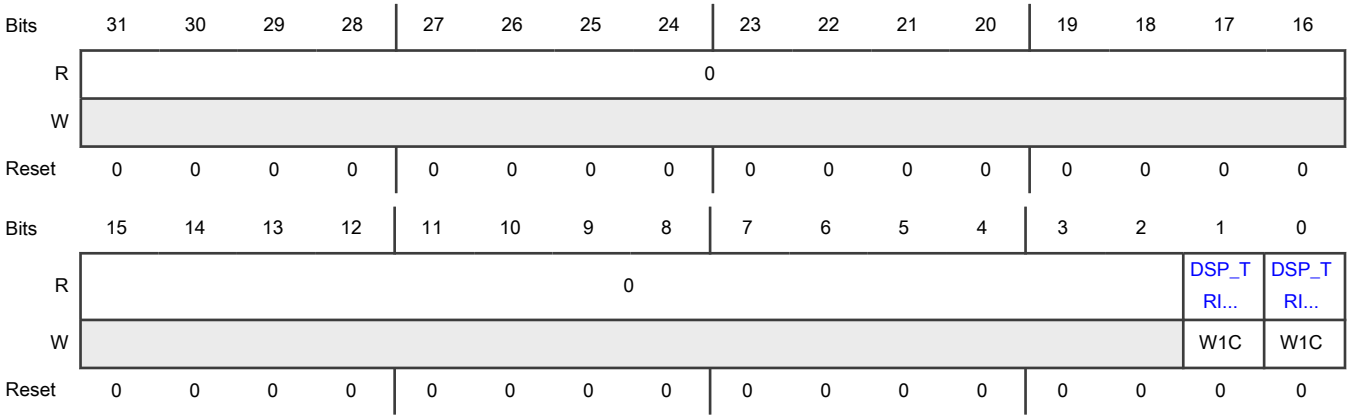
Register	Offset
DSPSS_DSP_CORE_TRIGGER_SAFETY	C24h

Function

Works with DSP Trigger to Core (DSPSS_DSP_IO_INTF0) to send triggers to the host core.

DSP directly changes the fields in this register to 1 whenever DSP intends to send a trigger to the Cortex-M7 core. The Cortex-M7 core uses a write-1-to-clear operation to return the fields to 0.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 DSP_TRIGGER_SAFETY_2	Safety Thread Trigger 1
0 DSP_TRIGGER_SAFETY_1	Safety Thread Trigger 0

66.5 DSPSS_IO register descriptions

This section presents the DSPSS registers that are available to the DSP core. Not all of these are available, or available in the same way, to the Cortex-M7 core; see DSPSS register descriptions.

The DSPSS_IO address interface supports only half-word addressing and the DSP C compiler compiles accordingly.
For example:

- A value of 6h on DSP IOMEM represents the access on LSB half-word of the register with address Ch in the memory map below.
- A value of 7h on IO address bus represents the access on MSB half-word of the register with address Ch in the map.

The following table relates the memory-map address with the software-defined address in the compiled code.

Table 376. Memory-map and DSP software-compiled addresses

Register mnemonic	Software IO address	Memory map address	Half-word location
DSP_CORE_BUF_ADDR0	Eh	1Ch	15:0
DSP_CORE_BUF_ADDR0	Fh	1Ch	31:16
DMA_WRITE_ADDR5	7A0h	F40h	15:0
DMA_WRITE_ADDR5	7A1h	F40h	31:16

66.5.1 DSPSS_IO memory map

dspss_1 base address: 0h

Offset	Register	Width (In bits)	Access	Reset value
Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0)	32	R	0000_0000h
14h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR0)	32	R	0000_0000h
1Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR0)	32	RW	0000_0000h
28h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR0)	32	RW	0000_0000h
2Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR0)	32	RW	0000_0000h
30h	Reference DMA Read Region (DMA_READ_ADDR0)	32	RW	0000_0000h
38h	DMA Error Status (DMA_ERROR_STATUS0)	32	RW	0000_0000h
40h	Reference DMA Write Region (DMA_WRITE_ADDR0)	32	RW	0000_0000h
44h	DMA Current Write Pointer (DMA_CURR_WR_PTR0)	32	RW	0000_0000h
48h	DMA Current Read Pointer (DMA_CURR_RD_PTR0)	32	RW	0000_0000h
50h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS0)	32	RW	0000_0000h
5Ch	Thread Status (DSPSS_DSP_TH_STATUS0)	32	RW	0000_0000h
7Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS0)	32	RW	0000_0000h
80h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS0)	32	RW	0000_0000h
84h	DSP Output Control (DS_GATE_STATUS_REGISTER0)	32	R	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
88h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER0)	32	RW	0000_0000h
8Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP0)	32	RW	0000_0000h
90h	DMA Error Control (DMA_ERROR_CTRL0)	32	R	0000_0000h
94h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0)	32	RW	0000_0400h
30Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH1)	32	R	0000_0000h
314h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR1)	32	R	0000_0000h
31Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR1)	32	RW	0000_0000h
328h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR1)	32	RW	0000_0000h
32Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR1)	32	RW	0000_0000h
330h	Reference DMA Read Region (DMA_READ_ADDR1)	32	RW	0000_0000h
338h	DMA Error Status (DMA_ERROR_STATUS1)	32	RW	0000_0000h
340h	Reference DMA Write Region (DMA_WRITE_ADDR1)	32	RW	0000_0000h
344h	DMA Current Write Pointer (DMA_CURR_WR_PTR1)	32	RW	0000_0000h
348h	DMA Current Read Pointer (DMA_CURR_RD_PTR1)	32	RW	0000_0000h
350h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS1)	32	RW	0000_0000h
35Ch	Thread Status (DSPSS_DSP_TH_STATUS1)	32	RW	0000_0000h
37Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS1)	32	RW	0000_0000h
380h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS1)	32	RW	0000_0000h
384h	DSP Output Control (DS_GATE_STATUS_REGISTER1)	32	R	0000_0000h
388h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER1)	32	RW	0000_0000h
38Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP1)	32	RW	0000_0000h
390h	DMA Error Control (DMA_ERROR_CTRL1)	32	R	0000_0000h
394h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE1)	32	RW	0000_0400h
60Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH2)	32	R	0000_0000h
614h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR2)	32	R	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
61Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR2)	32	RW	0000_0000h
628h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR2)	32	RW	0000_0000h
62Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR2)	32	RW	0000_0000h
630h	Reference DMA Read Region (DMA_READ_ADDR2)	32	RW	0000_0000h
638h	DMA Error Status (DMA_ERROR_STATUS2)	32	RW	0000_0000h
640h	Reference DMA Write Region (DMA_WRITE_ADDR2)	32	RW	0000_0000h
644h	DMA Current Write Pointer (DMA_CURR_WR_PTR2)	32	RW	0000_0000h
648h	DMA Current Read Pointer (DMA_CURR_RD_PTR2)	32	RW	0000_0000h
650h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS2)	32	RW	0000_0000h
65Ch	Thread Status (DSPSS_DSP_TH_STATUS2)	32	RW	0000_0000h
67Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS2)	32	RW	0000_0000h
680h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS2)	32	RW	0000_0000h
684h	DSP Output Control (DS_GATE_STATUS_REGISTER2)	32	R	0000_0000h
688h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER2)	32	RW	0000_0000h
68Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP2)	32	RW	0000_0000h
690h	DMA Error Control (DMA_ERROR_CTRL2)	32	R	0000_0000h
694h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE2)	32	RW	0000_0400h
90Ch	Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3)	32	R	0000_0000h
914h	Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR3)	32	R	0000_0000h
91Ch	Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR3)	32	RW	0000_0000h
928h	Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR3)	32	RW	0000_0000h
92Ch	Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR3)	32	RW	0000_0000h
930h	Reference DMA Read Region (DMA_READ_ADDR3)	32	RW	0000_0000h
938h	DMA Error Status (DMA_ERROR_STATUS3)	32	RW	0000_0000h
940h	Reference DMA Write Region (DMA_WRITE_ADDR3)	32	RW	0000_0000h
944h	DMA Current Write Pointer (DMA_CURR_WR_PTR3)	32	RW	0000_0000h
948h	DMA Current Read Pointer (DMA_CURR_RD_PTR3)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
950h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS3)	32	RW	0000_0000h
95Ch	Thread Status (DSPSS_DSP_TH_STATUS3)	32	RW	0000_0000h
97Ch	DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS3)	32	RW	0000_0000h
980h	DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS3)	32	RW	0000_0000h
984h	DSP Output Control (DS_GATE_STATUS_REGISTER3)	32	R	0000_0000h
988h	DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER3)	32	RW	0000_0000h
98Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP3)	32	RW	0000_0000h
990h	DMA Error Control (DMA_ERROR_CTRL3)	32	R	0000_0000h
994h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE3)	32	RW	0000_0400h
C14h	DSP Trigger to Core (DSPSS_DSP_IO_INTF0)	32	RW	0000_0000h
C24h	>DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY)	32	RW	0000_0000h
C30h	Reference DMA Read Region (DMA_READ_ADDR4)	32	RW	0000_0000h
C38h	DMA Error Status (DMA_ERROR_STATUS4)	32	RW	0000_0000h
C40h	Reference DMA Write Region (DMA_WRITE_ADDR4)	32	RW	0000_0000h
C44h	DMA Current Write Pointer (DMA_CURR_WR_PTR4)	32	RW	0000_0000h
C48h	DMA Current Read Pointer (DMA_CURR_RD_PTR4)	32	RW	0000_0000h
C50h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS4)	32	RW	0000_0000h
C8Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP4)	32	RW	0000_0000h
C90h	DMA Error Control (DMA_ERROR_CTRL4)	32	R	0000_0000h
C94h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE4)	32	RW	0000_0400h
F30h	Reference DMA Read Region (DMA_READ_ADDR5)	32	RW	0000_0000h
F38h	DMA Error Status (DMA_ERROR_STATUS5)	32	RW	0000_0000h
F40h	Reference DMA Write Region (DMA_WRITE_ADDR5)	32	RW	0000_0000h
F44h	DMA Current Write Pointer (DMA_CURR_WR_PTR5)	32	RW	0000_0000h
F48h	DMA Current Read Pointer (DMA_CURR_RD_PTR5)	32	RW	0000_0000h
F50h	DMA Request Status (DSP_TO_DMA_REQUEST_STATUS5)	32	RW	0000_0000h
F8Ch	Stop DMA Request (HW_CTRL_DMA_REQ_STOP5)	32	RW	0000_0000h
F90h	DMA Error Control (DMA_ERROR_CTRL5)	32	R	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
F94h	Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE5)	32	RW	0000_0400h
1200h - 120Ch	Thread Status Info n (DSPSS_DSP_THREAD_INFO0 - DSPSS_DSP_THREAD_INFO3)	32	R	0000_0000h

66.5.2 Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0 - DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3)

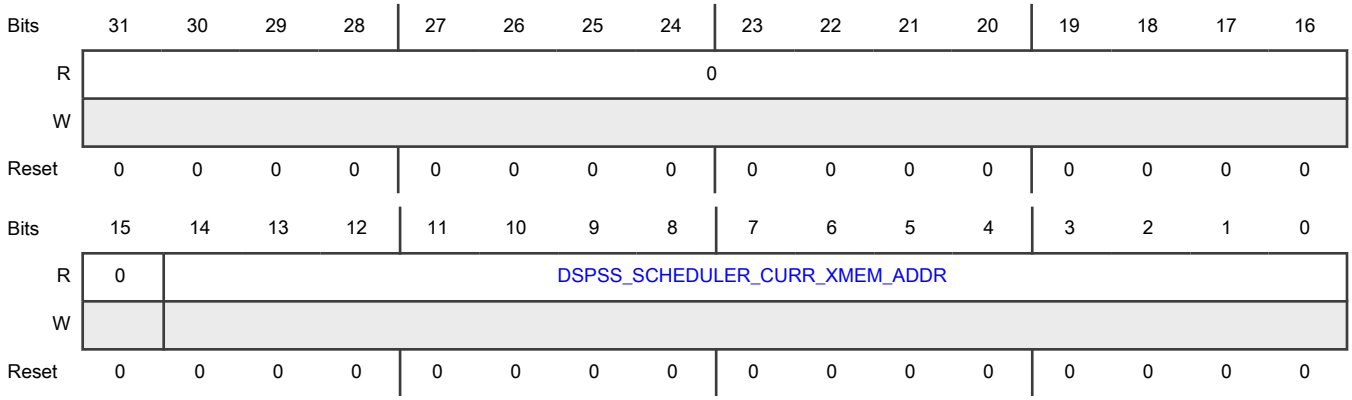
Offset

Register	Offset
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0	Ch
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH1	30Ch
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH2	60Ch
DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3	90Ch

Function

See Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0 - DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3) for the definition of this register.

Diagram



Fields

Field	Function
31-15 —	Reserved
14-0 DSPSS_SCHEDULER_CURR_XMEM_ADDR	Current Write Pointer Location See Current XMEM Write Pointer (DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH0 - DSPSS_SCHEDULER_CURR_XMEM_ADDR_TH3).

66.5.3 Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR0 - DSP_SDADC_CURR_READ_PTR3)

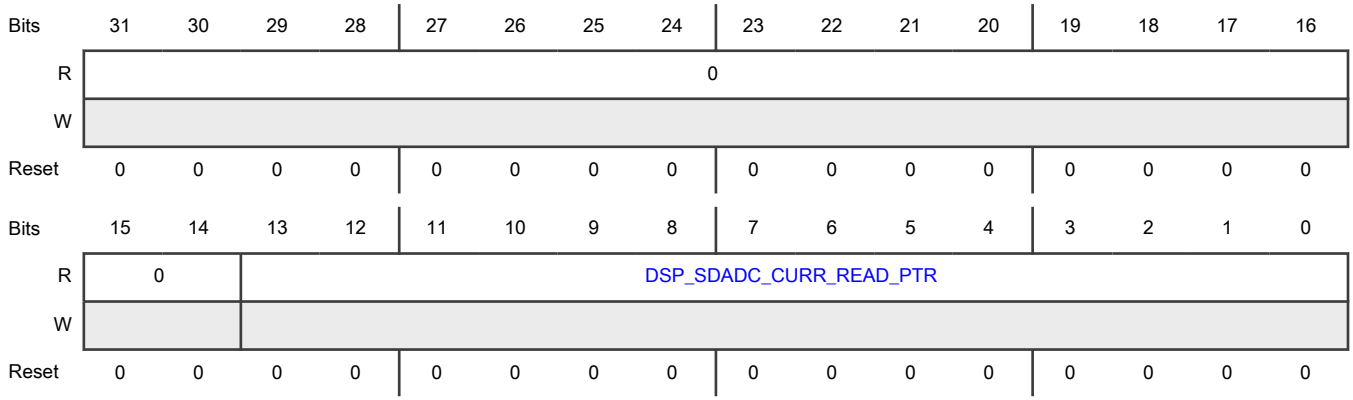
Offset

Register	Offset
DSP_SDADC_CURR_READ_PTR0	14h
DSP_SDADC_CURR_READ_PTR1	314h
DSP_SDADC_CURR_READ_PTR2	614h
DSP_SDADC_CURR_READ_PTR3	914h

Function

See Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR0 - DSP_SDADC_CURR_READ_PTR3) for the definition of this register.

Diagram



Fields

Field	Function
31-14 —	Reserved
13-0 DSP_SDADC_CURR_READ_PTR	Address Pointer See Last Scheduled-Request Address (DSP_SDADC_CURR_READ_PTR0 - DSP_SDADC_CURR_READ_PTR3).

66.5.4 Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR0 - DSP_CORE_BUF_ADDR3)

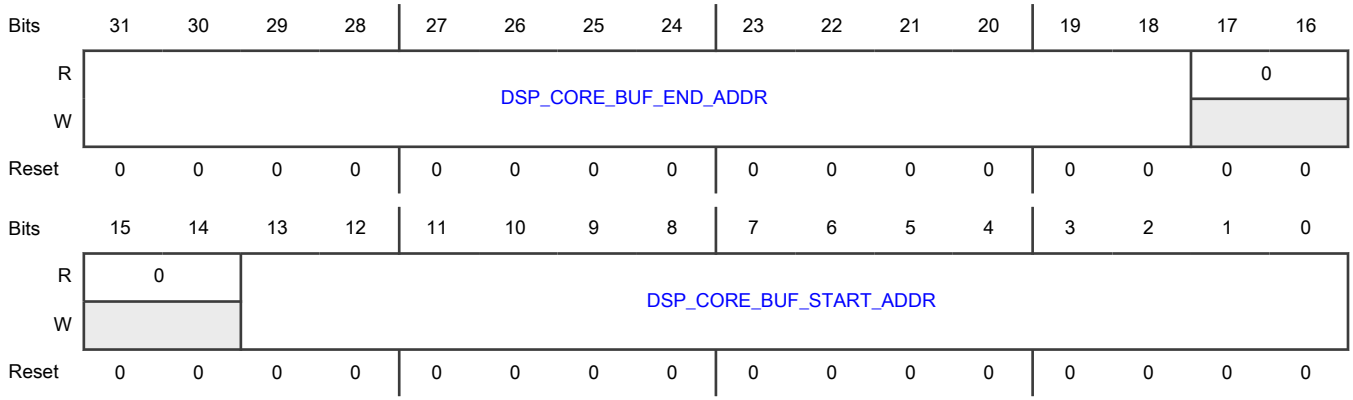
Offset

Register	Offset
DSP_CORE_BUF_ADDR0	1Ch
DSP_CORE_BUF_ADDR1	31Ch
DSP_CORE_BUF_ADDR2	61Ch
DSP_CORE_BUF_ADDR3	91Ch

Function

See Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR0 - DSP_CORE_BUF_ADDR3) for the definition of this register.

Diagram



Fields

Field	Function
31-18 DSP_CORE_BUF_END_ADDR	End Pointer See Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR0 - DSP_CORE_BUF_ADDR3).
17-14 —	Reserved
13-0 DSP_CORE_BUF_START_ADDR	Start Pointer See Start And End Pointers For DSP And Cortex-M7 Core Shared Buffer (DSP_CORE_BUF_ADDR0 - DSP_CORE_BUF_ADDR3).

66.5.5 Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR0 - DSP_CORE_CURR_RD_PTR3)

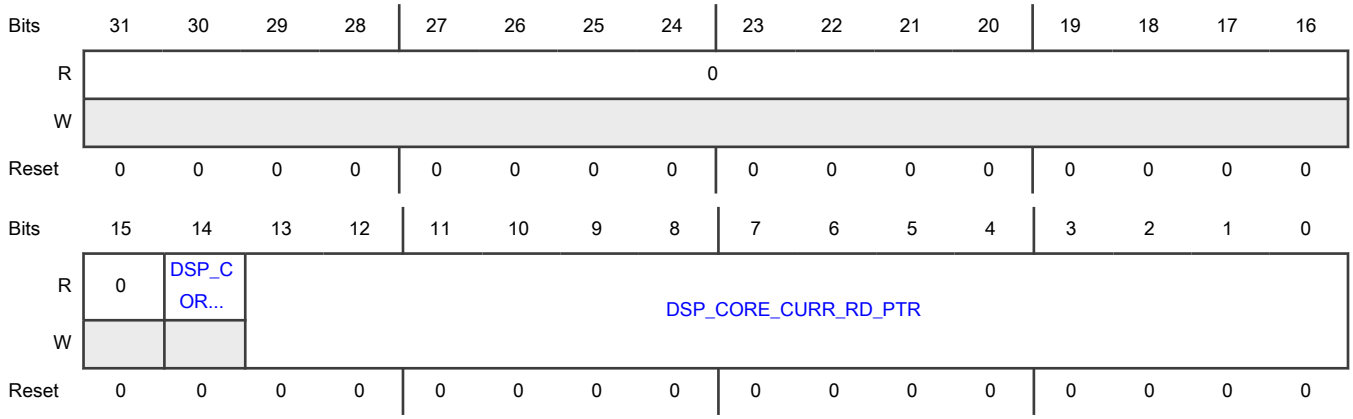
Offset

Register	Offset
DSP_CORE_CURR_RD_PTR0	28h
DSP_CORE_CURR_RD_PTR1	328h
DSP_CORE_CURR_RD_PTR2	628h
DSP_CORE_CURR_RD_PTR3	928h

Function

See Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR0 - DSP_CORE_CURR_RD_PTR3) for the definition of this register.

Diagram



Fields

Field	Function
31-15 —	Reserved
14 DSP_CORE_CURR_RD_PTR_WRAP	Wrap Status See Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR0 - DSP_CORE_CURR_RD_PTR3).
13-0 DSP_CORE_CURR_RD_PTR	Read Pointer See Read Pointer In DSP Buffer (DSP_CORE_CURR_RD_PTR0 - DSP_CORE_CURR_RD_PTR3).

66.5.6 Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR0 - DSP_CORE_CURR_WR_PTR3)

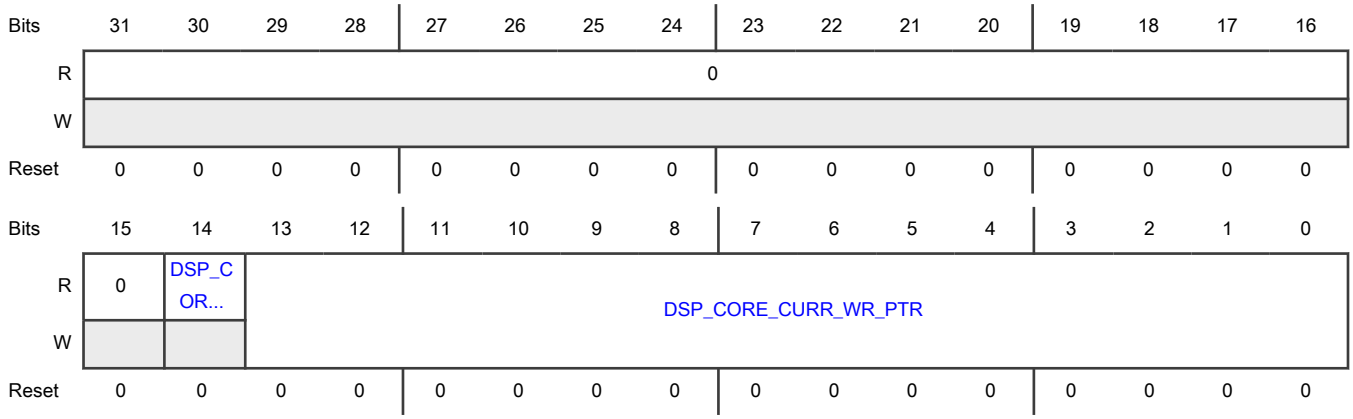
Offset

Register	Offset
DSP_CORE_CURR_WR_PTR0	2Ch
DSP_CORE_CURR_WR_PTR1	32Ch
DSP_CORE_CURR_WR_PTR2	62Ch
DSP_CORE_CURR_WR_PTR3	92Ch

Function

See Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR0 - DSP_CORE_CURR_WR_PTR3) for the definition of this register.

Diagram



Fields

Field	Function
31-15 —	Reserved
14 DSP_CORE_CURR_WR_PTR_WRAP	Wrap Status See Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR0 - DSP_CORE_CURR_WR_PTR3).
13-0 DSP_CORE_CURR_WR_PTR	Write Pointer See Write Pointer In DSP Buffer (DSP_CORE_CURR_WR_PTR0 - DSP_CORE_CURR_WR_PTR3).

66.5.7 Reference DMA Read Region (DMA_READ_ADDR0 - DMA_READ_ADDR5)

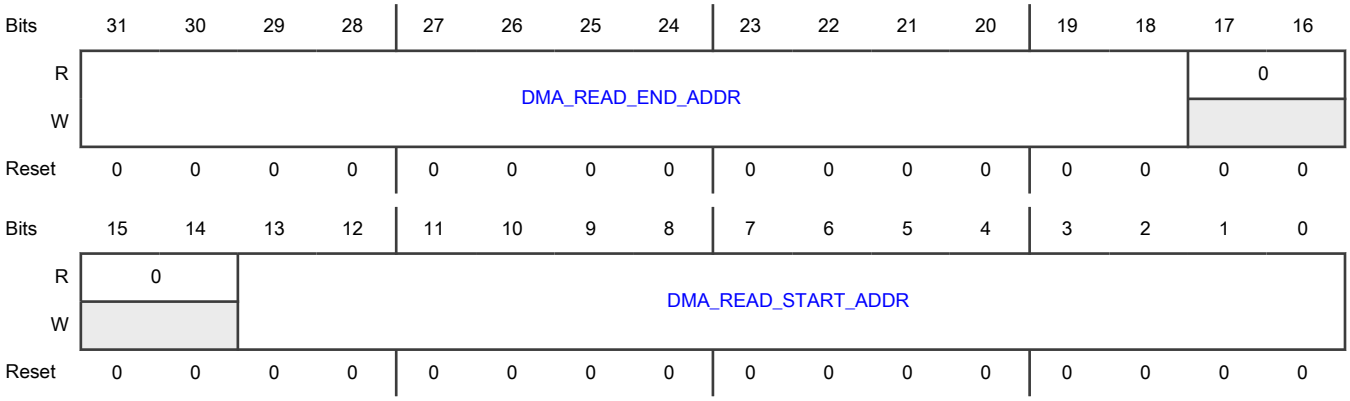
Offset

Register	Offset
DMA_READ_ADDR0	30h
DMA_READ_ADDR1	330h
DMA_READ_ADDR2	630h
DMA_READ_ADDR3	930h
DMA_READ_ADDR4	C30h
DMA_READ_ADDR5	F30h

Function

See Reference DMA Read Region (DMA_READ_ADDR0 - DMA_READ_ADDR5) for the definition of this register.

Diagram



Fields

Field	Function
31-18 DMA_READ_END_ADDR	End Address See Reference DMA Read Region (DMA_READ_ADDR0 - DMA_READ_ADDR5).
17-14 —	Reserved
13-0 DMA_READ_START_ADDR	Start Address See Reference DMA Read Region (DMA_READ_ADDR0 - DMA_READ_ADDR5).

66.5.8 DMA Error Status (DMA_ERROR_STATUS0 - DMA_ERROR_STATUS5)

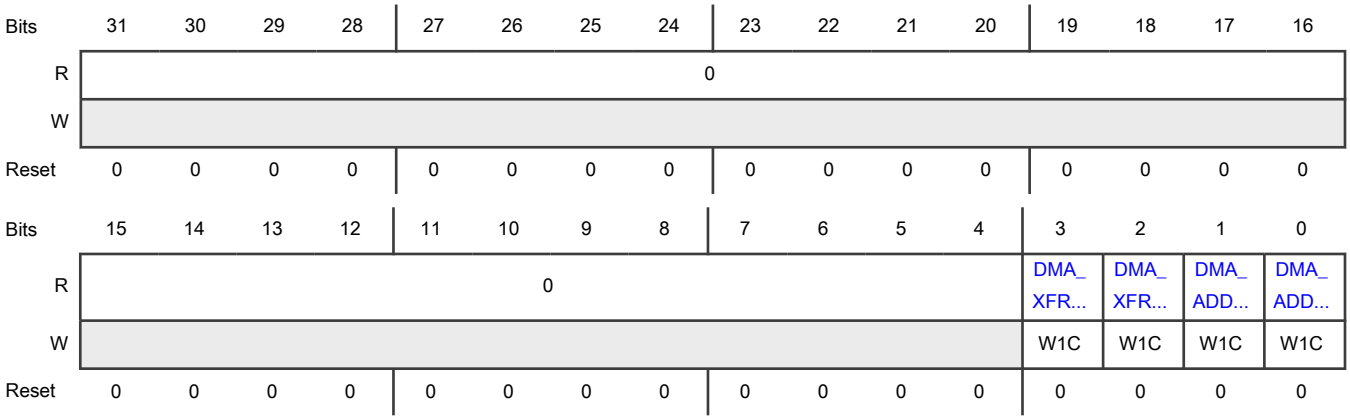
Offset

Register	Offset
DMA_ERROR_STATUS0	38h
DMA_ERROR_STATUS1	338h
DMA_ERROR_STATUS2	638h
DMA_ERROR_STATUS3	938h
DMA_ERROR_STATUS4	C38h
DMA_ERROR_STATUS5	F38h

Function

See DMA Error Status (DMA_ERROR_STATUS0 - DMA_ERROR_STATUS5) for the definition of this register.

Diagram



Fields

Field	Function
31-4 —	Reserved
3 DMA_XFR_ERR_READ	w1c by M7 core/DSP. See DMA Error Status (DMA_ERROR_STATUS0 - DMA_ERROR_STATUS5).
2 DMA_XFR_ERR_WRITE	w1c by M7 core/DSP. See DMA Error Status (DMA_ERROR_STATUS0 - DMA_ERROR_STATUS5).
1 DMA_ADDR_MISMATCH_RD_BUFFER	w1c by M7 core/DSP. See DMA Error Status (DMA_ERROR_STATUS0 - DMA_ERROR_STATUS5).
0 DMA_ADDR_MISMATCH_WR_BUFFER	Address Mismatch Write Flag See DMA Error Status (DMA_ERROR_STATUS0 - DMA_ERROR_STATUS5).

66.5.9 Reference DMA Write Region (DMA_WRITE_ADDR0 - DMA_WRITE_ADDR5)

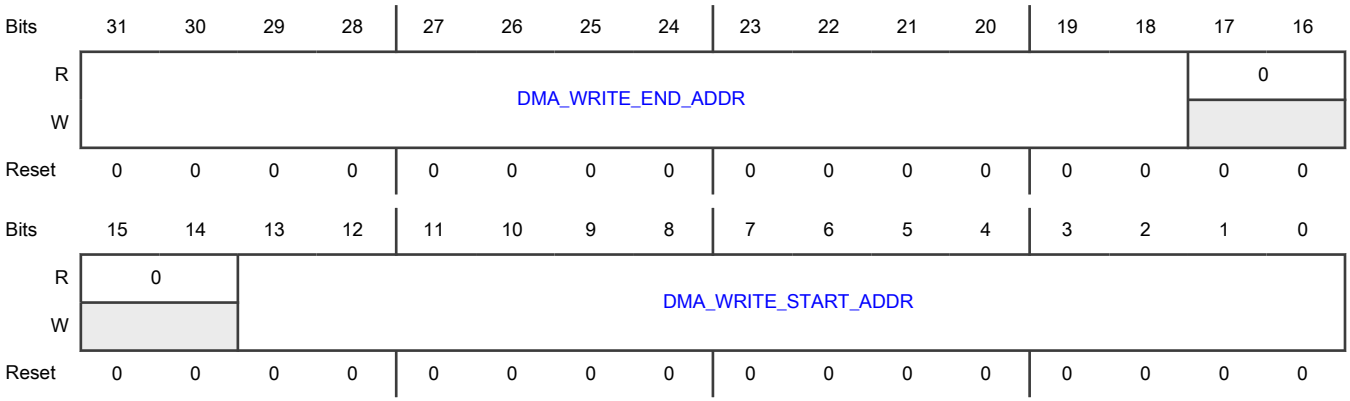
Offset

Register	Offset
DMA_WRITE_ADDR0	40h
DMA_WRITE_ADDR1	340h
DMA_WRITE_ADDR2	640h
DMA_WRITE_ADDR3	940h
DMA_WRITE_ADDR4	C40h
DMA_WRITE_ADDR5	F40h

Function

See Reference DMA Write Region (DMA_WRITE_ADDR0 - DMA_WRITE_ADDR5) for the definition of this register.

Diagram



Fields

Field	Function
31-18 DMA_WRITE_END_ADDR	End Address See Reference DMA Write Region (DMA_WRITE_ADDR0 - DMA_WRITE_ADDR5).
17-14 —	Reserved
13-0 DMA_WRITE_START_ADDR	Start Address See Reference DMA Write Region (DMA_WRITE_ADDR0 - DMA_WRITE_ADDR5).

66.5.10 DMA Current Write Pointer (DMA_CURR_WR_PTR0 - DMA_CURR_WR_PTR5)

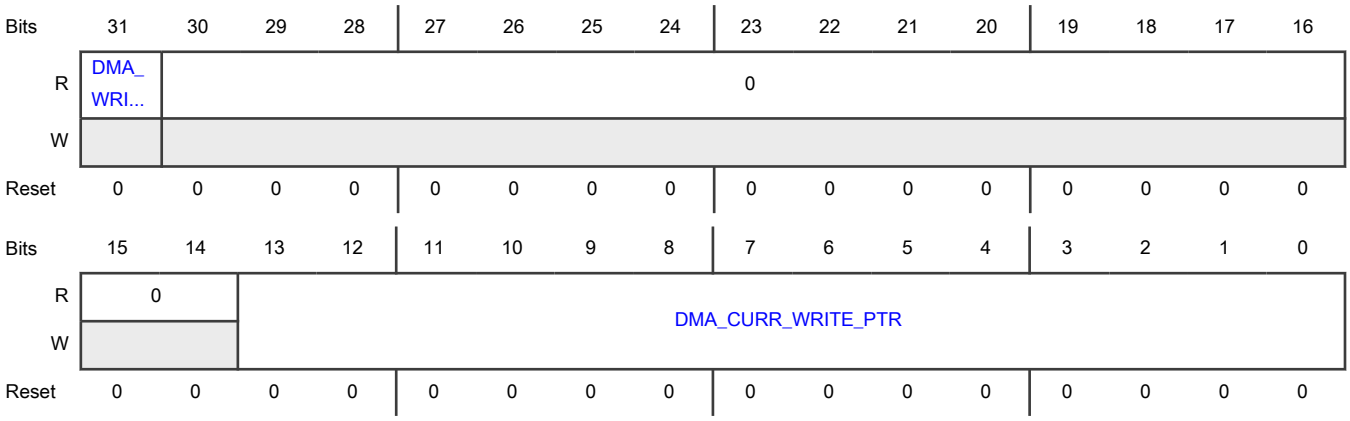
Offset

Register	Offset
DMA_CURR_WR_PTR0	44h
DMA_CURR_WR_PTR1	344h
DMA_CURR_WR_PTR2	644h
DMA_CURR_WR_PTR3	944h
DMA_CURR_WR_PTR4	C44h
DMA_CURR_WR_PTR5	F44h

Function

See DMA Current Write Pointer (DMA_CURR_WR_PTR0 - DMA_CURR_WR_PTR5) for the definition of this register.

Diagram



Fields

Field	Function
31 DMA_WRITE_PTR_WRAP	DMA-WRITE Buffer Wrap See DMA Current Write Pointer (DMA_CURR_WR_PTR0 - DMA_CURR_WR_PTR5).
30-14 —	Reserved
13-0 DMA_CURR_WRITE_PTR	Write Pointer See DMA Current Write Pointer (DMA_CURR_WR_PTR0 - DMA_CURR_WR_PTR5).

66.5.11 DMA Current Read Pointer (DMA_CURR_RD_PTR0 - DMA_CURR_RD_PTR5)

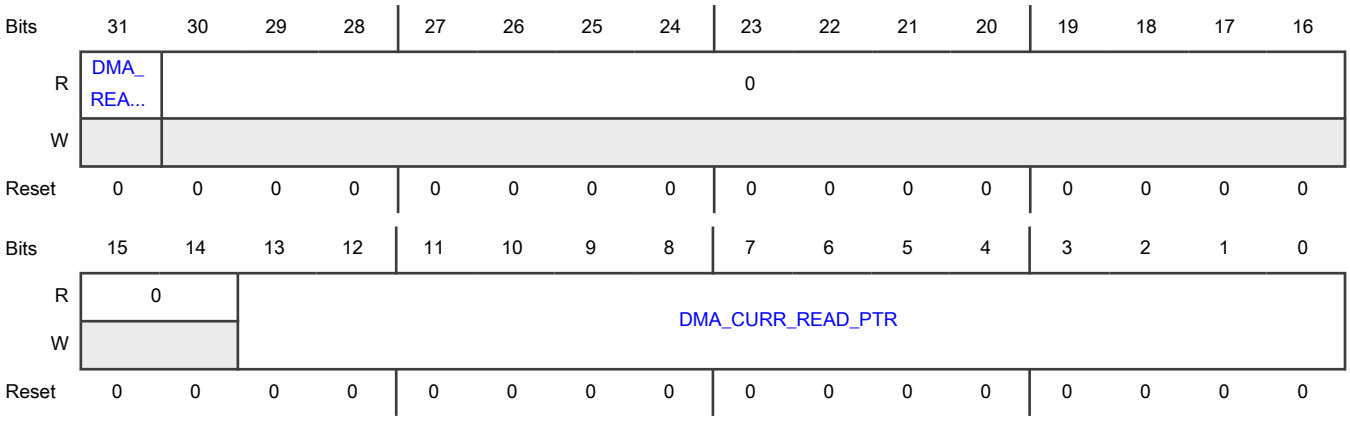
Offset

Register	Offset
DMA_CURR_RD_PTR0	48h
DMA_CURR_RD_PTR1	348h
DMA_CURR_RD_PTR2	648h
DMA_CURR_RD_PTR3	948h
DMA_CURR_RD_PTR4	C48h
DMA_CURR_RD_PTR5	F48h

Function

See DMA Current Read Pointer (DMA_CURR_RD_PTR0 - DMA_CURR_RD_PTR5) for the definition of this register.

Diagram



Fields

Field	Function
31 DMA_READ_PTR_WRAP	DMA-READ Buffer Wrap See DMA Current Read Pointer (DMA_CURR_RD_PTR0 - DMA_CURR_RD_PTR5).
30-14 —	Reserved
13-0 DMA_CURR_READ_PTR	Read Pointer See DMA Current Read Pointer (DMA_CURR_RD_PTR0 - DMA_CURR_RD_PTR5).

66.5.12 DMA Request Status (DSP_TO_DMA_REQUEST_STATUS0 - DSP_TO_DMA_REQUEST_STATUS5)

Offset

Register	Offset
DSP_TO_DMA_REQUEST_STATUS0	50h
DSP_TO_DMA_REQUEST_STATUS1	350h
DSP_TO_DMA_REQUEST_STATUS2	650h
DSP_TO_DMA_REQUEST_STATUS3	950h
DSP_TO_DMA_REQUEST_STATUS4	C50h
DSP_TO_DMA_REQUEST_STATUS5	F50h

Function

See DMA Request Status (DSP_TO_DMA_REQUEST_STATUS0 - DSP_TO_DMA_REQUEST_STATUS5) for the definition of this register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0														DMA_TO_...	DSP_TO_...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-2 —	Reserved
1	DMA Acknowledgment Status

Table continues on the next page...

Table continued from the previous page...

Field	Function
DMA_TO_DSP_ACK_STATUS	See DMA Request Status (DSP_TO_DMA_REQUEST_STATUS0 - DSP_TO_DMA_REQUEST_STATUS5).
0 DSP_TO_DMA_REQUEST_STATUS	DMA Request Status See DMA Request Status (DSP_TO_DMA_REQUEST_STATUS0 - DSP_TO_DMA_REQUEST_STATUS5).

66.5.13 Thread Status (DSPSS_DSP_TH_STATUS0 - DSPSS_DSP_TH_STATUS3)

Offset

Register	Offset
DSPSS_DSP_TH_STATUS0	5Ch
DSPSS_DSP_TH_STATUS1	35Ch
DSPSS_DSP_TH_STATUS2	65Ch
DSPSS_DSP_TH_STATUS3	95Ch

Function

Indicates the status of DSP0 for thread *n*.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												Reserved	Reserved	Reserved	dspss_t...
W													W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved
3 —	Reserved
2 —	Reserved
1 —	Reserved
0 dspss_th_suspended	Thread Status Indicates whether the thread is suspended or not. 0b - Not suspended 1b - Suspended

66.5.14 DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS0 - DSP_CORE_BUFFER_STATUS3)

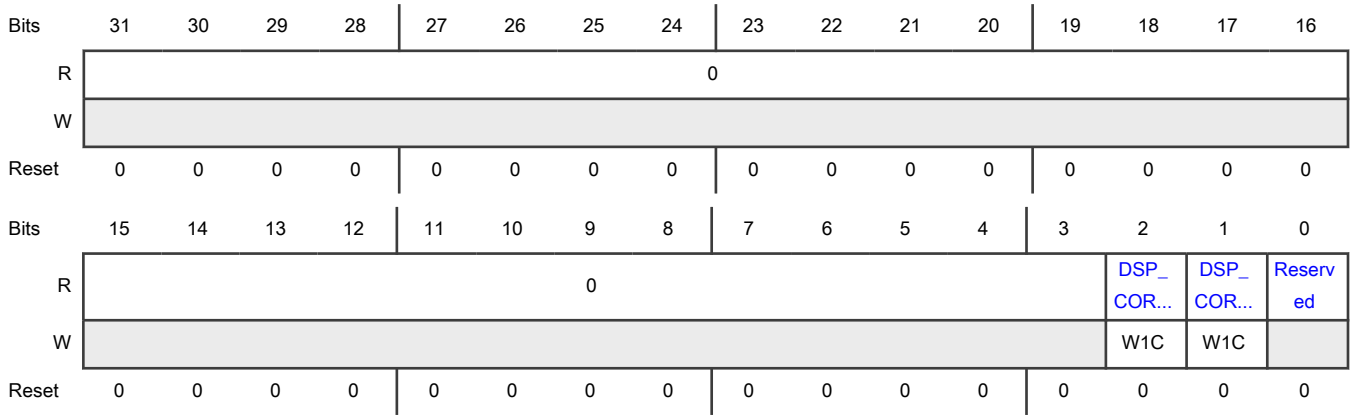
Offset

Register	Offset
DSP_CORE_BUFFER_STATUS0	7Ch
DSP_CORE_BUFFER_STATUS1	37Ch
DSP_CORE_BUFFER_STATUS2	67Ch
DSP_CORE_BUFFER_STATUS3	97Ch

Function

See DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS0 - DSP_CORE_BUFFER_STATUS3) for the definition of this register.

Diagram



Fields

Field	Function
31-3 —	Reserved
2 DSP_CORE_BUFFER_UNDF	Buffer Underflow Flag See DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS0 - DSP_CORE_BUFFER_STATUS3).
1 DSP_CORE_BUFFER_OVF	Buffer Overflow Flag See DSP Core Buffer Status (DSP_CORE_BUFFER_STATUS0 - DSP_CORE_BUFFER_STATUS3).
0 —	Reserved

66.5.15 DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS0 - DSP_TO_CORE_TRIG_ERR_STATUS3)

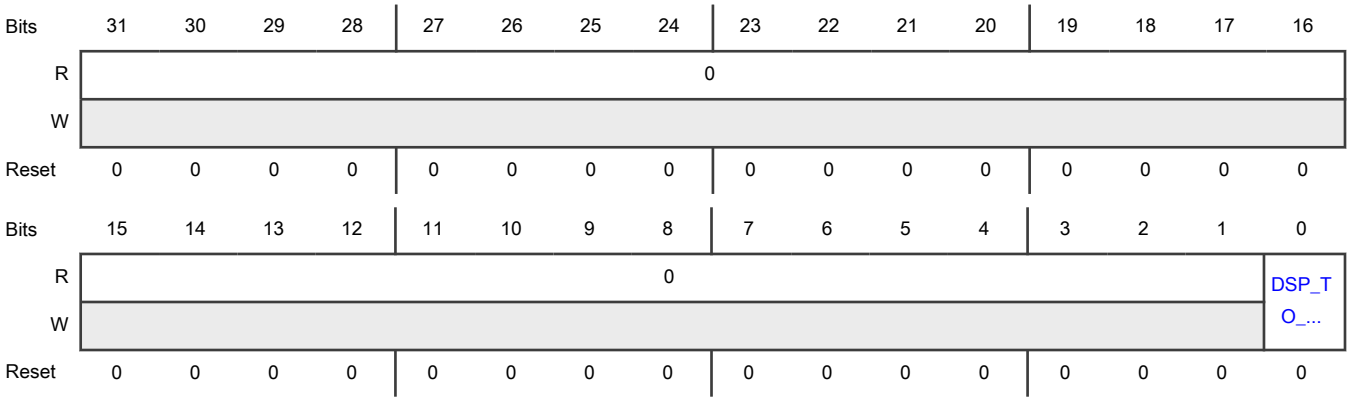
Offset

Register	Offset
DSP_TO_CORE_TRIG_ERR_STATUS0	80h
DSP_TO_CORE_TRIG_ERR_STATUS1	380h
DSP_TO_CORE_TRIG_ERR_STATUS2	680h
DSP_TO_CORE_TRIG_ERR_STATUS3	980h

Function

See DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS0 - DSP_TO_CORE_TRIG_ERR_STATUS3) for the definition of this register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 DSP_TO_CORE_TRIG_ERR_STATUS	Error Status See DSP To Cortex-M7 Core Error Trigger (DSP_TO_CORE_TRIG_ERR_STATUS0 - DSP_TO_CORE_TRIG_ERR_STATUS3).

66.5.16 DSP Output Control (DS_GATE_STATUS_REGISTER0 - DS_GATE_STATUS_REGISTER3)

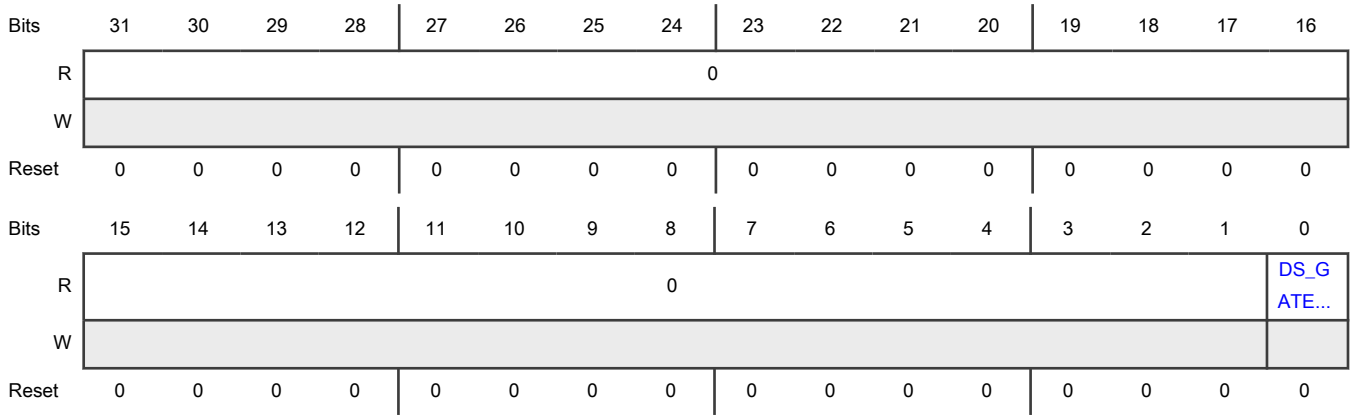
Offset

Register	Offset
DS_GATE_STATUS_REGISTER0	84h
DS_GATE_STATUS_REGISTER1	384h
DS_GATE_STATUS_REGISTER2	684h
DS_GATE_STATUS_REGISTER3	984h

Function

See DSP Output Control (DS_GATE_STATUS_REGISTER0 - DS_GATE_STATUS_REGISTER3) for the definition of this register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 DS_GATE_STATUS_REGISTER	RO by M7 core/DSP. See DSP Output Control (DS_GATE_STATUS_REGISTER0 - DS_GATE_STATUS_REGISTER3).

66.5.17 DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER0 - DS_GATE_TRIGMUX_REGISTER3)

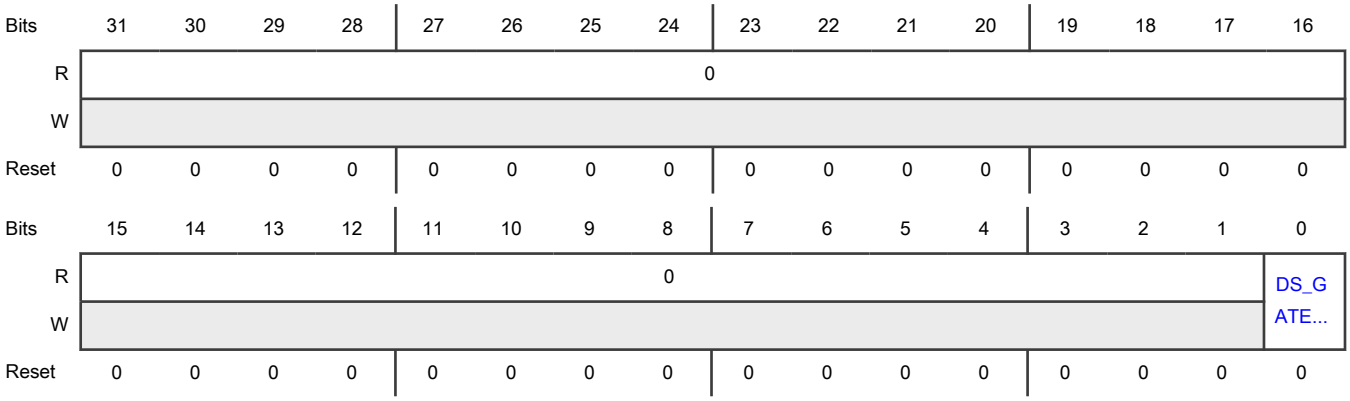
Offset

Register	Offset
DS_GATE_TRIGMUX_REGISTER0	88h
DS_GATE_TRIGMUX_REGISTER1	388h
DS_GATE_TRIGMUX_REGISTER2	688h
DS_GATE_TRIGMUX_REGISTER3	988h

Function

See DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER0 - DS_GATE_TRIGMUX_REGISTER3) for the definition of this register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 DS_GATE_TRIGMUX_TRIGGER	Trigger To TRIGMUX See DSP Trigger To TRIGMUX (DS_GATE_TRIGMUX_REGISTER0 - DS_GATE_TRIGMUX_REGISTER3).

66.5.18 Stop DMA Request (HW_CTRL_DMA_REQ_STOP0 - HW_CTRL_DMA_REQ_STOP5)

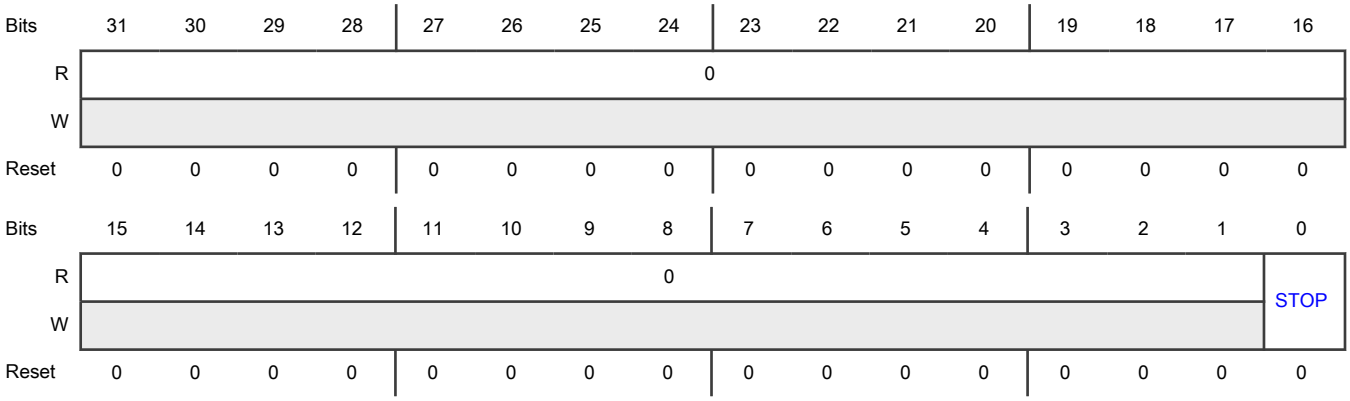
Offset

Register	Offset
HW_CTRL_DMA_REQ_STOP0	8Ch
HW_CTRL_DMA_REQ_STOP1	38Ch
HW_CTRL_DMA_REQ_STOP2	68Ch
HW_CTRL_DMA_REQ_STOP3	98Ch
HW_CTRL_DMA_REQ_STOP4	C8Ch
HW_CTRL_DMA_REQ_STOP5	F8Ch

Function

See Stop DMA Request (HW_CTRL_DMA_REQ_STOP0 - HW_CTRL_DMA_REQ_STOP5) for the definition of this register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 STOP	Stop Request See Stop DMA Request (HW_CTRL_DMA_REQ_STOP0 - HW_CTRL_DMA_REQ_STOP5).

66.5.19 DMA Error Control (DMA_ERROR_CTRL0 - DMA_ERROR_CTRL5)

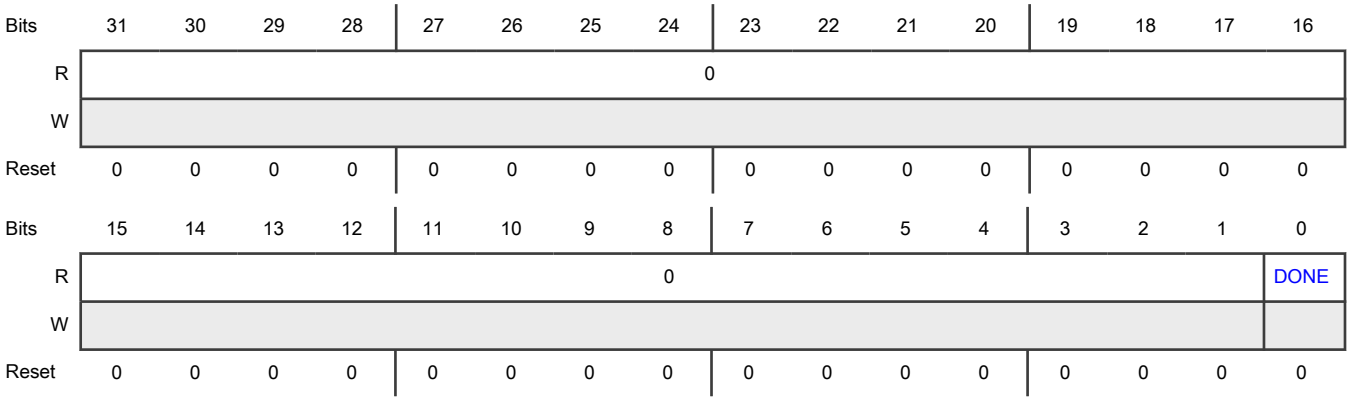
Offset

Register	Offset
DMA_ERROR_CTRL0	90h
DMA_ERROR_CTRL1	390h
DMA_ERROR_CTRL2	690h
DMA_ERROR_CTRL3	990h
DMA_ERROR_CTRL4	C90h
DMA_ERROR_CTRL5	F90h

Function

See DMA Error Control (DMA_ERROR_CTRL0 - DMA_ERROR_CTRL5) for the definition of this register.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 DONE	Dummy Done See DMA Error Control (DMA_ERROR_CTRL0 - DMA_ERROR_CTRL5).

66.5.20 Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0 - HW_CTRL_DMA_REQ_RESPONSE5)

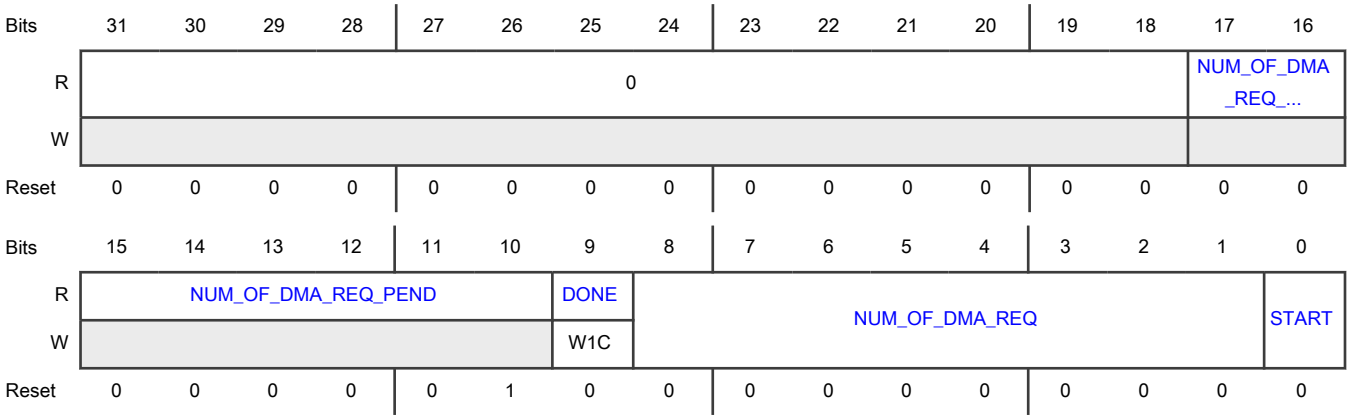
Offset

Register	Offset
HW_CTRL_DMA_REQ_RESPONSE0	94h
HW_CTRL_DMA_REQ_RESPONSE1	394h
HW_CTRL_DMA_REQ_RESPONSE2	694h
HW_CTRL_DMA_REQ_RESPONSE3	994h
HW_CTRL_DMA_REQ_RESPONSE4	C94h
HW_CTRL_DMA_REQ_RESPONSE5	F94h

Function

See Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0 - HW_CTRL_DMA_REQ_RESPONSE5) for the definition of this register.

Diagram



Fields

Field	Function
31-18 —	Reserved
17-10 NUM_OF_DMA_REQ_PEND	Number of Pending DMA Requests See Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0 - HW_CTRL_DMA_REQ_RESPONSE5).
9 DONE	Done Generating DMA Requests See Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0 - HW_CTRL_DMA_REQ_RESPONSE5).
8-1 NUM_OF_DMA_REQ	Number of DMA Requests See Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0 - HW_CTRL_DMA_REQ_RESPONSE5).
0 START	Start Request See Hardware Control Handling for DMA Request And Response (HW_CTRL_DMA_REQ_RESPONSE0 - HW_CTRL_DMA_REQ_RESPONSE5).

66.5.21 DSP Trigger to Core (DSPSS_DSP_IO_INTF0)

Offset

Register	Offset
DSPSS_DSP_IO_INTF0	C14h

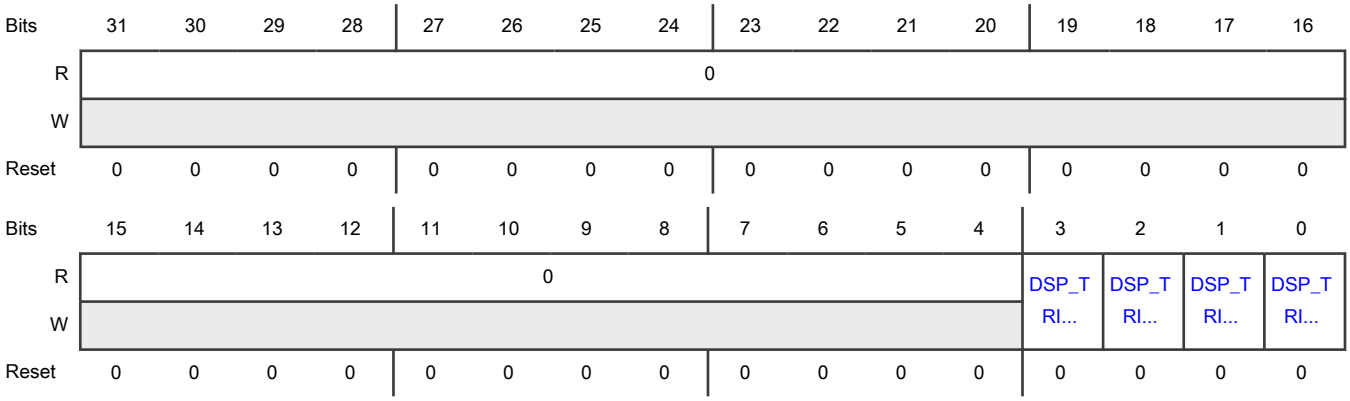
Function

See DSP Trigger to Core (DSPSS_DSP_IO_INTF0) for the definition of this register.

NOTE

NXP recommends not using DSP to write 0 to the fields of this register. This is because only the Cortex-M7 core can return the fields to 0.

Diagram



Fields

Field	Function
31-4 —	Reserved
3 DSP_TRIGGER_CORE_TH3	Trigger for Thread 3 See DSP Trigger to Core (DSPSS_DSP_IO_INTF0).
2 DSP_TRIGGER_CORE_TH2	Trigger for Thread 2 See DSP Trigger to Core (DSPSS_DSP_IO_INTF0).
1 DSP_TRIGGER_CORE_TH1	Trigger for Thread 1 See DSP Trigger to Core (DSPSS_DSP_IO_INTF0).
0 DSP_TRIGGER_CORE_TH0	Trigger for Thread 0 See DSP Trigger to Core (DSPSS_DSP_IO_INTF0).

66.5.22 >DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY)

Offset

Register	Offset
DSPSS_DSP_CORE_TRIGGER_SAFETY	C24h

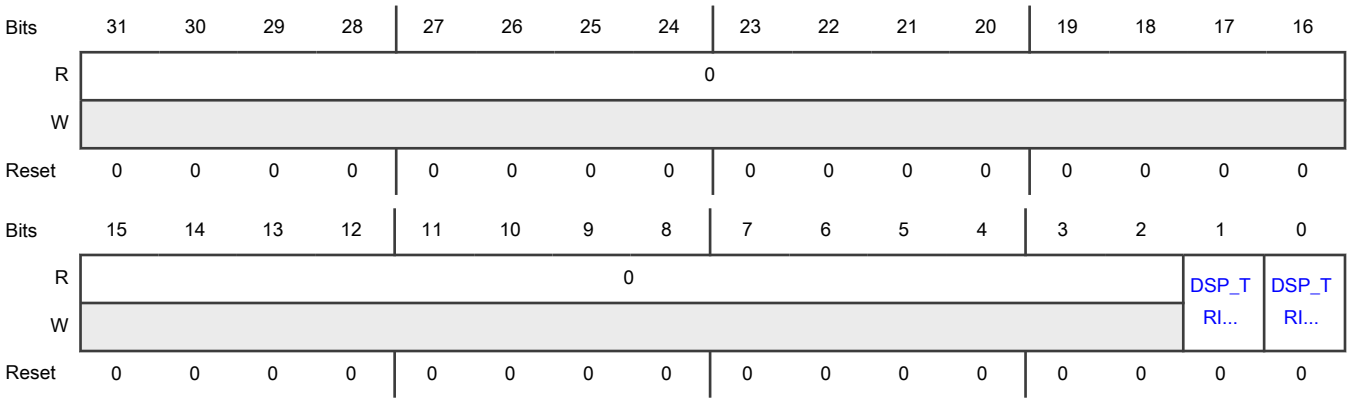
Function

See DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY) for the definition of this register.

NOTE

NXP recommends not using DSP to write 0 to the fields of this register. This is because only the Cortex-M7 core can return the fields to 0.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 DSP_TRIGGER_SAFETY_2	Safety Thread Trigger 1 See DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY).
0 DSP_TRIGGER_SAFETY_1	Safety Thread Trigger 0 See DSP Safety Trigger to Core (DSPSS_DSP_CORE_TRIGGER_SAFETY).

66.5.23 Thread Status Info n (DSPSS_DSP_THREAD_INFO0 - DSPSS_DSP_THREAD_INFO3)

Offset

Register	Offset
DSPSS_DSP_THREAD_INFO0	1200h
DSPSS_DSP_THREAD_INFO1	1204h

Table continues on the next page...

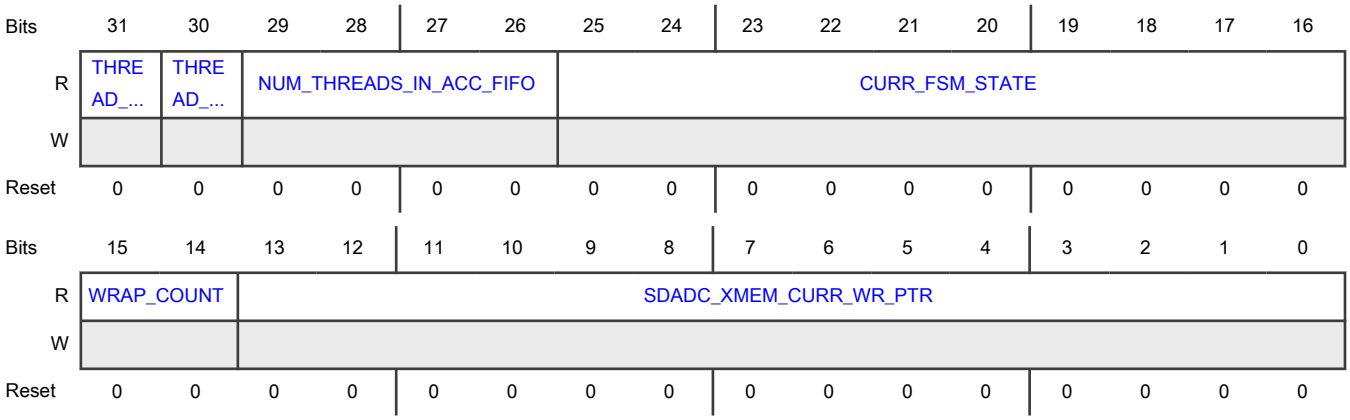
Table continued from the previous page...

Register	Offset
DSPSS_DSP_THREAD_INFO2	1208h
DSPSS_DSP_THREAD_INFO3	120Ch

Function

Indicates the status of different parameters pertaining to ongoing threads in the hardware scheduler.

Diagram



Fields

Field	Function
31 THREAD_ACC_FIFO_OVF	Accumulator FIFO Overflow Indicates whether the thread accumulator FIFO has overflowed. 0b - No overflow 1b - Overflow
30 THREAD_ACC_FIFO_FULL	Accumulator FIFO Full Indicates whether the thread accumulator FIFO is full. 0b - Not full 1b - Full
29-26 NUM_THREADS_IN_ACC_FIFO	Number of Threads In Accumulator FIFO Indicates the number of threads that are currently waiting to be scheduled in the thread accumulator FIFO.
25-16	Hardware Scheduler Current FSM State

Table continues on the next page...

Table continued from the previous page...

Field	Function
CURR_FSM_STATE	00_0000_0001b - IDLE state. Nothing happens in this state. This is the scheduler's default state after reset. 00_0000_0010b - CLOCK_MODE state. If Clock Threshold mode is active, the scheduler waits in this state for a request to be scheduled. 00_0000_0100b - SAMPLE_MODE state. If Sample Threshold mode is active, the scheduler waits in this state for a request to be scheduled. 00_0000_1000b - REQ_TO_DSP state. A CTXT request to DSP is given. 00_0001_0000b - ACK_FROM_DSP state. The scheduler waits for the current active thread to change to last requested context. 00_0010_0000b - DSP_SLEEP_WAIT state: The scheduler waits in this state until the DSP acknowledges the Sleep instruction. 00_0100_0000b - SOFTWARE_SCHD_MODE state. If Software mode is active, the scheduler stays in this state until you or DSPSS assert a suspend request. When the suspension completes, the scheduler returns to this state again. 00_1000_0000b - WAIT_SUSPEND_CURR_THRD state. The scheduler enters this state when the thread suspension request asserts, and remains in this state until it receives a suspend acknowledgment from DSP. 01_0000_0000b - SUSPEND_CURR_THRD state. The scheduler asserts a suspend request to DSP.
15-14 WRAP_COUNT	Wrap Count Indicates the wrap count in XMEM. Saturated after three.
13-0 SDADC_XMEM_CURR_WR_PTR	Current Write Pointer Indicates the current write pointer of SDADC data in XMEM.

66.6 Glossary

Table 377. Glossary

Term	Meaning
ADDR	Address
CRC	Cyclic redundancy check
DSP	Digital signal processor; a submodule of DSPSS
ECC	Error correcting code
EN	Enable
FW	Firmware
INIT	Initial

Table continues on the next page...

Table 377. Glossary (continued)

Term	Meaning
PC	Program counter
PMEM	Program memory
TH	Thread
XMEM	Data memory

Chapter 67
Enhanced Time Processing Unit (eTPU)

67.1 Chip-specific eTPU information

67.1.1 Device-specific features

- Single instance in dual engine configuration, 2x32 channels[6]
- 32KB SCM, 7 bit ECC
  - eTPU generates bus faults when accessing the reserved memory slots of SCM.
- 8KB SDM, 20 bit ECC (20 bit ECC to support byte access ECC).
- eTPU Supports NEXUS Class 3 Debug and chip supports AMBA Trace Bus (ATB), which is an Arm debug protocol. So, there is NEXUS to ATB Converter in between eTPU and DEBUG Trace.
- For eTPU triggers details, see the TRGMUX connectivity file attached to this document.
- Engine 1 and Engine 2 STAC registers information

Table 378. Engine 1 and Engine 2 register information

Engine	Timebase	Server ID
1	TCR1	0
1	TCR2	2
2	TCR1	1
2	TCR2	3

NOTE

Since reaction channel is not implemented hence shared subsystem area feature is not available in S32K396.

NOTE

- Only one instance of eTPU is supported in S32K396.
- eTPU is not supported in S32K37.

NOTE

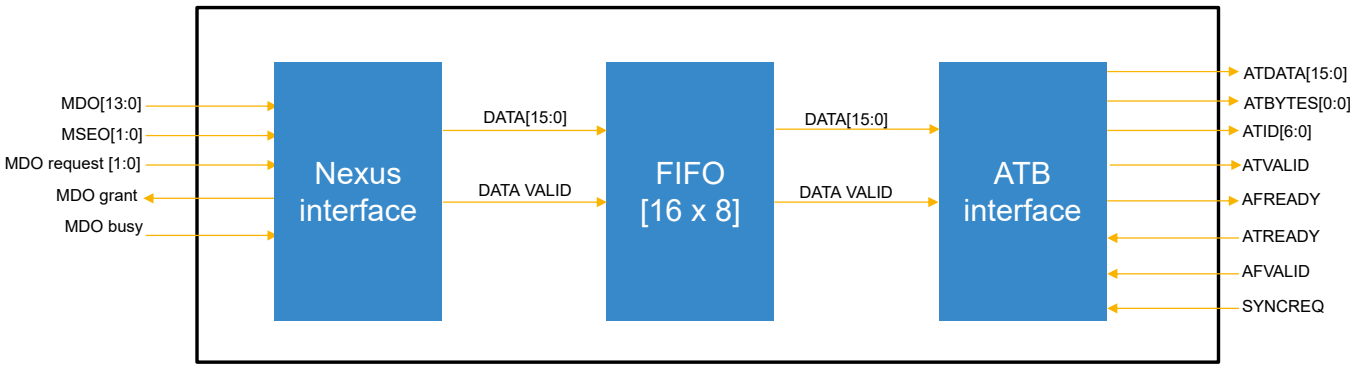
The interaction of the eTPU with other peripherals is detailed in the PCMC Block diagram. The eTPU is connected to TRGMUX through etp_odis.

NOTE

Unaligned access is not supported.

[6] 16-31 channels are not supported in S32K36x.

67.1.2 Nexus to ATB interface converter



NOTE

eTPU supports NEXUS interface for DEBUG. To enable this functionality, NEXUS to ATB converter is used. For other eTPU DEBUG related information, such as CTI, EVTO, EVTI, refer to Table 763. And, for IPG related information, see Figure 681.

67.1.3 Guidelines for configuring ETPU output channel events

While triggering an ETPU channel, through the ETPU output channel events, the ETPU.PSTO register should be configured to ensure ETPU output cycles to be at least two system clock cycles.

67.1.4 eTPU output disable channel groups

The output display channel group are defined in the following table:

Table 379. Output display channel groups

Output display signal	eTPU channels
eTPU_1/2_odis[0]	0 to 7
eTPU_1/2_odis[1]	8 to 15
eTPU_1/2_odis[2]	16 to 23
eTPU_1/2_odis[3]	24 to 31

NOTE

See Input Glitch Filter chapter for details of IGF channel mapping.

67.1.5 Time base Synchronization

The following figure shows the synchronization between eTPU time bases and eMIOS time bases.

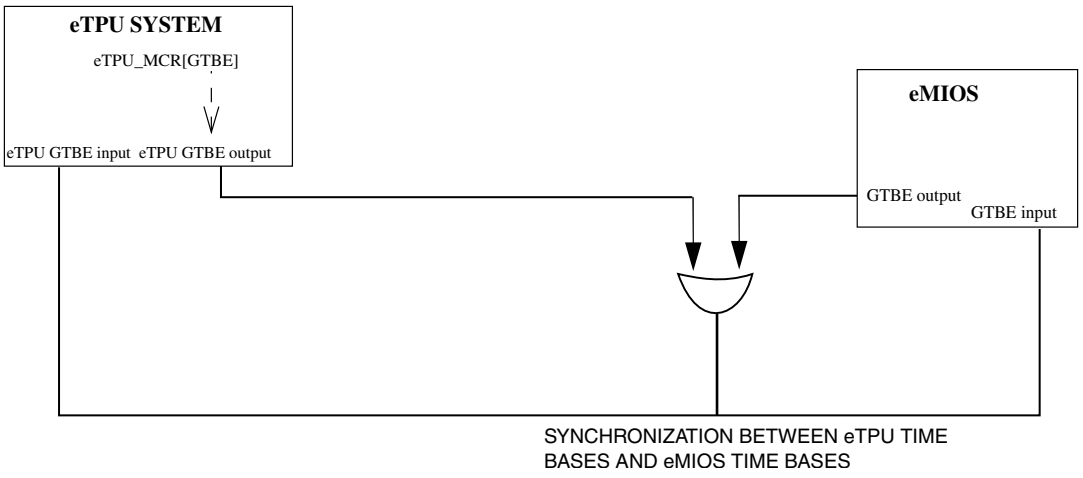


Figure 436. Time base Synchronization between eTPU time bases and eMIOS time bases

67.2 Overview

eTPU is an intelligent, semi-autonomous coprocessor designed for timing control. Operating in parallel with the Host CPU, the eTPU processes instructions and real-time input events, performs output waveform generation, and accesses shared data without Host intervention. Consequently, for each timer event, the Host CPU setup and service times are minimized or eliminated.

High-level assembler, compiler, and documentation enable customers to develop their own functions on the eTPU.

eTPU architecture aims at high resolution timing capabilities. From a system perspective, high-resolution timing is limited by Host CPU overhead required for servicing timing tasks such as period measurement, pulse measurement, pulse width modulated waveform generation, and so on. On the eTPU, high-resolution timing is achieved by three main capabilities:

- Reduced latency: pin actions are immediate.
- Reduce or eliminate host interrupt service time.
- Double action channel capability reducing the channel request rate.

eTPU provides higher resolution than the Host CPU can achieve and creates no Host overhead for servicing timing tasks.

Latency is the interval from occurrence of an event to the start of event servicing. eTPU can service its own events without interrupting the Host. There are two types of timing events:

- Input pin transition.
- Selected Time Base match, that is, a selected Time Base counter reached or exceeded a pre-programmed value.

Service time is the time spent servicing an event. In general, in microcontrollers the service time is constrained because the instruction set is not optimized for time function synthesis. The eTPU instruction set is optimized, so that time functions can be implemented with much fewer instructions than the Host CPU. Instructions execute faster, service time is reduced and program memory compacted.

Instructions executed by the eTPU are connected directly to the eTPU timing hardware and allow parallelism of hardware-related actions.

67.2.1 Block diagram

The figure below shows a top-level eTPU block diagram. It displays a dual eTPU Engine configuration.

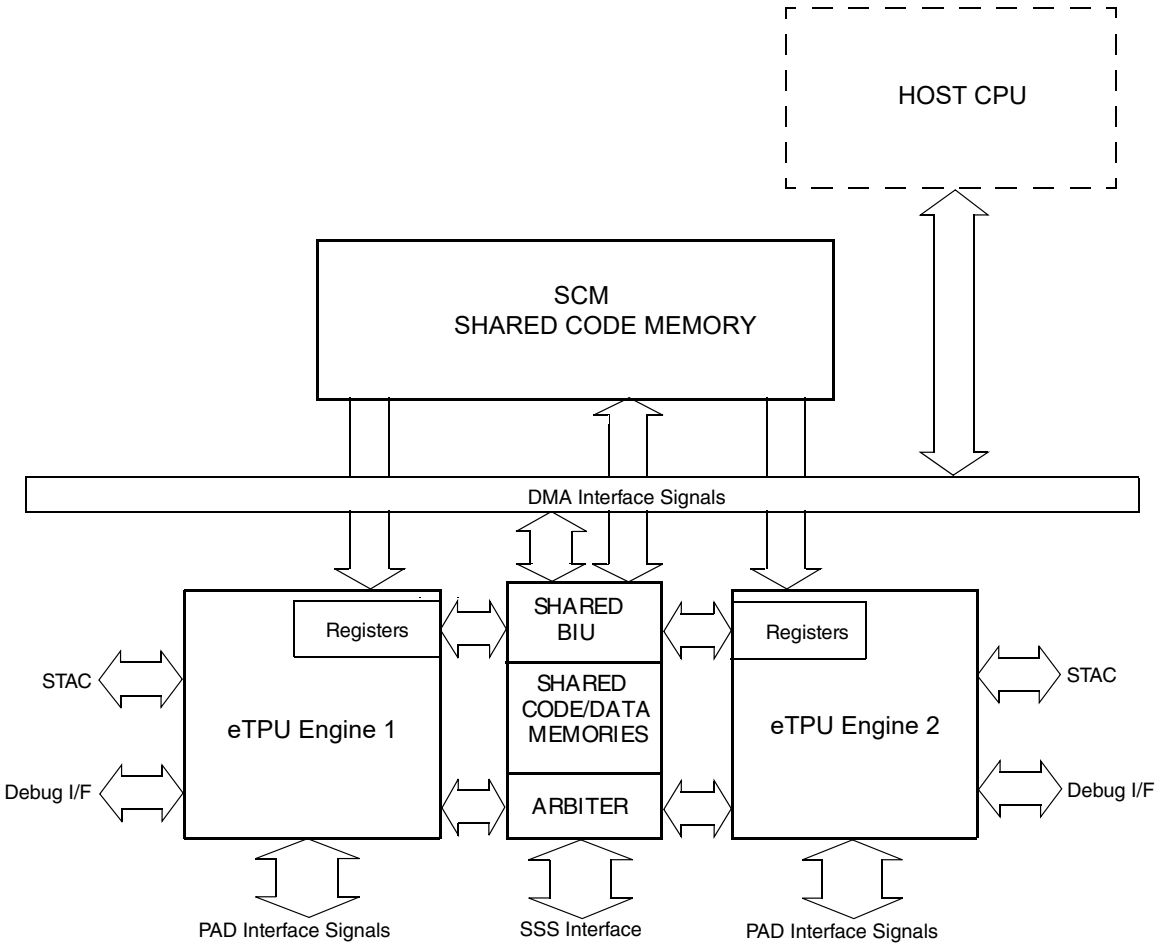


Figure 437. eTPU block diagram

eTPU Engine is responsible for processing input pin transitions and output pin waveform generation based on the **Time Bases**. Each eTPU Engine has its own microprocessor and dedicated hardware for processing signals on I/O pins and can also interface with external time bases through the STAC bus.

Both eTPU Engine CPUs, from this point on, called **microengines**, fetch microinstructions from a **Shared Code Memory - SCM**.

Shared Data Memory - **SDM -** holds eTPU application parameters and work data. It is accessed by Host and both microengines.

Bus Interface Unit - BIU - allows Host to access eTPU registers, SCM, and SDM.

Each I/O signal pair is associated with a dedicated **Channel**, which provides hardware for input signal processing and output signal generation, in relationship with selected Time Bases.

The eTPU, as a microprocessed subsystem, works much like a typical real-time system: it runs microengine code from instruction memory (SCM) to handle specific events, accessing data memory (SDM) for parameters, work data, and application state information; events may originate from I/O Channels (due to pin transitions and/or time base matches), Host CPU requests, or inter-channel requests; events that call for local eTPU processing activate the microengine by issuing a **Service Request**. The Service Request microcode may set an interrupt to the Host CPU. I/O channel events cannot directly interrupt the Host CPU.

Each Channel is associated with a **Function**, which defines its behavior: the Function is a software entity consisting, within the eTPU, of a set of microengine routines that attend to Service Requests. The Function routines are also responsible for Channel configuration. Function routines reside in SCM, which may contain several Functions. A Function may be assigned to several Channels, but a Channel can be associated with just one Function at a given moment. The association between Functions and Channels is defined by Host CPU, and is explained in detail in Functions and threads.

eTPU hardware supplies resource sharing features that support concurrency:

- A hardware **Scheduler** dispatches the Service Request microengine routines based on a set of priorities defined by the Host CPU. Each Channel has its associated priority.
- A Service Request routine cannot be interrupted until it ends. This sequence of uninterrupted instruction execution is called a **Thread**.
- Channel-specific context (registers and flags) is automatically switched between the end of a Thread and the beginning of the next one.
- SDM arbitration, a dual-parameter coherency controller, and semaphores can be used to ensure coherent access to eTPU data shared by both eTPU Engines and Host CPU.

67.2.1.1 eTPU Engine

Each eTPU Engine consists of all blocks that are duplicated in a dual eTPU configuration: two 24-bit time bases, independent timer channels, a task scheduler, a microengine, and a Host interface. In addition, a 32-bit Shared Data Memory (SDM) is used for two eTPU Engines data storage and for passing information between the eTPU Engines and the Host CPU.

The following figure shows the block diagram for the eTPU Engine.

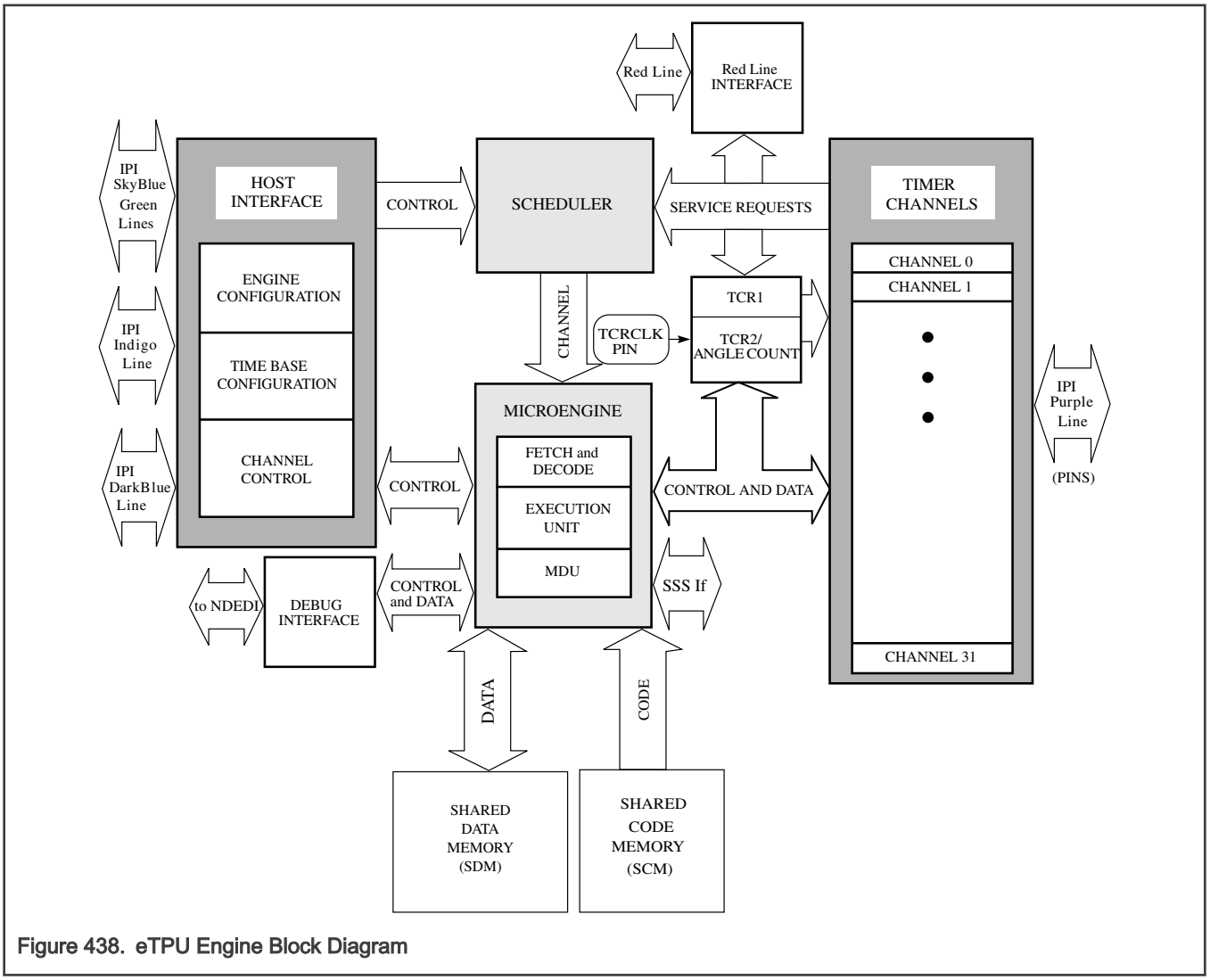


Figure 438. eTPU Engine Block Diagram

eTPU Engines 1 and 2 are sometimes called eTPU 1 and eTPU 2 for short throughout this chapter.

67.2.1.1.1 Time Bases

Two 24-bit counters TCR1 and TCR2 provide reference time bases for all match and input capture events. Prescalers for both time bases are controlled by the Host CPU through bit fields in the eTPU Engine configuration registers. The eTPU is able to export/import time to/from TCR1 or TCR2 in accordance to the STAC bus specification.

The clock for each of TCR1 and TCR2 clock can be independently derived from the eTPU clock or from an external input via the TCRCLK clock pin. In addition, the TCR2 timebase can be derived from special angle-clock hardware which enables implementing angle-based functions. This feature is added to support advanced angle-based engine control applications.

For further details refer to Time bases.

67.2.1.1.2 eTPU Timer Channels

Each eTPU Engine has 32 independent channels, each corresponding to an Input/Output signal pair. The channel time resolution is 24 bits, and are all identical.

Each channel consists of logic which supports two events and output controls. The event logic contains two 24-bit capture registers, two 24-bit match registers, greater-equal and equal-only comparators. Supporting two events enables many combinations of double action functions (for example the channel can handle two events with a single microcode service).

The channel configuration can be changed immediately by the microengine. Each channel can perform double capture, double match and other capture-match combinations. Channel modes available can do ordered or unordered match. Some modes are also provided that can block one match by the occurrence of the other. Service request can be generated on one or both of the match events.

Input signal can be separated from output signal in each channel. They can, optionally, be combined in a single I/O pin driver. An output buffer enable is controlled by the SIU (or SIUL). Digital filters are provided for the input signals, with distinct filtering modes available.

Each channel can use any time base or angle counter for either match or capture operation. For example, a match on TCR1 can capture the value of TCR2. The channels can request service from the microengine due to recognized pin transitions (input events) or timebase matches.

Channel configuration combinations:

- Single input capture, no match
- Single input capture with single match timeout
- Single input capture with double match timeout with several double match sub-modes
- Double input capture with single or double match timeout with several double match sub-modes
- Single output match
- Double output match with several double match sub-modes
- Input-dependent output generation

The double match functionality has various combinations for generation of service request and determining pin actions. For more details refer to Enhanced Channels.

In addition to the predefined channel configurations above, the user can also program its own channel configuration, defining how input captures, matches and service-requests are related.

67.2.1.1.3 Host interface

The Host interface allows the Host CPU to control the operation of the eTPU. The Host CPU must initialize the eTPU by writing to the appropriate Host interface registers to assign a Function and priority to each channel. In addition, the Host writes to the Host Service Request and channel configuration registers to further define Function operation for each initialized channel. Refer to Host interface for a detailed description.

When the SCM is implemented by RAM, the Host must first initialize it with the proper microcode program prior to enabling any eTPU Function, and then enable eTPU access (which also disables Host access).

67.2.1.1.4 Shared Data Memory - SDM

The SDM works as data RAM which can be accessed by the Host CPU and up to two eTPU Engines. This memory is used for information transfer between the Host CPU and the eTPU, as data storage for the eTPU microcode program or for communication between the two eTPU Engines. SDM width is 32 bits, and is accessible by the Host as byte, 16-bit or 32-bit wide. eTPU can access it as full 32-bits, lower 24-bits or upper byte (8-bit).

The host can also access the SDM space mirrored in other area with Parameter Sign Extension (PSE). Parameter Sign Extension accesses differ from the usual host accesses to the original SDM area as follows:

- Writes are effective only to the lower 3 bytes of a word: the word's most significant byte is kept unaltered in SDM.
- Reads return the lower 3 bytes of a word sign-extended to 32 bits, i.e.: the most significant bit of the word's 2nd most significant byte is copied in all 8 bits of the most significant read byte.

Each eTPU channel can be associated with a variable number of parameters located in the SDM, according to its selected Function. In addition, the SDM can be fully shared between two eTPU Engines, enabling direct communication between them.

High flexibility of the SDM utilization is achieved as follows:

- Each channel has a programmable base address pointing to the address of its first parameter with two parameter granularity. This way the SDM can be partitioned according to the actual function needs.
- The microcode can access the first parameters of the selected channel in channel relative access mode.
- Each Engine can access all the SDM address space in indirect addressing mode. Blocks of data are easily transferred using stack operation.
- Absolute addressing mode can access the first parameters, implementing a shared pool of parameters holding global variables.

In the Host address space each parameter occupies four bytes. eTPU usage of the upper byte is achieved by having a 32-bit P register which can access the upper byte, the lower 24 bits or all the 32 bits. The microcode can switch between access sizes at any time.

Each Function may require a different number of parameters. During the eTPU initialization the Host has to program channel base addresses, allocating proper parameters for each channel according to its selected Function.

67.2.1.1.5 Shared Subsystem Area

The Shared Subsystem (SSS) area is a memory map region used by both the host and the eTPU to access registers of the reaction channel, giving the user the option to control them by the host, the eTPU code, or a combination of both .

67.2.1.1.6 Scheduler

Out of reset, all channels are disabled. The Host CPU makes a channel active by assigning it one of three priorities: high, middle, or low. The Scheduler determines the order in which channels are serviced based on channel number and assigned priority. The priority mechanism, implemented in hardware, ensures that all requesting channels are serviced. For additional details refer to Scheduler.

67.2.1.1.7 Microengine

eTPU microengine is a simple RISC implementation which performs each instruction in a microcycle of two eTPU clocks, while prefetching the next instruction through an instruction pipeline. Instruction execution time is constant unless it gets wait states from the SDM arbitration. Two eTPU Engines share code memory without having any performance degradation by interleaving their accesses (the Shared Code Memory has one-clock access time).

Instruction width is 32 bits. The microengine instruction set provides basic arithmetic and logic operations, flow control (jumps and subroutine calls), SDM access, and Channel configuration and control. The instruction formats are defined in such a way that allow particular combinations of two or three of these operations with non-conflicting resources to be executed in parallel in the same microcycle.

Microengine has also an independent Multiply/Divide/MAC unit that performs these complex operations in parallel with other microengine instructions.

Channel functionality is tightly integrated to the instruction set through Channel Control operations and conditional Branch operations, which support jumps/calls on Channel-specific conditions. This allows quick and terse Channel configuration and control code, contributing to reduced service time.

Detailed description can be found in Microengine.

67.2.1.1.8 Dual eTPU Engine System

A typical eTPU implementation includes two eTPU Engines sharing SDM and the same code in SCM.

The two eTPU Engines share the Bus Interface Unit (BIU) and the data memory (SDM) which enable Host-eTPU and eTPU Engine-Engine communication. The shared BIU includes coherency logic which supports dual parameter (8 bytes) coherency in transfers between Host and eTPU, using a temporary parameter area within the SDM. More details on this can be found on Parameter sharing and coherency.

67.2.2 Features

The following sections show eTPU features and enhancements.

67.2.2.1 eTPU Feature Summary

The eTPU includes these distinctive features:

- Up to 32 channels for each eTPU Engine, each channel is associated with an Input/Output signal pair.
  - enhanced input digital filters on the input pins for improved noise immunity. The eTPU digital filter can use 2 samples, 3 samples or work in continuous mode.
  - Identical, orthogonal channels, except for channel 0: each channel can perform any time function. Each time function can be assigned to more than one channel at a given time, so each signal can have any functionality. Channel 0 has the same capabilities of the others, but can also work with special Angle Counter logic (see below).
  - Link Service Request allows activation of a Channel function by request of another channel, even between eTPU Engines.
  - Host Service Request allows activation of a Channel function by Host CPU request
  - each channel has an event mechanism which supports single and double action functionality in various combinations. It includes two 24-bit capture registers, two 24-bit match registers, 24-bit greater-equal and equal-only comparators.
- Two independent 24-bit time bases for channel synchronization:
  - first time base clocked by eTPU clock with programmable prescaler division from 1 to 512 (in steps of 2), or by output of second time base prescaler.
  - first time base can also be clocked by external signal with programmable prescaler division of 1 to 256.
  - second time base clocked by external signal with programmable prescaler division from 1 to 64.
  - second time base external clock source can be replaced by eTPU clock divided by 8.
  - both time bases can be exported or imported via Shared Time and Counter bus.
  - second time base counter can work as an Angle counter, enabling angle based applications to match angle instead of time.
  - second time base can also be used as a pulse accumulator gated by external signal.
- Event-triggered RISC processor (microengine):
  - 3 stage pipeline implementation (fetch, decoding and execution), with separate instruction memory - SCM - and data memory - SDM (Harvard architecture)
  - fixed-length instruction execution in one microcycle of two eTPU clocks

- interleaved SCM access in dual eTPU Engine avoids contention in time for instruction memory
- SDM with interleaved access in dual eTPU Engine avoids contention for data memory
- instruction set with embedded Channel support, including specialized Channel control subinstructions and conditional branching on Channel-specific flags.
- channel-oriented addressing: channel-bound address mode with Host configured Channel Base Address allows channel data isolation, independent of microengine application code.
- channel-bound data address space of up to 32-bit parameters (bytes)
- global parameter address mode allows access to common Channel data of up to 32-bit parameters (bytes)
- support for indirect and stacked data access schemes.
- parallel execution of: data access, ALU, Channel control and flow control sub-instructions in selected combinations.
- 32-bit microengine registers and 24-bit resolution ALU, with 1 microcycle addition and subtraction, absolute value, bitwise logical operations on 24-bit, 16-bit, or byte operands; single bit manipulation, shift and rotate operations, sign extension and conditional execution.
- additional 24-bit Multiply/MAC/Divide unit which supports all signed/unsigned Multiply/MAC combinations, and unsigned 24-bit Divide. The MAC/Divide unit works in parallel with the regular microcode commands.

- Resource sharing features support channel sharing of channel registers, memory and microengine time:
  - hardware Scheduler works as a "task management" unit, dispatching event service routines by predefined, Host-configured priority.
  - automatic Channel context switch when a "task switch" occurs, i.e., one Function Thread ends and another begins to service a request from other Channel: Channel-specific registers, flags and parameter base address are automatically loaded for the next serviced channel.
  - individual channel priority setting in 3 levels: high, middle and low.
  - Scheduler priority scheme allows calculation of worst case latency for event servicing and ensures servicing all channels by preventing permanent blockage.
  - SDM shared between Host CPU and both eTPU Engines, supporting communication either between Channels and Host or inter-channel.
  - hardware implementation of 4 Semaphores supports resource sharing between both eTPU Engines.
  - Hardware semaphores directly supported by the microengine instruction set.
  - dual parameter coherency hardware support allows atomic (to host) access to 2 parameters by microengine(s) in back-to-back accesses.
  - coherent dual-parameter controller allows atomic (to microengines) accesses to 2 parameters by the host.
- Development support features:
  - Nexus class 3 debug support (optional, associated with the eTPU-Nexus Block NDEDI).
  - Software breakpoints.
  - Debug interface supporting single-step execution, forced microinstruction execution, Hardware breakpoints and watchpoints on several conditions.
- Safety support features:
  - SCM (code memory) continuous signature-check built-in self test (MISC - Multiple Input Signature Calculator), runs concurrently with eTPU normal operation.

67.2.2.2 eTPU Plus Enhancements over eTPU

eTPU Plus features include the enhancements below in addition to all eTPU features

- TCR1, channel logic and digital filters (both channel and TCRCLK) now have an option to run at divisions of full eTPU clock speed, besides eTPU clock / 2 (see T2/T4 channel timing) .
- Channels support unordered transitions: transition B can now be detected before transition A. Related to this enhancement, TDLA and TDLB can now be independently negated by microcode (see Channel Mode Logic and Event Flags).
- Channel logic can now work on full eTPU clock, allowing faster response with slow clocks (see T2/T4 channel timing).
- Added a new User Programmable Channel Mode: the blocking, enabling, service request and capture characteristics of this channel mode can be programmed via microcode (see General Channel registers).
- Microinstructions now provide an option to issue Interrupt and Data Transfer requests selected by CHAN . They can also be requested simultaneously at the same instruction (see Channel Interrupt and Data Transfer Requests).
- Channel Flags 0 and 1 can now be tested for branching, besides selecting the entry point (see Branch Operations).
- Channel digital filters can be bypassed, and can be clocked by full eTPU clock (see Bypass Mode).

Backward compatibility is maintained so that all legacy object code (both Host and microcode) runs on eTPU Plus without modification.

67.2.2.3 eTPU2 enhancements over eTPU Plus

eTPU2 features include the enhancements below in addition to all eTPU Plus enhancements and eTPU features.

- Scheduler priority-passing mechanism can now be disabled (see Priority passing disabling).
- New Watchdog mechanism kills threads over a programmable timeout (see Watchdog).
- New counter allows microengine load information collection for performance analysis (see Idle Counter).
- Channels 1 and 2 (besides channel 0) can now be selected to control the EAC (see the TBCR_ENG1 and TBCR_ENG2 eTPU Time Base Configuration Registers).
- Timebase prescalers are now reset when the GTBE input is negated, guaranteeing synchronization with eMIOS in all cases (see Global time base enable (GTBE)).
- New MISC flag indicates when an SCM signature calculation round is completed. This allows measuring of the average MISC scan period in a real application situation (see the eTPU Module Configuration Register - MCR).
- New channel TCCEA flag allows continuous capture even after TDLA is set, making it fully compatible with TPU behavior (see TCCEA - Transition Continuous Capture Enable).
- New branch condition PRSS tells the pin state at the time when a channel (match or transition) service request occurred (see Pin Control Registers).
- MRLEA/B can now be negated independently by microcode (see Disable Matches).
- New Engine Relative address mode allows a function to access SDM address space common to one engine, but distinct between engines (see Engine Relative Addressing Mode under SDM Addressing Modes).
- Memory error support for Code (SCM) and Data (SDM) memories: error detection, correction, and hardware-assisted soft-error fixing (see Memory error support).
- Sharing of microengine and host accesses to subsystem modules (for instance, the Reaction Module), allowing their control by the eTPU, the host, or both (see Shared subsystems support).

Backward compatibility is maintained so legacy object code (both Host and microcode) runs on eTPU2 without modification.

67.2.2.4 eTPU2 Plus enhancements over eTPU2

eTPU2 Plus features include the enhancements listed below in addition to all eTPU features, eTPU Plus enhancements and eTPU2 enhancements.

- Watchdog can now be configured to disable thread forced ending and channel blocking, allowing it to monitor thread lengths with no interference on the application.

- EAC Angle Tick Generator can now be clocked by the TCR2 prescaler output, as an alternative to the TCR1 clock.
- EAC now supports up to 7 missing teeth on hardware.

Backward compatibility is maintained so legacy object code (both Host and microcode) runs on eTPU2 Plus without modification.

67.3 Functional description

67.3.1 Modes of operation

eTPU can be seen as capable of working in the following modes:

- **User Configuration Mode**

  User has the ability to program the eTPU Cores with User Time Functions, having access to the Shared Code Memory (SCM).

- **User Mode**

  User does not access the eTPU Shared Code Memory:

  — Use of predefined eTPU Functions

  — No need for eTPU Core programming ability

- **Debug Mode**

  User debugs eTPU code, accessing special Trace/Debug features via Nexus interface:

  — hardware breakpoint/watchpoint setting

  — access to internal registers

  — single-step execution

  — forced instruction execution

  — software breakpoint insertion and removal.

- **Module Disable Mode**

  eTPU Engine clocks are stopped through a register write to the MDIS field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2), saving power. Input sampling stops. eTPU Engines can be in Module Disable Mode independently. Module Disable Mode stops only the Engine clock, so that the Shared BIU, and Global Channel registers can be accessed, and interrupts and DMAs can be cleared and enabled/disabled. An Engine only enters Module Disable Mode when any currently running thread is finished (see Functions and threads).

- **Stop Mode**

  Stop Mode is entered when eTPU answers assertion with . The definition of which clocks are stopped is made at the MCU level, which defines whether or not registers can be accessed, interrupts and DMA requests cleared.

These modes are loosely selected: there is no unique register field or signals to choose between them. Some features of one mode can be used with features of other mode(s). More on this subject can be found on eTPU mode selection below.

NOTE

Throughout this chapter, an engine is said to be "stopped" if it is either in Module Disable mode or Stop mode.

67.3.1.1 eTPU mode selection

User and User Configuration are the production operating modes, and differ from each other only in access to SCM. User programmability is only possible with a RAM SCM.

On chips where the SCM is implemented as a RAM, it can either be accessed directly from IP-Bus for code loading, or for software breakpoint setting . On chips with a ROM SCM, an internal SCM Emulation RAM may be used, depending on the specific MCU implementation, to replace ROM SCM for test or debug purposes. SCM Emulation RAM is selected in a MCU-specific way. For more details, see SCM Emulation.

Debug Mode is characterized by the use of the debug interface features. Specifically, Nexus blocks provide Nexus class 3 debug features. For more information on debug features, refer to Development support features.

Module Disable Mode is entered by setting the MDIS field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2). eTPU Engines can be individually stopped going into Module Disable Mode (there is one eTPU_SCR_ECR register for each Engine). Each engine can leave Module Disable Mode by writing MDIS=0 (which can only be done if VIS=0).

Stop Mode is activated by IP-Bus (). In this case, the eTPU waits for both eTPU Engines to enter in Stop mode, and then asserts the line. eTPU leaves Stop Mode when is negated, but only if VIS=0. If is negated and VIS = 1, eTPU will leave Stop Mode as soon as VIS = 0.

NOTE

An Engine can stay in Module Disable mode when it leaves Stop Mode if its bit MDIS = 1, even if the other leaves it.

67.3.2 Functions and threads

eTPU processing is event-driven, in the sense that eTPU microcode only runs to service a request from an event. Service Requests may result from the occurrence of any of the following events:

- Host CPU writing a non-zero value to the channel HSR (Host Service Request) field in C*a*HSRR_ENG1 and C*a*HSRR_ENG2.
- Occurrence of a time base match, an input signal transition, or a specific combination of them (depending on the Channel Mode currently configured).
- A Link Service Request.

A given event is always associated to only one Channel:

- There is one HSR register field for each Channel
- Each signal is associated with only one Channel, which has its own Match registers and independent mode configuration.
- Each Link Service Request can have only one Channel as a target.

Service Request processing is done by a set of microengine routines. A set of related routines that implement a specific channel application is called a **Function**. One or more Functions reside on SCM, limited only by the SCM space available, size of microcode Functions and the number of entry points available. Each Engine can be controlled by up to 32 Functions at a time.

A Function can be assigned to several channels, but only one Function can be assigned to a given Channel at a time. This is defined by the Host through the Channel Configuration Registers (see Channel Configuration Control memory map and registers).

The term **Thread** will be used hereafter to refer to a service routine of a Function, or its execution. A Thread is constructed of a specific number of microinstructions, typically the code necessary to calculate the next phase of waveform to be input to, or output from, a given channel. Once a Thread begins, its execution cannot be interrupted. A Thread normally finishes when an END microinstruction is executed.

A given Thread is selected and called by the Scheduler depending on the following:

- the type of event that generated the service request.
- the Function assigned to the target channel.
- target channel pin state.
- the state of the channel logic.
- the priority assigned to the target channel, relative to the priorities of other channels with pending service requests

The mechanism to select a thread based on the channel Function and type of event is described in Entry Points.

The priority mechanism that determines the order of Thread execution among pending service requests is described in Scheduler.

67.3.2.1 Entry Points

67.3.2.1.1 Entry table

Each Thread has its **Entry Point**, which contains the SCM address of its first instruction, besides other information. For a complete Entry Point description, see Entry Point format.

Once the Scheduler chooses a channel among pending Service Requests, the Entry Point is taken from an **Entry Table**, based on the Function assigned for the channel and other conditions. Entry Table layout is shown in the following figure.

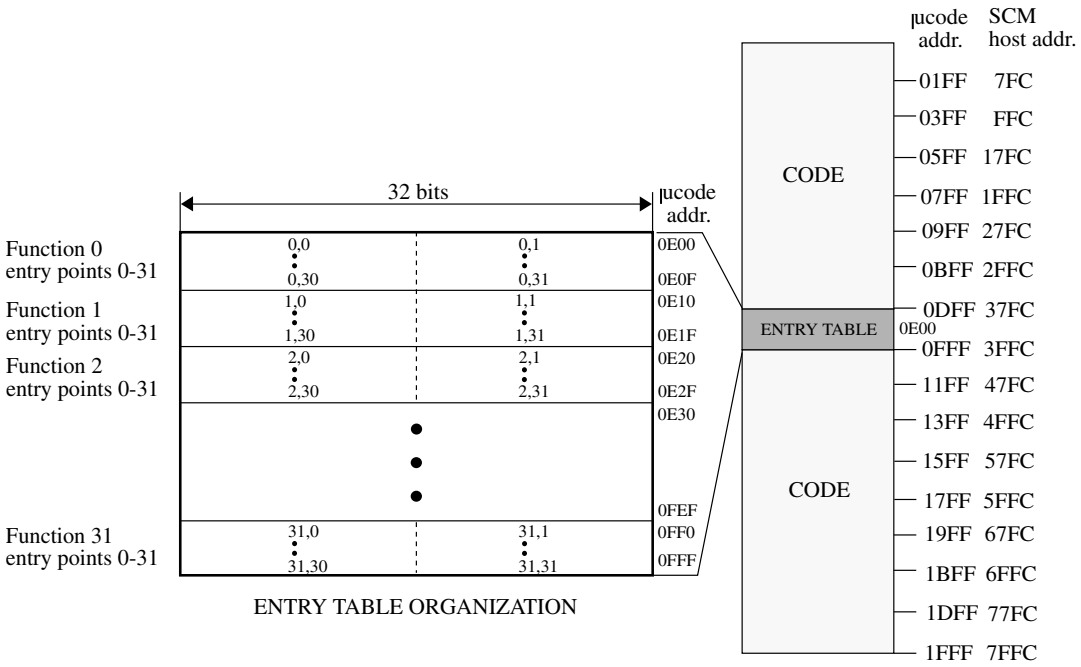


Figure 439. Entry table

The Entry Table is organized by Functions. Each Function can have up to 32 Entry Points of 16 bits each, corresponding to 32 possible Threads per Function. Each Entry Point location in the table corresponds to a combination of events and channel states (see Entry Point address generation). A single Thread can be associated to more than one combination, having its Entry Point repeated in the table. Each 32-bit word in the Entry Table holds two Entry Points.

Note that the Entry Table can be placed in any SCM address multiple of the Entry Table size, determined by the ETB field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2). However, it is recommended to place the Entry Table at the start of the SCM to get continuous code memory and to ease the eventual migration of the code from larger parts down to smaller ones without rearranging the binary image, but this is not a restriction. Unused Entry Points may be used for microcode, so this organization extends the microcode continuous area to the unused area of the Entry Table. For this purpose, Function numbers should be selected from 0 up to 31. If, for example, only 8 functions are implemented, only the Entry Table locations for Functions 0 to 7 are used, and the Entry Table locations for functions 8 to 31 can be used as microinstruction memory (adding extra continuous 1536 bytes for microprogram usage).

One way of implementing different sets of Functions is having more than one Entry Table, and configuring the eTPU with the appropriate one for the application by changing the ETB field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2). Note that the Engines can use different Entry Tables, with or without the same set of Functions.

67.3.2.1.2 Entry Point address generation

The Entry Point address within the Entry Table is determined by the Function assigned to the Channel, the state of the Channel, the type of event, and the condition encoding scheme. Together with the Entry Table base address, they form the Entry Point Address at the SCM, as shown in the following figure.

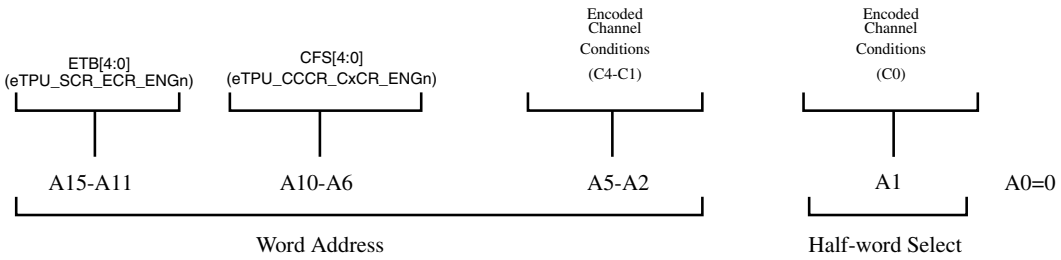


Figure 440. Entry Point Address (host address offset)

The type of event and channel state are coded in the Encoded Channel Conditions field C -C0, according to one of two encoding schemes:

- Standard Entry Table Condition encoding scheme, shown in Standard condition encoding scheme, which privileges Host Service Requests.
- Alternate Entry Table Condition encoding scheme, shown in Alternate condition encoding scheme, which focus on other events and state decoding.

The events that take part on condition encoding generate a Service Request, and have four origins:

1. Match Recognition (caused by greater/equal match, or equal-only, between the value TCR1/2 and the value stored in the channel match registers). eTPU channels support single and double match in various modes of match recognition; see Match Recognition.
2. Transition Detect Service Request (channel input signal transition detection of a selected edge). The eTPU channels support single and double transition, which together with the double match options provide various modes of transition detection; see Transition detection and Time Base Capture.
3. Channel Linking Service Request (microcode writing the channel number to the LINK register). Link service request allows one channel to activate another (see Channel link). Links may also come from Shared Subsystem units (see Shared subsystems support).
4. Host Service Request (Host writes a non-zero value to the HSR bits of the channel; see Host Service Requests).

NOTE

Even if a Transition or Match Service Request is inhibited (by channel mode/state or SRI), the Transition Detection and Match Recognition are taken into account for condition encoding. That is, the MRLA/B and TDLA/B flags are used, not their respective Service Requests.

Columns Host Request Bits, Link Request, MatchA/TransB, and MatchB/TransA determine the type of event. A non-zero value in these columns represents the recognition of the event, while "x" indicates that its recognition is irrelevant. Values 1 and 0 mean that event was recognized or not, respectively. Note that Match and Transition events may occur and not be recognized, and in this case it assumes value 0 for the condition encoding. The recognition of such an occurred event depends on the channel mode assigned and other conditions, as described in Enhanced Channels.

The **Host Service Request Bits** column refers to the value written by the Host CPU to the Host Service Request Registers (C*a*HSRR_ENG1 and C*a*HSRR_ENG2) of the Channel being serviced. Note that the bits on this row are coded (3-bit representation). If the value of HSR is not zero, then the Host actually requested service.

The **Link Request** column refers to the occurrence of a Channel Link or SSS Link requests.

The **MatchA/TransB** column refers to the recognition of either a Match event specified by MatchA channel register or the detection of a channel input signal event specified by the IPACB configuration register (see Pin Control Registers).

The **MatchB/TransA** column refers to the recognition of either a Match event specified by MatchB channel register or the detection of a channel input signal event specified by the IPACA configuration register (see Pin Control Registers).

For the channel input signal, MatchA and MatchB provide double timeout conditions which depend on the channel mode programming (see Channel Modes). If the channel is used for output only, there are no transition detections, so the MatchB/

TransA column represents only Match B, and MatchA/TransB column the Match A. In this case Match A and Match B are separated to give better state resolution in double match output functions. For more information about channel requests refer to Enhanced Channels.

Besides those events, the following channel state conditions help to determine the Entry Point:

1. Channel Flags 0 and 1: these are channel-internal flags (not in SDM) associated with a channel. Their values are set by microcode (see Channel flags operations).
2. Input Pin state or Output Flip Flop: the state (0 or 1) of the channel input signal after the Enhanced Filter (see Enhanced digital filter (EDF)), or the state driven to the output signal. Which one (input or output) is used is selected by the ETPD field in C*a*CR_ENG1 and C*a*CR_ENG2.

The two Entry Table Condition encoding schemes combine events and state conditions differently, as detailed in the following sections.

67.3.2.1.3 Standard condition encoding scheme

In this scheme, shown in the following table, all 7 HSR combinations are used and other event type columns are marked "x" when HSR is non-zero, indicating that Host Service Request has priority over any other type of event. However, when an HSR service thread is called (entry numbers 0 to 9), other events may also have been recognized, and it is microcode responsibility to check them.

When HSR is 0, i.e., Host did not issue a Service Request to the channel, the other event conditions, the input signal state and channel flags determine the Entry Point. Note that channel flag 1 does not influence the encoding in this scheme.

Table 380. Standard channel condition encoding scheme

No.	Encoded channel conditions [C4-C0]	Host Service Request bits	Link request	MatchA/ TransB	MatchB/ TransA	In/output pin state[1]	Channel Flag1	Channel Flag0
0	001	00000	x	x	x	0	x	0
1	00001	001	x	x	x	0	x	1
2	00010	001	x	x	x	1	x	0
3	00011	001	x	x	x	1	x	1
4	00100	010	x	x	x	x	x	x
5	00101	011	x	x	x	x	x	x
6	00110	100	x	x	x	x	x	x
7	00111	101	x	x	x	x	x	x
8	01000	110	x	x	x	x	x	x
9	01001	111	x	x	x	x	x	x
10	01010	000	1	1	1	x	x	0
11	01011	000	1	1	1	x	x	1

Table continues on the next page...

Table 380. Standard channel condition encoding scheme (continued)

No.	Encoded channel conditions [C4-C0]	Host Service Request bits	Link request	MatchA/ TransB	MatchB/ TransA	In/output pin state[1]	Channel Flag1	Channel Flag0
12	**01100**	**000**	**0**	**0**	1	**0**	**x**	**0**
13	**01101**	000	**0**	**0**	1	0	**x**	1
14	01110	000	**0**	**0**	1	1	**x**	0
15	01111	000	**0**	**0**	1	1	**x**	1
16	**10000**	000	**0**	1	0	**0**	**x**	**0**
17	**10001**	000	**0**	1	0	0	**x**	1
18	**10010**	000	**0**	1	0	1	**x**	0
19	**10011**	000	**0**	1	0	1	**x**	1
20	**10100**	**000**	**0**	1	1	**0**	**x**	**0**
21	**10101**	000	**0**	1	1	0	**x**	1
22	**10110**	000	**0**	1	1	1	**x**	0
23	**10111**	000	**0**	1	1	1	**x**	1
24	**11000**	000	1	0	0	**0**	**x**	**0**
25	**11001**	000	1	0	0	0	**x**	1
26	**11010**	000	1	0	0	1	**x**	0
27	**11011**	000	1	0	0	1	**x**	1
28	**11100**	000	1	0	1	**x**	**x**	**0**
29	**11101**	000	1	0	1	**x**	**x**	1
30	11110	000	1	1	**0**	**x**	**x**	0
31	11111	000	1	1	0	**x**	**x**	1

1. The ETPD field in C*a*CR_ENG1 and C*a*CR_ENG2 selects between input and output pin state.

67.3.2.1.4 Alternate condition encoding scheme

This scheme is shown in the following table. Because the HSR bits cannot be tested by microcode, only three distinct Host Service Requests can be used:

1. HSR=010 or 011, which are coded into the same Entry Points (0 to 3)
2. HSR=100, 101 or 001, which are all coded into Entry Point 4

3. HSR=110 or 111, which are both coded into Entry Point 5

The remaining Entry Points use both channel flags for better state decoding, making this scheme better for Functions which need more states and/or faster state decoding, without needing many HSRs.

Table 381. Alternate channel condition encoding scheme

No.	Encoded channel conditions [C4-C0]	Host Service Request bits	Link request	MatchA/ TransB	MatchB/ TransA	In/Output pin state[1]	Channel Flag1	Channel Flag0
0	00000	01x	x	x	x	0	x	0
1	00001	01x	x	x	x	0	x	1
2	00010	01x	x	x	x	1	x	0
3	00011	01x	x	x	x	1	x	1
4	00100	10x/001	x	x	x	x	x	x
5	00101	11x	x	x	x	x	x	x
6	00110	000	1	0	0	0	x	x
7	00111	000	1	0	0	1	x	x
8	01000	000	x	1	0	0	0	0
9	01001	000	x	1	0	0	0	1
10	01010	000	x	1	0	0	1	0
11	01011	000	x	1	0	0	1	1
12	01100	000	x	1	0	1	0	0
13	01101	000	x	1	0	1	0	1
14	01110	000	x	1	0	1	1	0
15	01111	000	x	1	0	1	1	1
16	10000	000	x	0	1	0	0	0
17	10001	000	x	0	1	0	0	1
18	10010	000	x	0	1	0	1	0
19	10011	000	x	0	1	0	1	1
20	10100	000	x	0	1	1	0	0
21	10101	000	x	0	1	1	0	1

Table continues on the next page...

Table 381. Alternate channel condition encoding scheme (continued)

No.	Encoded channel conditions [C4-C0]	Host Service Request bits	Link request	MatchA/ TransB	MatchB/ TransA	In/Output pin state[1]	Channel Flag1	Channel Flag0
22	**10110**	000	**x**	0	1	1	1	0
23	**10111**	000	**x**	0	1	1	1	1
24	**11000**	000	**x**	1	1	0	**0**	**0**
25	**11001**	000	**x**	1	1	0	0	1
26	**11010**	000	**x**	1	1	0	1	0
27	**11011**	000	**x**	1	1	0	1	1
28	**11100**	000	**x**	1	1	1	**0**	**0**
29	**11101**	000	**x**	1	1	1	0	1
30	11110	000	**x**	1	1	1	1	0
31	11111	000	**x**	1	1	1	1	1

1. C*a*CR_ENG1[ETPD] and C*a*CR_ENG2[ETPD] select between input and output pin state.

67.3.2.1.5 Entry Point format

Entry Point information includes a Preload-Parameter selection field, a Match Enable field, and the first microcode address of the thread. The Entry Point format is illustrated in the following figure.

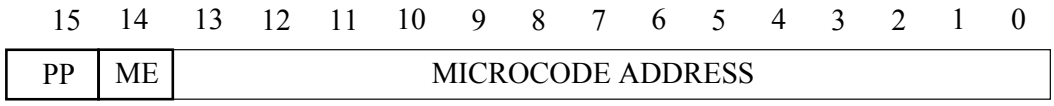


Figure 441. Entry Point format

PP - Preload Parameter

PP indicates which pair of channel parameters are loaded into registers P and DIOB from the SDM prior to the execution of a thread. Preloading occurs during the time-slot transition period (see Time Slot Transition).

1 = microengine register P is preloaded from parameter 2 and DIOB from parameter 3.

0 = microengine register P is preloaded from parameter 0 and DIOB from parameter 1.

The parameter numbers are offsets from the channel parameter base address. For more info, see Parameter Access.

ME - Match Enable

Table continues on the next page...

Table continued from the previous page...

ME specifies whether match event recognitions are enabled or disabled for the thread associated with the entry point during the thread execution. If they are disabled, a match recognition can only occur after channel service. For more details refer to Match Recognition.

1 = Matches are enabled during the thread.

0 = Matches are disabled during the thread.

The disabling of Match A/B recognition by MEF is dependent on IPACA/B configuration on the serviced channel (see Pin Control Registers). If IPACA=1xx, Match A is not disabled by ME=0. Likewise, IPACB=1xx overrides the effect of ME on Match B to "always on" If IPACA/B=0xx, Match A/B is disabled for two microcycles during TST (see Time Slot Transition) and is re-enabled when Entry Point is loaded, if ME=1. Note that if the comparator is in equal-only mode and the time base reaches the value of the Match register during the time that recognition is disabled (beginning of TST, plus whole thread if ME=0), the match recognition is lost. If the comparator is in greater-equal mode, the match event may be recognized after the disabling period if it satisfies the "greater-than" condition.

MICROCODE ADDRESS - Starting Microcode Address

This field specifies the microcode address on which the thread is to begin execution.

67.3.2.2 Time Slot Transition

The Time Slot Transition period (also called TST for short) is the interval between the servicing of two channels, during which all Channel-specific context is loaded for the new serviced Channel. The primary tasks completed during this period include:

- Set MEF for the TST wait-states, if any.
- Reset MEF for the first two microcycles (after eventual wait-states).
- Update of the CHAN register with the number of the new channel to be serviced.
- Parallel update of ERTA and ERTB from CaptureA and CaptureB registers of the new serviced channel.
- Sampling of the branch conditions of the new channel to be serviced into the branch logic (this means flags TDLA/B, MRLA/B, LSR, FM[1], FM[0], and PSS). The branch conditions are coherent with the timebase capture values sampled into ERTA/B (if MRLA/B, TDLA/B are set at the same time of the sampling, either both old flag state and capture values are sampled, or both new values are sampled).
- Formation of the entry point address.
- Copy the ME bit in the Entry Point into MEF.
- Access to the entry point location and getting the first microinstruction address.
- Preload of two parameters from the SDM into P (32 bits) and DIOB (24 bits).
- Fetch the first instruction of the thread to be executed for the new channel.
- Preset the RAR register value (see RAR Register).

The preload operation is 32-bit wide for P and 24-bit wide for DIOB. The P register is loaded with all the 32-bit parameter. The DIOB register is loaded with the lower 24-bits of the parameter. The microcode can switch at any time to access the lower 24-bits, upper byte, or all the 32-bits of any parameter in the SDM. Preload of P-DIOB pair of parameters is atomic with respect to Host and CDC accesses, and so are coherent with their dual-parameter coherent transfers. For more details see Parameter sharing and coherency.

No instructions are executed at the Engine where the time slot transition period occurs, but the other Engine can execute normally. Match A/B is unconditionally disabled on the first two TST microcycles, if IPACA/B=0xx (respectively). During the rest of time slot transition, match recognition can be disabled or not, depending on IPACA/B field and ME. See Match Recognition.

Time Slot Transition takes a minimum of 3 microcycles (6 eTPU clocks), which may be extended due to SDM arbitration wait-states for the first preload access (see SDM arbitration). When no wait-states are received (), DIOB is preloaded twice, one for each PP value, and the correct value remains in DIOB when the Entry Point is loaded. and show the timing for one and two wait-states, respectively.

Registers B, C, D and SR are not altered by TST and keep their values from the previous thread. The values of registers A, MACL and MACH are not guaranteed at the thread start.

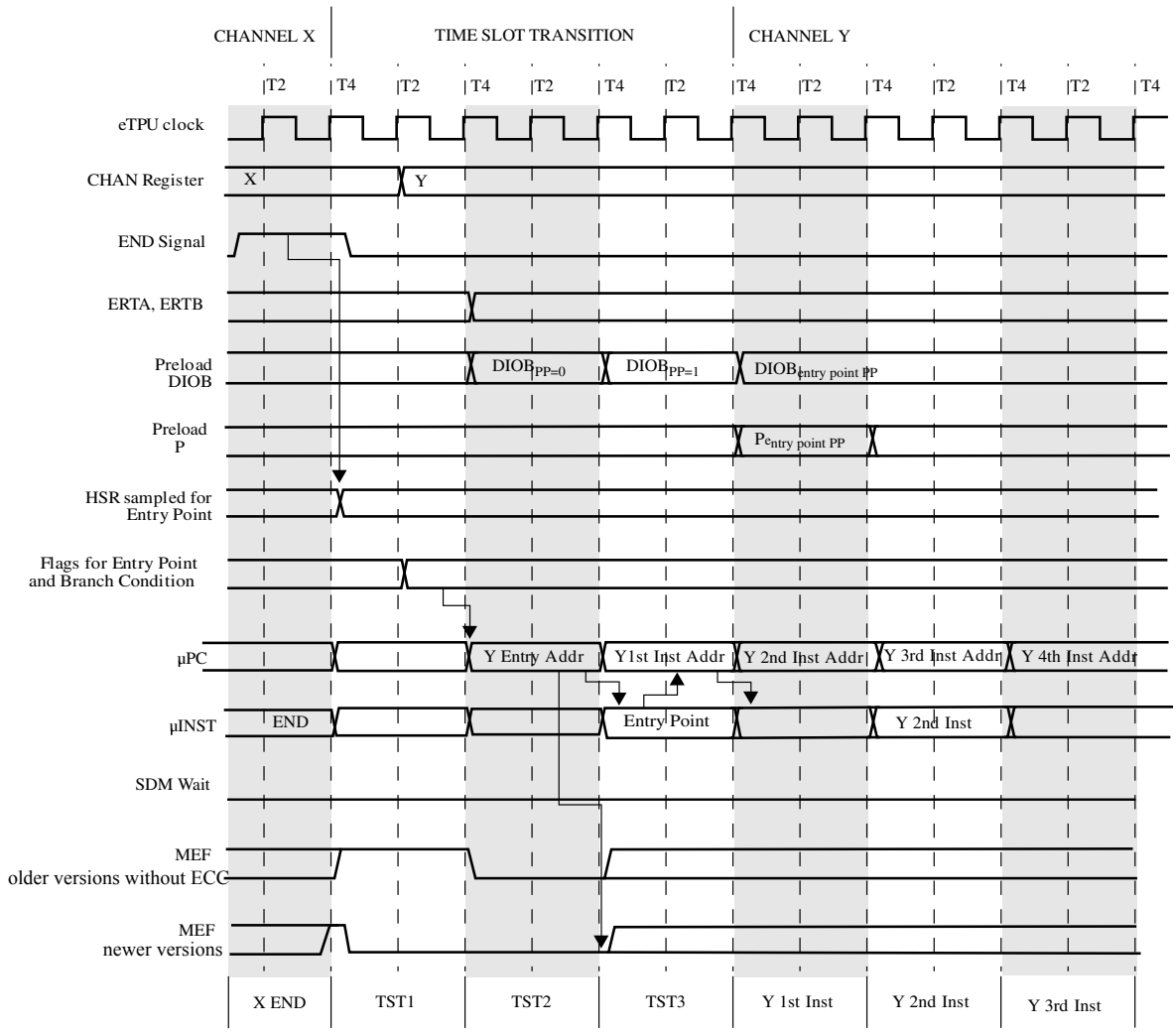


Figure 442. TST Timing - No Wait-states

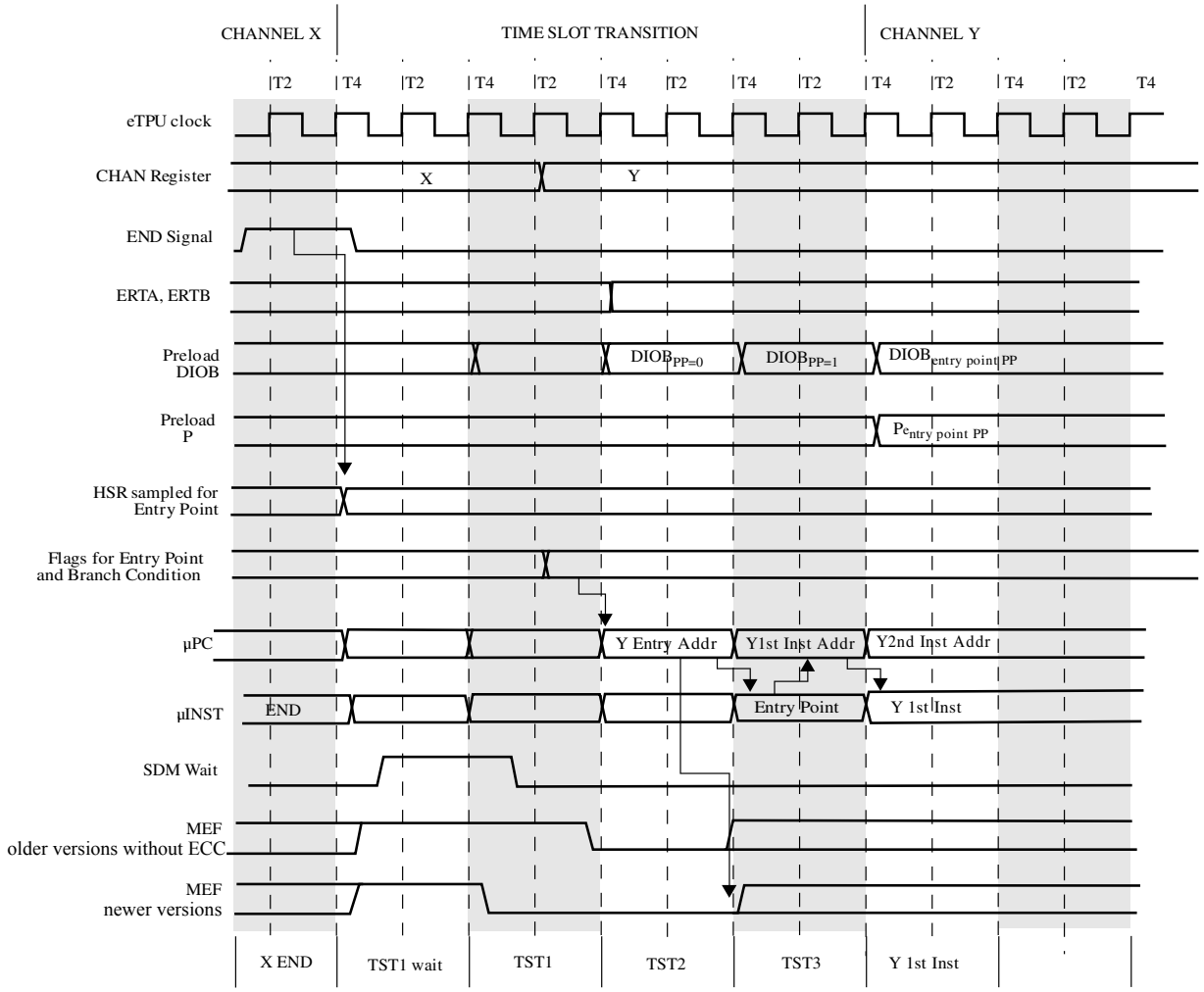


Figure 443. TST Timing - 1 Wait-State

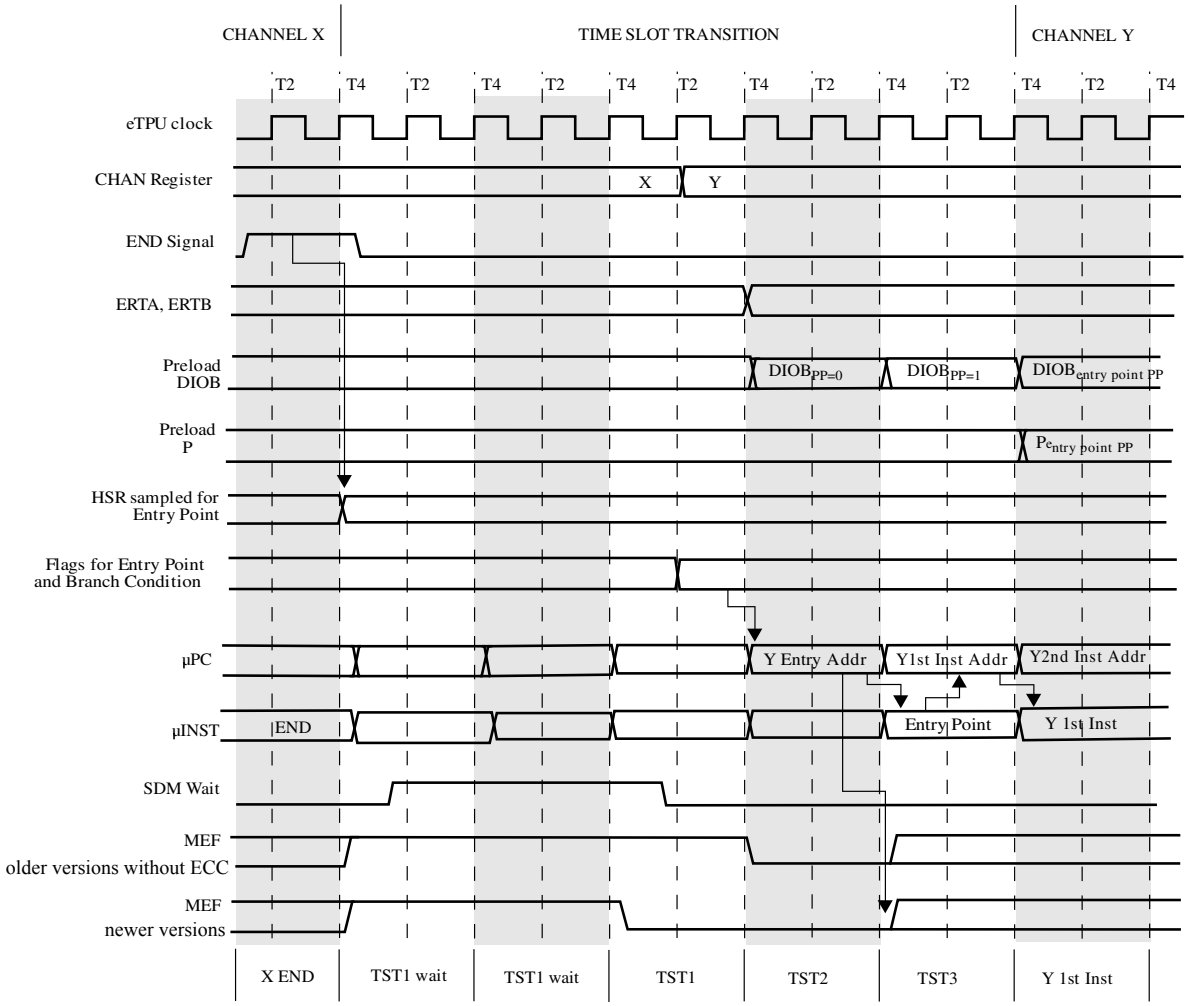


Figure 444. TST Timing - 2 Wait-states

For more information on Channel-specific registers and flags, refer to Enhanced Channels. For more information on P, ERTA/B and DIOB registers refer to Registers.

67.3.2.2.1 Thread gap

The MEF timing has changed from previous eTPU/eTPU2 versions, now being reset for two microcycles from the start of TST.[7] Therefore, two consecutive threads with ME=0 serving the same channel could block any match until the end of the second thread (see Time Slot Transition). This could cause latency problems and also break compatibility with legacy code, so the thread transition logic was modified to introduce a one-microcycle gap between consecutive threads servicing the same channel, as shown in the following figure. During the gap MEF is set to one, regardless of the previous or the next entry point ME field. The thread gap is inserted only between threads serving the same channel.

[7] the new MEF timing is found on all eTPU2 instances starting from the first version with Memory Error Support; all previous eTPU2 versions maintain the former MEF timing .

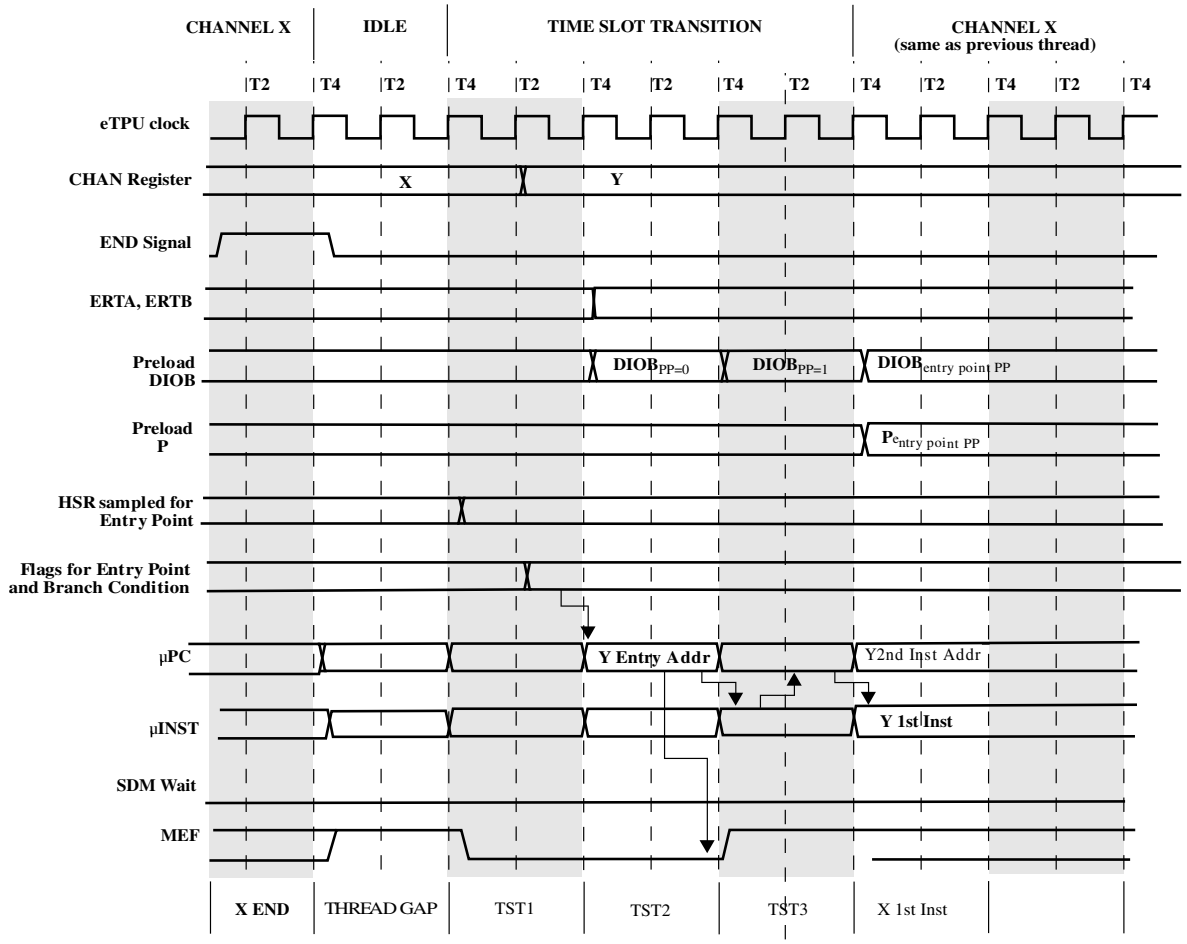


Figure 445. Thread gap

67.3.2.3 Thread ending

Threads can finish by either:

- an instruction with the END field active (see Ending Current Thread - END).
- a forced END by host writing to the FEND field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2).
- a forced END caused by Watchdog timeout (see Watchdog) .
- a forced END caused by a non-correctable memory error (see Memory error support) .

67.3.2.4 Watchdog

Each engine has a watchdog mechanism to prevent a thread or a sequence of threads from running too long, impacting the latency of the other channel services . The watchdog is configured through eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1) and eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2) . When the watchdog is enabled, an internal counter increments on each microcycle when a thread is executing . If the count is greater than the value specified in the WDCNT field in eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1) and eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2) and a thread is still executing, the watchdog:

1. If the WMO field in eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1) and eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2) is negated, forces an END of the thread, allowing other channels to be serviced

2. Sets the WDS status bit of the serviced channel in eTPU Watchdog Status Register for Engine 1 (WDSR_ENG1) and eTPU Watchdog Status Register for Engine 2 (WDSR_ENG2) .
3. If the WMO field in eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1) and eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2) is negated, the channel is disabled, not initiating any thread until its WDS bit is cleared (however, its CPR field in C*a*CR_ENG1 and C*a*CR_ENG2 is not changed).
4. Issues a Global Exception and sets MCR[WDTO1] (engine 1) or MCR[WDTO2] (engine 2) , regardless of the WMO bit state .

If the WMO field in eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1) and eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2) is asserted, the watchdog can be used to monitor the execution time threshold of a thread or thread sequence without interfering with the eTPU code execution .

The watchdog can be configured in one of the following modes, defining how the internal watchdog count is reset:

- **Thread Length Mode**: the watchdog count is reset at the end of each thread.
- **Busy Length Mode**: the watchdog count is reset when the microengine goes idle . A sequence of threads, one right after another, keeps the count running . The counter is also reinitialized when a thread is forced to end, so that a new count begins if another TST initiates at the following microcycle.

The following applies to the watchdog mechanism:

- Microcycles during TST and SDM access wait-states (on TST or instruction execution) are counted.
- If the watchdog count equals WDCNT in the last microinstruction (with SDM wait-states or not) of a thread servicing a channel, its WDS bit is not set.
- If the watchdog count expires (gets greater than WDCNT) during the TST, the thread is forced end on its first instruction.
- The watchdog count does not wrap, so that a thread (in thread length mode) or a thread sequence (in busy length mode) that lasts for more than the maximum value of WDCNT does get a forced end.

NOTE

Watchdog must not be enabled when the microengine enters halt mode.

The counter does not run when the engine is stopped, and resets when the watchdog is disabled .

67.3.3 Host interface

67.3.3.1 System configuration

System Configuration Registers are described in System Configuration memory map and registers. Detailed explanation of the configured functionalities is found throughout Functional description and a specification for the initial configuration sequence is found in Configuration sequence.

67.3.3.2 Interrupts and data transfer requests

67.3.3.2.1 Interrupt types and sources

Each one of the eTPU channels can be a source of two requests: **Channel Interrupt** request and **Data Transfer Request**. Channel Interrupts are targeted to a Host CPU. Data Transfer Requests may be targeted to a data transfer module (for example, a DMA controller). Interrupt and Data Transfer registers are used by the Host to enable interrupts and data transfer requests, indicate their status and service them. Interrupt and Data Transfer requests have the same sets of registers and external signals, and are handled in the same way. They differ only by the fact that Data Transfer Requests are also cleared by the assertion of respective .

NOTE

Interrupt and Data Transfer requests can be cleared even when Engines are in Module Disable Mode, through the Global Channel Registers, and also for Data Transfer requests.

Channel Interrupts and Data Transfer Requests can only be issued by eTPU microcode, through one of the Channel Control instruction fields (see Channel Interrupt and Data Transfer Requests).

Both Channel Interrupt and Data Transfer requests can be individually enabled for each channel.

eTPU Interrupt and Data Transfer Registers are mirrored in two organizations: grouped by Channel and grouped by type (interrupt status, interrupt enable, data transfer status, data transfer enable). This allows either "channel-oriented" or "bundled channel" Host interrupt service schemes, or a combination of them. For a detailed description, refer to the Channel Register Layout and Global Channel Registers sections.

eTPU can also assert a **Global Exception** interrupt indicating a global illegal state. There are six possible sources for a Global Exception:

- Execution of an illegal instruction by the microengine (see Illegal instructions). This Global Exception source is flagged by MCR[ILF1] and MCR[ILF2].
- An SCM signature mismatch detected by the Multiple Input Signature Calculator - MISC. See SCM test - multiple input signature calculator. This source is flagged by MCR[SCMMISF].
- Microcode request, through microinstruction field CIRC (see Channel Interrupt and Data Transfer Requests). This Global Exception source is flagged by MCR[MGE1] (Engine 1) and MCR[MGE2] (Engine 2). The cause of this illegal state is application-dependent. The microcode may write an error code into the SDM to indicate the cause of the exception, for instance.
- A Watchdog timeout, flagged by MCR[WDTO1] and MCR[WDTO2] (see Watchdog) .
- An SDM or SCM non-correctable error on a microengine or host access, flagged by MCR[SDMERR] and MCR[SCMERR], respectively (see Memory error support) .
- Bus errors on microengine accesses to the Shared Subsystem Area, flagged by MCR[SSAERR] (see Shared subsystems support) .
-

Global Exceptions cannot be directly disabled within eTPU, except by disabling its sources (Memory Error, SSS, MISC and microcode), and it is cleared by writing 1 to MCR[GEC]. Clearing Global Exception clears all Global Exception source status bits (ILF1, ILF2, SCMMISF, MGE1, MGE2, SSAERR, SCMERR, SDMERR). If GEC is written 1 at the same time any of the sources issues a Global Exception, both the interrupt and the status bit of that source remains asserted. The assertion of Global Exception by one of the sources above does not prevent the others from asserting it too, so any number of them, in any combination, can be flagged.

NOTE

There can be a race between the clear of a Global Exception and occurrence of a new set condition, such that the set happens just before the clear and cannot be sensed by the Host. Therefore, Global Exception cannot be used as a normal interrupt source. It should only be used for emergency procedures.

Memory Error Correction support (see Memory error support) has a distinct interrupt source, which can activate on any correctable error occurrence, either to SCM or SDM accesses, but does not activate on non-correctable errors (which assert Global Exception instead) . Memory Error Correction interrupt asserts when it is enabled through MECR[MECIE] (see eTPU Memory Error Status Register (MESR)) and either DCERR or CCERR in eTPU Memory Error Status Register (MESR) is asserted . The interrupt is negated when both DCERR and CCERR are negated, or MECIE is negated .

67.3.3.2.2 Interrupt and Data Transfer Request overflow

If a Channel Interrupt was issued, its status bit is still set, and microcode issues another Channel Interrupt, the Interrupt Overflow status bit is set for that channel. Interrupt Overflow status can be checked by the Host in the CIOS field of C*a*CR_ENG1 and C*a*CR_ENG2, mirrored in eTPU Channel Interrupt Overflow Status Register for Engine 1 (CIOSR_ENG1) and eTPU Channel Interrupt Overflow Status Register for Engine 2 (CIOSR_ENG2). Interrupt Overflow status is not cleared automatically when Interrupt Status is cleared. The same mechanism and respective registers (eTPU Channel Data Transfer Request Overflow Status Register for Engine 1 (CDTROSR_ENG1) and eTPU Channel Data Transfer Request Overflow Status Register for Engine 2 (CDTROSR_ENG2)) are available for Data Transfer Requests.

If interrupt is set and cleared at the same time, set prevails and overflow is not altered (keeps the same state as it was before, asserted or not).

Global Exception has no overflow status.

67.3.3.3 Parameter Access

67.3.3.3.1 Parameter Access Widths

From the Host side the SDM address space is mapped in bytes, and each 32-bit parameter occupies 4 contiguous, aligned bytes. The Host can read/write the SDM by 8-, 16-, or 32-bit accesses in aligned addresses.

In 32-bit access, Host can access all 32 bits or only the lower 24 bits with an automatic sign extension (see Parameter Sign Extension area).

67.3.3.3.2 Parameter Addresses and Endianness

To access parameter number xxx, eTPU Microengine(s) would select address xxx. The Host would add *(xxx*4)* to the SDM base address to access the same parameter. For example, parameter 0x101 is seen by the Host in *(SDM base address +0x404)*. An example of SDM memory map is shown in SDM organization. The Host can access the SDM with a 32-bit-wide bus cycle to a four-byte aligned address, 16-bit-wide bus cycle to a two-byte aligned address, or 8-bit wide bus cycle to any byte address.

The address of the 24-bit parameters and the most significant byte depends on the endianness of the MCU. For more details, see the Endianness.

67.3.3.3.3 Parameter concurrency

Host accesses to parameters may occur in parallel with eTPU Microengine accesses. Readings taken from a group of parameters while they are being simultaneously updated may lack coherency. eTPU provides mechanisms to ensure parameter coherency in accesses from both Host side and Microengine side, including the use of a coherent dual-parameter transfer mechanism, described in detail on Parameter sharing and coherency.

67.3.3.3.4 Parameter Sign Extension area

The SDM address space to the Host is mirrored in a Parameter Sign Extension (PSE) area (see Memory map). Accesses from the Host to the PSE area differ from accesses to the standard SDM address space as follows:

- **Writes**: the most significant byte of the parameters is not written, and the SDM retains the old byte value, regardless of the Host access size.
- **Reads**: the most significant bit of the 24-bit parameter (that is, the MSB of the second most significant 32-bit parameter byte) is repeated in the 8 most significant bits of the read value on all 32-bit reads and most significant 16- and 8-bit reads.

The same parameters written in the standard SDM address space are read from the PSE area with the same offsets, and vice-versa. See Endianness for a reference of the address offsets in big and little endian machines.

This feature reliefs the Host from extending the signal of 24-bit eTPU parameters before calculations, and from read-modify-write accesses to modify 24-bit parameters at the SDM.

67.3.3.4 SDM organization

The SDM internal partition for channel allocation is dynamic and programmed in the Channel Registers (see C*a*CR_ENG1 and C*a*CR_ENG2).

The Host application is responsible for allocating a different parameter base address to each channel during the initial eTPU configuration, and to allocate enough parameters for the selected Function, with no unintentional overlapping between parameters of different functions.

Besides channel parameters, global areas may have to be allocated for parameters that are shared by more than one channel, in one or both Engines. Also, temporary parameter areas should be reserved to be used by the coherent parameter transfer

mechanisms described in Parameter sharing and coherency, if necessary. An SDM organization example is shown in the following figure.

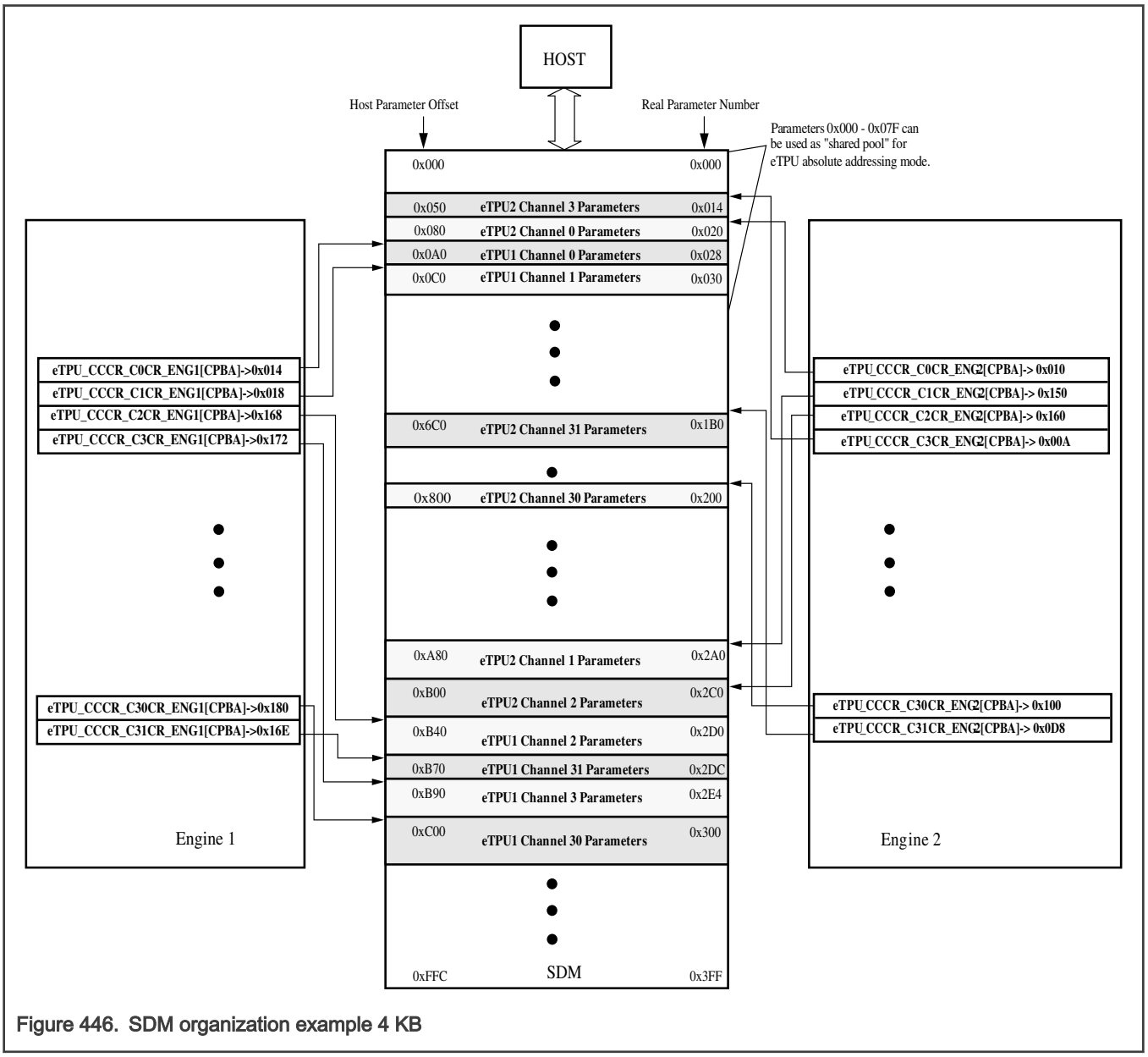


Figure 446. SDM organization example 4 KB

Single-engine eTPU or dual eTPU system may require fewer parameters than the maximum number provided by the SDM. Since the SDM partition is fully dynamic, there is no limitation of fixed channel addresses, and the reduced array can be fully utilized.

67.3.3.5 Host Service Requests

Host CPU can request immediate service from a channel by writing a non-zero value to the Host Service Request register field - HSR (see CaHSRR_ENG1 and CaHSRR_ENG2). There is one HSR field for each channel, so that writing to it generates a Service Request to the respective channel only. A zero value in HSR means no Host Service Request is pending for the channel.

HSR value turns to 000 automatically at the end of microengine service for that channel, but only if the thread started due to an HSR.

The meaning of a non-zero HSR value depends on the Function assigned for the channel. These bits are part of the conditions which select the Function entry point, and cannot be tested by microcode. For more details, refer to Entry Points.

If Host writes HSR=000 when a thread for the same channel is already running, the thread runs until the end and is not aborted. If Host writes HSR>000 when an HSR thread for the same channel is already running, HSR value resets at the end of the thread, and no new HSR will be pending. If HSR is written before its value is resolved by the scheduler during TST, the entry point will obey the new HSR value, and if this new value is 000, no service thread is executed for the HSR.

The scheduling of HSRs is completely asynchronous with Host accesses, and there is no race-free manner to change an HSR value before service thread execution, so generally the safe way is: write HSR>0 only when HSR=0. Error recovery or emergency host procedures may require one to the safely abort service and reset channel state when an HSR is already pending or executing. In these cases, the procedure below should be followed:

1. Disable the channel, writing CPR=00 in C*a*CR_ENG1 and C*a*CR_ENG2. That will prevent any pending HSR to be serviced.
2. Check if the channel is currently being serviced, reading its service status bit in eTPU Channel Service Status Register for Engine 1 (CSSR_ENG1) and eTPU Channel Service Status Register for Engine 2 (CSSR_ENG2). If it is, wait for the time necessary to finish the service pending, or check again until HSR == 0, or channel service bit in eTPU Channel Service Status Register for Engine 1 (CSSR_ENG1) and eTPU Channel Service Status Register for Engine 2 (CSSR_ENG2) is cleared.
3. Write HSR with the error recover value. This value should, possibly combined with other host-defined flags in SDM or FM bits, initiate a channel reset or error recovery procedure.
4. Re-enable the channel, writing CPR value > 0 in C*a*CR_ENG1 and C*a*CR_ENG2.

67.3.3.6 SCM access

Only Host can access SCM as data. Depending on the specific device, SCM may be implemented as a RAM or ROM. This determines Host accesses to the SCM as shown below.

67.3.3.6.1 SCM RAM implementations

When SCM is implemented as RAM, the Host may read or write to SCM by setting MCR[VIS]=1. If VIS=0 and Host tries to access SCM space, a bus error is issued, writes are ineffective and read data is meaningless. Both Engines must be stopped or halted to set VIS=1.

NOTE

It is necessary to turn VIS bit on to set software breakpoints (see Software breakpoints).

67.3.3.6.2 SCM low power

SCM turns off its internal clocks when both Engines are stopped (STF field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2) asserted), MCR[VIS], and MISC is not enabled (SCMMISEN=0). The SCM clocks are automatically turned on if either one of the STF bits is negated or VIS turns to 1, or SCMMISEN turns to 1.

SCM clocks are not turned off if any of the Engines is not stopped, even if they are both halted.

The conditions for SCM Clocks and MISC activation are summarized in the following table.

Table 382. SCM clocks and MISC activation

STF in eTPU_SCR_ECR_ENG1	STF in eTPU_SCR_ECR_ENG2	VIS in eTPU_SCR_MCR	SCMMISEN in eTPU_SCR_MCR	SCM clocks	MISC
0	x	0	1	On	On
0	x	0	0	On	off
x	0	0	1	On	On

Table continues on the next page...

Table 382. SCM clocks and MISC activation (continued)

STF in eTPU_SCR_ECR_ENG1	STF in eTPU_SCR_ECR_ENG2	VIS in eTPU_SCR_MCR	SCMMISEN in eTPU_SCR_MCR	SCM clocks	MISC
x	0	0	0	On	off
1	1	0	0	off	off
1	1	0	1	On	On
1	1	1	0	On	off
1	1	1	1	On	off[1]
0	0	x	0	On	off
0	0	x	1	On	On

1. MISC resets and stays so when VIS=1, restarting automatically when VIS goes 0 if SCMMISEN=1.

67.3.3.6.3 SCM off-range data

When read accesses are made, either by the Host or by a microengine, to addresses above the limit corresponding to MCR[SCMSIZE], the value read comes from eTPU SCM Off-range Data Register (SCMOFFDATAR). The Host can program the register at initialization with an opcode value with operations that try to protect or recover the system from runaway code, for instance: terminate the thread, clear channel flags, disable match and transition service requests, issue an interrupt, jump to an error recovery procedure[8]. Writes to unimplemented addresses do not return error and can write on unspecified mirror addresses, so they should be avoided.

67.3.3.7 Bus error conditions

Follows a summary of the possible causes of bus errors on host accesses to the eTPU memory space:

- Read or write access to the SCM with MCR[VIS] = 0.
- Read or write access to the channel registers with eTPU_SCR_ECR_ENG*n* bits MDIS = 1, or bit STF = 1 (see eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2)).
- Write access to the Time Base Registers with eTPU_SCR_ECR_ENG*n* bits MDIS = 1, or bit STF = 1 (see eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2)).
- Non-correctable errors in the SCM on reads of any size or writes less than 32-bits wide when MECR[CEDD] = 0.
- Non-correctable errors in the SDM on reads when MECR[DEDD] = 0.
- Accesses to the Shared Subsystem Area, when propagating a bus error issued by the attached subsystem.

67.3.4 Scheduler

Every Function is composed of one or more Threads. A Thread consists of a group of instructions that, once begins execution, cannot be interrupted by host or channel events. Each active channel intents to be serviced, being granted time for Thread execution. Since one microengine handles several channels operating concurrently, the Function threads must be executed serially.

The task of the Scheduler is to recognize and prioritize the channels needing service and to grant execution time to each channel. The time given to an individual Thread for execution or service is called a **Time Slot**. The duration of a time slot is determined by the number of instructions executed in the Thread plus SDM wait-states received, and varies in length.

[8] Only part of these suggested operations can be parallelized in a single instruction, see Microinstruction formats.

At any time, an arbitrary number of channels can require service. To request service, channel logic, eTPU microcode or Host application notifies the Scheduler by issuing a Service Request.

67.3.4.1 Channel enabling and priority assignment

Every channel is assigned one of three priority levels - high, middle, or low - by the Host CPU, through the CPR field in C*a*CR_ENG1 and C*a*CR_ENG2). These registers are also used to disable the channel, which is equivalent to assigning it a "null" priority. In this case, the Scheduler does not grant any of its Service Requests.

It is possible to change the channel priority level or disable it dynamically. If the Host disables a channel when it is currently being serviced, channel service thread will complete. This means that it is possible for the output level of a channel signal to change, or a Host interrupt occur, even after its priority register was written to "null". For instance, if an output transition is scheduled, the transition will occur even after the channel is disabled.

Service requests previously pending or that occur while a channel is disabled remain asserted while the channel is disabled, and are serviced if the channel is enabled again, in due time determined by the priority scheme and concurrent requests from other channels. Channels are disabled after reset, and it is recommended to configure a Host Service Request for initialization of a channel before that channel is enabled to active priority (see Initialization/application information).

67.3.4.2 Channel priority schemes

The Scheduler holds a Service Grant register with one bit for each channel. Once the Scheduler grants a time slot to channel, the Service Grant bit for that channel is asserted in the Service Grant register. When the Service Grant bit of a channel is set, the channel may request new service but is not serviced again before its Service Grant bit is cleared.

When all channels in a same priority level are serviced, their Service Grant bits are cleared at the end of the thread, one eTPU clock before the next serviced channel is calculated, according to the scheme below[9]:

- Clear all grant bits of priority High if all channels of that priority that are requesting have their grant bits in 1.
- Clear all grant bits of priority Medium if all channels of that priority that are requesting have their grant bits in 1.
- Clear all grant bits of priority Low if all channels of that priority that are requesting have their grant bits in 1.
- Clear all grant bits of disabled channels.

This scheme assures that no channel is left with its grant bit forever asserted (preventing it from being serviced again), even if the channel priorities are reassigned during the execution.

Priority level is determined based on the maximum latency desired for each channel. A channel having a Function that requires the most frequent or more immediate service should be allocated a high priority level.

The eTPU employs a **primary** and a **secondary priority scheme**. These two schemes ensure frequent servicing of high-demand Functions and ensure a minimum time allocation to all channels requesting service, regardless of their priority level. The primary scheme prioritizes requesting channels that have different priority levels; the secondary scheme prioritizes requesting channels that have the same priority level.

Initially, a channel requests service and is granted a time slot by the Scheduler: Service Grant bit is asserted. If only high-level channels constantly receive service first because of their priority level, middle- and low-level channels would only be serviced by default, i.e., if no high-level channels request service. To ensure that each priority level receives an opportunity for servicing, every time slot has a fixed priority level that the Scheduler honors first. Divided into sets of seven, time slots are numbered from one to seven. The figure below illustrates the numbered time slots in sets of seven (fields A and B) and identifies their assigned default priority level. The high level has more time slots than the middle and low levels. Out of every seven time slots available, four are assigned to honor high-level channels first, two are assigned to honor middle-level channels first, and one is assigned to honor low-level channels first. Only one request (in each Engine) is serviced per time slot. When no channel requests service and the microengine is idle the priority scheme is initialized to time slot one, to prevent priority inversion on the next request[10].

[9] Grant bits are also cleared in the next clock, when the service channel is chosen, or when the microengine is idle, using the same scheme.

[10] Priority inversion would occur in the following situation: no channel is requesting service, and the current time slot is primarily assigned to a low-priority channel. If the Scheduler was not reset to time slot one and two channels requested service at the same time, one with high priority and the other with low priority, the channel to be serviced would be the low-priority channel.

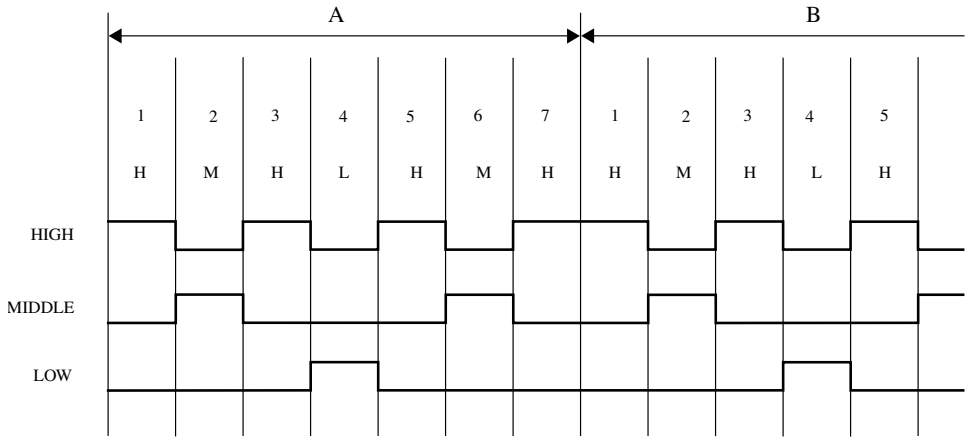


Figure 447. Time Slot Priority levels

67.3.4.2.1 Primary scheme - priority among channels on different levels

Although time slot priority assignment is fixed, the servicing priority is not. The primary scheme acknowledges the priority level assigned to a time slot, granting service first to a channel having the same priority. In Channel priority schemes, time slot one has a high-level assignment; therefore, a high-level channel requesting service is recognized first. However, if no high-level channel requests service, the Scheduler recognizes a requesting middle-level channel. If this level has no request, the Scheduler continues to the low-level. If no requests occur, the Scheduler truncates the seven state cycle and starts a new cycle at time slot one, waiting for the first request. Granting service to a different-level channel is called priority passing. The order of passing always gives the highest priority to the assigned level, and the second priority to the higher of the remaining requesting priority levels as shown in the following table.

Table 383. Priority Passing

Assigned Priority Level	Next Priority Level	Next Priority Level
High	Middle	Low
Middle	High	Low
Low	High	Middle

When priority is passed to another level, that level is serviced and the fixed-priority-level sequence is resumed with the next time slot.

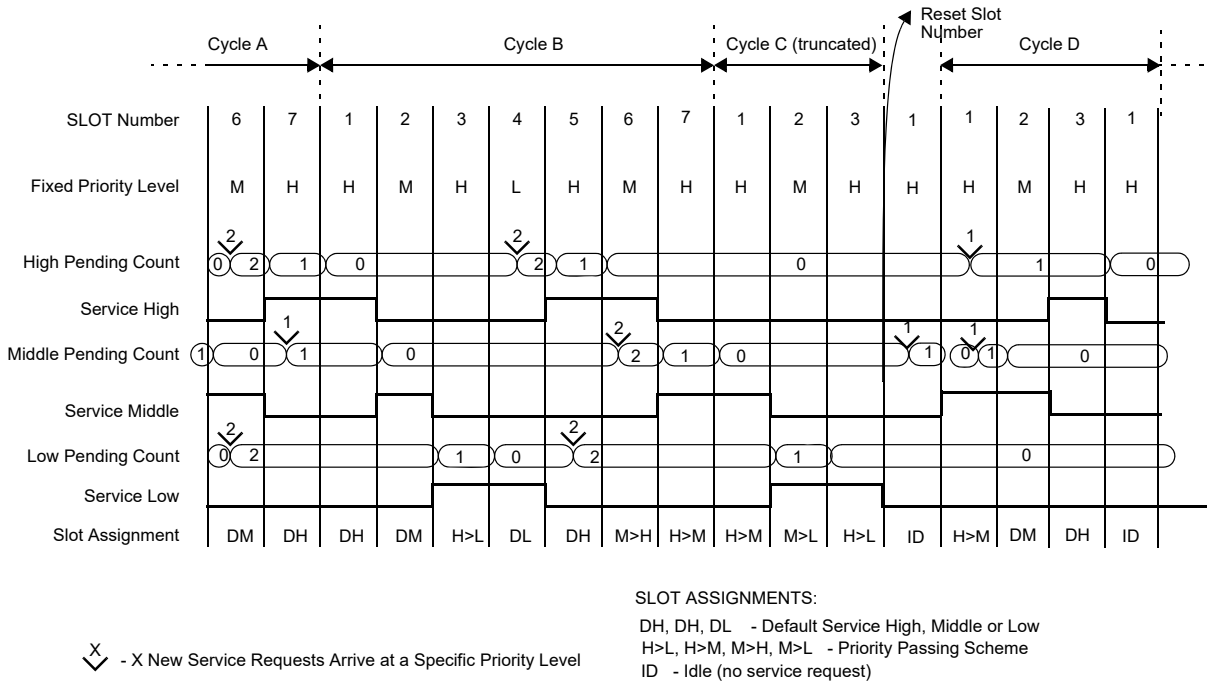


Figure 448. Priority passing example

Examples of priority passing are shown in the above figure. Each cycle contains seven time slots (or less if no service request exist). In cycle B, no high-level or middle-level service requests are present before time slot three which is assigned by default to high-level priority. Thus, time slot three is passed to the low level. In cycle B there are also no middle-level service requests before time slot six, so it passes the priority to a requesting high-level channel. During time slot six no more high level requests are left, but two new middle-level requests arrive, and there are also three low level pending service requests. Thus, time slot seven of cycle B and time slot one of cycle C are passed to the middle-level which is the next priority level after high. Time slots two and three of cycle C are passed to the low level which contains the three remaining channel service requests. At time slot three of cycle C the last low level request is serviced, and the Scheduler passes to idle state. At this point the cycle C is truncated and the Scheduler passes to time slot one of cycle D.

67.3.4.2.2 Priority passing disabling

The priority-passing scheme allows a case where a high priority channel looses to a lower priority one right after another lower priority has been serviced, exemplified in the Cycle D on Primary scheme - priority among channels on different levels. A middle priority channel wins time slot 1 due to priority passing from high to middle. While it is being serviced, two new service requests arrive, one high and one middle priority. The high priority request looses to the middle one on next time slot 2 by default priority assignment.

This priority inversion can be avoided by setting the SPPDIS field in the eTPU_SCR_ECR_ENG*n* registers (see eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2)), which disables the priority-passing mechanism. When priority passing is disabled, at the end of the thread the slot number is incremented until a time slot that matches the priority of one of the requesting channel(s). The time slot advance takes no extra clocks. If no channel requests service, the time slot counter stays at time slot 1. The priority selection scheme with disabled priority passing is summarized in the following table.

Table 384. Priority Passing Disabling

At the end of time slot	servicing priority	if any request of priority	service it on time slot	else if any request of priority	service it on time slot	else if any request of priority	service it on time slot
1	High	Medium	2	High	3	Low	4
2	Medium	High	3	Low	4	Medium	6
3	High	Low	4	High	5	Medium	6
4	Low	High	5	Medium	6	Low	4
5	High	Medium	6	High	7	Low	4
6	Medium	High	7	Medium	2	Low	4
7	High	High	1	Medium	2	Low	4

An example of the priority passing disabling scheme is illustrated in the figure below. The sequence of service requests is the same as in the example of Primary scheme - priority among channels on different levels, and although the time slot incrementing differs, the priorities granted are the same for cycle B. Cycle C has one of the low-priority channels serviced before the second middle one. Cycle D, however, no longer has the priority inversion.

In cycle B, after the time slot 2 only a low-priority request remains, so the time slot count advances directly to 4, which has a low priority assigned. Time slot keeps on 4 for the next service, as only a low-priority request remains also, and only time slot 4 is assigned to low. Two high priority services contend for the next time slot 5 (assigned to High). The second high priority channel is serviced on the next time slot, jumped to 7 because there is no middle request, ending cycle B. Cycle C starts with time slot 2, as there are no high priority requests and two middle and two low ones. After the first middle service, time slot count skips 3 assigned to high (no high requests), and services a low-priority channel on time slot 4. It follows the same scheme until there are no other requests and cycle C is truncated, resetting the time slot counter to 1.

Cycle D begins with a middle request, jumping to time slot 2. During this service two requests arrive, one high and one middle. Unlike what happened with priority passing, the next serviced is the high priority channel, as the time slot increments to 3. The second middle priority channel request in cycle D is finally serviced next, on time slot 6.

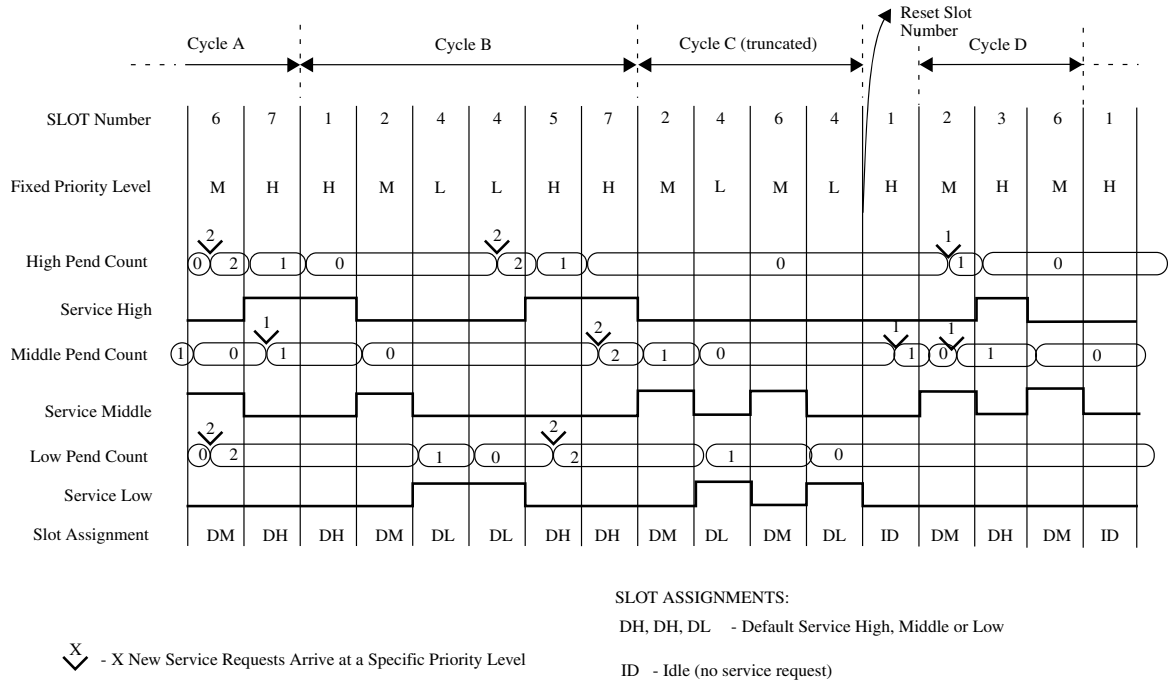


Figure 449. Priority passing disabling example

67.3.4.2.3 Secondary Scheme - Priority Among Channels on the Same Level

Because channels can randomly request service, channels having the same priority level will inevitably request service simultaneously. A secondary scheme prioritizes these requests. The Scheduler services channels on each of the three priority levels, beginning with the lowest numbered channel on that level.

67.3.4.2.4 Priority Scheme Example

The overall priority scheme simultaneously incorporates both primary and secondary schemes. Combining both schemes in the following example conveys their correlation.

1. One high-priority and one low priority channels request service, while the Scheduler is in time slot one. Having its service request bit asserted, a single high-level channel is granted the time slot, which has high-level priority (primary scheme) and its service grant bit is asserted. At the end of the thread, the service grant bit is negated (no more requests of high priority level channels).
2. The Scheduler proceeds to time slot two, which has middle-level priority; however, no middle-level channel is requesting service. Priority is passed to the high level, but no high-level channel is requesting service; therefore, priority is passed again, and service is granted to the single requesting low-level channel. Once serviced, this channel's grant bit is negated (no more low-level requests).
3. The Scheduler resumes with the fixed-priority sequence on time slot three; however, no channels are requesting service. The Scheduler returns to time slot one, waiting for requests.
4. Two high-level and two middle-level channels simultaneously request service. Being in time slot one which is assigned high priority, the Scheduler finds the lowest numbered high-level channel (secondary scheme) and selects it for service. This channel's service grant bit is asserted.
5. The Scheduler continues to time slot two, which has middle priority (primary scheme), and allocates the slot to the lowest numbered middle-level channel requesting service (secondary scheme). The Scheduler notes the still unserviced middle-level channel and proceeds to time slot three.
6. Time slot three is allocated for high priority. The slot is allocated to the remaining unserviced high-priority channel, and the channel's service grant bit is asserted. The Scheduler checks again at the end of the thread. All service grant bits

of high-level requested channels are asserted; therefore, all high-priority channels that requested have been allocated execution time. Under this condition, all service grant bits of the high-level serviced channels are negated. The Scheduler proceeds to time slot four.

7. Time slot four is allocated for low-priority channel; however, no low-level channel is requesting service. Priority is passed to the high level, but no high-level channel is requesting service; therefore, priority is passed again, and service is granted to the remaining middle-level channel which requests service. This channel's service grant bit is asserted. The Scheduler checks again at the end of the thread. All grant bits of middle-level requested channels are asserted; therefore, all middle-priority channels have been allocated execution time. Under this condition, all service grant bits of the middle-level serviced channels are negated. The Scheduler proceeds to time slot five. Meanwhile a low priority channel requests service.
8. Time slot five is allocated for high-priority channels, but there are no more requests from high-priority or middle priority channels. The single low-level channel which required service is granted time slot five. Once serviced, the channel's service grant bit is asserted. Next, the service grant bit is negated (no more requests of low priority level channels).
9. The Scheduler resumes with the fixed-priority sequence on time slot six; however, no channels are requesting service. The Scheduler returns to time slot one and waits for requests.

67.3.4.3 Time slot latency

Latency is the amount of time between a service request and the beginning of service on that channel. The following factors affect latency:

- Number of active channels
- Number of channels on a priority level
- Number of available time slots on a priority level
- Number of microcycles required to execute a thread of a Function
- Number of SDM accesses during execution of a Function thread
- eTPU clock frequency

Each time slot may require a different number of microcycles, depending on the thread of a Function to be executed. This variation is shown in the figure below.

For more details on latency evaluation, see Estimating Worst Case Latency.

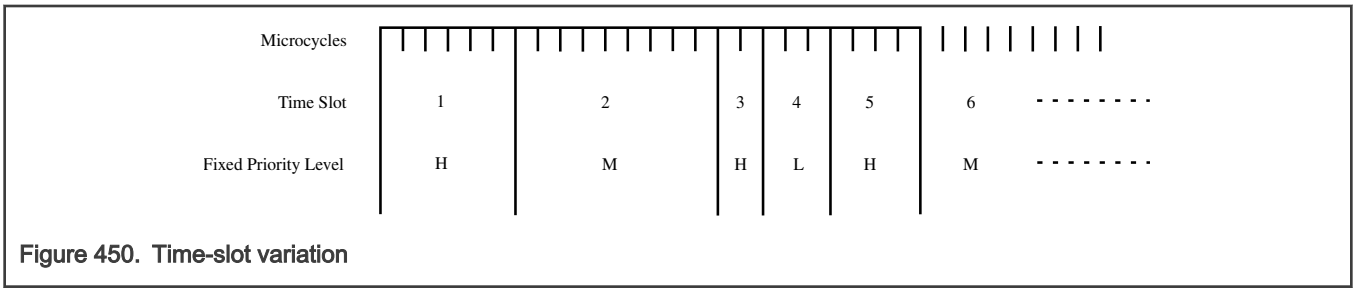


Figure 450. Time-slot variation

67.3.5 Parameter sharing and coherency

SDM can be concurrently accessed by Host and Microengines (two in a Dual eTPU Engine system). In general, there is no guaranteed order by which a group of parameters is accessed, which may lead to a lack of internal consistency if two or more related parameters are read when only part of them is updated.

eTPU provides mechanisms to guarantee parameter coherency. The most generic mechanisms for Host-eTPU coherency, suitable for any number of parameters, are:

- the use of Transfer Service Thread mechanism.
- the mailbox (or "software semaphore") mechanism.

These mechanisms, described in Multiple parameter coherency methods, use microcode to transfer parameters from temporary buffers in SDM to their definitive locations (or vice-versa). These methods have the disadvantage of wasting processing and code memory resources.

eTPU also provides a **Coherent Dual-parameter Controller - CDC** - mechanism. It is used by Host to coherently transfer pairs of parameters from/to a parameter buffer located on SDM to/from the locations on SDM where parameters are accessed directly by the channels. Coherency is guaranteed by SDM access arbitration. Although limited to two parameters only, it has lower latency and wastes no microengine resources[11]. CDC usage is described in Coherent Dual-parameter Controller (CDC).

For parameters shared by both Engines, eTPU provides **Hardware Semaphores**. Coherency is assured given the semaphores are used to prevent concurrent access to the changing parameters. Microengine can request semaphores using specific microinstructions (see Semaphore Operations). Hardware Semaphores are described in detail in Hardware Semaphores.

Neither Host nor CDC have access to the hardware semaphores, but they can be combined with microcode transfer mechanisms if Host must coherently access parameters which are also shared by both Engines.

In order to ensure coherent access to a group of parameters by two or more contenders, **each contender must have atomic access** to the shared parameters. Atomicity conditions are discussed in Host side atomic access and Microengine Side Atomic Accesses.

67.3.5.1 Host side atomic access

Host side atomic accesses can be achieved by either of following ways:

- For one parameter, the SDM should be accessed by 32-bit-wide data transfers to ensure coherency
- For two parameters only, using the Coherent Dual Parameter Controller.
- Indirectly, for any number of parameters, by requesting microcode to coherently access SDM in its behalf. The host side atomicity problem becomes, then, a microengine side atomicity problem. Some methods that use this approach to achieve coherency are described in Multiple parameter coherency methods.

67.3.5.2 Microengine Side Atomic Accesses

67.3.5.2.1 Microengine Single Parameter Atomicity

SDM should be accessed by 32-bit-wide data transfers to ensure atomicity for 32-bit parameters. This applies either to Host-Microengine coherency or Microengine-Microengine coherency in a dual eTPU Engine system.

67.3.5.2.2 Microengine Dual Parameter Atomicity

Microengine has the ability to access two parameters coherently in back-to-back accesses, at random addresses: once it accesses SDM, it has priority over Host for another access in the next microcycle (see SDM arbitration). Note that it applies **only to Microengine-Host** coherency. For Microengine-Microengine coherency in a dual eTPU Engine system, one must use Hardware Semaphores (see Hardware Semaphores).

Microengine dual back-to-back accesses are guaranteed to be atomic in relation to Host accesses or Coherent Dual-parameter Controller, regardless of semaphore usage: Host or CDC accesses cannot break-up a back-to-back Microengine access, neither Microengine can break a CDC transfer, due to the SDM arbitration mechanism described in SDM arbitration.

Atomicity is not guaranteed if microengine enters halt state in the middle of a back-to-back access (see Microengine Halt State): Host can access SDM while microengine is halted in the middle of a back-to-back access.

67.3.5.2.3 Microengine Side Multiple Atomicity

Hardware Semaphores must be used for Microengine-Microengine coherency (more than 1 parameter) since two or more accesses from one Microengine are not atomic with respect to the other.

[11] A microengine access to the SDM in the moment CDC is performing the transfer may suffer a maximum of two wait-states.

For multiple Microengine-Host coherency, the software methods described in Multiple parameter coherency methods, or similar ones, must be used. Some of these methods rely on the fact that parameter access of a thread is atomic in relation to another thread in the same Engine, since a thread cannot be suspended (preempted).

For 1 parameter coherent access, or dual parameter coherency between only one Microengine and Host, the alternatives shown in previous sections apply.

67.3.5.3 Coherent Dual-parameter Controller (CDC)

Dual-parameter coherency is supported by a Coherent Dual-parameter Controller hardware (CDC), which contends with microengine for SDM access. CDC atomically transfers, upon Host's command, two parameters from one area of the SDM to another. One area is a temporary (buffer) area, where the two parameters are directly read or written by the Host. This temporary area has to begin in an SDM address multiple of 2 words, and the two parameters must be sequential. The other area is the channel parameter area where the microcode normally accesses the parameters, usually with the channel relative address mode (see SDM Addressing Modes). In this area, the parameters transferred by CDC don't have to be sequential. A transfer from the temporary area to the channel area, when the Host sends data to the channel, is called a **write transfer**. Inversely, in a **read transfer** the parameters are copied from the channel area to the temporary area (channel to Host).

Coherency is guaranteed by the SDM access contention rules implemented in the SDM arbiter (see SDM arbitration). CDC transfers are coherent in respect to the two Engines, so the target parameters in the channel area may be shared by channels on them both. During CDC operation, the Host may suffer from 3 up to eTPU clocks wait states[12], and the Microengine(s) may suffer up to 2 microcycle wait-states[13]. CDC accesses are atomic with respect to Microengine(s) accesses to the SDM. Even when neither engine is in TST, CDC may suffer up to 4 eTPU clock internal wait-states from SDM arbiter, meaning 9 wait-states to Host, so that it does not break atomic back-to-back accesses from microengine(s). CDC also cannot break TST preload accesses. Host can initiate CDC back-to-back transfers: there is no need of idle cycles between two transfers.

NOTE

SDM memory error detection and correction does not affect the number of wait-states to host due to CDC (see Memory error support) .

CDC can be used to atomically fix SDM soft errors . For more details, see Error fixing .

67.3.5.3.1 CDC programming

The Coherent Dual-parameter Controller Register (see eTPU Coherent Dual-Parameter Controller Register (CDCR)) is used to configure and initiate CDC transfers between the temporary area and channel parameter area. Host asserts STS bit in order to start the data transfer. CDC then contends for the SDM and starts the transfer. When the data transfer is complete, STS returns to 0. Host receives wait-states for writing STS = 1 while CDC contends for SDM and during the transfer. The write access ends when CDC finishes the transfer. Host receives wait-states during the CDC transfer. If Host writes eTPU Coherent Dual-Parameter Controller Register (CDCR) with STS = 0 or does not write the STS byte, the CDC transfer does not occur. CDC programming can be summarized as follows:

1. If it is a write transfer, that is, from Host to channel, write the two parameters into temporary area.
2. Write CDCR[STS]=1 and the remaining CDC programming parameters: parameter width (32 or 24 bits, field PWIDTH), transfer direction (read or write, field WR), temporary parameter area base address (field PBBASE), and the absolute addresses of the parameters to be transferred (concatenation of the fields CTBASE and PARM0/1).
3. If it is a read transfer -- that is, from channel to host -- read the two parameters from the temporary area into Host memory/registers.

[12] The maximum number of Host wait states on CDC occurs when both microengines overlap their TSTs, delayed 3 eTPU clocks from each other.

[13] One microcycle takes two eTPU clocks. Microengines get wait-states in multiples of microcycles, while Host and CDC wait-states are multiples of eTPU clocks.

67.3.5.4 Hardware Semaphores

eTPU provides Hardware Semaphores accessible by the Microengine only. It is the responsibility of the application to ensure proper use of the semaphores (i.e., agree upon a specific semaphore and use it properly, to ensure coherency).

The eTPU microinstruction set has support for locking and freeing the semaphores, described in Semaphore Operations, and this is the only way to access them.

There are four semaphores available, which reduces the amount of collisions by assigning unrelated data transfers to different semaphores. Semaphores are used for parameters which can be shared by channels in different Engines, and for Engine-to-Engine synchronization. Semaphores are also the only way to ensure coherent access to parameters shared between the two Microengines.

Attempting to lock one semaphore (even not successfully) frees the other locked by the same Engine, ensuring one can lock just one semaphore at a time. That prevents deadlock conditions between the two Engines.

Microcode END command or Engine being in idle state (no thread executing) automatically releases all semaphores from one Engine side, even if a semaphore lock is done in parallel. However, it is recommended to write the microcode in a way which locks semaphores for the shortest required period, and frees them without waiting for the END command, to improve the performance of the other microengine. Semaphores are free after reset. An Engine can only free a sempaphore locked by itself.

Semaphore lock requests are always **non-blocking**, in the sense that they do not suspend the requester in case the semaphore is already locked. The semaphore status after the lock request - indicating if it was successfully locked or not - must be tested through the SMLCK microengine branch condition (see Branch conditions).

67.3.5.5 SDM arbitration

Up to four entities can access SDM:

- Two Microengines (in a dual eTPU Engine system)
- The Coherent Dual-parameter Controller (CDC)
- The Host CPU (direct memory-mapped access)

The following rules specify the access priorities for contended access. They have dual parameter access atomicity, but only between the microengine and CDC (not Host accesses through bus).

1. Microengine accesses from the two eTPU Engines are interleaved between each other, but not with Host or CDC accesses;
2. The eTPU microengine(s) gives priority for SDM accesses to either the Host CPU or the CDC under any of the following conditions:
    a. The microengine has completed accessing the second parameter in a back-to-back SDM access.
    b. The SDM was not accessed during the last arbitration slot for the microengine and the host does not loose the access to the other engine in the current arbitration slot
    c. CDC is transferring data, after its first (read) access. Note that the CDC can be in middle of a data transfer of another pair of parameters, unrelated to the ones that microengine tries to access.
3. The eTPU microengine takes priority for SDM accesses under either of the following conditions:
    a. the Host CPU or CDC has done a data transfer during the last access arbitration slot for the engine. Also, the Host CPU does not hold a pending access against the other eTPU microengine.
    b. the microengine is arbitrating for the access of its second parameter in a back-to-back access. All pairs of back-to-back parameter accesses are coherent with respect to Host and CDC (not to the other microengine).

The direction (read or write) of any individual access by Host or microengine is irrelevant to the arbitration. The use of Normal or PSE SDM area by the Host is also irrelevant to the arbitration.

[14] If microengine tries to access the SDM in the following microcycles, the third and fourth consecutive accesses are considered the first and second of a new back-to-back dual access.
[15] The microengine access slot is between its own T4 and T2 edges (see Microcycle and I/O timing).

The first parameter preloading in a TST is considered first access by the arbiter, regardless of any access made at the END microinstruction of the previous thread, that is, the last access of a thread and the first preload are never considered a back-to-back access. On the other hand, the TST preload accesses are considered back-to-back and are, therefore, atomic with respect to Host or CDC.

NOTE

The Zero SDM operation (see Zero SDM Operation) is considered an SDM access for arbitration purposes both on writes and reads; the fact that read SDM data is discarded is irrelevant for arbitration.

67.3.6 Enhanced Channels

Enhanced Channels comprise hardware support for input digital signal processing and output signal generation. Each Channel is associated with one input and one output signal. Enhanced Channel logic is combined with Function microcode (and optionally Angle Mode logic) to implement Channel I/O functionality.

eTPU's Enhanced Channels are capable of **dual action**, meaning that each channel logic can handle two events at different times and/or cause two separated actions - these actions and events can be mutually dependent (with the first either blocking or enabling the other), or both independent, depending on the programmed **Channel Mode**.

Each Enhanced Channel contains event logic containing two **Event Register sets**, each set supporting one input and/or output action, the pair implementing dual action support. Each Event Register set contains two 24 bit registers: Match and Capture. The **Match register** holds the pending match value which is compared against one of the two time bases by an equal-only/greater-equal comparator. The **Capture register** captures one of the two time bases as a result of a Match or Transition detection. Service Requests are issued on particular combination of match and capture events, defined by the selected Channel Mode.

In the context of the eTPU channels, a **Match** is a comparison between a time base value and a channel Match register. If those two values are coincident, or the time base value is greater than the value of the Match register, a **Match Event occurs**. Depending on the channel mode of operation and current state of the channel logic, the match event may be recognized, i.e., change the state of the channel, or be ignored. A match event recognized by the channel logic is called a **Match Recognition**. Match Recognitions can cause, also depending on Channel Mode and current state, the channel to request service, configuring a **Match Service Request**.

eTPU uses two kinds of comparator to assert a Match Event: an **Equal comparator**, in which both the Match Register and the value of the selected time base must match exactly, and a **Greater-Equal comparator**. The Greater-Equal comparator considers any time base value between the range [N : N+0x800000-1] as a valid match against the value of N in the Match Register, even when the value N+0x800000-1 wraps around the point of origin (0x0). See the following figure for an illustration of the matching values on a Greater-Equal comparator.

The second source of events for the eTPU channel is a **Transition** detected at the corresponding channel's input signal. Two distinct Transition detections can be programmed individually for each channel, allowing recognition of all possible combinations of edge detection. It is also possible to check the sampled state of an input signal upon the occurrence of a Match: the sampling of the expected value is treated as a Transition, even if the input signal did not necessarily toggled at the time of the Match, or at any time at all.

Like Match Events, **Transitions Events** may or not be recognized by the channel logic. When they are, a **Transition Detection** occurs. As well as Match Recognitions, Transition Detections can issue a Channel Service Request, depending on Channel Mode and current state.

Transition Detections and Match Recognitions are sometimes simply called Transitions and Matches throughout this document, for short.

Input and output signals can be processed separately by the channel logic and microcode, and can also be combined such that Matches and Transitions are used to cause **output signal actions**. The output signals can also be directly controlled by microcode. Many event combinations are allowed for a channel, given the possibility of configuring pairs of matches and transitions for the dual action logic, where each event is able to block or enable the next one. There is a full set of Channel Modes described in Channel Modes, exploring all the capabilities mentioned here.

Each channel has its own set of registers and flags. They are selected, and made accessible to the Microengine, according to the value written into the microengine **CHAN Register** that points to the desired channel . Every time the CHAN register is written, even if with the same previous value, a channel is selected and its flags and registers are updated. For further detail, see the Channel Selection Register-CHAN topic in the General Channel Registers section .

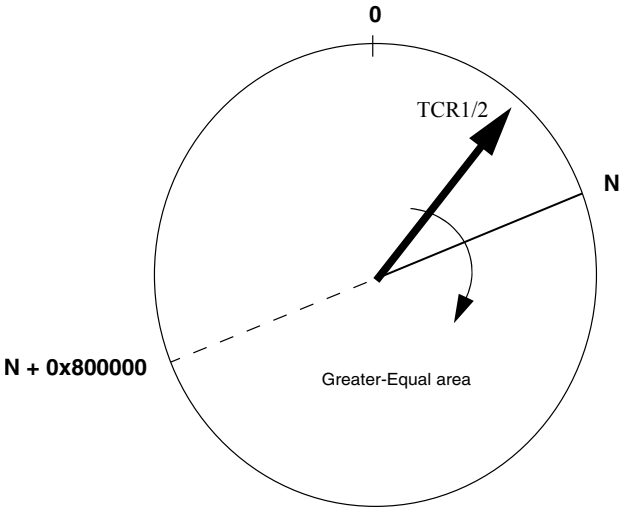


Figure 451. Greater equal comparator

Beyond the request of services due to the signal and timing internal to each channel, one eTPU channel microcode can explicitly request service from another channel through the microengine **LINK Register**. A microcode write to the LINK Register asserts a service request to the channel whose number matches the contents of LINK. See Channel link for a complete description of this mechanism.

These service requests originated in the eTPU Enhanced Channels (either time base match, input signal transition, or link service request) result in a call to the corresponding channel service routine, which is the sequence of microinstructions that is called a **Thread**. For further detail, see Functions and threads.

In addition to Event Logic, each Channel has an Output Buffer Enable signal, controlled by microcode, and an Enhanced Digital Filter, which eliminates spurious glitches on input pin signal. See the chip-specific eTPU information for how the Output Buffer Enable signal is controlled.

A high level diagram of Channel logic and registers is shown in the following figure.

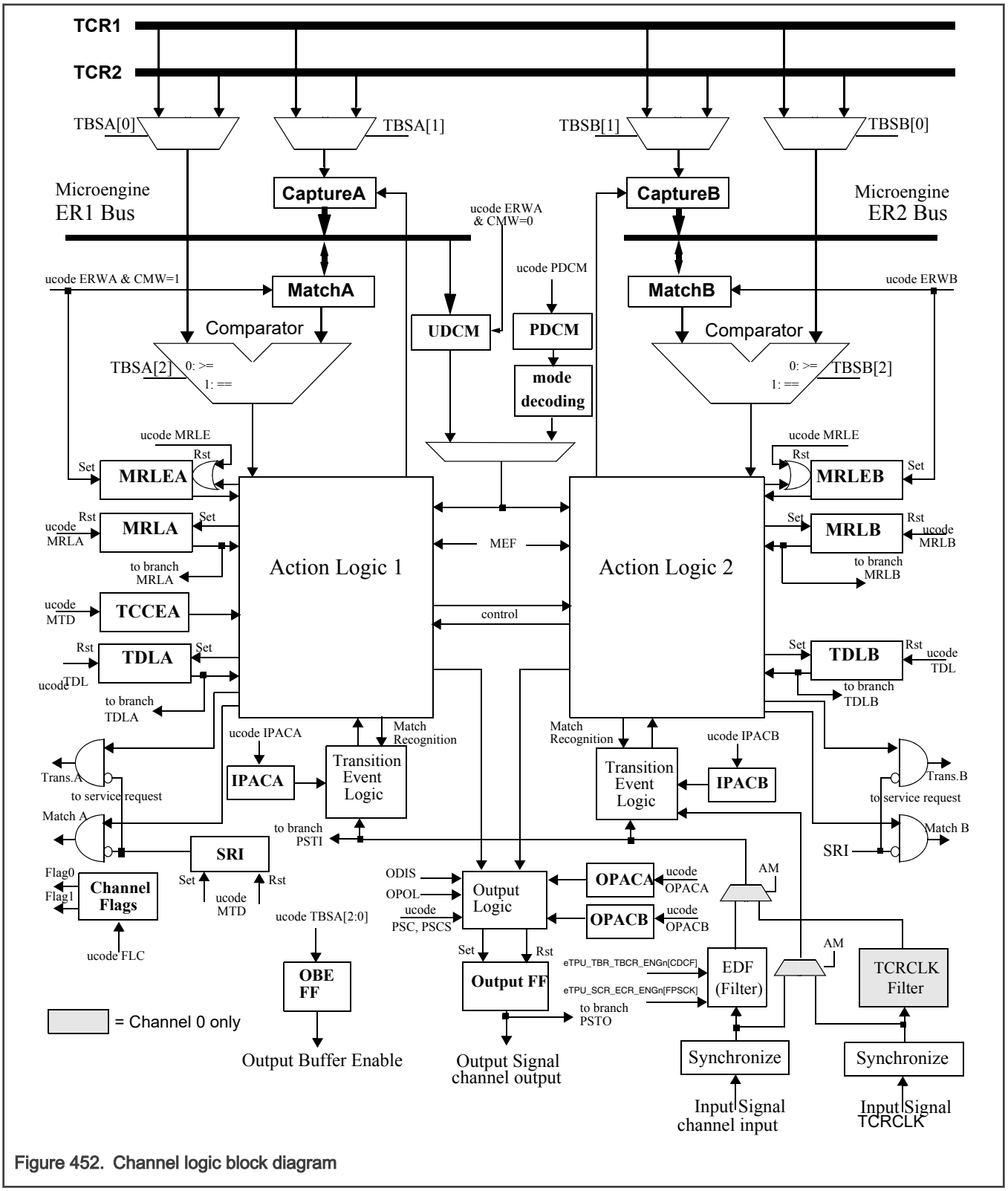


Figure 452. Channel logic block diagram

67.3.6.1 Channel registers and flags

Channel configuration and control registers can be divided in the following groups:

- **Host Configuration and Control registers**, which define channel Function and parameter allocation in SDM, input signal filtering, manage Host interrupts, and are used for Host Service Requests; they can only be accessed by Host, except for the Function Mode bits which can be also tested by microcode.
- **Event Registers**, which can only be accessed by eTPU Microengine, through dedicated Channel Control microinstruction operations (see Channel Control and Configuration Microoperations); these registers are directly used to implement channel functionality, and include channel event status latches which can be directly tested by Microengine branch instructions.
- **Pin Control registers**, which basically define pin state and transition polarity (but not input signal filtering); they are accessible only by dedicated Channel Control microinstruction operations.
- **Link registers**, which implement the channel link mechanism that allows one channel to request service to another one; they are accessible only by microinstruction operations.
- **General Channel registers**: CHAN, SRI, Flag0/1, PDCM, UDCM.

Most of those registers are channel exclusive, i.e., there is one copy of them for each channel. Microcode can access registers from only one channel at a time. The Channel Selection (CHAN) register (see Channel Selection Register - CHAN), accessible only by microcode, defines the channel whose registers are being accessed, with exception of link register and function mode. CHAN register assumes the value of the channel to be serviced at the beginning of TST.

The Service Request Inhibit - SRI - register controls the generation of Service Requests on matches and transitions, also affecting channel logic behavior. For a full description see SRI - Match/Transition Service Request Inhibit Latch. Flag0/1 are used to select channel service threads based on channel software state. See Flag1,Flag0 - Channel "state resolution" flags for more details.

Host Configuration and Control registers are described in Channel Configuration Control memory map and registers.

Time Base configuration is common to all channels, and described in Time bases. Time Base selection for matches and captures, however, is individual to each channel, and is part of the Event Registers.

Link registers are described in Channel link.

The following sections describe the Event Registers and Pin Control registers.

67.3.6.1.1 ER - Event Registers

Each channel contains two identical Event Register sets, named ERA and ERB, corresponding to the two actions supported. Each Event Register set contains:

- a 24-bit Match register (Match A or Match B), which holds a match value. This value is compared against the selected match time base (TCR1 or TCR2).
- a 24-bit Capture register (CaptureA or CaptureB), which samples the selected capture time base (TCR1 or TCR2)
- a Time Base Selection register (TBSA or TBSB)
- a Match Recognition status flag (or latch) (MRLA or MRLB)
- a Match Recognition Enable latch (MRLEA or MRLEB)
- a Transition Detection flag (or latch) (TDLA or TDLB)
- a Transition Continuous Capture enable (TCCEA only)

ERA and ERB are associated with the first and second events in double action modes, not necessarily in that order. The order of Match events associated with ERA and ERB depends on the programmed channel mode, the MatchA and MatchB values, and the timebases selected by TBSA and TBSB. Similarly, the order of Transition events associated with ERA and ERB depends on the programmed channel mode, and the transition detection selected by IPACA and IPACB.

These registers are directly or indirectly accessed by the microcode. TBSA and TBSB registers are defined in TBSA and TBSB - Time Base Selection Registers. The other registers are explained in Match Recognition and Transition detection and Time Base Capture.

Access to the Event Registers is qualified by the channel currently selected by the microengine (i.e., the channel value currently in the CHAN register). During the channel transition period (automatic CHAN assignment), or whenever CHAN is written by microcode, Capture values of the new selected channel are sampled into Microengine registers ERTA and ERTB, therefore

becoming visible to the microcode. At the same time, updated values of MRLA, MRLB, TDLA and TDLB are sampled into the branch logic, making the register values and the flags coherent with respect to each other and with the thread selected by the Scheduler. [16]

NOTE

The Function Mode bits are also sampled from the Host interface on Time Slot Transition, so that they remain constant to microengine even when Host changes them.

During service, the microcode can access updated values of the Event Registers of any channel by writing the channel number to CHAN. Writing CHAN with the same value (CHAN := CHAN) updates ERTA and ERTB with the new captured values, the branch logic with updated MRLA/B and TDLA/B flags. Writing CHAN with a different value does the same with the values from the newly selected channel.

Match values are also accessed through ERTA and ERTB Microengine registers, which are copied to/from the channel MatchA and MatchB registers by specific microinstruction operations.

Microcode writes to the flags and selections (MRLA/B, TDLA/B and TBSA/B) are immediately effective to the channel. The MRLA/B and TDLA/B branch conditions are also immediately reset when their correspondent flags are reset by microcode. Match registers are indirectly written by microcode through ERTA/B. MRLEA/B is unconditionally asserted when respective Match register is updated from ERTA/B, and its negation is immediate.

The following table summarizes Event Registers accesses.

Table 385. Event Registers microcode accesses

Register	Access type	Sampled from channel	Update to channel	Microcode fields[1]	Reset value[2]
CaptureA, CaptureB	read through ERTA/B	to ERTA/B on CHAN assignment	no	T2ABD	n.a.
MatchA, MatchB	read and write through ERTA/B	to ERTA/B by microcode	from ERTA/B by microcode	ERWA, CMW, ERWB, T4ABS	n.a.
MRLEA, MRLEB	write to 0 (negate) directly; write to 1 (assert) upon MatchA/B update from ERTA/B	no	immediate	MRLE, ERWA, ERWB	0, 0
TBSA, TBSB	write only	no	immediate	TBSA, TBSB	000, 000
MRLA, MRLB	flag test on branch, write to 0 (negate) only	on CHAN assignment	immediate	BCC (test) MRLA, MRLB (reset)	0, 0
TDLA, TDLB	flag test on branch, write to 0 (negate) only	on CHAN assignment	immediate	BCC (test) TDL (reset)	0, 0
TCCEA	write only	no	immediate	MTD	0

[16] The thread selected is determined by the Entry Point which, in turn, is determined partially by the channel latches. See Entry Point address generation.

1. See Microinstruction Set.
2. n.a. means that value of the register is undetermined after reset.

67.3.6.1.1.1 MatchA and MatchB Registers

MatchA and MatchB registers hold a match value to be compared against the selected channel time base. A match value can only be written into the Match register by microcode, through ERTA/B microengine registers (see Write Channel Match and UDCM Registers). Microcode can also read the Match register as a special T4ABS source operation, when T4ABS=0101, and the source for T4ABS is selected from the second register set. In this operation, MatchA/B registers are copied into ERTA/B registers (see Selecting sources and destination). For more information on time base matches, see Match Recognition.

67.3.6.1.1.2 CaptureA and CaptureB Registers

CaptureA and CaptureB registers capture the selected channel time base. CaptureA/B registers cannot be directly written or read by microcode. During the Time Slot Transition (TST) or during CHAN assignment, CaptureA/B registers are copied into ERTA/B microengine registers. For more information, see Transition detection and Time Base Capture.

67.3.6.1.1.3 TBSA and TBSB - Time Base Selection Registers

TBSA/B are 3-bit registers which have the following effect on channel configuration:

- Selection of the timebase (TCR1 or TCR2) to be compared against the match values in MatchA and/or MatchB registers.
- Selection of the timebase (TCR1 or TCR2) to be captured in the CaptureA and/or CaptureB registers by a match or transition detection event.
- Selection of comparator mode to be used with MatchA and MatchB registers: equal-only or greater-equal.

After reset TBSA/B are 000. The following table shows values of TBSA and TBSB for configuration selection. Note that the time base selection for capture is independent of the time base selected for matches.

Table 386. TBSA/B Programming States

TBS bit	2	1	0
bit value	Comparator selection	Capture time base selection	Match time base selection
0	greater or equal	TCR1	TCR1
1	equal-only	TCR2	TCR2

TBSA/B are written through the microcode fields TBSA/B (see Comparator and Time Base Selection). Note that microcode field TBSA is also used to control the OBE pin control register (see Pin Control Registers), which is separate from the TBSA register.

67.3.6.1.1.4 MRLA/B - Match Recognition Latches

See MRLA/B - Match Recognition Latches.

67.3.6.1.1.5 MRLEA/B - Match Recognition Latch Enable

See MRLEA/B - Match Recognition Latch Enable.

67.3.6.1.1.6 TDLA/B - Transition Detection Latch

See TDLA/B - Transition Detect Latches.

67.3.6.1.1.7 TCCEA - Transition Continuous Capture Enable

See TCCEA - Transition Continuous Capture Enable.

67.3.6.1.2 Pin Control Registers

Pin Control Registers are replicated one per channel, accessed only by microcode and qualified by the CHAN register in the same way as Event Registers.

The following table lists Pin Control Registers, explained in following subsections, and their accesses.

Table 387. Pin Control Registers microcode accesses

Register	Access type	Sampled from channel	Update to channel	Microcode fields[1]	Reset value
IPACA, IPACB	write only	no	immediate	IPACA, IPACB	000,000
OPACA, OPACB	write only	no	immediate	OPACA, OPACB	000,000
PSTI	flag test on branch	no	no	BCC	0
PSTO	flag test on branch, write	no	immediate	BCC (test) PSC, PSCS (set)	0
OBE[2]	write only	no	immediate	TBSA values 1000,1001	0 (negated)
PSS	flag test on branch	on CHAN assignment	no	BCC	n.a.[3]
PRSS	flag test on branch	on CHAN assignment	no	BCC	n.a.[4]

1. See Microinstruction Set.
2. Although this register exists for code compatibility reasons, OBE functionality is not available on this chip.
3. PSS is PSTI or PSTO sampled on CHAN assignments and at thread start.
4. PRSS is PSTI sampled on channel service request.

67.3.6.1.2.1 IPACA/B and OPACA/B - Input and Output Pin Action Control Registers

These registers determine the transition detections and output pin actions which takes place due to match or transition events. Each field is three bit wide. After reset, the IPACA/B and OPACA/B registers are set to 000. IPACA and IPACB registers are mutually independent and have identical encoding, and so do OPACA and OPACB. The table below shows IPAC and OPAC encoding. Note that transition detections are independent from the output actions, but some options of output actions are triggered by transition detections. Output actions can also be triggered by Matches. For a detailed definition of Transition Detections, see Transition detection and Time Base Capture.

IPACA/B define the Transition events treated by channel logic. Although the name "transition" is generically used for the transition detections, IPAC options 100 and 101 do not really detect transitions: they actually sample the state of the input signal at the occurrence of the corresponding Match (Match A used for IPACA, Match B used for IPACB).

Table 388. IPACA/B and OPACA/B Encoding

Value	IPAC meaning	OPAC meaning
000	Do not detect transitions	Do not change output signal
001	Detect rising edge only	Match sets output signal high
010	Detect falling edge only	Matchsets output signal low
011	Detect either edge	Match toggles output signal
100	Detect input signal = 0 on Match	Transition sets output signal low
101	Detect input signal = 1 on Match	Transition detection sets output signal high
110	reserved	Transition detection toggles output signal
111	n.a.	n.a.

67.3.6.1.2.2 Output Pin Control Logic and Pin State Output Register - PSTO

The output signal control logic uses OPACA/B, the Pre-defined Channel Mode (PDCM) and the User Defined Channel Mode (UDCM), and the microcode Pin State Control (PSC and PSCS) fields. It is responsible for setting the Pin State Output (PSTO) register to the specified logic value required by microcode, by input events, or by Match A and/or Match B events. The PSTO register stores the driven pin state determined by the Pin Control logic. The Output Buffer Enable signal, if used at MCU integration, must be set by microcode (using TBSA field) to make the pad propagate the PSTO register output to the actual pin.

PSTO register output also goes to the microengine branch logic, enabling branching on the driven pin state (see OBE - Output Buffer Enable control latch). PSTO is set to 0 on reset.

The PSC and PSCS microcode fields are used for setting the PSTO register to a fixed value, or to the value specified by the OPACA or OPACB microcode field, as shown in the following table.

Table 389. PSC and PSCS encoding

PSC	Output pin action
00	Force pin state according to OPACA (PSCS=0) or OPACB (PSCS=1).
01	Force pin high.
10	Force pin low.
11	Do not change pin state.

See Channel Control and Configuration Microoperations for details.

On occurrence of match recognitions or transition detections, the pin control logic sets PSTO value according to the event number (Match A/Transition A or Match B/Transition B) and the contents of OPACA/IPACA or OPACB/IPACB registers. There are cases in which two match or transition events may occur at the same time, each of them trying to force a different pin action. The resolution of the selected match event which sets the value depends on the Pre-defined Channel Mode (PDCM) register and the User Defined Channel Mode (UDCM). For details refer to Match/Transition Pin Action Conflict Resolution.

67.3.6.1.2.3 PSTI and PSS - Pin State Input and Pin Sampled State Registers

During the time slot transition period, or whenever the CHAN register is written by microcode, the filtered[17] input signal PSTI or output signal PSTO (selected by the ETPD field in C*a*CR_ENG1 and C*a*CR_ENG2) is sampled into the branch logic as the PSS flag (see Conditional/unconditional branch). The microcode can then branch on either the currently driven (PSTO) or input (PSTI) pin state, or on sampled pin state (PSS, which is stable as long as CHAN does not change).

NOTE

If a transition occurs simultaneously (after the filter) with the CHAN assignment, PSS samples the new pin value. Therefore, if TDLA/B is cleared simultaneously with the assignment CHAN := CHAN, the occurrence of a transition at this very moment can still be tested with PSS.

67.3.6.1.2.4 PRSS - Pin Request Service Sample

Channel logic can, depending on its state and programmed mode, request service to the eTPU microengine (see Functions and threads) . When the channel logic issues a service request, the filtered input signal PSTI is sampled into an internal channel flag PRSS . There is one such PRSS flag for each channel (see Pin Control Registers) . Channel PRSS keeps its value until all its service request sources are cleared and until a new channel service request rises .

NOTE

Only channel service requests update PRSS. It is not updated by host service requests (HSRs) or by link service requests. Moreover, a channel service request updates PRSS even if the channel is disabled (its CPR set to 0, see C*a*CR_ENG1 and C*a*CR_ENG2).

The channel PRSS flag is sampled into the branch logic as the PRSS flag (see Conditional/unconditional branch) during the time slot transition period, or whenever the CHAN register is written by microcode.

67.3.6.1.2.5 OBE - Output Buffer Enable control latch

OBE latch drives the Output Buffer Enable signal, which can be used to control the output signal pad driver. Channel output comes disabled from reset. If an Output Buffer Enable signal[18] from eTPU is used on MCU integration and a signal is desired to be output in a channel, OBE signal must be set by microcode. Microcode field TBSA is used to set/reset the Output Buffer Enable control when microcode field TBSA bit 3 is 1, according to the following table.

Table 390. TBSA Output Buffer control

microcode TBSA[2:0]	meaning when TBSA[3]=1
000	enable output buffer
001	disable output buffer
111	do nothing
other values	reserved

[17] The filter can be bypassed.
[18] There is one independent signal for each channel.

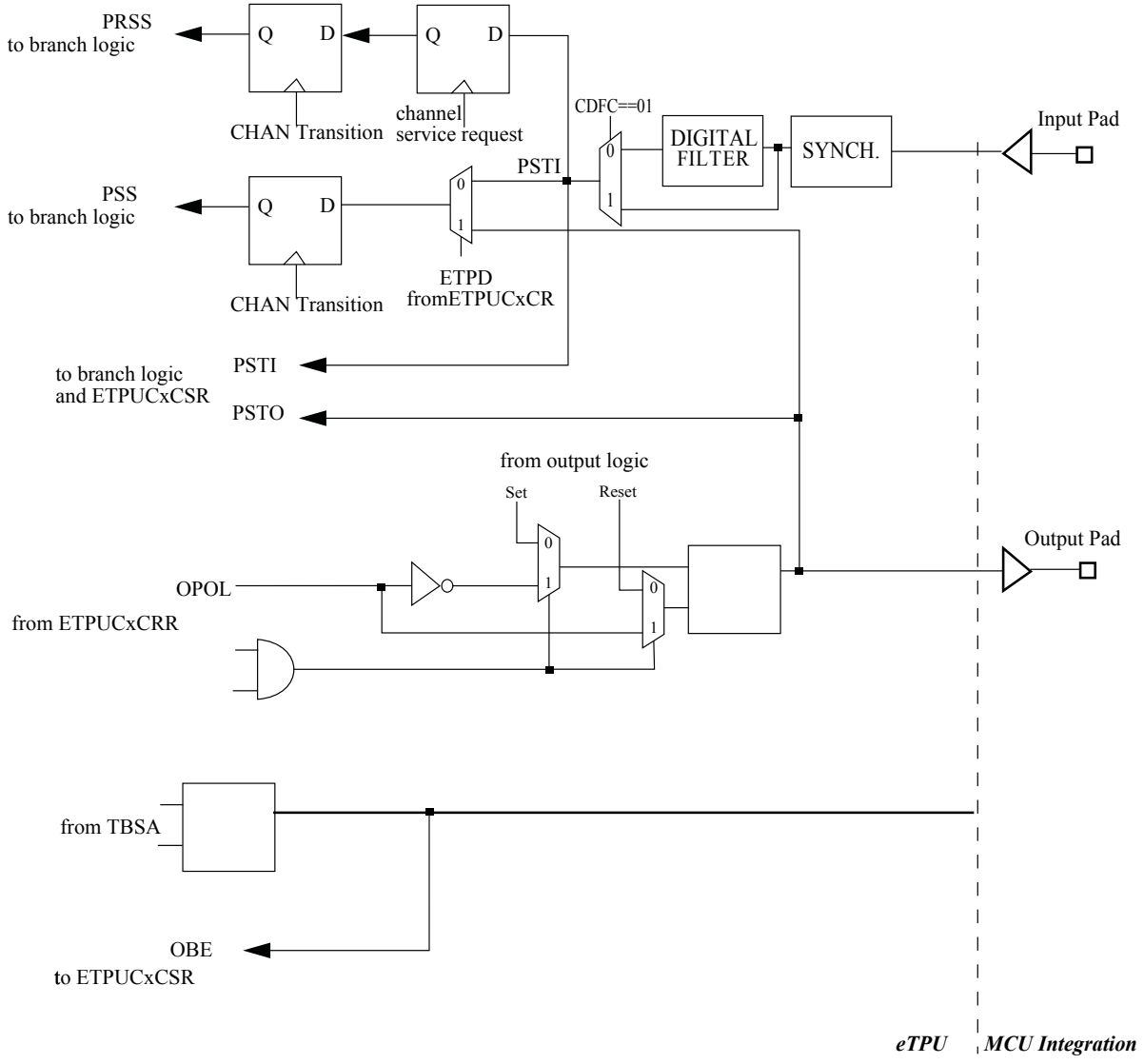


Figure 453. Pin State Input/Output Logic

67.3.6.1.3 General Channel registers

These registers control other aspects of channel logic. Except for CHAN, they are unique per channel. The following table summarizes the registers and access options.

Table 391. General Channel registers microcode access

Register	Access type	Sampled from channel	Update to channel	Microcode fields[1]	Reset value
CHAN	read/write	n.a.	n.a.	T4ABS, T4BBS, T2ABD	defaults to serviced channel at thread start
PDCM	write only	no	immediate	PDCM	1100 (sm_st)

Table continues on the next page...

Table 391. General Channel registers microcode access (continued)

Register	Access type	Sampled from channel	Update to channel	Microcode fields[1]	Reset value
UDCM	write only	no	from ERTA by microcode	CMW, ERWA	parameter value defined at integration
SRI	write only	no	immediate	MTD	1
Flag1, Flag0	branch flag test, write	no	immediate	BCC,FLC	0, 0

1. See Microinstruction Set.

67.3.6.1.3.1 Channel Selection Register - CHAN

CHAN is the register that holds the number of the channel that qualifies the context of most Channel Registers, including Pin Control and ER accesses, and is common to all channels in a same Engine.

When a thread begins executing, the contents of CHAN are automatically updated on Time Slot transition to the number of the channel to be serviced. Serviced channel is constant during channel servicing, but the selected channel can be changed any time by microengine writing into CHAN register.

Some microinstructions are affected by the serviced channel instead of CHAN. These are:

- Conditional branch using LSR (see LINK Register) or Function Mode (see C*a*SCR_ENG1 and C*a*SCR_ENG2).
- Negate channel flag LSR, Interrupt CPU and Data Transfer Request (see Channel Interrupt and Data Transfer Requests).

When CHAN register is written, accesses are qualified by the new CHAN register value from the instruction following CHAN assignment on, except CaptureA/B sampling into ERTA/B and Match register writing from ERTA/B (see CHAN assignment, Read Match and ERWA/B).

Writing CHAN (including with the same value, CHAN:= CHAN) updates ERTA and ERTB with the new captured values, the branch logic with updated MRLA/B and TDLA/B flags.

The following table shows the commands, flags and registers selected by the CHAN register value.

Table 392. CHAN-selected features

Feature used	Selected by CHAN
Channel-relative SDM access	YES
Branch using PSS, PRSS, PSTI and PSTO channel flags	YES
Branch using MRLA/B, TDLA/B, Flag0/1[1]	YES
Branch on all other conditions[2]	no
ERTA/B Value	YES
Configure (selected) channel	YES
Channel commands applied to: MRLA/B, TDLA/B, TBSA/B, IPACA/B, OPACA/B, PSC, PSCS, OBE, PDCM, MRLE, Flag0/1	YES
Channel command: set/reset SRI	YES

Table continues on the next page...

Table 392. CHAN-selected features (continued)

Feature used	Selected by CHAN
Channel command: write to Match registers (ERWA/B)	YES[3]
Channel command: read Match registers into ERTA/B	YES
Clear LSR	no
Channel interrupts and data transfer requests (CIRC)	optionally

1. In TPU, these conditions retained the old values.
2. See Branch Operations
3. If write Match (ERWA/B) occurs at the same time of a CHAN assignment, the channel which is target of the write is the one selected by the new CHAN value. See CHAN assignment, Read Match and ERWA/B.

67.3.6.1.3.2 PDCM - Predefined Channel Mode

PDCM determines the channel mode assigned to the channel. Channel mode defines much of the channel logic behavior, specially how matches blocks and enables transitions and vice-versa, as well as occurrence of time base captures and service requests based on matches and transitions. For a complete description see Channel Modes.

PDCM is a 4-bit register set by the microcode field of the same name (see Predefined Channel Modes), and cannot be read or tested in branch instructions. The table below relates the PDCM value with channel modes. The second column specifies the mnemonic used to reference the mode, introduced in Channel Modes Overview. There is one PDCM for each channel, initialized with 1100 on reset.

PDCM is also used to select the User Programmable Channel Mode . If this selection is made, the channel behavior is defined by the settings of the UDCM register (see UDCM - User Defined Channel Mode).

Table 393. PDCM encoding

PDCM	Channel mode
0000	em_b_st
0001	em_b_dt
0010	em_nb_st
0011	em_nb_dt
0100	m2_st
0101	m2_dt
0110	bm_st
0111	bm_dt
1000	m2_o_st
1001	m2_o_dt
1010	User Defined Channel Mode

Table continues on the next page...

Table 393. PDCM encoding (continued)

PDCM	Channel mode
1011	reserved
1100	sm_st[1]
1101	sm_dt
1110	sm_st_e
1111	n.a.[2]

1. This is the reset value, also compatible with TPU channel behavior.
2. This value is used as a neutral (do not change) value in the PDCM microinstruction field.

67.3.6.1.3.3 UDCM - User Defined Channel Mode

UDCM holds the control signals that define the channel logic behavior in terms of Match and Transition blocking and enabling, captures and service requests triggered by events . The register layout is defined in the figure below . The individual fields are defined in Channel Mode Logic and Event Flags . There is one UDCM register for each channel, which can be independently programmed.

UDCM can only be written into the Match register by microcode, through ERTA/B microengine registers (see Write Channel Match and UDCM Registers).

13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSR		MCAP	M1ET	M1EM2	M1BM2	M2BM1	M2BT	T1BM1	T2BM1	TBM2	T1ET2	TSR	TCAP

Figure 454. UDCM Register

67.3.6.1.3.4 SRI - Match/Transition Service Request Inhibit Latch

SRI blocks channel service requests due to the assertion of MRLA/B and/or TDLA/B. SRI does not affect recognition of Link Service Requests or Host Service Requests, neither MRLA/B or TDLA/B microcode branch tests nor Entry Table selection[19]. SRI is asserted during reset and is controlled by microcode field MTD.

To unburden the microengine, SRI asserted configures a channel "dumb" regarding the servicing of match and capture channel service requests. Even with SRI=1, TDLA/B and MRLA/B can still be asserted, and the level specified by the OPAC (Output Pin Action Control) registers will be output to the pin.

67.3.6.1.3.5 Flag1,Flag0 - Channel "state resolution" flags

Each channel has a pair of flags, simply called Flag0 and Flag1, that can be set/reset by microcode through microinstruction field FLC. FLC sets/resets Flag0/1 of the channel selected by CHAN. These flags can be tested by microcode, and are also used to resolve the microcode entry point for the channel service (see Entry Points"). Flag0 and Flag1 are, so, typically used for fast state resolution. FLC microinstruction field also allows Flag1,Flag0 to be copied from selected bits of P register high byte, which is also meant to be used to hold application state. Flag0 and Flag1 are both zero out of reset.

67.3.6.2 Match Recognition

The match operation is performed every microcycle by comparing the channel MatchA and MatchB registers against the value of the TCR bus specified for each match. TCR1 or TCR2 bus is selected according to TBSA and TBSB fields. Both results have effect on the next clock cycle (see Microcycle and I/O timing).

[19] In TPU, SRI also blocked TDL and MDL branches and enabled any transition to capture time base.

A Match A/B event is qualified by a set of match enabling conditions to the Match Recognition Registers MRLA/B. To recognize the match, the following match enabling conditions are required:

- For IPACA/B=0xx, Match Enable Flag (MEF), qualified by the channel currently being serviced must be asserted. For IPACA/B =1xx, Match A/B is always enabled (even during Time Slot Transition - TST), regardless the state of the Match Enable Flag (MEF). See MEF - Match Enable Flag for the conditions of MEF assertion.
- Match Recognition Latch Enable 1/2 (MRLEA/B) is asserted. A match event recognition may only occur if its corresponding MRLEA/B bit is set, which only happens upon a write to a channel match register by the microcode, copied from ERTA/B. MRLEA/B is negated when the respective match occurs or, in some double match channel modes, when a match for the other Match register occurs. It ensures that the greater-equal comparison will not cause additional matches[20].
- In selected modes (see Channel Modes), the particular conditions of MRL and TDL flags of the other event, i.e.:
  - MRLA, TDLA enable or block MRLB;
  - MRLB, TDLB enable or block MRLA.
- The respective MRL is negated.
- In selected modes (see Channel Modes), the state of its respective TDL flag.

If the Match A and/or Match B conditions are met, the channel immediately forces the pin state if specified by the appropriate OPACA/B registers (Output Pin Action Control 1/2) and, in some cases, by IPACA/B registers. Refer to IPACA/B and OPACA/B - Input and Output Pin Action Control Registers.

If both Match A and Match B events occur at the same time, with conflicting pin actions, the priority over the pin action is mode dependent. For further details on pin action resolution refer to Match/Transition Pin Action Conflict Resolution.

67.3.6.2.1 MRLA/B - Match Recognition Latches

MRLA/B indicate the recognition of a match event detected by the comparator. They can be asserted either on T2 or T4 (see Microcycle and I/O timing). Assertion of MRLA/B issues a match Service Request in specific channel modes, depending on previous events and state of SRI. After reset MRLA and MRLB are both negated.

When MRLA or MRLB is asserted, it may change the output signal level according to the Input and Output Pin Action Control registers (refer to IPACA/B and OPACA/B - Input and Output Pin Action Control Registers). Assertion of MRLA/B causes a capture of one or two time bases, according to the selected mode capturing scheme (see Transition detection and Time Base Capture)

A match recognition is self-blocking, regardless of Channel Mode: once MRLA (MRLB) has been asserted, it negates its associated MRLEA (MRLEB) register, preventing future match recognitions, until the associated match register is rewritten by microcode. The microcode has to enable new matches by updating the new match value in the MatchA (MatchB) register[21]. In addition, assertion of MRLA/B can block its twin MRLB/A, depending on the channel mode. In some double match blocking channel modes, Match A/B event blocks the occurrence of Match B/A in a "first win" scheme.

It is the transition from 0 to 1 in MRL that causes the Match actions, except the service request: apart from MRLEA/B negation(s) and service request, no action due to a Match occurs if MRL was already set to 1, even if the other MRL assert conditions are satisfied. However, if a Match and a microoperation negating its corresponding MRL occur at the same time, MRL negation by microcode overrides its assertion, but any dependable captures and pin action occurs anyway (if MRL was already negated before), and also the negation of MRLE(s) (the respective one and, in some channel modes, the other, regardless of MRL state before). Note that MRLE must have been set before (by writing a new Match value).

67.3.6.2.2 MEF - Match Enable Flag

MEF is a one-bit latch that is unique for all channels in an Engine.

MEF can selectively enable assertion of MRLA/B, depending on the IPACA/B field. For IPACA/B=0xx, MEF=1 enables assertion of MRLA/B for the scheduled channel during service. For IPACA/B=1xx, Match A/B is always enabled, regardless the state of the

[20] Microcode can also negate MRLEA/B.
[21] Before that, microcode should also negate MRLA (MRLB), otherwise an old match may be recognized by the scheduler and serviced as a new one

MEF, but it still depends on the other Match recognition conditions. Matches of channels not being serviced are never disabled by MEF.

MEF is not accessible by Microengine or Host. MEF is negated for two microcycles in the beginning of the time slot transition period. After two microcycles (plus wait-states) into TST, the ME bit in the entry point is copied to MEF to allow selective enabling of MRL for each thread (refer to Time Slot Transition). MEF is asserted unconditionally soon after a thread ends.

If a channel service needs to postpone a programmed match, MEF assures that microcode wins the race against match event after time slot transition (only for IPAC=0xx).

Note that a match event may be lost during the periods when MEF is negated only if:

- the match comparator is configured for "equal-only" behavior, and
- IPACA/B=0xx, and
- TCR increments at the rate of eTPU clock divided by 2 or faster.

When the comparator is configured as "greater-equal", the match event that occurred when MEF was negated may be recognized after MEF is asserted again, due to the "greater than" condition.

67.3.6.2.3 MRLEA/B - Match Recognition Latch Enable

MRLEA/B is negated upon the assertion of its respective MRLA/B. In blocking match channel modes it may also be negated together with the assertion of the twin MRLB/A. The MRLEA/B bits ensure that data captured due to the first match event will not be overwritten when MRLA/B is negated: due to greater-equal comparison, the match condition continues to be true, but should not cause another capture event.

In addition to negation by local match event, the microcode can negate both MRLEA and MRLEB, to block pending matches, and also MRLA/B, individually. This action will prevent future match events from the selected channel.

Writing the MatchA/B registers by microcode to schedule the next match values sets MRLEA and/or MRLEB and enables new matches. This setting overrides the MRLE negation conditions due to channel logic or microcode (see Channel Modes). By combining write to Match A/B with MRLEA/B negation microinstructions, the microcode can negate one MRLE while asserting the other.

NOTE

If the MRLE negation conditions continue after writing MatchA/B registers, the respective MRLE does not keep asserted. For instance, if MRL=1 and a match is programmed for a time value in the past during a thread with ME=1, then MRLE will be cleared soon after MatchA/B is written, even though a match does not occur (because MRL was already asserted, neither captures nor pin toggles occur).

When the match register is updated (with MRLE already asserted before) and field MRLA/B = 1 (no clear, see Clear Transition/Match Event Registers) and MRLA/B flag is zero, the eTPU behaves exactly as the TPU, that is: a match that comes concurrently with the rewrite of the match register, matching the old value, sets the MRL, as if the setting of the MRLE due to match register write had precedence over its clear by the match at that moment. After this simultaneous operation, the MRLE value stays at 1, and the captured time base value, if any, reflects the match value.

When the match register is updated (with MRLE already asserted before) and field MRLA/B = 0 (clear MRL, see Clear Transition/Match Event Registers) and MRLA/B flag is zero, the match captures will occur, the MRLA/B flag will keep negated, and MRLE will stay asserted. Special care must be taken when a match is reprogrammed on a channel running at T2/T4 timing, please see the details in the “T2/T4 Channel Timing” section.

67.3.6.3 Transition detection and Time Base Capture

Time Base Capture(s) occur when the value of a specified TCR is sampled into the CaptureA and/or CaptureB register. TBSA[1] and TBSB[1] select which TCR will be captured in CaptureA and CaptureB, respectively.

A capture event may occur due to either of the following events:

- The assertion condition of Match Recognition Latch (MRL), even if MRL is simultaneously negated by microcode
- The assertion condition of Transition Detection Latch (TDL), even if TDL is simultaneously negated by microcode.

- Any Transition Event specified by IPACA if both the Transition Detection Latch TDLA and Transition Continuous Capture Enable TCCEA are asserted.

A capture event occurs together with the assertion of MRL or TDL either on T2 or T4 positive edges, and captures the time-base value that caused the match, even if TCR1/2 increments concurrently with the assertion (see Microcycle and I/O timing). MRLA/B and TDLA may, depending on the channel mode, inhibit the capture of the second event's TCR into CaptureA/B. As a general rule, values captured by signal transitions are not overwritten by values captured by match events.

When the enable bit TCCEA is asserted, captures due to Transition Events also occur after TDLA is asserted . Those captures happen on transition events specified by IPACA, and the TCR value is saved into CaptureA register only .

The capturing scheme is defined by the Channel Mode programmed at register PDCM, or at register UDCM when User Defined Channel Mode is selected. For more information on mode-dependent capture schemes refer to Channel Modes.

67.3.6.3.1 TDLA/B - Transition Detect Latches

TDLA/B indicate detection of specific transition occurrences on a channel input signal. TDLA and TDLB assertion causes service request in single and double transition predefined modes, respectively. TDLB assertion does not cause Service Request in single transition predefined modes, and TDLA assertion does not cause Service request in double transition predefined modes. In single transition channel predefined modes TDLB can be asserted on the second transition, but does not generate Service Request. Yet on predefined modes, TDLB assertion is enabled only if TDLA is asserted to detect an ordered input signal double transition. All the restrictions above, however, may be overridden by using the User Defined Channel Mode. The IPACA and IPACB registers indicate the programmed edges of the first and second detected transition, respectively.

The sampling of a determined value (0 or 1) on the input signal due the occurrence of a Match is also treated as a "transition", depending on IPACA/B programming (see IPACA/B and OPACA/B - Input and Output Pin Action Control Registers). When using a channel mode where the transition1 is initially blocked and IPACA is programmed to detect such "transitions", the occurrence of a Match A only unblocks the transition after the sampling. It means that the transition on the first Match (IPACA configurations 100 and 101) is not effective on predefined modes where Transition A is enabled by Match A (m2_st, m2_dt, m2_o_st and m2_o_dt) or user-defined modes with UDCM bit M1ET asserted. A Transition A can still happen after the Match A, however, if MatchA register is reprogrammed without clearing MRLA.

TDLA/B assertion conditions initiates a capture event of one or both selected TCR buses. TDLA or TDLB transition event generates a Service Request, depending on channel mode, previous events and the state of SRI. For more information on service request scheme refer to Entry Point address generation" and Channel Modes.

Assertion of TDLA/B occurs on either T2 or T4 positive edges. The capture event occurs on the same clock, and captures the time base value present when TDLA/B was asserted. TDLA and TDLB are negated during reset and may also be negated independently by microcode. TDLA/B is reset by no way other than reset and microcode.

It is the transition from 0 to 1 in TDL that causes the Transition actions: even if TDL assert conditions are satisfied, no action due to a Transition occurs if TDL was already set to 1. However, if a Transition and a microoperation negating TDLs occur at the same time and TDL was already negated, TDL negation by microcode overrides its assertion, but any dependable captures and pin action occurs anyway.

67.3.6.3.2 TCCEA - Transition Continuous Capture Enable

TCCEA enables capture from transitions after the TDLA flag is set . TCCEA is negated on reset, so that a capture occurs only when TDLA asserts . TCCEA can be set and reset by microcode only, through the instruction field MTD (see Disable Match and Transition Service Requests) . It can only be set together with inhibiting of the channel service requests (SRI = 1)[22].

When TCCEA is asserted, the transition events specified by IPACA that occur after TDLA is set also cause captures, into the CaptureA register only . However, output actions related to transition events are still blocked by TDLA.

67.3.6.4 Channel Modes

The Enhanced Channels support various modes of operation combining Match A/B recognition and transition detection events which set MRLA/B and TDLA/B. The channel mode is individually set for each channel by eTPU microcode, through the PDCM

[22] TCCEA provides compatibility with TPU when service request is inhibited.

register (see PDCM - Predefined Channel Mode). The PDCM register selects among a set of 13 predefined channel modes, and also a user-defined channel mode.

The order in which events occur, combined with assigned channel mode, establish which following event detections are inhibited and/or enabled, as well as the actions taken: Time Base capture, flag setting (MRLA/B, TDLA/B), match disabling (MRLEA/B), output signal transition, and Service Request. Those channel mode characteristics are fixed in the predefined modes, but can be individually programmed in the user-defined channel mode.

A generic description of channel modes from the usage point of view can be found in Channel Modes Overview. Each mode is named with a mnemonic acronym for terse reference. The individual programmed attributes of the user-programmable channel mode are also described.

The modes are used differently for input and output signals, as explained in Predefined Channel Modes on Input Signal Processing and Channel Modes on Output Signal Generation. Modes also allow combining input processing and output generation in a single channel, as exemplified in Combining input and output signals.

Channel Mode Logic and Event Flags shows a structural definition of channel logic and its relation to channel modes. A dynamic, event-oriented view of each channel mode can be found in Channel Mode Summary.

67.3.6.4.1 Channel Mode Logic and Event Flags

shows a more detailed diagram of channel mode logic. The logic shown here is not necessarily identical to the actual channel logic implementation, but is equivalent with respect to conditions for event blocking, enabling, capture, and service requests.

Signals MSR, TSR, MCAP, TCAP, M1ET, M1EM2, M1BM2, M2BM1, M2BT, T1BM1, T2BM1, TBM2 and T1ET2 are decoded from programmed channel mode PDCM in predefined modes, and come directly from the UDCM register when user-defined mode is selected:

- TSR (1 bit) defines Service Requests issued by Transitions, as shown in .
- MSR (2 bits) defines Service Requests issued by Matches, as shown in .
- TCAP (1 bit) defines time base captures caused by Transitions, as shown in
- MCAP (1bit) defines time base captures caused by Matches, as shown in .
- M1ET, M1EM2, M1BM2, M2BM1, M2BT, T1BM1, T2BM1, TBM2, T1ET2 (1 bit each) define Match and Transition reciprocal blocking and enabling, as well as Transition ordering, as shown in and .

shows the decoded values of those control signals for each predefined channel mode. The first column shows the mnemonic reference for the predefined channel modes described in the following sections.

Changing PDCM or the UDCM when user mode is selected may set or reset any of the channel flags, or issue captures and service requests, so it is advisable to switch channel modes only in a quiescent channel state, with channel flags MRLEA/B, TDLA/B, MRLA/B cleared. Furthermore, an event flag asserted in one mode may keep asserted after the mode programming change, even if the flag is impossible to be set in the new mode.

Table 394. MSR signals - Match Service Requests

value	MSR
00	issue no Service Requests on Matches
01	issue Service Request on Match B only
10	issue Service Request on 2nd[1] Match
11	issue Service Request on both Matches

1. 2nd Match means the Match that happens after the 1st Match in time, either Match A or Match B.

Table 395. TCAP and TSR signals - Transition Captures and Service Requests

value	TCAP	TSR
0	1st Transition captures Time Bases corresponding to Transition A and Transition B[1] Transition A captures corresponding Time Base if it is the second transition; Transition B captures corresponding Time Base if it is the second transition.	issue Service Request on the 1st Transition
1	Transition A captures corresponding Time Base. Transition B captures corresponding Time Base.	issue Service Request on the 2nd[2] Transition

1. Match capture(s) never overwrites a Transition capture. Transition captures can always overwrite a Match capture.
2. 2nd Transition means the Transition that happens second in time, either Transition A or Transition B

Table 396. MCAP signal - Match Capture

value	MCAP
0	Match A captures corresponding Time Base; Match B captures corresponding Time Base
1	either Match captures Time Bases corresponding to Match A and Match B[1]

1. Match capture(s) never overwrites a Transition capture. Transition captures can always overwrite a Match capture.

Table 397. TBM2 signal - Transition Blocks Match B

value	TBM2
0	Transition A Blocks Match B
1	Transition B Blocks Match B

Table 398. M1ET, M1EM2, M1BM2, M2BM1, M2BT signals

signal	active value meaning
M1ET (Match A Enable Transitions)	Transitions are initially blocked, and Match A enables Transitions
M1EM2 (Match A Enables Match B)	Match B is initially blocked, and Match A enables Match B
M1BM2 (Match A Blocks Match B)	Match B is initially enabled, and Match A blocks Match B
M2BM1 (Match B Blocks Match A)	Match A is initially enabled,and Match B blocks Match A
M2BT	Match B blocks Transitions

Table continues on the next page...

Table 398. M1ET, M1EM2, M1BM2, M2BM1, M2BT signals (continued)

signal	active value meaning
(Match B Blocks Transitions)	
T1BM1 (Transition A Blocks Match A)	Transition A blocks Match A
T2BM1 (Transition B Blocks Match A)	Transition B blocks Match A
T1ET2 (Transition A Enables Transition B)	Transition B is initially blocked, and Transition A enables Transition B

Table 399. Predefined Channel Mode control signals decoding

Predefined Mode	MSR	MCAP	M1ET	M1EM2	M1BM2	M2BM1	M2BT	T1BM1	T2BM1	TBM2	T1ET2	TSR	TCAP
em_nb_st	11	0	off	off	off	off	off	On	off	0	On	0	0
em_nb_dt	11	0	off	off	off	off	off	On	off	1	On	1	1
em_b_st	11	1	off	off	On	On	off	On	off	0	On	0	0
em_b_dt	11	1	off	off	On	On	off	On	off	1	On	1	1
bm_st	10	0	off	off	off	off	off	On	off	0	On	0	0
bm_dt	10	0	off	off	off	off	off	off	On	1	On	1	1
m2_st	01	0	On	off	off	On	off	On	off	0	On	0	0
m2_dt	01	0	On	off	off	On	off	On	off	1	On	1	1
m2_o_st	01	0	On	On	off	off	On	On	off	0	On	0	0
m2_o_dt	01	0	On	On	off	off	On	On	off	1	On	1	1
sm_st	11	1	off	On	On	On	off	On	off	0	On	0	0
sm_dt	11	1	off	On	On	On	off	off	On	1	On	1	1
sm_st_e[1]	11	0	off	On	On	On	off	On	off	0	On	0	0

1. sm_st_e is an exception in the capture scheme. See Single match enhanced mode (sm_st_e).

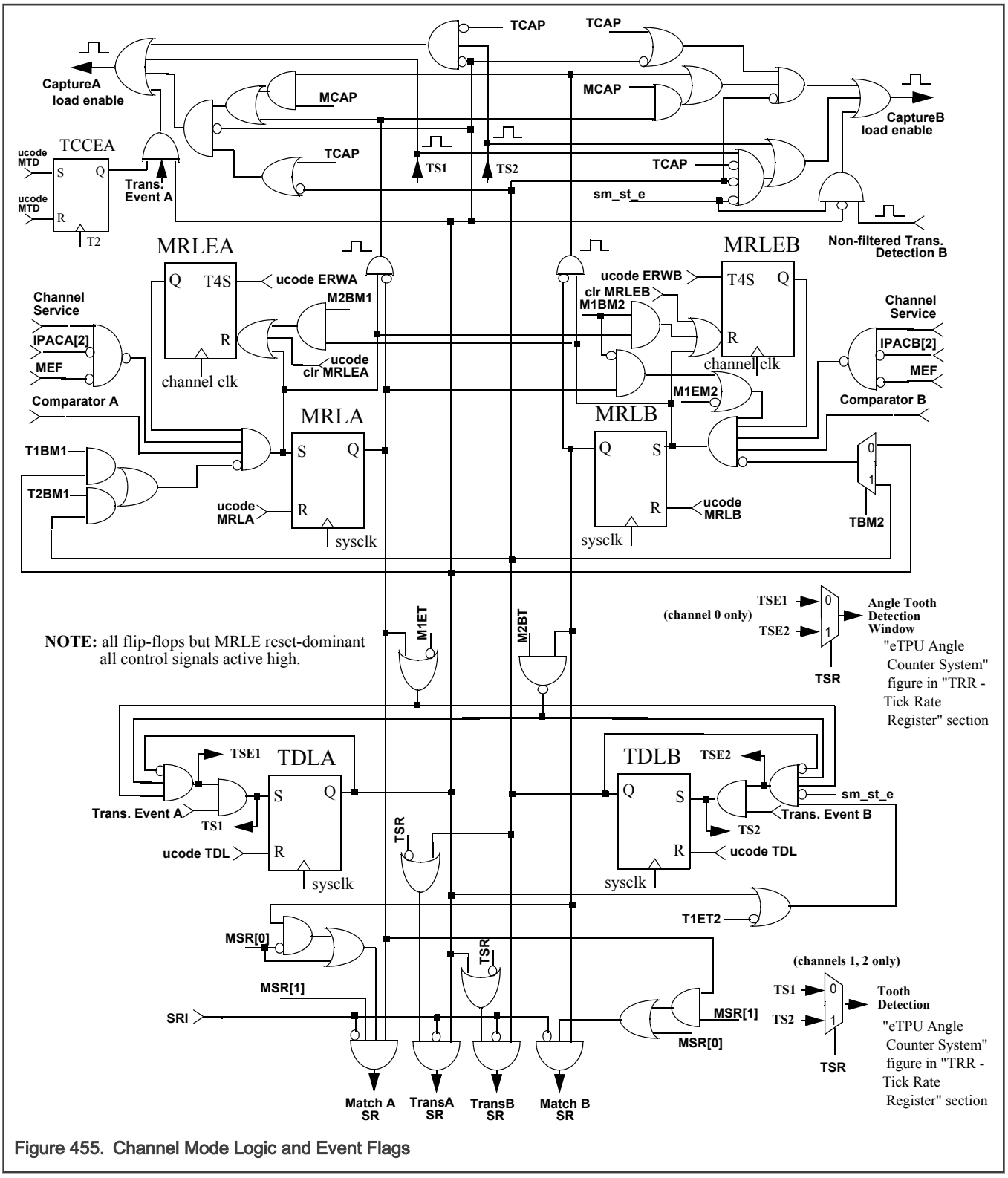


Figure 455. Channel Mode Logic and Event Flags

67.3.6.4.2 Channel Modes Overview

The predefined channel modes are divided, according to the way they treat transitions, in two basic modes:

- **Single Transition Modes** (mnemonic suffix **_st**): in these modes the first transition (flagged in TDLA) issues a service request, and captures both time bases (selected by TBSA[1] and TBSB[1]) except on sm_st_e. The second transition (flagged in TDLB) does not issue a service request, but it captures time base selected by TBSB[ ], except on sm_st_e.
- **Double Transition Modes** (mnemonic suffix **_dt**): in these modes the second transition (flagged in TDLB) issues a service request, and each transition captures its own selected time base (Transition A and Transition B capture time bases selected by TBSA[1] and TBSB[1], respectively).

In predefined modes, Transition B is always (but not only) enabled by Transition A, so that transitions are always ordered: TDLA is set on the first transition and TDLB on the second. Unordered transitions are possible with user-defined mode, when UDCM bit T1ET2=0. Matches are generally not ordered, except on specific ordered match modes m2_o_st and m2_o_dt. Match capture(s) never overwrites a Transition capture, while Transition captures can always overwrite a Match capture, either in predefined or user-defined modes.

The following general rules apply to both predefined and user-defined modes:

- Blocking of one Match by the other, when it occurs, is done through MRLEs.
- Matches always block themselves by resetting their own MRLEs (Match A always blocks Match A, Match B always blocks Match B).

Predefined modes differ mostly by the way matches affects and are affected by other matches and transitions, as explained in next sections. However, some general rules on Match blocking apply:

- Match B is blocked by first transition (TDLA) in single transition modes, and by second transition (TDLB) in double transition modes.
- Both Matches are blocked by first transition in single transition modes.

NOTE

The rules above and in following sections may be overruled by the state of the channel latches if they are set/reset by microcode or if channel mode is changed. Care must be taken to change channel modes, and is advisable to reset channel flags MRLA/B, TDLA/B and MRLEA/B before writing PDCM, or to UDCM when user-defined mode is selected.

67.3.6.4.2.1 Either match, blocking modes (em_b_st, em_b_dt)

In these modes the first match recognition that occurs blocks the other match recognition and generates a service request. They end up with one service request for two programmed match recognitions where only the first match recognition has an actual effect. If both match recognitions occur at the same time, both MRLA and MRLB are set, before the mutual blocking takes effect. The associated logic is shown in the following figure.

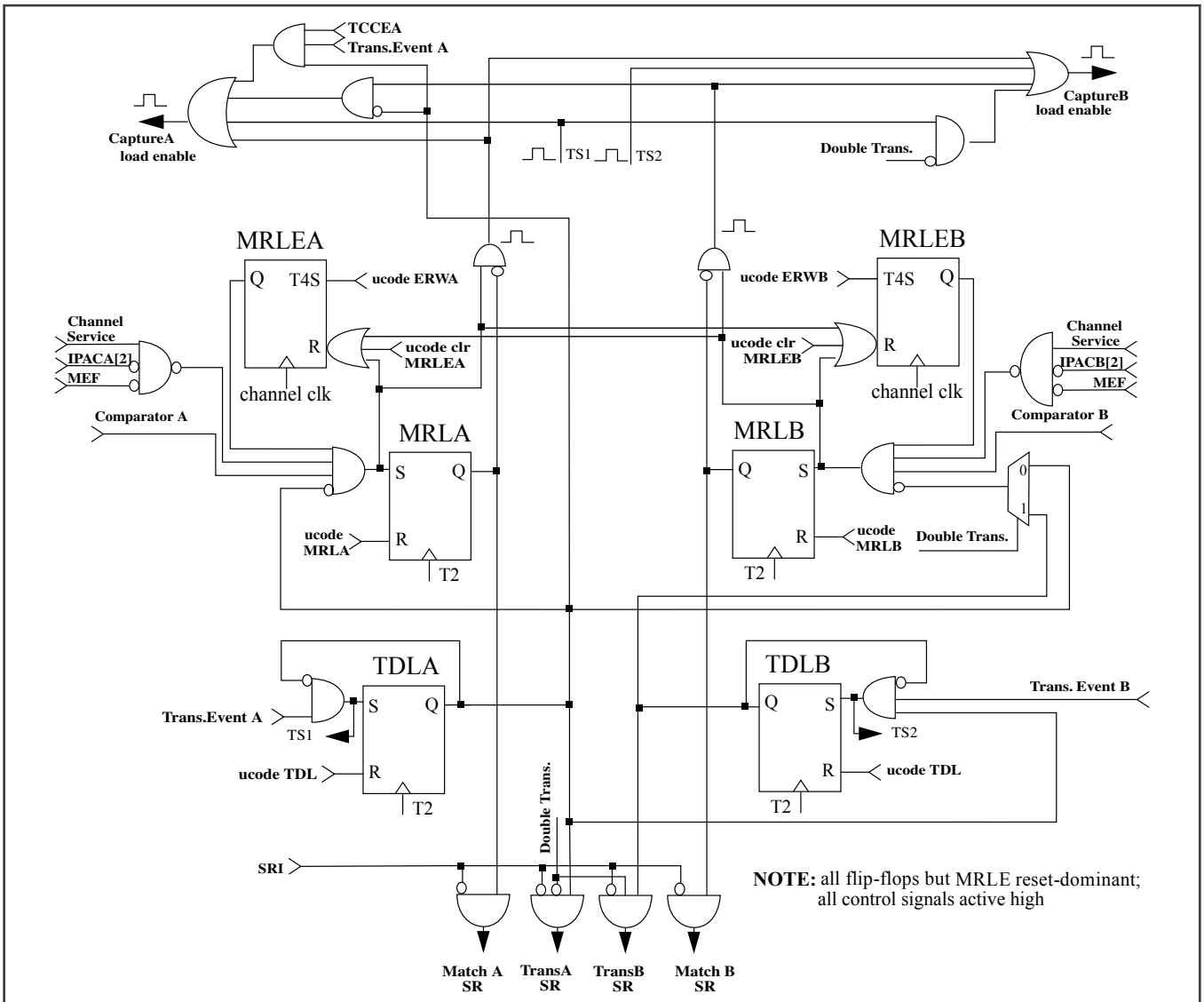


Figure 456. Either match, blocking_modes (em_b_st, em_b_dt)

67.3.6.4.2.2 Either match, non-blocking modes (em_nb_st, em_nb_dt)

In these modes both match recognitions are independent and each of them generates service request. Each match recognition captures its related time base and does not block the other. The associated logic is shown in the following figure.

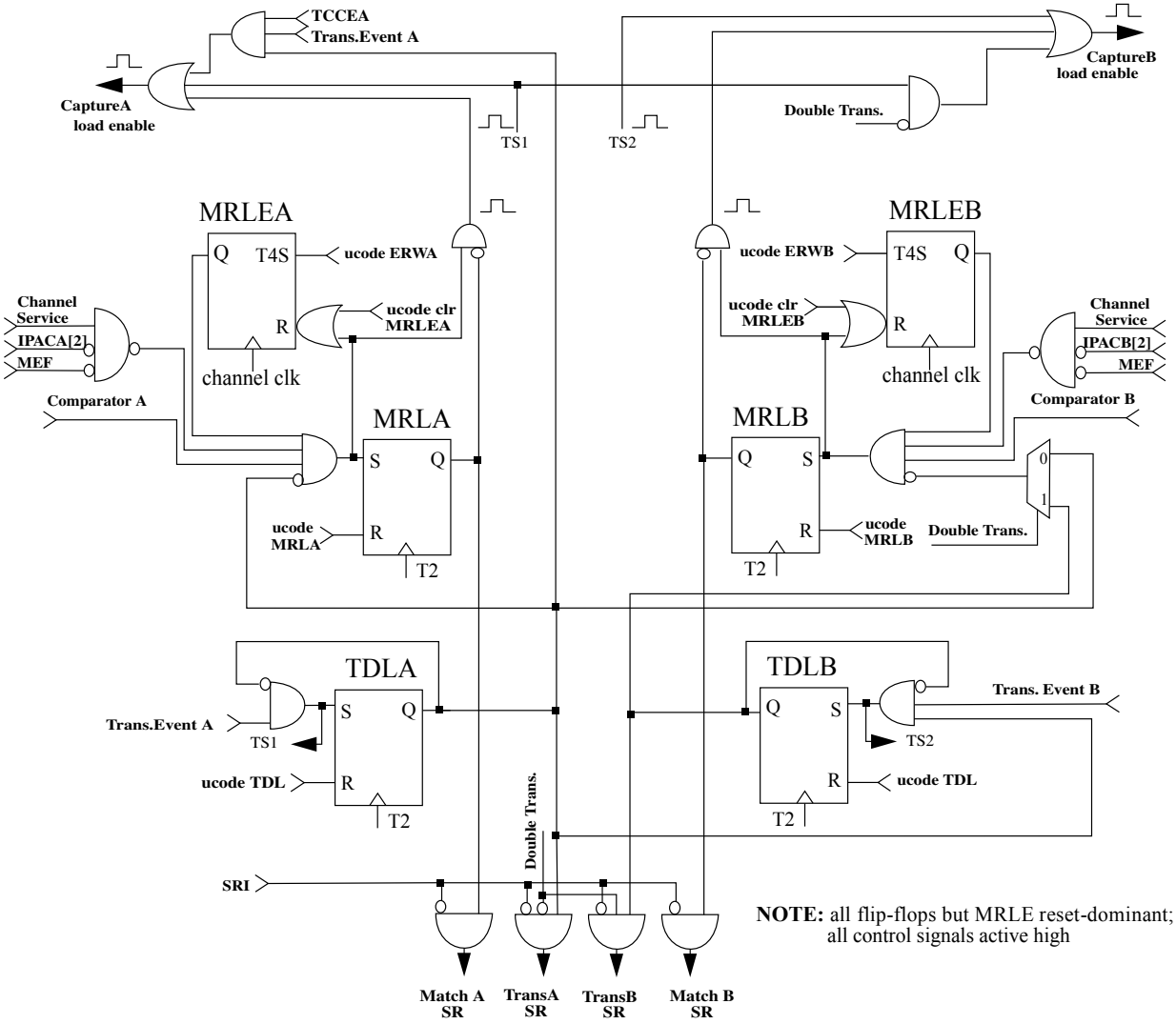


Figure 457. Either match, non-blocking modes (em_nb_st, em_nb_dt

67.3.6.4.2.3 Match B request modes (m2_st, m2_dt)

In these modes transitions are initially blocked, and are enabled by Match A. Match B recognition generates the match service request and disables Match A recognition. Each match recognition captures its own programmed timebase. In case of simultaneous match recognition, both MRLA and MRLB are set, and OPACB register has priority over OPACA for selecting the pin action. The associated logic is shown in the following figure.

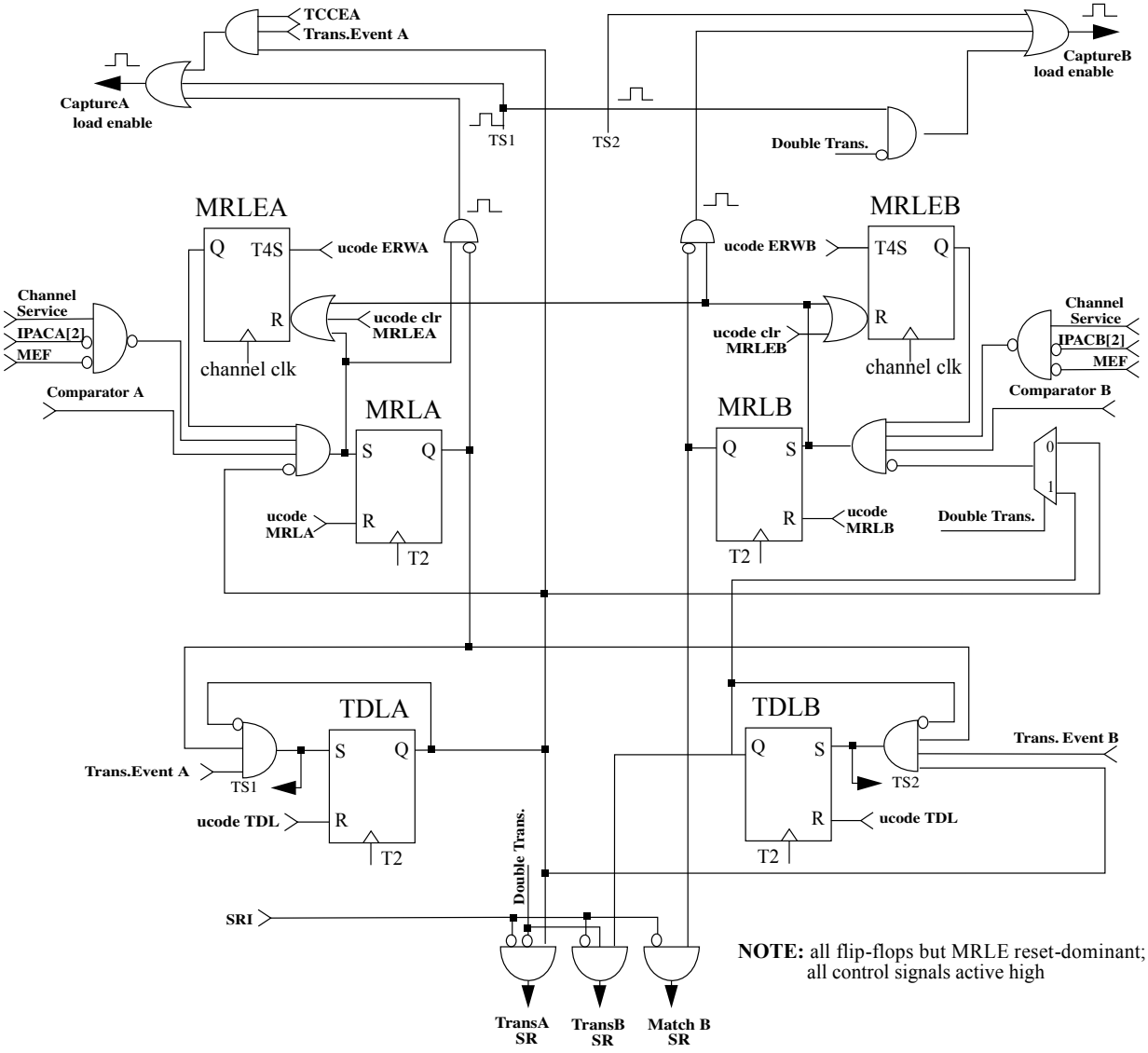


Figure 458. Match B request modes (m2_st, m2_dt)

67.3.6.4.2.4 Both match request modes (bm_st, bm_dt)

In these modes, match service request is generated only after both match recognitions occurred. By definition this is a non-blocking match mode: match recognitions do not block each other, implementing a last-served scheme. Unlike other double transition modes, bm_dt blocks Match A with Transition B (not with Transition A), so that the second transition blocks both matches. The associated logic is shown in the following figure.

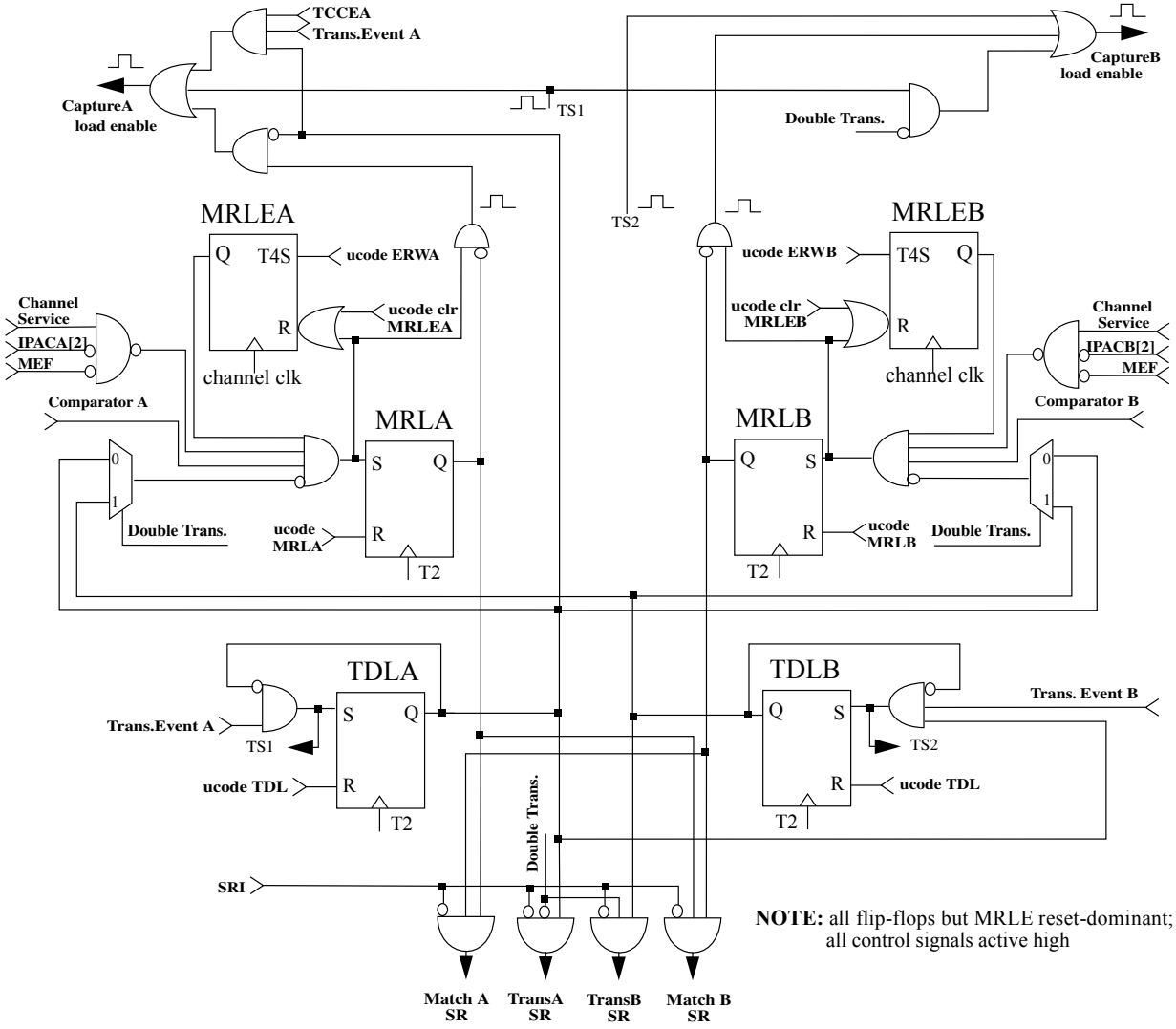


Figure 459. Both match request modes (bm_st, bm_dt)

67.3.6.4.2.5 Ordered modes with match B request (m2_o_st, m2_o_dt)

These are ordered match modes on which Match A recognition must precede Match B recognition (ordered 1->2). Match A asserts MRLA and enables Match B and transitions. Match B asserts MRLB, generates a match service request, and blocks both transitions. The associated logic is shown in the following figure.

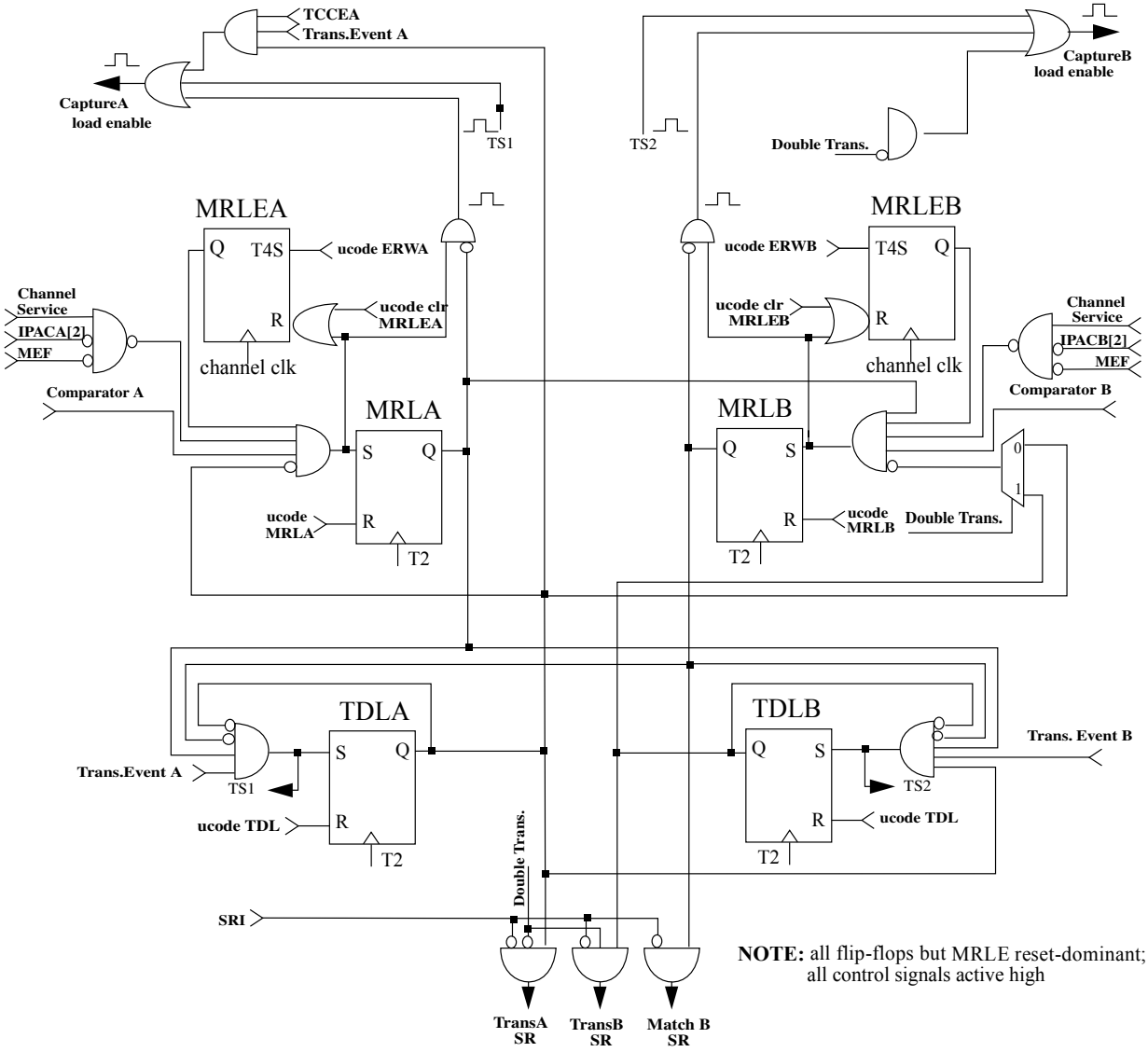


Figure 460. Ordered modes with match B request (m2_o_st, m2_o_dt)

67.3.6.4.2.6 Single match modes (sm_st, sm_dt)

Single match modes support single or double transition with single match recognition. MRLB is never set, and MRLEB has no effect. The associated logic is shown in the following figure.

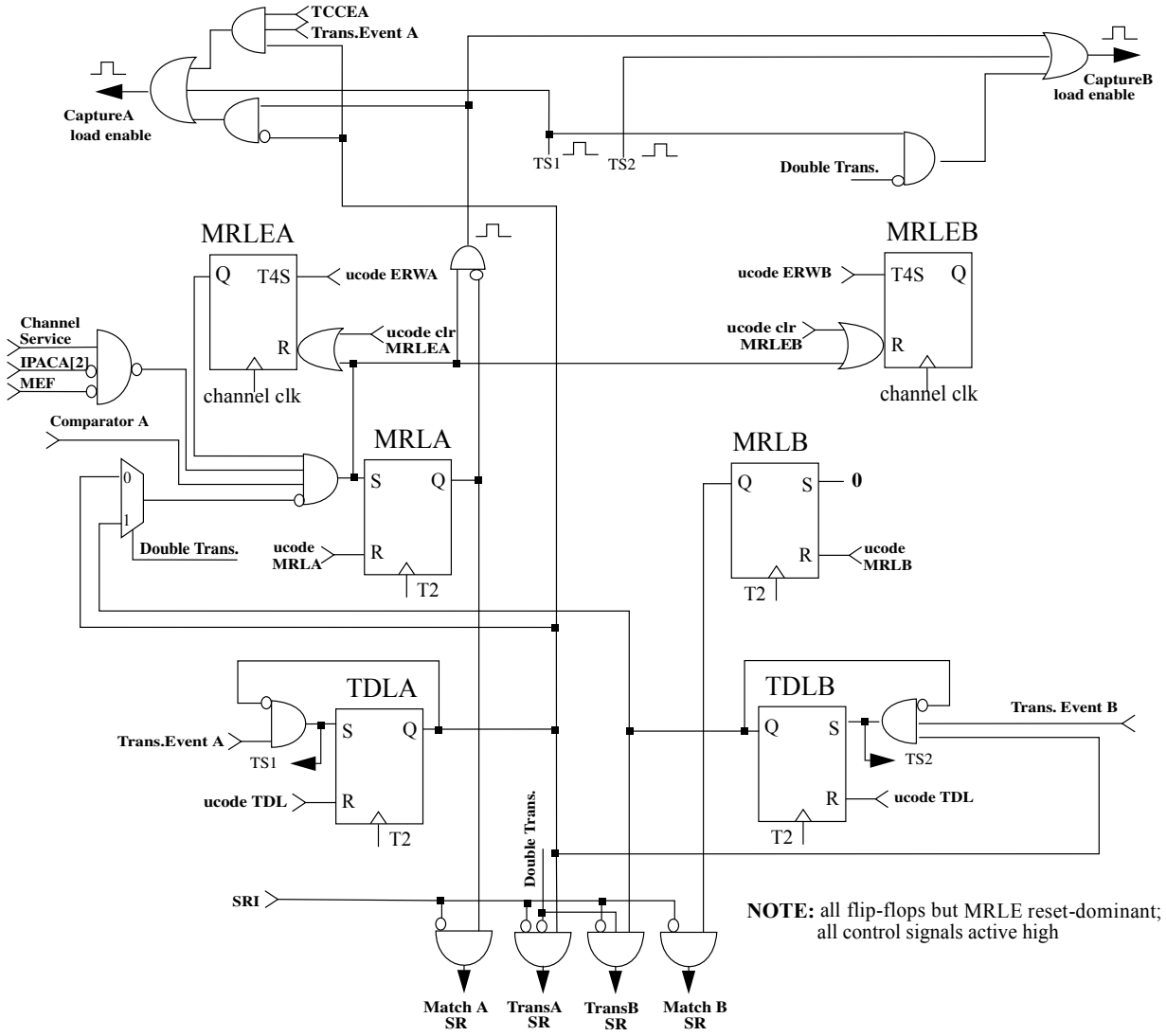


Figure 461. Single match modes (sm_st, sm_dt)

67.3.6.4.2.7 Single match enhanced mode (sm_st_e)

This is an enhanced single transition and single capture mode, which provides non-filtered input captures in addition to the single capture, allowing one to measure the delay of the digital filter. In an output channel, it has the same functionality of sm_st (captures both time bases at once due to a match recognition). The associated logic is shown in the following figure.

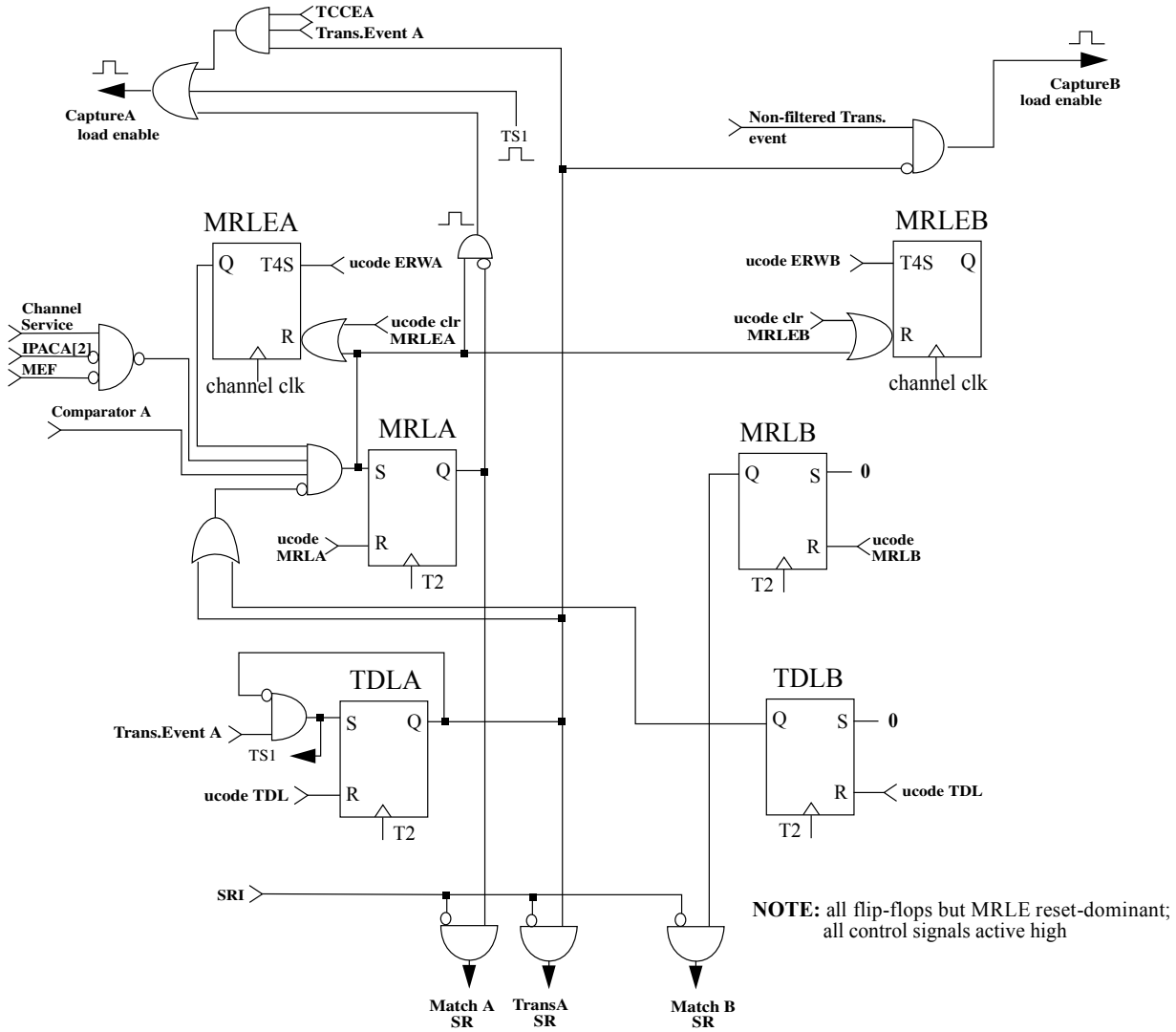


Figure 462. Single match enhanced mode (sm_st_e)

67.3.6.4.3 Predefined Channel Modes on Input Signal Processing

When processing an input signal, the predefined channel modes can be classified in the following primary mode groups:

- Single Transition, Single Match: em_b_st, sm_st, sm_st_e
- Single Transition, Double Match: em_nb_st, bm_st, m2_st, m2_o_st
- Double Transition, Single Match: em_b_dt, sm_dt
- Double Transition, Double Match: em_nb_dt, bm_dt, m2_dt, m2_o_dt

In single transition modes, TDLA assertion may capture both time bases at once, while in double transition modes each transition captures its related time base in its related capture register.

Double transition is always ordered, i.e. TDLB is enabled by TDLA and generates the service request.

The channel logic supports various input modes with combinations of single/double transition and single/double match, explained in the following subsections.

67.3.6.4.3.1 Either Match, Blocking, Single Transition (em_b_st)

On an input signal, this mode provides double timeout mechanism on a programmed transition edge with two timebases. The signal transition blocks both pending matches, indicating that no timeout condition occurred. The two match recognitions block each other, giving good separation in the entry table as to which match recognition caused the first timeout condition, and generating only one service request. Either match performs timebase captures which do not overwrite captures by transitions.

67.3.6.4.3.2 Either Match, Blocking, Double Transition (em_b_dt)

In double transition mode each transition is related to one match recognition. TDLA assertion captures its related timebase, blocks Match A and enables TDLB. TDLB assertion blocks Match B, captures its related timebase and generates a service request. Match recognitions block each other, so if there is a match timeout condition on TDLA, only one match service request is generated. This mode is good for qualifying two signal transitions by match timeout mechanisms, with one service request. Note that although TDLA assertion does not block Match B recognition, the value captured in CaptureA by TDLA assertion is not overwritten by this recognition. The second transition blocks Match B. Either match performs timebase captures which do not overwrite captures by transitions.

67.3.6.4.3.3 Either Match, Non Blocking, Single Transition (em_nb_st)

On an input signal, this is a double timeout mechanism of independent match recognitions of two different timebases. The match recognitions do not block each other, such that the microcode can check if one or two match recognitions occurred before their related signal transition. The signal transition detection (by IPACA) asserts TDLA, blocks both matches, captures both time bases and generates a transition service request, indicating that none of the two timeout conditions occurred. Any combination can be easily resolved by microcode (for example, signal transition after Match A and before Match B, or signal transition after both Match A and Match B).

Another possible use of this mode is allocating one match recognition for transition timeout and the other for another non-critical timed task, adding functionality to a single channel. Since the transition detection blocks both match recognitions, the match recognition of the other timed task is based on the fact that the comparator checks greater-equal conditions. It may be delayed if it occurs in the period between the signal transition detection (which blocks it) and the time TDLA is negated by microcode. If matches are enabled during the service, the same code can check if the match recognition of the timed task occurred in this period, by negating TDLA and writing to the CHAN register its own value (in order to update the MRLA flag in the branch logic).

67.3.6.4.3.4 Either Match, Non Blocking, Double Transition (em_nb_dt)

In this mode each transition is related to one match recognition, and the match recognitions are independent of each other. This mode can be used to give independent timeout conditions for the first and the second signal transition recognitions, and call service in any case of any timeout condition.

The first transition detection programmed in IPACA sets TDLA, captures its related timebase, blocks Match A recognition and enables TDLB assertion. The second transition detection programmed in IPACB sets TDLB, blocks Match B recognition, captures its related timebase and generates a service request. Any match recognition that occurs captures its related time base and generates a match service request, independent on the other match recognition.

67.3.6.4.3.5 Match B Request, Single Transition (m2_st)

On an input signal, this mode provides an open window filter for a single signal transition. MRLA assertion opens the window, and enables transition detection on TDLA from this time on. MRLB assertion blocks Match A (by negating MRLEA), providing conditional window opening, because transitions are indirectly blocked. It also generates service request, but if it happens after Match A it does not block transitions, providing a non-blocking timeout mechanism for the estimated signal transition time (typically it indicates a missing transition, or mis-prediction of the transition time).

Transitions can be detected from the microcycle following MRLA assertion. The Transition A detection asserts TDLA, blocks both matches, captures both timebases and generates service request.

Using this mode, the channel can replace software open window filtering of qualified transitions with the channel hardware window. The window opening and timeout can be scheduled for any of the two time bases or combination of them. Typically, Match A will be used to open a prediction window, and Match B will be used as a timeout condition which does not close the prediction

window. This configuration improves noise immunity from early signal transitions, and reduces the probability for blocking late signal transitions due to timeout mis-prediction.

Using these conditions, the microcode can easily resolve the state:

- If TDLA and MRLA are asserted and MRLB negated, signal transition is in the expected range.
- If MRLA and MRLB are both asserted, and TDLA is asserted, the signal transition had a timeout condition due to Match B mis-prediction.
- If MRLB is asserted and TDLA negated, a timeout condition occurred, and the expected signal transition had not occurred yet.
- If MRLA is negated and MRLB is asserted, the conditional window did not open at all (for example: a time window is open only after a specific angle, otherwise it is not opened).

67.3.6.4.3.6 Match B Request, Double Transition (m2_dt)

This mode is used as an open window filter for two signal transitions. In this case the Match A recognition opens the window (unless Match B recognition occurred first), and Match B recognition blocks Match A and generates a match service request. It is similar to m2_st, but in this case, it is the second transition that blocks Match B. MRLB assertion is a global timeout condition for the two pulses. Like m2_st, MRLB can conditionally eliminate the window from opening.

Using the TDLA, TDLB, MRLA and MRLB conditions, the microcode can easily resolve the state, in a similar manner as m2_st, with additional information on the second transition (TDLB).

67.3.6.4.3.7 Both Match Request, Single Transition (bm_st)

On an input signal, this is a double timeout mechanism on two different time bases. Both match recognitions must occur before the signal transition to generate a match timeout service request. Assertion of TDLA blocks both Match A and Match B recognitions, and captures both time bases, indicating there was no double timeout condition from both time bases.

Using the same timebase implements two timeout conditions, the first only sets its related MRL and the second generates a service request. Using these flags allows the microcode to check if one or both match recognitions precede the signal transition.

67.3.6.4.3.8 Both Match Request, Double Transition (bm_dt)

In this mode the first transition detection does not block matches, since both match recognitions are required to generate a match service request. The second transition detection asserts TDLB, blocks Match A and Match B, captures its related timebase and generates transition service request. In this mode, a Match A recognition which occurs after the assertion of TDLA does not capture a new value in CaptureA, to preserve the actual signal transition time. Assertion of TDLA, however, always captures its related timebase.

This mode allows putting a double match timeout condition on the second transition. Typically, a pulse trailing edge timing can be checked against two time bases, to indicate if the pulse has not ended when both MRLA and MRLB are asserted. When a transition service request is generated by TDLB assertion, the state of MRLA and MRLB indicates which timeout condition occurred, if any.

67.3.6.4.3.9 Ordered Mode with Match B Request, Single Transition (m2_o_st)

On an input channel, this mode provides a closing window filter for a single signal transition. Match A assertion captures its programmed time base in CaptureA, opens the filter window (enables assertion of TDLA), and enables assertion of MRLB. Match B recognition captures its related timebase, closes the window (disables assertion of TDLA) and generates a service request. Due to Match A and Match B ordering, the window is opened for at least one microcycle. Match B recognition indicates a window timeout condition which blocks late signal transitions, outside the prediction window. Transition detection blocks both matches, indicating the transition occurred inside the estimated window. Transitions can be detected from the microcycle following MRLA assertion until the microcycle on which MRLB is asserted. When TDLA is asserted inside the window range it disables both matches, captures both time bases and generates a transition service request.

Using this mode, the channel can replace software window filtering of qualified transitions with the channel hardware window. The window opening and closing time can be scheduled for any of the two time bases or a combination of them.

67.3.6.4.3.10 Ordered Mode with Match B Request, Double Transition (m2_o_dt)

In this mode the channel logic implements a window filter for two detected signal transitions. MRLA assertion captures its related timebase and enables the assertion of both TDLA and TDLB. MRLB assertion captures its related timebase and disables the assertion of both TDLA and TDLB. Transitions can be detected from the microcycle following MRLA assertion until the microcycle on which MRLB is asserted. The first signal transition (following MRLA assertion) asserts TDLA, captures its related timebase and enables assertion of TDLB. The second signal transition detection asserts TDLB, blocks Match B, captures its related timebase and generates the service request.

If both signal transitions occur inside the scheduled window, Match B recognition is blocked. If one or both signal transitions do not occur inside the scheduled window, Match B recognition generates a match service request and blocks further transition detections. The microcode can resolve the state using MRLA, MRLB, TDLA and TDLB, which affect the entry point selection.

67.3.6.4.3.11 Single Match Enhanced Mode (sm_st_e)

This is an enhanced single transition and single match channel mode which provides timing information of the digital filter delay.

The CaptureA register captures the timebase selected by TBSA due to transition detection specified by IPACA or match recognition, as in sm_st mode. Initially, the CaptureB register continuously captures the unfiltered IPACB-selected signal transitions from the digital filter input, directly from the signal synchronizer. When an IPACA-qualified, filtered transition detection occurs, TDLA is set, MRLA assertion is blocked, and, in addition, captures into CaptureB are also blocked. On service, CaptureA and CaptureB (copied into ERTA and ERTB) holds the time of the qualified transition detection (ERTA), and the time of the last signal transition at the input of the digital filter (ERTB). Subtracting the time in ERTB from the time in ERTA provides the delay of the digital filter.

In a quiet environment, the two captures provide the accurate delay of the digital filter in granularity of two eTPU clocks. In a noisy environment, false transitions may be detected at the input of the digital filter due to the noise, and the delay measurement may be reduced, especially if IPACB selects both edge detection. The microcode can do sanity checks on this value to recognize noise effects (for example: calculated delay is less than the minimum delay of the digital filter).

NOTE

In Channel 0, if eTPU_TBR_TBCR_ENG*n*[AM]=01 (Angle Mode), the unfiltered input comes from TCRCLK input and the filtered input comes from the TCRCLK filter output. The edge is selected by IPACA/B, and is independent of the edge selection by eTPU_TBR_TBCR_ENG*n*[TCR2CTL].

67.3.6.4.3.12 Single Match, Single Transition (sm_st)

In this mode, a match or transition detection captures at once both timebases. The mode recognizes a single transition with single match timeout. Either TDLA or MRLA generates service request and captures both timebases. Assertion of TDLA blocks future assertions of MRLA.

67.3.6.4.3.13 Single Match, Double Transition (sm_dt)

In this mode, the first transition detection asserts TDLA, captures a timebase in CaptureA and enables TDLB. The second signal transition asserts TDLB, blocks Match A, captures a timebase in CaptureB and generates a service request.

Match A (before TDLB) captures into CaptureB the timebase selected by TBSA, in order not to overwrite the captured value of TDLA.

This mode is used for scheduling one timeout condition on two input signal transitions (pulse timeout).

67.3.6.4.4 Channel Modes on Output Signal Generation

Since channel logic can generate output signal transitions based on Matches, the channel can be viewed as working in the following primary mode groups for signal generation:

- Single Match: em_b_st, sm_st, sm_st_e, em_b_dt, sm_dt
- Double Match: em_nb_st, bm_st, m2_st, m2_o_st, em_nb_dt, bm_dt, m2_dt, m2_o_dt

The channel logic supports various match channel modes with single/double match, as explained in the following subsections.

67.3.6.4.4.1 Either Match, Blocking Modes (em_b_st, em_b_dt)

On an output signal these modes are useful when using two different time bases to set a required signal transition. The first match condition which is met sets a required pin action, captures both time bases, blocks any effects of the other recognition, and generates a service request. Because the first match recognition blocks the other, the microcode can get good separation in the function entry table as to which match caused the timeout first, and both time bases are captured, enabling the microcode to compare one timebase to the other at the moment of the match recognition. These modes can be used for:

- Scheduling a required pin action to the first match recognition of two different time bases.
- Canceling a programmed pin action scheduled on one time base by match on another timebase (as a consequence of Match/Transition Pin Action Conflict Resolution). Microcode has to set the OPAC register of the canceling match to no-action and the OPAC register of the other match to the required pin action which may be blocked. If Match A is the canceling match, it blocks the pin action also in case of two matches at the same time, since it has priority in this case. If Match B is the canceling match, it does not block the pin action in case of two matches at the same time.

67.3.6.4.4.2 Either match, non-blocking modes (em_nb_st, em_nb_dt)

On an output signal these modes are useful in combination with the ME bit set on the entry point, to define an interlaced operation. For example, each match recognition can set a pin action, and the second pin action is not sensitive to microcode latency (ME bit asserted). Example for usage is PWM interlaced function on which the latency is determined by the period and not the duty cycle.

Another possibility is using one match for pin actions and the other match for an unrelated timed task without pin action (double the functionality of a single channel).

67.3.6.4.4.3 Match B Request Modes (m2_st, m2_dt)

On an output signal, these modes can generate narrow pulses or do conditional pin actions. A conditional pin action means that the pin state is changed only if the match recognitions occurred in the correct order, since the Match B recognition which generates the service request also has priority over the pin action and blocks future Match A recognitions.

Setting OPACA to a desired pin action and OPACB to no-action, and using different time bases for Match A and Match B defines a conditional OPACA pin action which can be blocked by Match B recognition. For example, setting Match A on time and Match B on angle can limit the pin action to a maximum angle value.

When pulses are generated, the service is requested at the trailing edge of the pulse, after MRLB is asserted.

67.3.6.4.4.4 Both Match Request Modes (bm_st, bm_dt)

On an output signal, each match recognition can affect the pin state, and capture its programmed time base. This way the pin action can be programmed separately for both match recognitions. For example, both match recognitions can negate the signal, and service request is generated after both conditions are met. This mechanism can set two conditions to do a required pin action, and the first recognition changes the signal, but service is called only after both conditions occur.

When using the same time base, these modes can generate narrow pulses in any required order. For example, in a PWM function, when duty cycle is below 50% the function can get service on the low time and program the pulse to the required duty cycle of the high time. When duty cycle is equal or above 50%, the function can get service on the high time and program a negative pulse with the width of the required low time. To switch between the two states the function can program once the same transition time to MatchA and Match B with a required pin action, and on the next service program double match for the new state.

Another usage is generating a required pin action on one programmed time and service request later on another time, after the second match recognition occurs, or capturing some timebase on one time and generating a required signal transition and service request later.

67.3.6.4.4.5 Ordered Modes with Match B Request (m2_o_st, m2_o_dt)

The order of the match recognitions imply that OPACA register programmed pin action always precede the OPACB register pin action. Setting OPACA to no-action, based on the greater-equal comparator, enables using Match A on one time base to delay

the signal effect of Match B on the other time base. This method implements a conditional pulse extension or conditional delay on signal transition.

These modes can also be used for deferred pulse generation with microcode service request after its trailing edge (if Match A condition comes after Match B condition). Another option is having Match A recognition associated with output pin actions and Match B recognition for a timed microcode task which has to be scheduled at a programmed time which may be delayed by the Match A pin action.

67.3.6.4.4.6 Single Match Modes (sm_st, sm_dt, sm_st_e)

There is no difference between plain and enhanced Single Match modes on an output signal.

Match A recognition generates service request and sets the pin state according to OPACA register. It captures at once the timebase selected by TBSA in CaptureA and the timebase selected by TBSB in CaptureB.

67.3.6.4.4.7 Match/Transition Pin Action Conflict Resolution

In output signals, matches and/or transitions automatically cause pin actions defined by the OPACA/B and/or IPACA/B channel control registers (see Pin Control Registers). Simultaneous matches/transitions may be associated with different, possibly contradictory, pin actions. These conflicts are resolved according to the table below.

If an OPACA/B=000 (no action) prevails over non-zero OPAC according to the table below, then if Match A/Transition A and Match B/Transition B occur simultaneously, no output pin action occurs, that is: a match on the action logic with OPAC=000 inhibits simultaneous actions of the other OPAC, if prevailing according to the following table. That also applies when output actions are caused by inputs (OPAC=1xx).

Table 400. Simultaneous Match Pin Action Priority

Channel Mode	Priority
em_nb_st / em_nb_dt	OPACA
em_b_st / em_b_dt	OPACA
bm_st / bm_dt	OPACA
m2_st / m2_dt	OPACB
m2_o_st / m2_o_dt	in these modes there is no possibility of simultaneous matches
user-defined	OPACB if M2BM1 = 1 and M1BM2 = 0, OPACA otherwise

67.3.6.4.5 Combining input and output signals

The processing of input signal can be combined with output signal generation. A detected input transition can trigger an output signal edge, even without microcode intervention, by using OPAC options 1xx.

The channel set-up examples below show these two capabilities combined (see the figure below).

The **first example** implements a fast (no microcode intervention) short-circuit protection feedback mechanism for driving high-current output devices. The signal after the high-current driver feeds back to the channel input. The input signal is normally delayed from the output signal by the device turn-on delay. After the channel output turns on, the channel logic must check if the driver output (connected to the channel input) follows the driven value after the maximum device turn-on delay. If it does not, the driver output is probably shorted, and the channel output must be turned off immediately to avoid damaging the device.

Match A causes the output to be driven high (for simplicity the output and input signals are shown as positive logic). It also causes a transition A, because IPACA=100 and the input is still low. Match B occurs after the expected driver delay, and causes a service request. If the output is shorted, a Transition B occurs on Match B because IPACB=100. This will cause the output to go low immediately, because OPACB=100.

In the **second example**, an output pulse is generated from an input transition without microcode intervention. Match A opens a window for transitions and also enables Match B. A rising edge on input sets output high. On Match B the window closes, and input signal is checked: if sampled high, the output resets; otherwise it stays high.

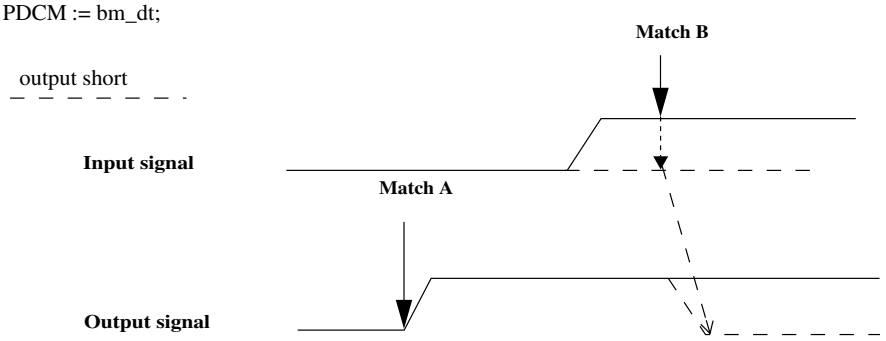
In the **third example**, a pulse is generated depending on the value sampled on the input signal at a predetermined time. Match A samples the input signal, causing a Transition. Low level on input sets output low, otherwise it stays high. Match B sets output high. In both cases a service request is issued (microcode intervention), at the beginning and at the end of the pulse (Match B), if required (SRI := 0).

NOTE

When IPAC = 1xx, a match event can cause simultaneously a Match recognition and a Transition detection. Depending on the Channel Mode, these Match and Transition may have conflicting effects on other Transition/Match blocking or enabling. In these cases, blocking always prevails over enabling, effective on the next microcycle.

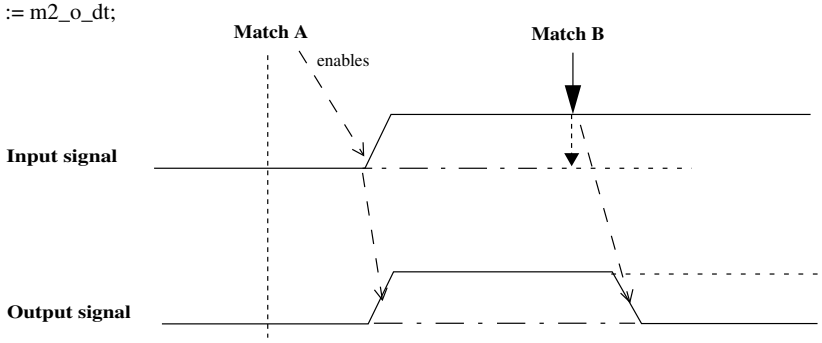
Example 1: Short-circuit protection feedback

IPACA := 100; OPACA := 001; MatchA := output activate time;
IPACB := 100; OPACB := 100; MatchB := MatchA + max. high-current driver turn-on delay;
PDCM := bm_dt;



Example 2: Pulse generation on windowed input transition

IPACA := 001; OPACA := 101; MatchA := window open time;
IPACB := 101; OPACB := 100; MatchB := window close time, input sampling;
PDCM := m2_o_dt;



Example 3: Pulse generation on input sampling

IPACA := 100; OPACA := 100; MatchA := window open time,input sampling;
IPACB := 000; OPACB := 001; MatchB := window close time = MatchA + pulse width;
PDCM := em_nb_dt;

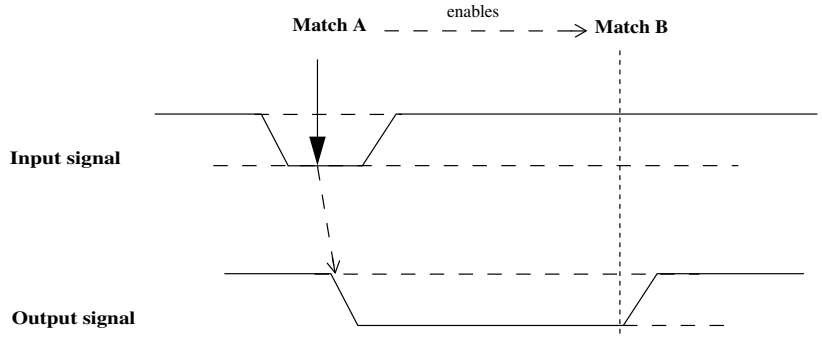


Figure 463. Input output combination

67.3.6.4.6 Channel Mode Summary

The initial state considered for all submodes is channel flags MRLEA and MRLEB asserted, MRLA, MRLB, TDLA and TDLB negated. From initial state one can follow the table below and verify how each submode behaves in a determined sequence of

events. Note that the actions performed by an event type depend on all previous events following the initial state, for a given channel submode.

There are three columns for each event: one for event type, one for enable/disable actions and one for capture. **Event type** column can be matchA, matchB, transA and transB (for double transition modes). **Enable/disable actions** column (identified as "**[blocks](enables)**" in column head) specifies which other events are enabled or disabled. Initially disabled events (specified in **"initially blocked"** column) are usually enabled by other events.

In double transition submodes, the first transition detected is always considered transA and the second is considered transB. This means that transA event actually enables the detection of transB event. This is not explicit in the table, since it is a general behavior for all double transition submodes.

A sequence of four events (two matches and two transitions) are necessary to describe the behavior of some channel submodes. When a determined sequence of events has less than four events, the other event columns are left blank.

Cells in an **"event type"** column that have light-grayed background indicate that a service request is generated. More than one event in the same event sequence can issue service request.

NOTE

The two tables below do not exhaust all possibilities of channel logic event sequences, because it does not account for possible microcode interventions. For instance, if matches are blocked by first transition and microcode resets TDLA, the matches become enabled again, and from this point on the channel behaves as if the first transition had never occurred.

Table 401. Channel Mode Summary 1 of 2

Mode	Initially Blocked	1st Event			2nd Event		
		Event Type	[Blocks] (Enables)[1]	Capture	Event Type	[Blocks] (Enables)	Capture
em_nb_st	none	match 1/2[2]	none	1/2	match 2/1	none	2/1
					trans 1	[matches]	both
		trans 1	[matches]	both	trans 2	none	2
em_nb_dt	none	match 1/2	none	1/2	match 2/1	none	2/1
		match 1	none	1	trans 1	none	1
		match 2	none	2	trans 1	[match 1]	1
		trans 1	[match 1]	1	match 2	none	2
					trans 2	[match 2]	2
em_b_st	none	match 1	[match 2]	both	trans 1	[matches]	both
		match 2	[match 1]	both			
		trans 1	[matches]	both	trans 2	none	2
em_b_dt	none	match 1	[match 2]	both	trans 1	none	1
		match 2	[match 1]	both			
		trans 1	[match 1]	1	match 2	none	2
					trans 2	[match 2]	2
bm_st	none	match 1/2	none	1/2	match 2/1	none	2/1
					trans 1	[matches]	both

Table continues on the next page...

Table 401. Channel Mode Summary 1 of 2 (continued)

Mode	Initially Blocked	1st Event			2nd Event		
		Event Type	[Blocks] (Enables)[1]	Capture	Event Type	[Blocks] (Enables)	Capture
		trans 1	[matches]	both	trans 2	none	2
bm_dt	none	match 1/2	none	1/2	match 2/1	none	2/1
					trans 1	none	1
		trans 1	none	1	match 1/2	none	none/2
					trans 2	[matches]	2
m2_st	trans 1	match 1	(trans 1)	1	match 2	none	2
					trans 1	[matches]	both
		match 1 and match 2	(trans 1)	both	trans 1	[matches]	both
		match 2	[match 1]	2	n/a	n/a	n/a
m2_dt	trans 1	match 1	(trans 1)	1	trans 1	none	1
					match 2	none	2
		match 1 and match2	(trans 1)	both	trans 1	none	1
		match 2	[match 1]	2	n/a	n/a	n/a
m2_o_st	trans 1 match 2	match 1	(match 2) (trans 1)	1	trans 1	[matches]	both
					match 2	[trans 1]	2
m2_o_dt	trans 1 match 2	match 1	(match 2) (trans 1)	1	trans 1	none	1
					match 2	[trans 1]	2
sm_st	match 2	match 1	none	both	trans 1	none	both
		trans 1	[match 1]	both	trans 2	none	2
sm_dt	match 2	match 1	none	both	trans 1	none	1
		trans 1	none	1	match 1	none	2
		trans 1	none	1	trans 2	[match1]	2
sm_st_e[3]	match 2 trans 2	match 1	none	1	trans 1	none	1
		trans 1	[match 1]	1	n/a	n/a	n/a

1. Transition 1 always enables Transition 2.
2. Shading indicates that a service request is generated.
3. It is not possible to include all functionality of this submode in table.

Table 402. Channel Mode Summary 2of 2

Mode	Initially Blocked	3rd Event			4th Event		
		Event Type	[Blocks] (Enables)[1]	Capture	Event Type	[Blocks] (Enables)	Capture
em_nb_st	none	trans 1[2]	[matches]	both	trans 2	none	2
					n/a	n/a	n/a
		trans 2	none	2	trans 2	none	2
em_nb_dt	none	trans 1	none	1	trans 2	none	2
		match 2	none	2	trans 2	none	2
		trans 2	[match 2]	2	n/a	n/a	n/a
		trans 2	[match 2]	2	n/a	n/a	n/a
		trans 2	none	2	n/a	n/a	n/a
em_b_st	none	trans 2	none	2	n/a	n/a	n/a
em_b_dt	none	trans 2	none	2	n/a	n/a	n/a
		trans 2	none	2	n/a	n/a	n/a
bm_st	none	trans 1	[matches]	both	trans 2	none	2
		trans 2	none	2	n/a	n/a	n/a
bm_dt	none	trans 1	none	1	trans 2	[matches]	2
		match 2/1	none	2 / none	trans 2	[matches]	2
		trans 2	[matches]	2	n/a	n/a	n/a
		match 2/1	none	2 / none	trans 2	[matches]	2
		trans 2	[matches]	2	n/a	n/a	n/a
m2_st	trans 1	trans 1	[matches]	both	trans 2	none	2
		trans 2	none	2	n/a	n/a	n/a
		trans 2	none	2	n/a	n/a	n/a
m2_dt	trans 1	trans 2	[match 2]	2	n/a	n/a	n/a
		match 2	none	2	trans 2	none	2
		trans 1	none	1	trans 2	none	2
		trans 2	none	2	n/a	n/a	n/a
m2_o_st	trans 1 match 2	trans 2	none	2	n/a	n/a	n/a
m2_o_dt	trans 1 match 2	trans 2	[match 2]	2	n/a	n/a	n/a
		match 2	[trans 2]	2	n/a	n/a	n/a
sm_st	match 2	trans 2	none	2	n/a	n/a	n/a
sm_dt	match 2	trans 2	none	2	n/a	n/a	n/a

Table continues on the next page...

Table 402. Channel Mode Summary 2of 2 (continued)

Mode	Initially Blocked	3rd Event			4th Event		
		Event Type	[Blocks] (Enables)[1]	Capture	Event Type	[Blocks] (Enables)	Capture
		trans 2	none	2	n/a	n/a	n/a
sm_st_e[3]	match 2 trans 2	n/a	n/a	n/a	n/a	n/a	n/a

1. Transition 1 always enables Transition 2.
2. Shading indicates that a service request is generated.
3. It is not possible to include all functionality of this submode in table.

67.3.6.5 Channel link

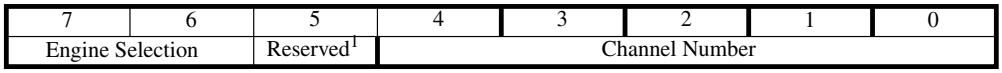
A channel can issue service requests to other channels through microcode, by assigning to the write-only microengine register LINK (refer to LINK Register) a value which specifies the target channel of the Link Service Request, as shown in the figure below.

Writing to the LINK register issues a link request to the target channel, setting its LSR flag. Each channel has its own LSR flag, which can be tested as a microcode branch condition (see Conditional/unconditional branch) and reset through the microcode field LSR (see Clear Link Service Request). The link branch condition samples, at the TST start, the value used to calculate the Entry Point.

Writing LINK with another channel target value in the same thread issues a Link Service Request to the new target, without negating the service request to the former one. This allows a channel to issue service requests to any number of channels, including itself. Neither LINK nor LSR microengine accesses are qualified by the CHAN register, i.e., they always access the serviced channel LINK and LSR, regardless of the value written in CHAN.

Channels can also receive link service requests from the Shared Subsystem Units (see Shared subsystems support) . These links are set by the interrupt signals from the shared subsystem and are level-sensitive, that is, they keep on requesting link service as long as the interrupt is active . Therefore, it is not enough to clear the link service request through the LSR instruction field: one must clear beforehand the respective shared subsystem unit interrupt source .

If microcode executes an instruction with field LSR=0 (clear Link Service Request), the link branch condition is cleared. However, the link service request itself is cleared only if no link from other channel was received by the serviced channel during the same thread[23]. Note that this applies only to links that come from the other engine or the same channel: if only Shared Subsystem link was received during the thread, the link service is also cleared with field LSR=0. If microengine clears LSR of its channel and, simultaneously, Link Service Request is issued to the current serviced channel, the branch condition is cleared but the link service request remains pending.



NOTES:
1 reserved bit must be written 0.

Figure 464. Microengine link register

A channel can issue Link Service Requests to channels in any of two Engines, determined by the LINK register field Engine Selection (2 bits), as shown in the following table. In a Single Engine eTPU, Link is ignored when sent to the other engine, or engine 2.

[23] That can only happen if the link service request came from the other Engine, or from the serviced channel itself.

Table 403. LINK Engine Selection

Engine Selection	Description
00	this Engine
01	Engine 1
10	Engine 2
11	the other Engine

There is no explicit hardware mechanism to allow the thread to identify the link service request source, but it can be done by a software protocol using SDM parameters. All links are negated on reset.

67.3.6.6 Enhanced digital filter (EDF)

EDF eliminates passing of signal transitions which are caused by noise. Its purpose is to eliminate false transition service requests caused by noise pulses which are shorter than a programmed width.

See the chip-specific eTPU information for connections between eTPU and input glitch filters.

EDF has three modes of operations, selected by the CDFC field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2). These modes offer selections of trade-off between noise immunity and signal latency. CDFC also allows the filter to be bypassed. Filter clock prescaler gives an example of minimum detected signal pulse and maximum filtered noise pulse in the three EDF operation modes. In Angle Mode, if AM=01, the EDF in channel 0 is replaced with the digital filter and synchronizer of the TCRCLK signal. In this mode, channel 0 works in combination with the Angle Counter logic, and their operation is fully synchronized.

Following subsections provide the functional description of the eTPU channel digital filter.

67.3.6.6.1 Two-sample mode

In this mode the EDF works like the TPU2/3 digital filter. It uses the filter clock which is the eTPU clock divided by (2, 4, 8,.., 256) as a sampling clock. The filter clock is selected by the FPSCK field ineTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2). The EDF compares two consecutive samples. If both samples have the same value, the input signal state is updated. Note that when the FPSCK field selects the eTPU clock divided by two, the EDF works like the TPU1 four-clock digital filter.

67.3.6.6.2 Three-Sample mode

In this mode, like in the TPU2/3 mode, the EDF uses the filter clock as a sampling clock. The EDF compares three consecutive samples. If all three samples have the same value, the input signal state is updated.

The Three-Sample mode gives more signal latency than the Two-Sample mode, but also better noise immunity and better ratio between minimum detected signal pulse to maximum filtered noise pulse. When a certain filter clock frequency is selected for Two-sample mode, double filter clock frequency can be selected to get better latency in Three-sample mode.

67.3.6.6.3 Continuous mode

In this mode the EDF compares all the values sampled at the rate of eTPU clock divided by two, between two consecutive filter clock pulses. If the signal is continuously stable for the entire digital filter clock period (i.e. all the samples have the same signal value), the input signal state is updated.

This method gives the same latency and the same ratio between minimum detected signal pulse to maximum filtered noise pulse, as the Two-Sample mode, as long as there is no noise. Each sampled noise delays the signal transition detection by at least a whole digital filter clock period.

The Continuous mode gives the best noise immunity by comparing multiple samples of the noise. On the other hand, when a short noise pulse appears in the middle of the filter clock period at the same time of a real signal transition, the Continuous mode may reject a real signal transition and delay the response to the first filter clock period in which the signal is continuously stable. This may add to the latency and also to the minimum detected signal pulse in a noisy environment.

67.3.6.6.4 Bypass Mode

In bypass mode the signal that feeds the edge detection comes directly from the output of the synchronizer, not filtered. Bypass mode automatically makes the channel logic work in T2/T4 timing mode (see Channel timing modes).

67.3.6.6.5 Filter clock prescaler

Each channel configured as an input has an associated synchronizer followed by a digital filter connected to the signal that samples signal transitions. After reset, the digital filter filters out high and low pulse widths smaller than the period of two eTPU clocks with eTPU_SCR_ECR_ENG*n* field FCSS = 0, or 1 eTPU clock with FCSS = 1 (see eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2)), preventing these transitions from being input to the transition detect logic. For FPSCK=0 and FCSS = 0, the synchronizer and digital filter are guaranteed to pass pulses that are as wide as or wider than four eTPU clocks, meaning a minimum period of 8 eTPU clocks. These figures are halved by setting FCSS = 1. By changing the FPSCK field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2) the user can select a lower clock rate for the filter signal to define wider valid pulses and filter out wider noise pulses. The filter prescaler clock control is a division of the eTPU clock. To guarantee pulse detection by the digital filter, the pulse must cover at least the stated number of samples at the filter clock rate. For example, a two sample digital filter must sample two points in the pulse to detect it. The table below shows the minimum guaranteed detected pulse width and the maximum filtered noise pulse width. The table refers only to the digital filter operation. The external pulses may have to be wider (to ensure detection) or narrower (to ensure filtering) depending on the rise/fall delay differences in the MCU receivers and internal logic. Delays introduced by synchronizer, filter and edge detection logic are explained in Input/output signal delays.

The TCRCLK signal also has a synchronizer and a filter. The FCSS bit has no influence on the clock prescaler of the TCRCLK filter, which works like the channel filter with FCSS=0.

Table 404. Pulse widths and delays

Filter control (FPSCK)		Filter clock period	Min. width guaranteed detected / max. width filtered (min. filter delay / max. filter delay)	
FCSS = 0	FCSS = 1		Two-Sample or Continuous mode	Three-Sample or Integrator[1] mode
not avail.	000	1	2 / 1 (2 / 3)	3 / 2 (3 / 4)
000[2]	001	2	4 / 2 (3 / 3)	6 / 4 (5 / 5)
001	010	4	8 / 4 (5 / 7)	12 / 8 (9 / 11)
010	011	8	16 / 8 (9 / 15)	24 / 16 (17 / 23)
011	100	16	32 / 16 (17 / 31)	48 / 32 (33 / 47)
100	101	32	64 / 32 (33 / 63)	96 / 64 (65 / 95)
101	110	64	128 / 64 (65 / 127)	192 / 128 (129 / 191)
110	111	128	256 / 128 (129 / 255)	384 / 256 (257 / 383)
111	not avail.	256	512 / 256 (257 / 511)	768 / 512 (513 / 767)

1. Integrator mode is available for TCRCLK filtering only, see TCRCLK digital filter.
2. These delays also apply to the TCRCLK filter when TCRCF selects eTPU clock/2 as filter clock.

NOTE

The TCRCLK filter is clocked as if FCSS = 0, always dividing eTPU clock /2 using FPSCK, regardless of the FCSS field .

67.3.6.7 Channel timing modes

Channels can work on two different timing schemes, defining the period of channel clocking, tied to T2 and T4 microengine phases, as explained in subsections below. Microengine T2 and T4 phases are shown in Microcycle and I/O timing.

67.3.6.7.1 T2 channel timing

In T2 timing mode the channel event state can only be updated every two eTPU clocks (see Execution and channel timing). Pin state, TDLs, MRLs and Capture registers are updated on the microengine's T2 clock phase. MRLE clears also happen on T2, but MRLE setting occurs on T4, together with the Match register write by microcode (see Write Channel Match and UDCM Registers).

Channels work in T2 timing mode when either the T4DIS field in C*a*CR_ENG1 and C*a*CR_ENG2 is 1 or all the following conditions are true:

- The TCR1CS field in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2) is 0.
- The Enhanced Digital Filter is not configured as bypass (see Enhanced digital filter (EDF)).
- The FCSS field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2) is 0 (see Filter clock prescaler).

67.3.6.7.2 T2/T4 channel timing

In T2/T4 timing mode the channel event state can be updated on any eTPU clock (see Execution and channel timing). Pin state, TDLs, MRLs, MRLEs, and Capture registers are updated either on microengine's T2 or T4 clock phases. MRLE clears can happen on T2 or T4, but MRLE setting occurs on T4 only, together with the Match register write by microcode (see Write Channel Match and UDCM Registers).

Channels work in T2/T4 timing mode when the T4DIS field in C*a*CR_ENG1 and C*a*CR_ENG2 is 0 and either one the following conditions are true:

- The TCR1CS field in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2) is 1.
- The Enhanced Digital Filter is configured as bypass (see Enhanced digital filter (EDF)).
- The FCSS field in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2) (see Filter clock prescaler).

T2/T4 timing mode demands special care on channel microcode that reprograms a match in a thread with matches enabled (entry point ME=1, see the “Entry Points” section). When the match register is written and the MRLA/B flag(s) is(are) cleared in the same instruction, a match can occur after MRLA/B is cleared, together with the set of respective MRLE. In this case, both MRL and MRLE will be set, and a match service request will occur if enabled. However, the match happened on the old match value, not on the new (reprogrammed) one. In order to prevent this ambiguity to the code that services the match, it is advisable to clear the MRLE (besides MRL) together with the match reprogramming, avoiding the match on the old value to occur while the new match value is being written. The set of the MRLE due to match reprogramming prevails over the MRLE clear, thus allowing the new programmed match to occur in the future.

A similar case occurs when a match is blocked by a transition, the blocking TDL is cleared and the blocked match is reprogrammed at the same instruction: in T2/T4 timing mode: a match can occur on the old match value. The solution is the same as the case above, that is, clear the respective MRLE in the same instruction.

67.3.7 Clocking

eTPU consists of these clocks:

- System clock

- Gated system clock
- Engine clock

67.3.8 Time bases

Each eTPU engine has two Time Counter Registers, TCR1 and TCR2. They provide 24-bit time bases, shared by all 32 channels. Any channel can use both time bases to:

- Match channel's internal registers MatchA or MatchB;
- Capture time base value to channel's internal registers, CaptureA and/or CaptureB, when a match recognition or an Input transition detection occurs. For more information on channel events refer to Enhanced Channels.

The TCR1 and TCR2 counters are accessible by the microcode for read and write operations. Its current value is used for getting the current time, and the captured values are used for channel relative time calculations of future events. When they are written at the same time they are incremented from any clock source, the written value prevails.

TCR1 with eTPU_TBR_TBCR_ENG*n*[TCR1CS]=0 and TCR2 values are updated in T2 and read in T4 (see Microcycle and I/O timing). TCR1 can also work at full-speed eTPU clock, and so be updated on both T2 and T4, when eTPU_TBR_TBCR_ENG*n*[TCR1CS]=1. Both TCR1 and TCR2 values can be imported from or exported to the STAC bus. When their values are imported (Clients), these registers are written from the bus and can only be read by microcode.

The TCR2 counters between the two Engines are out of phase by 1 eTPU clock, even when Time Bases are shared between them through . It also applies to TCR1 counters if eTPU_TBR_TBCR_ENG*n*[TCR1CS]=0, but they can be in phase otherwise.

67.3.8.1 Timer Count Register 1 (TCR1)

TCR1 can be used in the following modes:

- Internally Clocked Mode
- Externally Clocked Mode
- Bus Client Mode

The host program can read TCR1 time base through eTPU Engine 1 Time Base 1 (TCR1) Visibility Register (TB1R_ENG1) and eTPU Engine 2 Time Base 1 (TCR1) Visibility Register (TB1R_ENG2).

The TCR1 bus runs through all the local engine channels. In channels which select TCR1 as MatchA and/or MatchB source, when its value is greater or equal to the programmed match value, a Match A and/or Match B event occurs on that channel. A recognized match event sets its related Match Recognition Latch 1 or 2, and according to the Predefined Channel Modes (PDCM) it may generate a channel service request. For details on eTPU channels see Enhanced Channels.

67.3.8.1.1 Externally Clocked mode

TCR1 can be driven externally by the TCRCLK input, after the digital filter. The TCR1 clock source is configured by the TCR1CTL bit, as shown in the following figure. For more information on clock source selection, see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2).

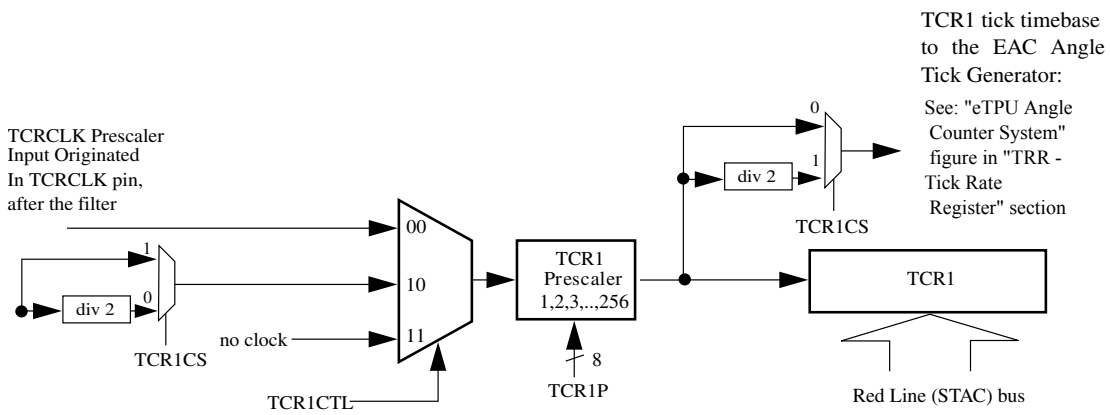


Figure 465. TCR1 clock selection

67.3.8.1.2 Internally Clocked Mode

TCR1 can be driven by the eTPU clock or eTPU clock divided by 2, before the prescaler. TCR1CTL can also be used to freeze TCR1 clock independently of TCR2 (unlike GTBE).

67.3.8.1.3 TCR1 clock prescaling

Any clock source selected by TCR1CTL is prescaled by a factor of 1 to 256, selected by the TCR1P field in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2). For more information on prescaler configuration, see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2). The TCR1 Prescaler resets when the eTPU GTBE input is negated. After reset, it starts counting up to TCR1P when the eTPU GTBE input is asserted. When TCR1 increments (the eTPU GTBE input = 1), the prescaler starts a new count and the new TCR1P becomes effective. When TCR1 is written by microcode, the prescaler is reloaded with TCR1P and it becomes effective, if the eTPU GTBE input is asserted.

67.3.8.1.4 STAC Bus Client Mode

In this mode the TCR1 register is continuously updated from the bus, and the clock selection and prescaling logic becomes ineffective. It is not writable by the microcode, and when read, it reflects the bus imported value. The use of EAC is not allowed in client mode. This mode is configured through eTPU Engine 1 STAC Configuration Register (STAC_ENG1) and eTPU Engine 2 STAC Configuration Register (STAC_ENG2).

67.3.8.1.5 STAC Bus Server mode

TCR1 bus can be exported to the bus as a server, providing time information to other peripherals. This mode is configured through eTPU Engine 1 STAC Configuration Register (STAC_ENG1) and eTPU Engine 2 STAC Configuration Register (STAC_ENG2).

67.3.8.2 Timer Count Register 2 (TCR2)

The TCR2 is a 24-bit counter which can be used in the following modes:

- Pin Transition Mode: Count the rise, fall, or both transitions of TCRCLK signal.
- Angle Clock Mode: Count internal tooth angle in combination with the eTPU Angle Counter (EAC) hardware which implements an Angle PLL, and generates angle information to the channels. This mode is targeted for angle-based applications.
- (STAC) Bus Client Mode: TCR2 is driven by an external source (see STAC Bus Client mode).
- Gated Mode: Count with rate derived from the eTPU clock divided by eight. The TCRCLK signal is used to gate this count, enabling pulse accumulator operations.
- Internally Clocked Modes: TCR2 is driven by internal clock, with count rate of eTPU clock divided by eight.

All clock sources pass through a prescaler. In addition, the TCR2 count can be originated from the EAC which is a hardware angle clock and angle counter. shows the diagram for TCR2 clock control. When TCR2 is not driven by the EAC or , the eTPU_TBR_TBCR_ENG*n*[TCR2CTL] field selects the clock source, also allowing TCR2 to be frozen independently of TCR1 (see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2)). When in Angle Mode, TCR2CTL selects the TCRCLK edge sensitivity.

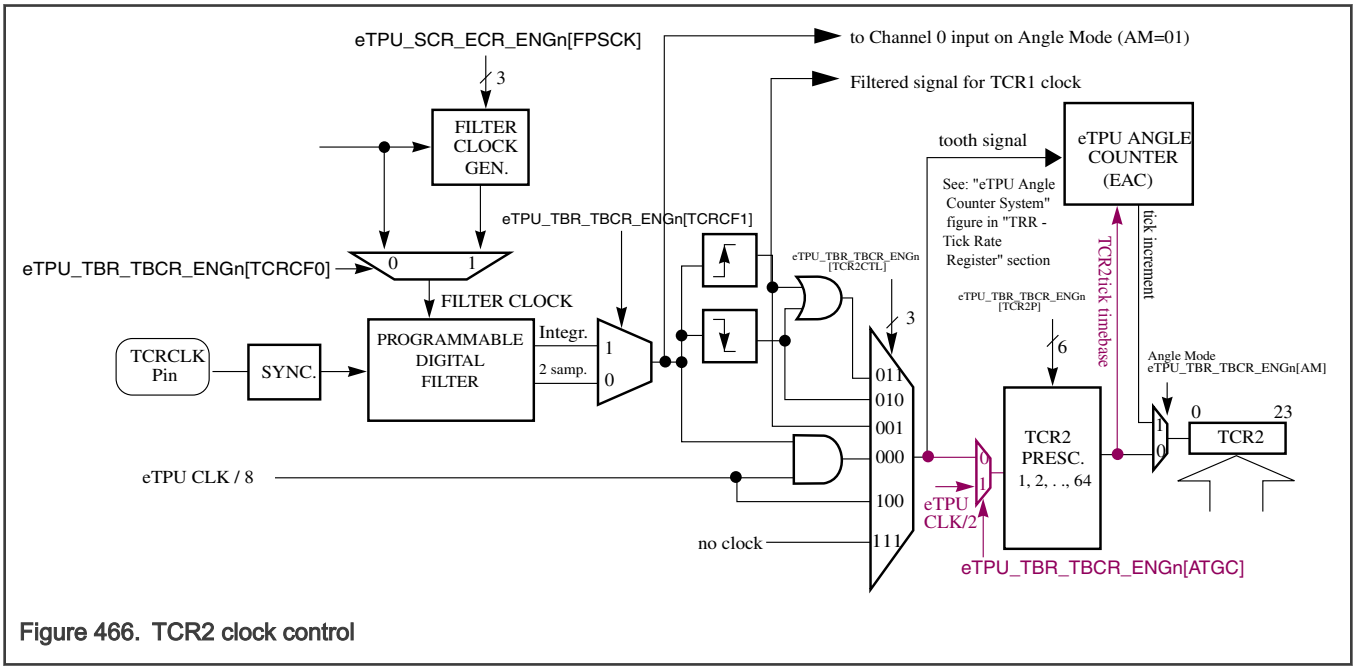


Figure 466. TCR2 clock control

The TCRCLK signal input is passed through a synchronizer and a programmable digital filter. In Angle Mode with AM=01, synchronizer and filter are also used in Channel 0, replacing its input synchronizer and filter, to get the same timing in the EAC and Channel 0. The TCRCLK synchronizer is an improved filter that provides best latency while maintaining proper noise filtering (see the field TCRCF in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1))

The TCR2 bus runs through all the local engine channels. It transitions on clock T2 (see Microcycle and I/O timing). In channels which select TCR2 as MatchA and/or MatchB source, TCR2 value is compared against MatchA and/or MatchB registers. A recognized match event sets its related Match Recognition Latch 1 or 2, and according to the Predefined Channel Modes (PDCM) it may generate a channel service request. For details on eTPU channels see Enhanced Channels.

The TCR2 counter is accessible by the microcode for read and write operations. Its current value is used for getting the current counter value (representing signal transitions, time or angle), and the captured values are used for channel relative count calculations of future events. The TCR2 value is readable to the host through eTPU Engine 1 Time Base 2 (TCR2) Visibility Register (TB2R_ENG1) and eTPU Engine 2 Time Base 2 (TCR2) Visibility Register (TB2R_ENG2). When the TCR2 bus value is imported from the bus (client mode), TCR2 is not writable by the microcode, and read access from the microcode or from the host reflect the imported TCR2 value.

67.3.8.2.1 TCR2 clock prescaling

Except in Angle Mode, any clock source selected by TCR2CTL is prescaled by a factor of 1 to 64, selected by eTPU_TBR_TBCR_ENG*n*[TCR2P]. For more information on prescaler configuration, see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2). The TCR2 Prescaler resets when the eTPU GTBE input is negated. After reset, it starts counting up to TCR2P when the eTPU GTBE input is asserted. When TCR2 increments (the eTPU GTBE input = 1), the prescaler starts a new count and the new TCR2P becomes effective. When TCR2 is written by microcode, the prescaler is reloaded with TCR2P and it becomes effective, if the eTPU GTBE input is asserted.

The counter that divides the eTPU clock by 8 before the prescaler also resets when the eTPU GTBE input is negated, or when TCR2 is written by microcode.

In Angle Mode the TCR2 prescaler is not used to directly increment TCR2, but can be used, selected by programming eTPU_TBR_TBCR_ENG*n*[ATGC]=1, as a clock source for the EAC generation of the angle ticks which increments TCR2 . In this case, the TCR2 prescaler input is eTPU clock/2, independently of TCR2CTL . See Generating the angle ticks for details .

67.3.8.2.2 TCR2 Gated mode

TCR2 Gated mode is selected in the eTPU_TBR_TBCR_ENG*n*[TCR2CTL] field. In this mode the TCRCLK signal enables or disables transfer of the eTPU clock divided by 8 to the TCR2 prescaler. By programming the prescaler, TCR2 can run at rates from eTPU clock divided by eight down to eTPU clock divided by 512, in steps of eight eTPU clock divisions. For more information, see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2).

67.3.8.2.3 TCR2 Signal Transition modes

These modes are selected when eTPU_TBR_TBCR_ENG*n*[TCR2CTL] is set to rise, fall or "rise-and-fall". In these modes the TCRCLK signal is the TCR2 clock source, and its maximum transition rate depends on the TCRCLK digital filter mode of operation. The TCRCLK digital filter can be programmed to use the eTPU clock divided by two, or use the same filter clock of the channels, controlled by eTPU_TBR_TBCR_ENG*n*[TCRCF]. It contains an up-down counter which operates as a digital integrator, optimizing signal latency in the selected mode and clock rate.

When eTPU clock divided by two is selected, the synchronizer and the digital filter are guaranteed to pass pulses that are wider than four eTPU clocks (two filter clocks). Otherwise the TCRCLK is filtered with the same filter clock as the channel input signals. For details on TCRCLK and channels digital filter control, see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1), eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2), and Enhanced digital filter (EDF).

67.3.8.2.4 STAC Bus Client mode

In this mode the TCR2 register is continuously updated from the bus, and the clock selection and prescaling logic becomes ineffective. It is not write accessible for the microcode, and when read, it reflects the bus imported value. The use of EAC is not allowed in client mode. This mode is configured througheTPU Engine 1 STAC Configuration Register (STAC_ENG1) and eTPU Engine 2 STAC Configuration Register (STAC_ENG2).

67.3.8.2.5 STAC Bus Server mode

When TCR2 bus is exported to the bus as a server, it can provide either time or angle bus to other peripherals, according to its operation mode. This mode is configured through eTPU Engine 1 STAC Configuration Register (STAC_ENG1) and eTPU Engine 2 STAC Configuration Register (STAC_ENG2). To provide sequential update of the clients, the Angle tick rate must not be faster than the programmed update rate. This requirement puts a limitation on the angle clock count rate on high rate mode. In this case the Angle and Angle Fraction accumulator (see Angle Tick Generator and Tick rate register (TRR)) are advanced at rate of eTPU clock divided by eight. Therefore, the update rate for the Angle Bus must not be slower than eight eTPU clocks.

67.3.8.2.6 TCR2 bus in Angle Clock mode

In this mode the TCR2 counter operates as part of the eTPU Angle Counter (EAC). The TCR2 bus value reflects this angle representation in which it counts Angle Ticks. Angle Mode is selected when eTPU_TBR_TBCR_ENG*n*[AM]=1.

Note that when TCR2 works in Angle Mode, it does not count directly from the TCR2 clock input which indicates tooth signal transition. Its Angle counter is controlled by the Count Control and High Rate logic (see Count Control and High Rate Logic), which provides the interpolated pin position, and handle cases of missing tooth, acceleration, de-acceleration and mechanical corrections.

The EAC uses the TCRCLK signal to get the tooth transition indications. The eTPU_TBR_TBCR_ENG*n*[TCR2CTL] field has to be set for the appropriate tooth edge detection rise, fall, "rise-and-fall" or none. TCR2 count clock comes from the EAC control and not directly from the physical tooth. This way the EAC control processes the signal transitions and handles missing teeth and flywheel mechanical corrections. Note that when TCR2CTL selects "none" for tooth edge selection, the TCR2 is not necessarily frozen, but can still be incremented by the EAC logic.

In Angle Mode, eTPU channel 0, 1 or 2 operation is combined with the EAC operation. When channel 0 is selected for EAC operation, the TCRCLK digital filter is used both by the EAC and by channel 0 to get full synchronization between the two logics.

The eTPU Angle Counter (EAC) logic runs continuously and updates the TCR2 Angle counter, eliminating the microcode latency in updating the TCR2 value.

67.3.8.3 STAC interface

Both time bases TCR1 and TCR2 can be shared between the Engines and with other blocks in the same MCU. Each one of both eTPU engines can drive their time bases to the (Shared Time and Count) bus, acting as a server, while any other block can capture the value into its resources and behave like a client. For further reference about the bus operation see eTPU Engine 1 STAC Configuration Register (STAC_ENG1) and eTPU Engine 2 STAC Configuration Register (STAC_ENG2).

The eTPU can export to the bus or import from the bus the following internal resources:

- TCR1: Can be exported to or imported from the bus. TCR1 can only be imported from bus when the engine is not in Angle Mode. When TCR1 is imported from the bus, it becomes read-only for the microcode and reflects the imported values. For details, see Timer Count Register 1 (TCR1).
- TCR2: Can be exported to or imported from the bus. TCR2 can only be imported from the bus when engine is not in Angle Mode. When TCR2 is imported from the bus, it becomes read-only for the microcode, and reflects the imported values. When exported to the bus, TCR2 can work in either Angle Mode or as a free running counter associated with the TCRCLK signal. For details, see EAC - eTPU Angle Counter.

Proper configuration of the following bits is necessary to determine what can drive the bus: eTPU_TBR_TBCR_ENG*n*[AM] and eTPU_TBR_STAC_ENG*n*[REN2, RSC2], according to the following table.

Table 405. bus and host read sources

AM (eTPU_TBR_TBCR_ENG*n*)	REN2, RSC2 (eTPU_TBR_STAC_ENG*n*)	TCR2 bus source (Host read of eTPU_TBR_TB2R_ENG*n*)	bus driver
00	0× (disabled)	TCR2/Time	×
01, 10 or 11	0× (disabled)	TCR2/Angle	×
00	11 (Server)	TCR2/Time	TCR2/Time
01, 10 or 11	11 (Server)	TCR2/Angle	TCR2/Angle
01, 10 or 11	10 (Client)	not allowed[1]	

1. client configuration in Angle Mode is also not allowed for TCR1.

Note that Angle Mode is not available for bus clients: configuring both at the same time brings unspecified results and must be avoided. When TCR2 is a standalone counter or a Bus server, the same value that is driven to the internal TCR2 bus is also exported to the bus (either Time Count or Angle).

bus configuration is provided by the eTPU_TBR_STAC_ENG*n* fields REN1/2 and RSC1/2. REN1/2 enable the interface to interact with the resource (either TCR1 or TCR2 bus). RSC1/2 configure the resource (either TCR1 or TCR2 bus) as Server or Client.

Each time base / angle count resource from each engine receives a unique 4-bit hardwired address that identifies it as a potential server. This address is used by the Controller to coordinate which resource will drive the bus at a given time-slot. For any time-slot there is a server driving the bus upon selection of the Controller, and there may be a client linked to that server by the eTPU_TBR_STAC_ENG*n* fields bits SRV1/2 on each Engine. When the server address on the Red Line bus matches the value in SRV1/2, the client will load the information into the appropriate resource. For information on eTPU Bus configuration, see eTPU Engine 1 STAC Configuration Register (STAC_ENG1) and eTPU Engine 2 STAC Configuration Register (STAC_ENG2).

The eTPU does not include a Controller module, which is instantiated once in the system integration.

NOTE

Setting a timebase as client of itself is not allowed.

67.3.8.4 Global time base enable (GTBE)

MCR[GTBE] enables time bases in both engines, allowing them to be started synchronously. GTBE is divided in two block interface signals: the eTPU GTBE output and the eTPU GTBE input. GTBE bit sets the eTPU GTBE output , and the eTPU GTBE input enables time bases to start. For more details, see the chip-specific eTPU information. If MCR[GTBE] must enable only the eTPU time bases, the eTPU GTBE output is simply connected to the eTPU GTBE input. These two cases are shown in the figure below. Synchronization logic can be as simple as an OR logic gate.

Once the eTPU GTBE input transitions to 1, the Engine 1 Time Bases start 1 eTPU clock earlier than Time Bases in Engine 2, except when TCRCLK is selected as clock source or TCR1 when eTPU_TBR_TBCR_ENG*n*[TCR1CS] = 1. This happens independently of prescaler values as long as they are the same for both engines, because the prescalers also freeze when the eTPU GTBE input = 0. Microcode can always write to TCR1/2 registers, with either value of the eTPU GTBE input.

NOTE

The timebase prescalers are reset when the GTBE input is negated.

67.3.8.5 TCRCLK digital filter

The TCRCLK signal has an improved integrating digital filter with a 2-bit up-down counter. The counter counts up to 3 when a high signal level is detected, or down to 0 when a low level is detected. The signal state is updated to one when the counter stops at 3, or zero when the counter stops at 0. The eTPU_TBR_TBCR_ENG*n*[TCRCF] field (see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2)) determines whether the TCRCLK signal input (after a synchronizer) is filtered with the same filter clock as the channel input signals (see Enhanced digital filter (EDF)) or uses the eTPU clock divided by 2, and also whether the TCRCLK digital filter works in integrator mode or the same two sample mode as the channel filters (see TBSA and TBSB - Time Base Selection Registers).

The TCRCLK filter delay and prescaling determine the minimum detectable TCRCLK pulse widths and, therefore, its maximum frequency, as shown in Filter clock prescaler and Filter clock prescaler. The TCRCLK signal delay from the module input to TCR1/TCR2 incrementing or detection in the EAC logic is explained in Input/output signal delays.

67.3.9 EAC - eTPU Angle Counter

67.3.9.1 General

The EAC logic contains a mechanism which follows the flywheel angle, based on the tooth rate. This hardware works in combination with the TCRCLK signal, the TCR2 counter and Channel 0, 1 or 2 (depending on the eTPU_TBR_TBCR_ENG*n*[AM] field) to generate angle information on the TCR2 bus which is passed to all the local engine channels. The EAC helps to implement a digital angle PLL (see Tick rate register (TRR)), which combines hardware with microcode processing at channel 0, 1 or 2. The angle measurement is based on history knowledge of the tooth period, for predicting the period of the next tooth. The tooth period is partitioned into a programmable number of **Angle Ticks**. The eTPU application will use the divider in the MAC/Divide unit to calculate an integer and a fraction part of the angle tick such that the full tooth period gets the correct programmed number of angle ticks with no accumulated error.

Each single tooth can be divided in angle ticks, up to 1024. In a 60 teeth flywheel, 128 Angle Ticks per tooth provide resolution of ~0.05 degrees per tick, which meets the accuracy requirement of 0.1 degrees in current automotive applications.

The measurement of one tooth in angle ticks is independent on engine RPM; it is the tooth period itself (and the corresponding tick period) that is re-calculated for each new tooth, based on the difference between the estimated tooth and the actual detection.

For these applications, one of the eTPU channels 0, 1 or 2 is dedicated to service the physical tooth detection. Channel 0 shares the same filtered input as the TCRCLK signal to get the same timing as the EAC. The TCRCLK edge detection is selected by the eTPU_TBR_TBCR_ENG*n*[TCR2CTL] field for the EAC, and by IPACA/B on channel 0, which must be set to detect the same edge(s). When channels 1 or 2 are selected to work with the EAC, IPACA/B is used to select the tooth signal edge detection for both the channel and the EAC, and the tooth signal that feeds the EAC is the same filtered input which feeds the channel.

Channel 0, 1 or 2 generates the signal transition service request, and can also be used for generation of a window filter on this transition, to qualify TCR2 clocks. For this purpose, the selected channel should be configured with double match window filtering mode (refer to Channel Modes). Depending on the channel mode set for the channel, Match A recognition opens the window, and Match B recognition may close it or leave it open. See Angle Logic and Channel Modes for details. Match B also generates a time-out service request. Its input signal transition comes from the tooth. The window can be defined by microcode to open at a predefined point inside the tooth period, and stay open for a desired percentage to the tooth period. The window can be measured in angle or time This method improves the noise immunity by allowing transition detection only on an expected period, a feature which was software responsibility in previous TPU versions.

The EAC supports deceleration, acceleration, last tooth and missing tooth scenarios. The large range of angle ticks per tooth can be used to cover longer tick counts caused by one or more missing teeth, or to provide extra resolution for future application requirements. In case of a missing tooth, the EAC can be configured to insert a dummy tooth or to simply measure a longer tooth.

Tick rate register (TRR) shows the block diagram of the Angle Counter system. TCR1 or TCR2 prescaler is used as a time base which measures the tooth period and is used for partitioning the period to angle ticks.

67.3.9.2 Angle Mode registers

In Angle Mode, the registers described below control eTPU angle operations. They are accessible only by microengine as source and destination registers in microinstructions. When eTPU is not in angle mode (eTPU_TBR_TBCR_ENG*n*[AM] field is negated), all Angle Mode registers can be used as general purpose registers.

67.3.9.2.1 TPR - Tooth Program Register

TPR provides configuration for the Angle Counter circuit. In this register, the microcode can properly adjust the tooth count (controlling last tooth, missing teeth, dummy tooth insertion, halt until tooth detection) and the number of angle ticks per tooth (field TICKS). Note that this register is sampled into a temporary register in the EAC logic when the High Rate Mode is detected (see High rate mode (acceleration) and TPR Buffering), which means that changes to this register may take effect only for the next tooth.

See Count Control and High Rate Logic and to Special Cases of Missing Teeth and Last Tooth until Handling False Tooth Detection for a detailed explanation about the use of this register. The figure below provides a detailed description of TPR register.

Several conflict issues on TPR writes are explained in Special TPR write cases.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	LAST	MISSCNT [1:0]		IPH	HOLD	MISS CNT [2]	TICKS									
RESET:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 467. TPR

Table 406.

LAST —Last Tooth Indication

Asserted by microcode and negated when a tooth is detected or inserted via IPH.

1 = Last Tooth - reset TCR2 Counter at the end of the tooth tick count (after physical tooth or IPH=1) when MISSCNT=0.

0 = Not Last Tooth.

If the tooth is detected or inserted before the tooth tick count completes (going High Rate mode, see High rate mode (acceleration)), LAST resets immediately, but TCR2 resets only when the tooth count completes and MISSCNT=0.

Table continues on the next page...

Table 406. (continued)

MISSCNT — Missing Tooth Counter

Decremented on each estimated tooth, stops at zero. Used for generation of up to 7 "Dummy Teeth" whenever it holds a non-zero value.

If the tooth is detected or inserted before the missing tooth tick count completes (going High Rate mode, see High rate mode (acceleration)), MISSCNT resets immediately, but missing teeth count continues in High Rate mode (see TPR Buffering).

IPH — Insert Physical Tooth

This bit generates a dummy physical tooth which has the same effect as a real physical tooth, and resets itself subsequently. If EAC is in Halt mode, it switches back to Normal mode[1]. If EAC is in Normal Mode, it switches to High Rate Mode. If Angle Logic is frozen by HOLD=1 (see below), it returns to the state it was at the freezing moment.

1 = Insert dummy physical tooth.

0 = No Operation.

NOTE

IPH reads as 1 in the next microinstruction after it is asserted, negating subsequently. However, it can be set twice in two consecutive microinstructions to generate two teeth and make the EAC go from Halt to Normal to High Rate Mode.

HOLD — Force EAC Hold

This bit forces the EAC to halt its operation in a special EAC freeze mode until a new physical tooth (a real one or emulated with IPH=1) is detected. Assertion of this bit immediately freezes the EAC in the middle of the tooth period. When a new physical tooth is detected, the bit is automatically negated by the EAC. The HOLD bit can be used for synchronizing the EAC tooth count, in case that a false physical tooth is detected due to noise.

1 = Force EAC to halt until detection of a physical tooth.

0 = Normal Operation.

TICKS — Angle Ticks Number in the Current Tooth

This field defines the number of angle ticks in the current physical tooth. It partitions the tooth period to the required number of angle ticks. The actual number of angle ticks in a tooth is (TICKS+1).

NOTE

In High Rate mode (see High rate mode (acceleration)), TPR writes are immediately effective only for bits IPH and HOLD. All other fields changes are "buffered" and become effective when EAC leaves High Rate mode. See also Special TPR write cases.

NOTE

Bits LAST, IPH and HOLD must not be asserted all at once

1. Missing a physical tooth naturally causes EAC to get into Halt mode.

67.3.9.2.2 TCR2 - Timer Counter 2

In Angle Mode, TCR2 (see the following figure) counts angle ticks instead of time.

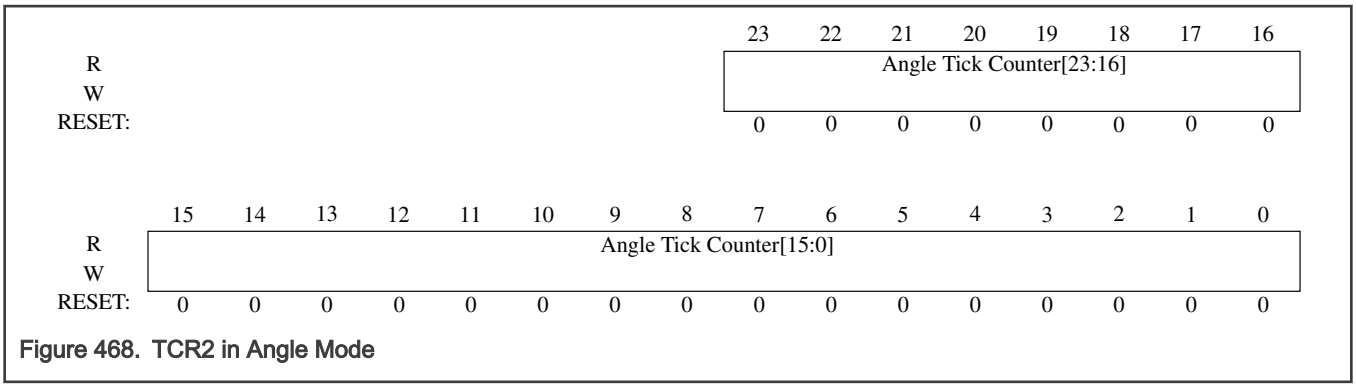


Figure 468. TCR2 in Angle Mode

This 24-bit free-running counter is used to generate an accumulated Angle Fraction value. It is updated by the Angle Tick Generator - refer to Angle Tick Generator for more details. Refer to Count Control and High Rate Logic for a detailed explanation about the use of this register in Angle Mode.

TCR2 provides continuous count of the angle in units of angle ticks. The Angle Tick Counter in TCR2 can be reset due to "Last Tooth" microcode indication. TCR2 Prescaling is disregarded in Angle Mode: physical tooth detection is done by EAC regardless of the value set in TCR2P.

67.3.9.2.3 Tick rate register (TRR)

The exact period of the Angle Tick is programmed in the Tick Rate Register (see the figure below) by microcode. The TRR time unit depends on eTPU_TBR_TBCR_ENG*n*[ATGC] (see):

- if ATGC=0, the TRR time unit is the period of TCR1 clocks taken as eTPU clocks divided by 2*(TCR1P + 1), even if TCR1CS=1 (see eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2)).
- if ATGC=1, the TRR time unit is given by the eTPU clock divided by 2*(TCR2P+1), using the TCR2 prescaler fed by eTPU clock/2 (independently of TCR1CS) .

See Calculating the angle tick period integer and fraction for a complete description about the mechanism to calculate the value to be written into this register.

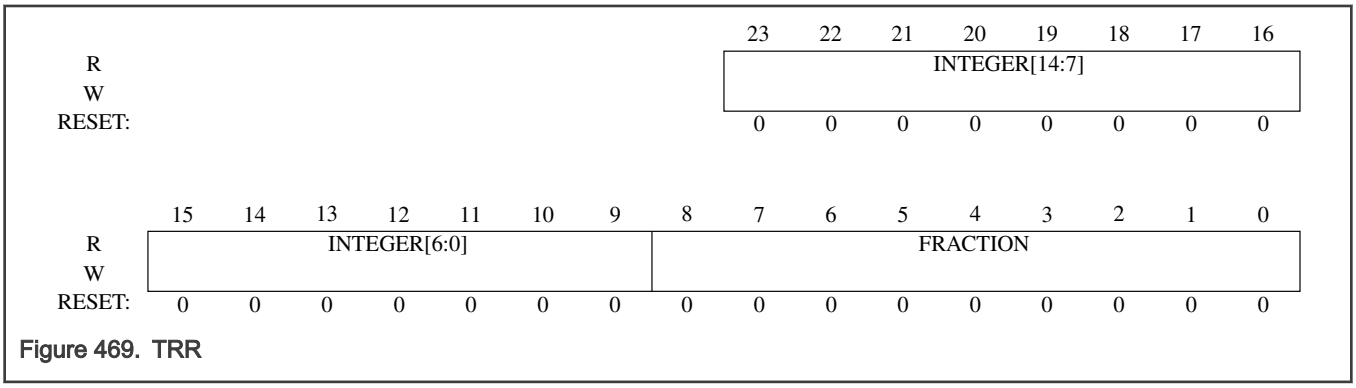


Figure 469. TRR

INTEGER — The integer part of TCR1/TCR2 clocks in one Angle Tick.

This number, decremented by one, works as a down counter preload value. A value of INTEGER=0 represents an integer of 32768. A new value written is reloaded into the counter (becoming effective) when a new tick starts or a tooth is detected or inserted via IPH.

FRACTION — Nine-bit fractional part of TCR1/TCR2 clocks in one angle tick.

Table continues on the next page...

Table continued from the previous page...

The FRACTION value is accumulated in the EAC Fraction Accumulator, and whenever the result overflows (that is, the accumulated fraction added up to an integer), the Tick Prescaler is halted for one TRR time unit.

67.3.9.3 Acceleration and Deceleration

Acceleration and deceleration affect the new tooth period relative to the known period of the last tooth. Changes in tooth period may be extreme at very low engine RPM (such as cold start and warm start). The worst case of tooth period changes is caused during missing teeth, since there is more time for changes in angular velocity to be unnoticed by the EAC hardware. For example, on cold start (~20 RPM) there may be extreme acceleration: the ratio between a known tooth period before two missing teeth and the new tooth period after the missing teeth can be very high (up to a factor of 75). Acceleration and deceleration effects from tooth to tooth are less extreme as the engine climbs to high RPM.

In case of deceleration, the estimated tooth period ends before the actual tooth detection arrives. In this case, the EAC hardware waits at the end of the current tooth period, when it is said to be in **Halt mode**, until the real tooth indication is received, then continues with normal operation (**Normal mode**). See Tick rate register (TRR).

In case of acceleration, the actual tooth period is shorter than the estimated tooth period. As a result, a new physical tooth indication arrives before the end of the estimated tooth period. In this case the EAC closes the gap on **High Rate mode** by counting on eTPU clock divided by eight to the end of the tooth, advances to the next tooth, and switches back to normal operation mode. See Tick rate register (TRR).

The reason that the EAC does not jump directly to the next tooth is the need to provide sequential angle count throughout the whole tooth period, for channels or external clients (if TCR2 is a server) which compare angle in "equal" mode. These peripherals must get all the valid angle values in a sequential manner, to avoid missing angle matches.

TCR2 advancing from one tooth to another is a continuous count, and can be optionally reset at the end of the tooth. An estimated tooth is generated after the Tooth Tick Counter reaches the TICKS programmed value.

The EAC works continuously and switches automatically between Normal, Halt and High Rate modes. It relies on the microcode to calculate the estimated tooth period on every tooth, and to update the correct angle tick and tooth parameters in the EAC control registers. On high RPM, tooth period changes are reduced from tooth to tooth, and the EAC may follow the angle with good accuracy for several teeth without microcode intervention.

The EAC handles missing teeth by insertion of "dummy" teeth, or by enlarging the expected tooth period. It is a good practice to locate the flywheel missing teeth in non-critical angles, since a missing tooth may increase the angle measurement error (acceleration and deceleration is detected late).

67.3.9.4 Angle Tick Generator

The Angle Tick Generator is responsible for generating a programmed number of angle ticks in the tooth period. It generates the ticks in an average rate which ensures completion of the correct number of angle counts in the estimated period of the tooth, since the count of one tooth in angle ticks is independent on engine RPM. The main output of the Angle Tick Generator is the tick clock that feeds TCR2 in Angle Mode, as well as the internal Tooth Tick Counter (see Tick rate register (TRR)). The Tooth Tick Counter counts ticks within a tooth, from 0 up to TICKS, is controlled by the Angle Tick Generator logic and cannot be accessed by microcode. Refer to Calculating the angle tick period integer and fraction for a generic presentation of the angle tick count and the measurement of a single tooth period.

67.3.9.4.1 Calculating the angle tick period integer and fraction

On each tooth the microcode has to update the exact period of a single angle tick used for counting the internal angle in the tooth. The period of an angle tick is determined by the EAC configuration, see Generating the angle ticks for details.

The microcode can use the eTPU MAC Divider unit (see MAC and Divide Unit (MDU)) to divide the tooth period by the number of angle ticks per tooth, which is stored in the TICKS field of TPR (refer to Angle Mode registers). This division yields the integer part of the angle tick period and the remainder. Dividing again the remainder shifted left nine positions, by the number of angle ticks per tooth translates the remainder to a 9-bit fraction. The microcode concatenates the 15-bit integer and the 9-bit fraction

to a 24-bit value and writes it to TRR. The new rate is effective immediately after the next Angle Tick is generated by the Angle Tick Generator[24].

For high RPM, note that shifting the tooth period value nine positions to the left prior to the first divide operation would calculate, in one operation, the integer and the fraction. For example: On 60 teeth flywheel running at 1000 RPM, tooth period is 1 msec. If TCR1/TCR2 counts @25 MHz, it counts 25,000 times in a tooth, which can be represented by 15 bits. Therefore the tooth period can be shifted nine positions to the left prior to divide operation, and be represented with 24 bits.

Using shift left nine positions and one divide operation would get the result in MACL register (in MDU) which holds the integer and nine bits of the fraction:

NOTE

In the pseudo code above, the tooth period (ToothPeriod) is not, in general, the value of estimated tooth time. It is obtained by microcode by subtracting TCR1 values between two teeth detections, converted to TCR2 periods if ATGC=1. Its comparison with the estimated tooth time indicates acceleration (if minor) or deceleration (if greater) to the microcode.

On low RPM the initial tooth period, measured in TCR1/TCR2 counts, may be too big to be shifted nine positions to the left. For lower RPM (for example 500 RPM) the tooth period cannot be represented by 15 bits, and shifting it nine positions to the left would lose the MSB. In this case, two divide operations are required as follows: first divide the Tooth Period by the number of TICKS - the integer is stored in MACL and remainder in MACH. MACL is saved in another register. MACH is shifted 9 positions to the left and divided again by TICKS. In parallel with the second divide, the register which saved the original MACL is shifted left 9 positions. After the divide MACL contains the 9 bits fraction and the other register contains the 15-bit integer, shifted left nine times. The logical OR of the two registers is written to the TRR:

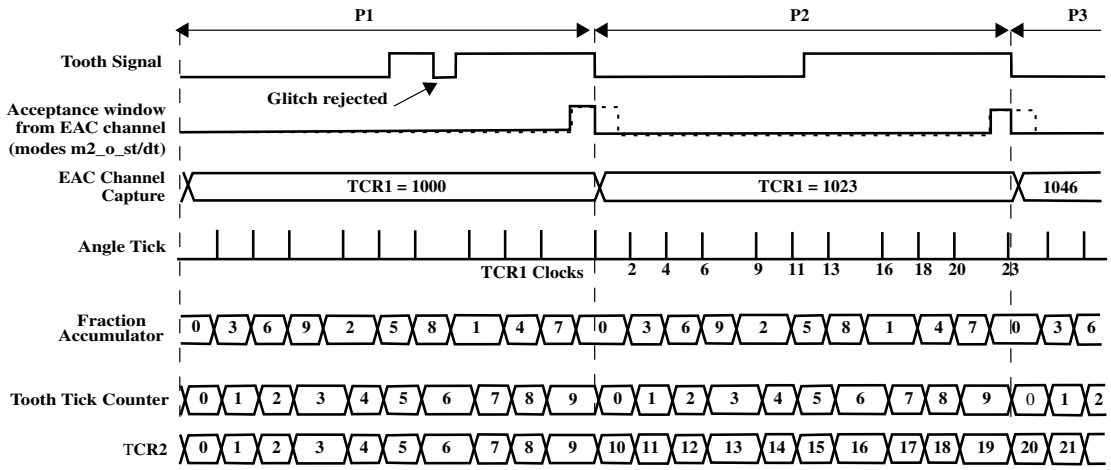


Figure 470. Angle ticks generation

67.3.9.4.2 Generating the angle ticks

The integer part of TRR is preloaded to a prescaler, which counts in time intervals as follows (see Tick rate register (TRR)):

- If eTPU_TBR_TBCR_ENG*n*[ATGC]=0, one unit of TCR1 clock period (if TCR1CS=0) or twice the TCR1 clock period (if TCR1CS=1)[25], that is, eTPU clock period*2*(TCR1P+1) (independently of TCR1CS).
- If ATGC=1, two units of the eTPU clock period multiplied by the TCR2 prescaler factor, that is, eTPU clock period*2*(TCR2P+1) .

[24] In High-rate mode, the tick keeps being updated at the rate of eTPU clock/8 until it goes back to Normal mode, when the new TRR value is used.

[25] The EAC logic overall runs at a rate of eTPU clock divided by 2, therefore the tick generator takes the halved TCR1 clock when TCR1CS=1 and ATGC=0.

When the down counter reaches zero, it generates an angle tick pulse to the Angle Counter Logic and a Load pulse to the Fraction Accumulator. It is then preloaded with most updated TRR integer part. Due to the Load pulse, the 9-bit fraction is accumulated in a 9-bit Fraction Accumulator. If a fraction overflow condition occurs (the 9-bit adder asserts carry out), the accumulator saves the lower 9 bits of the addition result, which is the remaining fractional part. The carry out bit indicates an accumulated integer "one" which means that the angle tick is early by one input clock. It halts the prescaler operation for one input clock to compensate the accumulated error generated by the integer prescaler. As a result, the average angle tick period takes into account both the integer and the fraction parts. The accuracy depends on the bit count of the fraction. Using 9-bit fraction part while the width of the field TICKS in register TPR is 10 bits provides accuracy of two LSB on a full scale (TICKS=1023) or one LSB on lower scale (TICKS<=511).

When the Tick Prescaler gets High Rate mode indication from the Angle Counter Logic, it generates angle ticks at a rate of eTPU clock divided by eight. In this case it does not generate Load pulses to the Fraction Accumulator, ignores its "hold" input and preloads internally to a fixed period of eight eTPU clocks. When High Rate mode is entered, the prescaler is preloaded to a period of eight eTPU clocks before its first angle tick generation, ensuring separation of at least eight eTPU clocks between the last Normal mode angle tick and the first High Rate mode angle tick. The fraction accumulator resets when the tick count advances to the next tooth, or when TRR is written by the microcode.

67.3.9.5 Count Control and High Rate Logic

The Count Control and High Rate Logic controls TCR2 operation in Angle Mode, using the angle ticks generated by the Angle Tick Generator. Count Control logic is responsible for advancing, holding and resetting the TCR2 and Tooth Tick Counter in the proper timing, such that the TCR2 time base will reflect the correct estimated angle. This logic also includes the Tooth Program Register (TPR, see Angle Mode registers for more information).

The Count Control and High Rate Logic handles deceleration, acceleration, missing teeth and last tooth. On High Rate (acceleration) it ensures that the angle bus scans all valid angle values in a rate which can be traced by the bus. This operation enables external clients (if TCR2 is a server) or channels working in "equal-only" comparator mode to match the TCR2 exported angle information in "equal" mode, in an exact match.

Because the eTPU channels are capable of capturing either TCR1 or TCR2 due to signal transition, the microcode can get either the angle or time of the physical pin transition. Since the EAC channel (0, 1 or 2) is connected to the physical tooth, the microcode can get the EAC error in angle domain (tooth appears at the wrong angle) or time domain (physical tooth captured time into the EAC channel, relative to the estimated tooth time). Note that in angle mode, the transition detect logic of the channel 0, if selected as the EAC channel, is fed from the digital filter of the TCRCLK signal, and not from the channel 0 internal digital filter. This ensures synchronous operation of channel 0 and the EAC hardware.

Another feature of the eTPU channel, when working in Single Match And Single Transition Enhanced Mode (refer to Single Match Enhanced Mode (sm_st_e)), is capturing a single time base due to signal transition before and after the digital filter. This option allows subtracting the digital filter delay to get accurate signal transition timing on the channel. This way, the TCRCLK signal may be programmed with a slow and reliable digital filter, and get accurate time measurement of the digital filter delay.

To assert the end of the estimated tooth period the Count Control and High Rate logic compares the TICKS field in TPR (refer to Angle Mode registers) with the current value of the tooth tick counter. When the Tooth Tick value is greater or equal to TICKS, it determines the end of the estimated tooth period. On acceleration this event occurs during High Rate mode operation, after the arrival of a physical tooth. In deceleration, this event occurs during Normal Mode, before the arrival of a physical tooth. On constant angular velocity, this event appears together with the arrival of a physical tooth.

The following sections describe the operation of the Counter Control and High Rate logic.

67.3.9.5.1 Normal mode

In Normal mode the Counter Control logic advances TCR2 and the Tooth Tick counter as if the engine has a constant speed during the tooth period. It receives the angle ticks from the Angle Tick Generator in an average rate which is determined by the Tooth Rate Register (TRR). This is the reset mode.

When the Tooth Tick Counter is about to reach the last value effectively stored in TPR field TICKS plus one, the hardware detects the end of the estimated tooth period. If the physical tooth and the estimated tooth arrive at the same time the EAC stays in Normal mode, the Tooth Tick Counter is reset, and TCR2 is incremented (depending on TPR bits LAST and MISSCNT). If the physical

tooth and the estimated tooth do not arrive at the same time, either acceleration or deceleration is detected, and the EAC switches to the proper mode. See the figure below for a detailed diagram of Normal Mode behavior.

The microcode which services the EAC channel physical tooth transition may update TRR according to various conditions to give the best estimation of the current tooth period, according to the previous tooth period and other engine parameters.

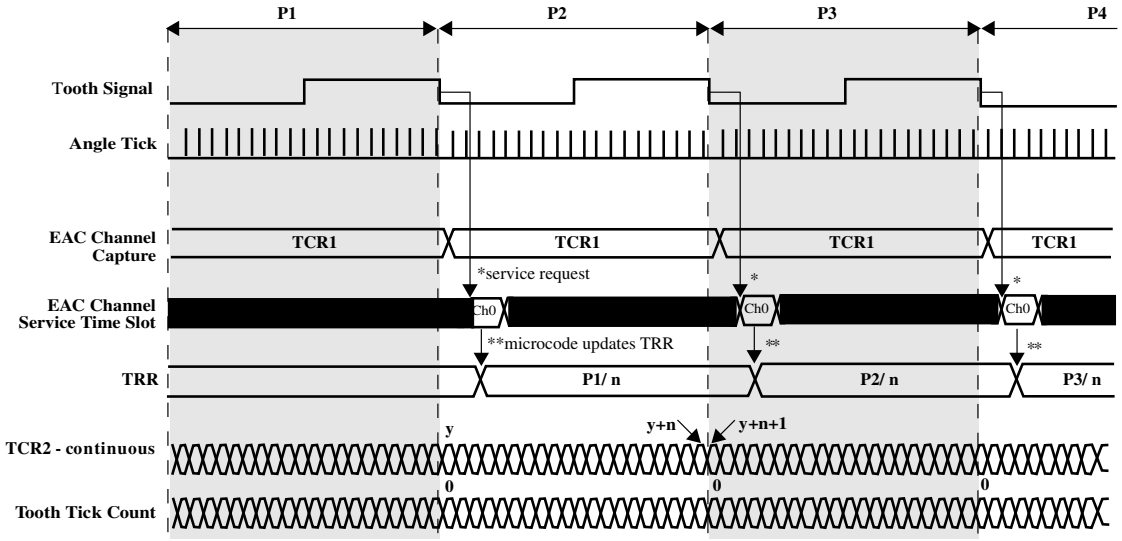


Figure 471. Normal mode

67.3.9.5.2 Halt mode (deceleration)

In case of deceleration, the Tooth Tick Counter reaches the TICKS value before the arrival of the next tooth. The Count Control logic does not reset neither advances TCR2 and Tooth Tick Counters. The Count Control logic halts TCR2 and Tooth Tick Counters at the end of the tooth, waiting for the physical tooth to arrive.

When the physical tooth is detected the EAC switches back to Normal Mode and releases TCR2 to count the angle ticks of the new tooth, also resetting the Tooth Tick Counter. Only then TCR2 may wrap to 0, if TPR bit LAST is asserted. See the figure below for a detailed diagram of Halt Mode behavior.

The microcode service caused by the physical tooth determines the deceleration, calculates the new tooth period and Angle Tick period and updates TRR. This operation slows the angle tick rate generated by the Angle Tick Generator on-the-fly, to the rate required for the new tooth period.

Since the microcode service is initiated by the physical tooth edge, microcode latency may introduce a small angle error caused by using the TRR value of the previous tooth at the beginning of the current tooth. On high RPM, deceleration is relatively small but the microcode latency may take a significant percentage of the tooth period. On low RPM microcode service latency takes little percentage of the tooth period, but there may be cases of extreme acceleration and deceleration. The microcode latency can be calculated knowing TCR1 value during the service time, and TCR1 value captured in the EAC channel due to the physical tooth pin transition. The duration of the Halt mode is obtained using the estimated tooth time.

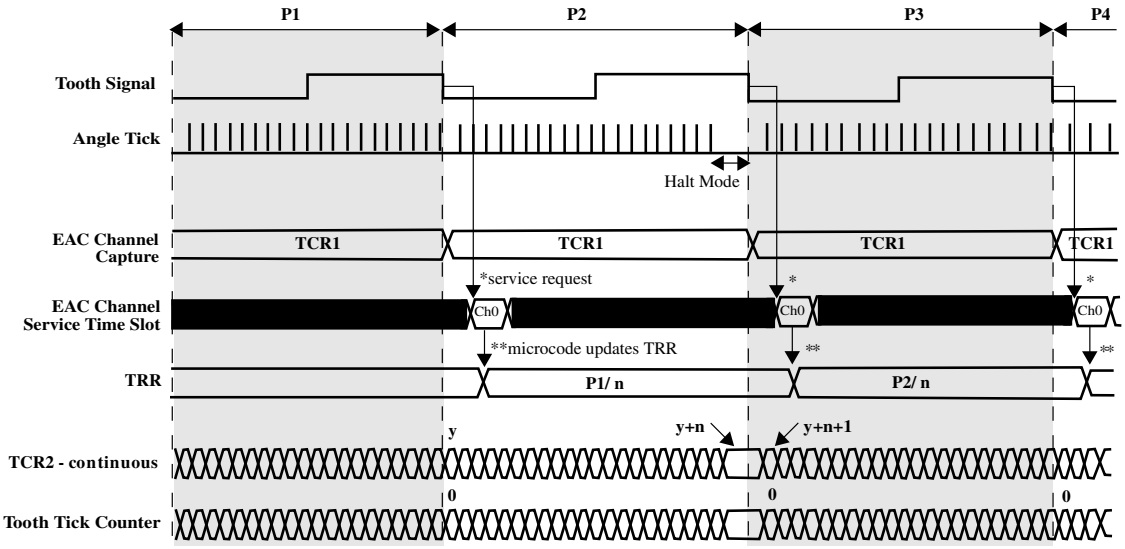


Figure 472. Halt mode (deceleration)

67.3.9.5.3 High rate mode (acceleration)

In case of acceleration, the next tooth arrives before the Tooth Tick Counter reaches the TICKS value. In this case the High Rate logic is responsible for closing the gap and advancing the tooth on the correct timing. The High Rate mode operates as follows:

- When the acceleration is detected (physical tooth arrives before the Tooth Tick Counter reaches the TICKS value), the Count Control and High Rate logic switches to High Rate mode in which both the Tooth Tick Counter and TCR2 count at rate of eTPU clock divided by eight, until the Tooth Tick Counter reaches the current TICKS value. To ensure correct operation, the TICKS value is sampled in the logic at the beginning of the mode.
- At this point, which represents the estimated tooth edge, the logic resets the Tooth Tick Counter and advances TCR2 (or resets it if LAST is asserted and MISSCNT = 0).
- The control logic switches back to Normal Mode, using the most updated TRR value as input to the Angle Tick Generator. The logic samples the updated TICKS value for the tooth estimation, last tooth indication and number of missing teeth from TPR.

In High Rate mode the angle ticks are provided at high speed until the end of the current tooth. This operation is required to scan all the valid angle values of the current tooth, in a rate which is not too high for the bus continuous update, but much higher than the rate dictated by TRR.

EAC channel microcode, which services the physical tooth transition detection, can start its service either before High Rate mode operation is complete (the Tooth Tick Counter has not reached the TICKS value) or after the EAC switched back to Normal mode. Any physical teeth received while the EAC is in High Rate Mode does not alter the immediate EAC state, but it is still detected by the EAC channel logic and can, therefore, alter future EAC behavior (for instance, closing the tooth detection window - see Angle Logic and Channel Modes).

At the beginning of High Rate mode operation, the TPR value is preloaded into a temporary register in the Counter Control Logic, used for scanning all the valid values to the end of the current tooth, with its appropriate LAST and MISSCNT attributes. While the EAC is in High Rate mode operation, the effect of microcode update of TPR fields LAST, MISSCNT and TICKS is delayed to the next estimated tooth, after the High Rate mode operation is complete (see Special TPR write cases). This is because the current physical tooth represents the next estimated tooth. If the microcode updates this field after High Rate mode operation is complete, the current physical tooth and estimated tooth are the same, and the effect is immediate. Either in High-Rate mode or not, the value read by microengine is the same written, even if not yet effective, until the EAC resets LAST and/or IPH, or decrements MISSCNT. Typically the microcode service may occur during the High Rate mode on extreme acceleration situation at low RPM. Therefore, the microcode operations are always related to the real physical tooth. From the above it can be seen that the microcode updates of the TICKS field in TPR affect the end time of the current physical tooth. For correct operation, this field should be updated before the Tooth Tick Counter has reached either the old or the new TICKS value.

During High Rate mode operation, TRR is ignored and the Angle Tick Generator uses eTPU clock divided by eight. Therefore, the TRR update by microcode will take effect only after the EAC switches back to Normal mode. If microcode service occurs after the Tooth Tick Counter has been reset, the EAC is already back in Normal mode, and some angle ticks may have been counted at the rate of the previous tooth. In this case the new TRR value will have immediate effect on the angle tick period, and the microcode should take into consideration the delay from the physical tooth to the estimated tooth in calculation of the next tooth period. See the figure below for a detailed diagram of High Rate Mode behavior.

An angle error may be introduced by the duration of the High Rate mode. Also, the scheduler latency may introduce a small accumulated error by using TRR value of the previous estimated tooth at the beginning of the current tooth. After the estimated tooth has advanced, the duration of the High Rate mode operation is the actual delay from the physical tooth edge to the estimated tooth edge. This delay can be obtained by comparing the estimated tooth time with the EAC channel capture register which captured TCR1 on the physical pin transition.

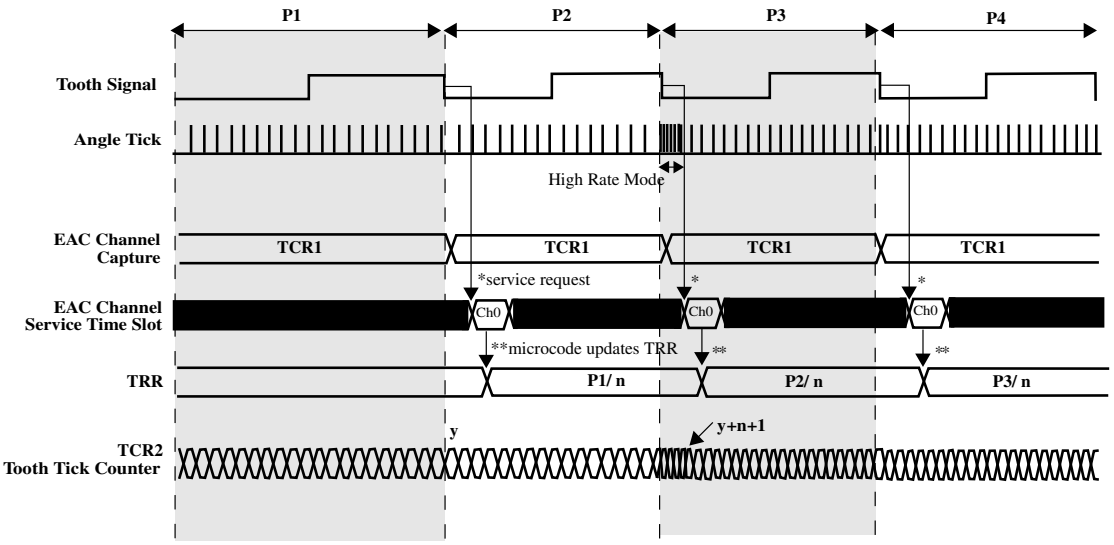


Figure 473. High rate mode (acceleration)

67.3.9.6 Special Cases of Missing Teeth and Last Tooth

The EAC handles cases of up to three missing teeth and the last tooth in the engine cycle. The following paragraphs describe these functions.

67.3.9.6.1 Handling the Last Tooth

The microcode can set the TCR2 counter to work in engine periods (wrap-around count) or continuous angle measurement.

For periodic operation, during the last engine cycle tooth the EAC microcode has to set the LAST flag in TPR. As a result, when the tooth period is ended, the Counter Control Logic generates a reset command to both the Tooth Tick Counter and TCR2 instead of an advance command. The operation resets the TCR2 based angle count, indicating a new period of the engine cycle. This implementation provides an engine cycle based periodic angle measurement.

67.3.9.6.2 Handling Missing Teeth

The EAC can handle up to three missing teeth in two ways:

- Count the angle ticks relative to the last physical tooth. The microcode should update the TPR TICKS field to the number of angle ticks included in two, three or four teeth, according to the flywheel type (one, two or three missing teeth). EAC hardware works in its regular manner.
- Insert a "dummy" tooth instead of the missing tooth, at the estimated point in time. After the "dummy" tooth, the Angle Tick Counter is incremented as if there was a physical tooth. A "dummy" tooth can be inserted only during Normal or High Rate operation modes. The microcode inserts "dummy" teeth by writing to the MISSCNT field in TPR.

In the first option the missing tooth is not counted on the angle measurement. For example, a flywheel with 59 physical teeth and one missing tooth can be considered as 58 identical teeth numbered (0-57) and tooth number 58 has a double number of angle TICKS. In this case a 720 degrees engine cycle has 118 teeth. TCR2 reflects the real angle, since it counts angle ticks continuously.

In the second option, the missing teeth are counted as "regular" teeth by automatic insertion of "dummy" teeth. The microcode has to write a non-zero value to the MISSCNT field in TPR. This field is a 3-bit down counter which affects the operation of the Counter Control logic.

For example, a flywheel with 59 physical teeth (0-58) and one missing tooth (59) can be considered as 60 teeth numbered (0-59), all having the same number of angle ticks. The microcode has to write "001" to the MISSCNT bits during the period of tooth number 58 to indicate that next tooth (59) is missing.

When the Tooth Tick Counter reaches the TICKS value, TCR2 is incremented as if a physical tooth has been detected. In addition, the MISSCNT value initializes a "dummy tooth counter" which is decremented to indicate the number of left "dummy teeth" which still need to be generated. Because a dummy tooth was counted, EAC does not enter Halt Mode and Tooth Tick Counter continues incrementing in the absence of a physical tooth detection.

In case of extreme acceleration on very low RPM (cold start) there can be a situation that the first physical tooth after one or two missing teeth appears even before the "dummy" tooth is generated. Due to the acceleration the EAC switches to High Rate mode in order to run through all the valid angle values, including the dummy teeth. When the Tooth Tick Counter reaches the TICKS value on High Rate mode, and the "dummy tooth" down counter is not zero, the generated "dummy tooth" advances to the next tooth and decrements the "dummy tooth" counter, but does not switch the EAC back to Normal mode. The last "dummy tooth" decrements the counter to zero, indicating that no more dummy teeth are to be inserted, and the next tooth is an estimated physical tooth. The EAC continues at High Rate mode until the Tooth Tick Counter reaches the TICKS value again, then advances to the next tooth while switching back to Normal mode. When in High Rate mode, the TPR register does not reflect the MISSCNT downcounting, see TPR Buffering for details.

MISSCNT can be rewritten before it reaches 0, allowing it to count more than 7 missing teeth, as long as no physical tooth arrives between the first MISSCNT write and the rewrite.

67.3.9.6.3 Combining missing teeth and last tooth

The Last Tooth indication takes effect when there are no more missing teeth to be generated, that is, the "dummy tooth" counter value is zero. If, for example, the microcode sets the missing teeth counter to "10" (two missing teeth) and sets the LAST flag, the first and the second dummy teeth will increment TCR2, and the third estimated tooth, which correlates with the physical tooth (the first of the next cycle), will reset TCR2, because LAST was set. This scheme enables the microcode to define one or more missing teeth to be replaced by "dummy tooth" insertion, and the end of the engine cycle in one service request. It is assumed that the two missing teeth must come together in the same engine cycle, and not split between two engine cycles (either the missing teeth are both last in an engine cycle or both not last, but not last in one engine cycle and first in the next).

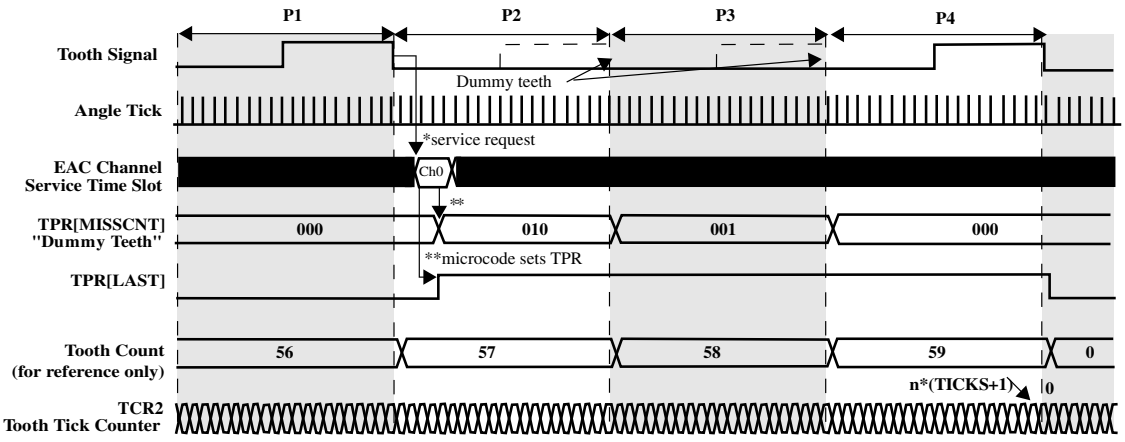


Figure 474. Combining missing teeth and last tooth

67.3.9.7 Handling Mechanical Tooth Correction

The EAC can handle tooth edge detection errors caused by flywheel mechanical errors. The eTPU application can hold a vector of tooth mechanical errors with one entry per tooth. This error can be measured in angle ticks which are independent of engine RPM. The TRR can be updated to the fixed period of any tooth, including its mechanical error.

Because TCR2 counts continuously, without being reset, the mechanical correction is transparent. Though the tooth has its own programmed TICKS value, TCR2 simply counts angle ticks, disregarding the boundary between two adjacent teeth.

67.3.9.8 Handling Mis-detected Tooth

When a physical tooth signal is missed by the engine sensor, the EAC may get into Halt mode at the end of the estimated tooth period, expecting the physical arrival. In this case, a Match timeout event of EAC channel will call service which detects extreme deceleration. The microcode can assert the IPH bit in TPR, to force the detection of the missed physical tooth. It can also calculate the accumulated angle bus error, and fix the next estimated tooth period, to close the gap.

67.3.9.9 Handling False Tooth Detection

Most of the false tooth detection, caused by noises on the engine tooth sensor, can be eliminated by the window blanking filtering, timed by EAC channel match recognitions. The EAC also provides means of fixing false detection of an additional tooth which passed the window filter. When such an event occurs, the EAC switched to High Rate mode (advancing to the next tooth) and when the next physical tooth arrives, an extreme acceleration is detected: the EAC sees the remaining portion of the current tooth period as another tooth period. The microcode can detect the situation when the acceleration in not realistic, or when immediately after the detection of this extreme acceleration, the following tooth indicates extreme deceleration back to the original RPM.

When the microcode detects such a case, the Tooth Counter has been advanced by mistake to the next tooth. The microcode can set the HOLD bit in the TPR, forcing the EAC to freeze and wait for the next physical tooth to close the gap. When the next physical tooth arrives, HOLD is automatically negated and the EAC proceeds from that point to the remaining portion of the tooth period, in the same mode it was when HOLD bit was asserted.

67.3.9.10 Angle Logic and Channel Modes

The TCRCLK transition detection is qualified by a signal that comes from channel 0 (see Tick rate register (TRR)) and depends on the particular mode (PDCM) programmed for that channel. This configures a window for TCRCLK detection for the angle logic which is the same (except on High Rate mode, see High rate mode (acceleration)) used to set the TDLA flag on single transition modes, and TDLB on double transition modes (see signals TSE1,TSE2 in Channel Mode Logic and Event Flags). The same applies when channels 1 or 2 are used to control EAC (see signals TS1, TS2 in Channel Mode Logic and Event Flags). As a consequence, the window depends on the channel mode as follows:

- on all modes, the window closes upon a tooth edge detection: TDLA asserted on single transition modes, TDLB asserted on double transition modes.
- on mode m2_st: the window opens on Match A (which enables Transition A) and does not close with Match B. If Match B comes before Match A, it blocks Match A and, hence, Transition A.
- on mode m2_o_st: the window opens on Match A (which enables Transition A) and closes on Match B. Match B is enabled by Match A, so it cannot come before.
- on all other Single Transition modes, the window is "always open", independently of matches.
- on mode m2_dt: the window opens on Transition A, which is enabled by Match A. The window does not close with Match B, but if it comes before Match A the later gets blocked and, hence, blocks Transitions. Match A is also a condition for the window, so the microcode closes it by clearing MRLA.
- on mode m2_o_dt: the window opens on Transition A, which is enabled by Match A. The window closes on Match B, which is enabled by Match A. Match A is also a condition for the window, so the microcode closes it by clearing MRLA.
- on all other Double Transition modes, the window opens on Transition A.

67.3.9.11 Restarting angle logic

It is not recommended to change the eTPU_TBR_TBCR_ENG*n*[AM] field while GTBE=1. However, if the angle logic must be restarted without interfering with the timebase count running on TCR1, the procedure below must be followed:

1. Program eTPU_TBR_TBCR_ENG*n*[AM]=00 and TCR2CTL=111 at once. That prevents TCR2 from incrementing while the angle logic is disabled. The angle logic state machine resets to Normal mode and the tick prescaler to the initial count with AM=00, but not the microengine registers TPR and TRR.
2. Start a thread to reconfigure the EAC. The thread must set the EAC controlling channel (0, 1 or 2) flags in a state, depending on the channel mode, that lets the channel tooth detection window open (see Angle Logic and Channel Modes). It can optionally write TCR2 with an angle preset value equivalent to the first tooth expected after restart. The thread must also set TPR bit HOLD=1. The TPR bit IPH must be 0.
3. After the thread is finished, program eTPU_TBR_TBCR_ENG*n*[AM]=01, 10 or 11, and TCR2CTL according to the desired tooth edge selection if AM=01.

The first tooth detected after this procedure restarts the TCR2 counting, unfreezing the Angle Mode logic into normal mode.

67.3.9.12 Special TPR write cases

This section describes how simultaneous modification of TPR fields are resolved, and how the effect of TPR writes depend on the EAC mode.

67.3.9.12.1 TPR Buffering

In High Rate mode (see High rate mode (acceleration)), TPR writes are immediately effective only for bits IPH and HOLD. Writes to all other fields are "buffered" and become effective when EAC leaves High Rate mode. However, if TPR is written a second time immediately after IPH is asserted in Normal mode, the second write behaves as if EAC is still in Normal mode. Wait at least two microcycles before writing to TPR a second time (after execution of two nop instructions, for example), so the TPR write is buffered, acknowledging High Rate mode. If the write happens in the next microcycle after IPH assertion, the next write to TPR register may fail.

MISSCNT and LAST can be written with any value during High Rate mode, and the value that prevails for the next tooth is the one sampled when EAC goes back to Normal mode (or the value written in Normal or Halt mode thereafter). If MISSCNT and/or LAST are not zero when High Rate mode begins, they are sampled into the internal EAC logic and are effective while High Rate lasts (missing teeth count continues, and TCR2 is reset at the end of High Rate if LAST = 1). However, their values in TPR are reset when High Rate mode starts. After that and until the end of High Rate mode, the value read by microcode is the same written. This behavior prevents read-modify-writes to TPR from unwillingly rewriting LAST or MISSCNT.

NOTE

When the Angle mode is configured (AM = 1) and global time base is disabled (GTBE = 0) on EAC transition to high-rate mode, the writes into TPR registers (fields LAST, MISCNT, or TICKS) while GTBE = 0 are not set and, after GTBE is enabled again (GTBE = 1), buffered values are not updated, so information is lost.

67.3.9.12.2 IPH and LAST

If both IPH and LAST are asserted in the same microinstruction with HOLD=0, the EAC acts as if LAST was set first and then IPH right after, so that:

- in Normal mode, it goes to High Rate with LAST=1;
- in Halt mode, it goes to Normal Mode resetting LAST (and TCR2);
- in High Rate mode, IPH is ignored and LAST becomes effective in the next tooth (physical or inserted) after it goes back to Normal mode.

67.3.9.12.3 IPH and TICKS

Because of different results depending on the EAC mode at the time of TPR write, it is not advisable to write 1 to IPH and change TICKS at the same microinstruction. A consistent behavior is obtained if IPH is written first and TICKS on the second

microinstruction after (for instance with a nop between them), making the new TICKS value valid for the next tooth regardless of the mode.

The mode-dependent behavior is (assuming HOLD=0):

- in Normal mode, the new TICKS value becomes valid before EAC goes High Rate due to the IPH;
- in Halt mode, the EAC goes to Normal mode, and new TICKS is valid for the next tooth;
- in High Rate mode, the new TICKS value is effective when EAC leaves High Rate mode, and IPH is ignored;

67.3.9.12.4 IPH and MISSCNT

If both IPH and MISSCNT are written non-zero values with HOLD=0:

- in Normal mode, at the next microcycle the EAC goes to High Rate mode, the MISSCNT field in TPR goes to 0, and the missing teeth are counted in High Rate mode.
- in Halt mode, the EAC goes to Normal mode for one microcycle and then, yet another microcycle later, goes to High Rate mode, counting the missing teeth. The TPR fields IPH and MISSCNT are zeroed on the transition from Normal to High Rate mode.
- in High Rate mode, IPH is ignored (resetting at the next microcycle) and MISSCNT is buffered (see TPR Buffering).

67.3.9.12.5 IPH and HOLD

If IPH and HOLD are asserted at once, IPH cancels the HOLD and both reset. The EAC is not frozen, regardless of the EAC mode (High Rate, Normal or Halt).

67.3.9.12.6 LAST and HOLD

If LAST and HOLD are written 1 at once, LAST asserts and EAC is frozen. Afterwards, when a physical tooth is detected or IPH is asserted, the EAC is unfrozen in the same state it was before, and LAST is kept asserted.

67.3.10 Microengine

Each eTPU engine has a microengine that fetches, decodes and executes microinstructions. The Microengine only works when there are service requests to be attended, otherwise it turns to idle state, controlled by Hardware Scheduler (see Scheduler).

Microcode is stored in Shared Code Memory (SCM) that is 32-bit wide. Microengine can access SDM using a different bus from the one used to accesses code memory, so that code and data can be accessed at the same time (Harvard Architecture).

Some of eTPU functionality can only be made through the microengine, like configuring channels and interrupting host. Microengine gives eTPU a high degree of flexibility, since any desired treatment for channel's events can be implemented; however, that flexibility comes at the cost of channel service's latency. Latency is worsened when channels from a same eTPU engine contend for microengine service. In the figure below, a block diagram of microengine architecture is shown.

Follows a summary of Microengine features:

- P, DIOB, A, B, C, D, SR, RAR, LINK, CHAN, MACL, MACH, ERTA, ERTB, TCR1, TCR2, TPR, TRR registers are accessible by microcode.
- 24-bit ALU and Post-ALU shifter performs basic arithmetic and logical operations described in ALU and Post-ALU Shifter.
- MDU (MAC/Divide Unit) performs integer MAC, multiply and divide operations.
- Fixed Microinstruction Size of 32bits.
- Fixed-length instruction execution (2 eTPU clocks)
- Static superscalar operation

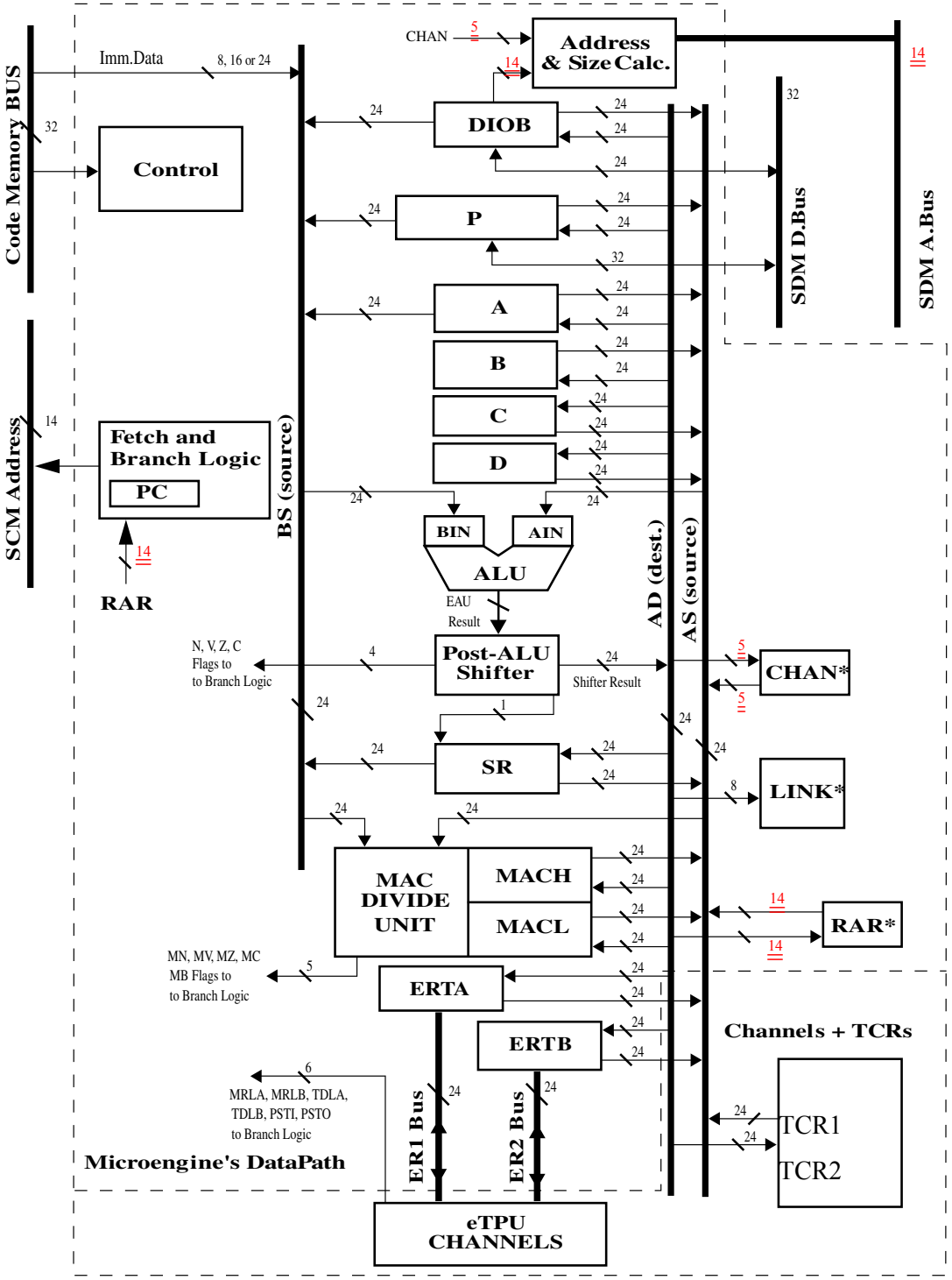


Figure 475. Microengine block diagram

67.3.10.1 Registers

eTPU microengine accesses a total of 18 registers. Fourteen of them are special purpose (registers A, B, C and D are for general use). Special purpose registers except CHAN and LINK can also be used as general use if the operation that use their contents are not performed. Register description is intended to just introduce their functionalities and not to provide detailed explanation of it since it will be described in Microinstruction Set. Registers less than 24 bits in size are right-justified.

None of the registers have guaranteed reset values. However, some are initialized just before the thread starts (see Time Slot Transition).

67.3.10.1.1 P Register

P register is the only one that is 32-bit wide. It can be used as source and destination for arithmetic/logical operation, and as source and destination for SDM read/write operations.

For P source/destination possibilities in ALU/MDU microoperations, see Selecting sources and destination.

When P is used as SDM read/write operations source or destination there are only 3 possibilities of access: all 32 bits, lower 24 bits and upper 8 bits. SDM operations are explained in detail in SDM Microoperations.

P is automatically loaded with one parameter before the thread starts (parameter preload). For more information see Entry Point format and Time Slot Transition.

Upper 8 bits of P register can be used as application state, since these bits can be tested as branch conditions. P[31:24] is also used in dispatch microoperation (see Dispatch Microoperation), and bit pairs P[29:28], P[27:26], P[25:24] can be directly copied into Channel flags 1 and 0 using field FLC. Together with Entry Table Condition Encoding, it provides fast state resolution without code execution.

67.3.10.1.2 DIOB Register

DIOB is an abbreviation for Data Input/Output Buffer. DIOB is 24-bit wide and can be used as source and destination for arithmetic/logical operations as well as SDM data source and destination. DIOB only can be accessed as 24 bits, both in arithmetic/logical and SDM read/write operations. When using DIOB to perform an SDM access, only lower 24 bits of SDM will be accessible (SDM upper 8 bits always remains unchanged).

DIOB can also be used as SDM addressing register, when DIOB contents is used as absolute SDM address (-bit wide). In this case DIOB can also be pre-decremented or post-incremented (see Indirect Addressing Mode).

DIOB is automatically loaded with one parameter before the thread starts (parameter preload). For more information see Entry Point format and Time Slot Transition.

67.3.10.1.3 ERTA and ERTB Registers

ERTA/B registers are 24-bit wide and can be used as source or destination in arithmetic/logical operations. ERTA/B are the only source for channel's match registers write (see Write Channel Match and UDCM Registers). ERTA can also be the source for UDCM write.

When a thread starts to be executed, ERTA and ERTB are loaded with a copy of CaptureA and CaptureB registers respectively. ERTA/B can be used to receive a copy of MatchA and MatchB registers. ERTA/B are the only destination of MatchA/B read operation (see Special T4ABS Source Operation: Read Match Registers).

ERTA and ERTB also receive a copy of CaptureA and CaptureB registers when CHAN register is written (see CHAN Register). For more information about Capture and Match registers see MatchA and MatchB Registers and CaptureA and CaptureB Registers.

67.3.10.1.4 SR register - Shift Register

SR is a 24-bit wide register that can be used as source and destination register for arithmetic/logical operations. SR can shift right its contents by 1 bit at time and, at the same time, receive in its bit 23 the lost bit of a shift-right operation in post-ALU shifter (ALU and Post-ALU Shifter), allowing SR to be used to perform 48-bit shift right (see Shift Operations).

67.3.10.1.5 MACH and MACL Registers

Both MACH and MACL are 24-bit registers, part of MAC/Divide unit (see MAC and Divide Unit (MDU)). They can be used as source and destination in most arithmetic/logic operations. When multiply or divide operations are used (multiply-accumulate included), MACH and MACL have special purpose and some restrictions apply, see MAC and Divide Unit (MDU) for more information.

67.3.10.1.6 LINK Register

Link Register is an 8-bit wide register and can be used only as destination in arithmetic operations. LINK is a write-only command register, which precludes its use as a source register for ALU operations. When LINK register is written, it issues a service request for the channel number and eTPU engine equal to the number written in LINK register (see Functions and threads and Channel link for information about Link Service Request).

67.3.10.1.7 RAR Register

RAR is a -bit register and can be used as source and destination in arithmetic operations. RAR also receives the contents of PC register when a subroutine call is executed. The contents of RAR register is loaded into PC when a return from subroutine is executed. RAR is loaded with value 0x3FFF during TST. For more information about subroutine call and return see Branch Operations and Return from subroutine respectively.

67.3.10.1.8 CHAN Register

CHAN is a -bit register that can be used as source and destination in arithmetic operations. The contents of CHAN register affects the execution of many channel-related microinstructions, because its number indicates the **selected channel**. CHAN register must not be used to store temporary values in arithmetic operations. For more details, refer to Channel Selection Register - CHAN.

67.3.10.1.9 Counter Registers: TCR1, TCR2, TPR and TRR

All these registers are 24-bit wide except TPR, which is a 16-bit register. They can be read or written in arithmetic/logical operations, and have special-purpose uses for time base and angle mode operations. For more information about those registers see Time bases and EAC - eTPU Angle Counter.

67.3.10.1.10 General Purpose Registers: A, B, C and D

A, B, C and D are 24-bit general purpose registers, which can be used to store intermediate values and do not have other specific uses with any eTPU feature.

67.3.10.2 ALU and Post-ALU Shifter

The ALU executes 24-bit arithmetic and logical operations. ALU's output goes directly to a 1-bit shifter, called post-ALU shifter, so it is possible, for example, to add and shift using only one microinstruction.

In some microinstruction formats, it is not possible to specify the operation executed by ALU. In these cases ALU will always perform addition.

In formats which have the field ALUOP for ALU operation selection, all of them can be performed, including add/subtract using C (carry) flag as ALU's carry-in, bitwise AND/OR/NOT/XOR, and shift/rotate of 2, 4, 8 and 16 bits. See ALU/MDU Operation Selection.

Subtraction, inversion, increment and decrement can be performed by combinations of source inversion and setting ALU's carry-in to 1.

ALU always performs 24-bit operations on its inputs, called **A-source** and **B-source**, and outputs a 24-bit result. 8-, and 16-bit inputs are zero padded to 24 bits. Likewise, ALU 24-bit output is always truncated to the destination register size.

67.3.10.2.1 ALU flags

Four flags - Carry, Negative, Overflow, Zero - described below, are related to ALU and post-ALU shift operations. Operation size and shifting affect flags generation logic. Operation size determines the result boundary to be used for flags generation. Operation size is determined by size of sources and destination (see Flags Sampling Control). For more information about flag generation, see Flags Sampling Control. ALU flags can be used as branch condition (see Conditional/unconditional branch) or conditional ALU/MDU operation (see Conditional ALU/MDU Operation Execution).

Field CCS/CCSV in microinstructions can force **no update** of all flags. Not all flags are updated in all ALU operations: Overflow is updated only on addition and absolute value operations, Carry flag is updated in most ALU operations, and only Zero and Negative are updated in all ALU operations.

ALU flags are never updated when microinstruction starts an MDU operation, regardless of CCS/CCSV, but are updated normally afterwards, on ALU operations that are executed in parallel with an ongoing MDU operation (MDU has its own flags).

NOTE

Operation size can be smaller than destination register. For example: 0xFFFF + 0x0001 (both 16-bit sources) stores 0x10000 in a 24-bit register and sets Zero and Carry flags because operation size is 16 bits.

67.3.10.2.1.1 Carry flag (C)

In an unsigned addition without shifting, Carry flag is the ALU carry from bit 7 to 8, 15 to 16, or 23 to 24 on 8-, 16- and 24-bit operation sizes respectively. In an unsigned subtraction without shifting, Carry Flag represent the sign of ALU's result considering operation size (Carry Flag equal to 1 means a negative result).

Carry flag definition is operation-dependent. The Carry flag in add/subtraction with Post-ALU shift is defined in ALU ADD operation with and without shifting. Find the definitions for other operations in the following sections.

67.3.10.2.1.2 Negative flag (N)

Negative flag indicates the sign of result based on the operation size, regardless of the operation performed, as shown in the following table.

Table 407. Negative (N) flag behavior

Operation size	Value
8 bits	N = result[7]
16 bits	N = result[15]
24 bits	N = result[23]

NOTE

The N flag may not reflect the sign of the value actually written into the destination register, if it does not have the same size of the operation (see Flags Sampling Control). This is always the case for registers RAR (14 bits) and CHAN (5 bits).

67.3.10.2.1.3 Overflow (V)

Overflow is updated only on addition (with or without carry) and absolute value operations. In signed operations, overflow flag indicates that the result of arithmetic operation (add or subtraction) can not be represented by a word of the size of the operation. Overflow flag behavior for addition is defined in the following table. Overflow flag for Absolute operation is explained in Absolute Value operation. V Flag is calculated using ALU adder output (i.e., it is not affected by 1-bit shift/rotate operations).

Table 408. Overflow flag on addition - V

Op. size	Value[1]
8 bits	(AS[7] & BS[7] & !alu_adder_output[7]) | (!AS[7] & !BS[7] & alu_adder_output[7])
16 bits	(AS[15] & BS[15] & !alu_adder_output[15]) | (!AS[15] & !BS[15] & alu_adder_output[15])
24 bits	(AS[23] & BS[23] & !alu_adder_output[23]) | (!AS[23] & !BS[23] & alu_adder_output[23])

1. BS is taken after any inversion by the BINV field, but not added to the carry bit (CIN field)

NOTE

For V-flag definition on the absolute operation, see “Absolute Value Operation".

67.3.10.2.1.4 Zero flag (Z)

Zero flag equal to 1 indicates that the result from the ALU, limited to the operation size, is zero, regardless of the operation performed, whether the result is written, or where it is written. It depends on the operation size, as shown in the following table.

Table 409. Zero flag - Z

Operation size	Value
8 bits	Z = (result[7:0] == 0x00)
16 bits	Z = (result[15:0] == 0x0000)
24 bits	Z = (result[23:0] == 0x000000)

67.3.10.2.2 ALU ADD operation with and without shifting

ADD operation is selected by ALUOP or ALUOPI fields and when none of them is available in a microinstruction format[26]. Optionally, result can be shifted or rotated right by 1 bit, which is selected by SHF, ALUOP or ALUOPI fields. See Microinstruction Set for more details. The following table describes how CIN and BINV fields change ADD operation behavior.

Table 410. Types of ADD operations

BINV	CIN	Operation (adder output)
1	1	AS + BS
1	0	AS + BS + 1
0	0	AS - BS
0	1	AS - BS - 1

ALU adder output can be 1-bit shifted or 1-bit rotated right as follows:

Shift right:

```
if BINV==1
  result [23:0] = adder_output[24:1]
else
  result [23:0] = adder_output [24:1] xor 0x800000
endif
```

Shift left:

```
result[23:1] = adder_output[22:0]
result[0]    = 0
```

[26] ALU operations only occur on formats where a destination field is found (T2ABD/T2D).

Rotate right:

```
case(opsize/CCSV)
8-bit:
  result[6:0]   = adder_output[7:1]
  result[7]     = adder_output[0]
  result[23:8]  = adder_output[23:8]
16-bit:
  result[14:0]  = adder_output[15:1]
  result[15]    = adder_output[0]
  result[23:16] = adder_output[23:16]
24-bit:
  result[22:0]  = adder_output[23:1]
  result[23]    = adder_output[0]
```

NOTE

Only for the Post-ALU rotate right, the operation size is determined by the field CCSV (see Flags Sampling Control). For example: if CCSV=00, T4ABS=P (24-bits), T4BBS=A (24 bits), T2ABD=B (24 bits), and ALUOP="Add ROR", then B gets A+P with bits 7:0 rotated, even though the operation size is 24 bits.

The following table describes Carry flag behavior.

Table 411. Carry flag update on ADD operation

BINV[1]	Op. size	shift/rotate	Value
1	8 bits	none	adder carry from bit 7 to bit 8
1	16 bits	none	adder carry from bit 15 to bit 16
1	24 bits	none	alu_adder_output[24]
0	8 bits	none	!adder carry from bit 7 to bit 8
0	16 bits	none	!adder carry from bit 15 to bit 16
0	24 bits	none	!alu_adder_output[24]
0 or 1	8 bits	shift left	alu_adder_output[7]
0 or 1	16 bits	shift left	alu_adder_output[15]
0 or 1	24 bits	shift left	alu_adder_output[23]
0 or 1	x	shift right	alu_adder_output[0]
1	8 bits	rotate right	adder carry from bit 7 to bit 8
1	16 bits	rotate right	adder carry from bit 15 to bit 16
1	24 bits	rotate right	alu_adder_output[24]
0	8 bits	rotate right	!adder carry from bit 7 to bit 8

Table continues on the next page...

Table 411. Carry flag update on ADD operation (continued)

BINV[1]	Op. size	shift/rotate	Value
0	16 bits	rotate right	!adder carry from bit 15 to bit 16
0	24 bits	rotate right	!alu_adder_output[24]
			except on max-constant generation (see Max Const Generation With T4BBS=111)

1. BINV has no effect on carry-out when used to code max constant (see Max Const Generation With T4BBS=111).

Flags N and Z on shift are updated according to the result after shift. Flag V with shift is updated according to the ADD operation only, the same way as without shift.

67.3.10.2.3 ADC Operation

ADC operation is selected by the ALUOP field. CIN field is ignored when this operation is selected. The following table describes how BINV change ADC operation behavior.

Table 412. Types of ADC operations

BINV	CIN	Operation
1	x	AS + BS + C flag
0	x	AS - BS - C flag

Flags behave exactly the same way as for ADD operation without shift/rotate.

67.3.10.2.4 Bitwise Operations

Bitwise AND, OR and XOR are selected by ALUOP field. On these operations CIN field is ignored and BINV field inverts (bitwise NOT) BS. C and V Flags are never updated on these operations. The following table describes AND, OR and XOR bitwise operations.

Table 413. Types of Bitwise Operations

ALUOP	BINV	Operation
10000	1	AS | BS
10000	0	AS | (~BS)
10001	1	AS ^ BS
10001	0	AS ^ (~BS)
10010	1	AS & BS
10010	0	AS & (~BS)

67.3.10.2.5 Set Bit / Clear Bit Operations

These operations set or clear the AS bit determined by BS[4:0]. If the bit number resolves to a value greater than 23, no bit is set or cleared (i.e., result is equal to AS). On these operations CIN field is ignored and BINV field inverts (bitwise NOT) BS. C and V flags are never updated for set/clear bit operations. These operations **override** B-Source size to 8 bits.

set bit (BINV = 1):

```
result = AS | (1 << BS)
```

clear bit (BINV = 1):

```
result = AS & ~(1 << BS)
```

set bit (BINV = 0):

```
result = AS | (1 << (31 - BS))
```

clear bit (BINV = 0):

```
result = AS & ~(1 << (31 - BS))
```

67.3.10.2.6 Exchange Bit

Exchange the AS bit determined by BS with C flag. If the bit number resolves to a value greater than 23, no exchange is performed (i.e., result is equal to AS and C flag is not updated). This operation **overrides** BS size to 8 bits. On this operation, CIN field is ignored and BINV field inverts (bitwise NOT) BS. V flag is never updated on exchange bit operation. C flag is always updated, regardless of CCSV, unless BS > 23.

Exchange Bit (BINV=1):

```
if BS <= 23
begin
  temp_C_flag = AS[BS]
  if C_flag == 1
    result = AS | (1 << BS)
  else
    result = AS & ~(1 << BS)
  C_flag = temp_C_flag
end
```

Exchange Bit (BINV = 0):

```
if (31 - BS) <= 23
begin
  temp_C_flag = AS[31 - BS]
  if C_flag == 1
    result = AS | (1 << (31 - BS))
  else
    result = AS & ~(1 << (31 - BS))
  C_flag = temp_C_flag
end
```

67.3.10.2.7 Multibit shift/rotate operations

These operations shift or rotate AS by 2, 4, 8 or 16 bits. Size of shift/rotate is determined by BS[1:0]. The following table describes the number of shifted/rotated bits depending on BS[1:0] value.

Table 414. Number of shifted/rotated bits for each BS[1:0] value

BS[1:0]	Bits shifted/rotated
0	2
1	4
2	8
3	16

Shift right is a logical operation (i.e., zeros are inserted on left). Multibit shift and rotate operations **overrides** BS size to 8 bits. The shifts and rotate operate on 24 bits, independently of the operation size.

V flag is never updated for multibit shift or rotate operations. Carry flag behavior is described in the following table. CIN is ignored in these operations, but BINV is effective.

Table 415. Carry flag value on multibit shift/rotate operations

ALUOP	BS[1:0]	C flag value[1]
11001 (shift left)	0	AS[22]
11001 (shift left)	1	AS[20]
11001 (shift left)	2	AS[16]
11001 (shift left)	3	AS[8]
11010 (shift right)	0	AS[1]
11010 (shift right)	1	AS[3]
11010 (shift right)	2	AS[7]
11010 (shift right)	3	AS[15]
11011 (rotate right)	0	AS[2]
11011 (rotate right)	1	AS[4]
11011 (rotate right)	2	AS[8]
11011 (rotate right)	3	AS[16]

1. CCS/CCSV can disable flag update on multibit shift/rotate, but the specified flag size in CCSV is ignored for the C flag.

67.3.10.2.8 Absolute Value operation

Absolute Value operation is selected by ALUOP field. On this operation, AS is interpreted as a signed number and its absolute value is the result. V and N flags are updated with the result signal determined by the operation size. AS bit 23 after size override and sign extension (if any, see A-Source Size Override), regardless of A-source register size, is used to check the operand signal and is copied to C-flag. Note that if AS is 8-bit or 16-bit, its sign is taken into account and copied to C only if sign-extension is performed. The following table summarizes flag updating for Absolute Value operation.

This operation is independent of B-source. Instruction fields T4BBS, BINV and CINV are ignored in this operation. The Absolute Value operation size is the minor between A-source size and Destination size.

Table 416. ALU flags in Absolute Value operation

operation size	V, N[1]	C	Z
8	alu_output[[7]	AS[23]	alu_output[7:0] == 0
16	alu_output[15]		alu_output[15:0] == 0
23	alu_output[23]		alu_output[23:0] == 0

1. V, N can be 1 on 8- and 16-bit Absolute Value, because the operand sign is always taken from bit 23. V, N can also be 1 in 23-bit Absolute Value (or 8-bit and 16-bit with sign extension), if the operand is 0×800000 (0×80, 0×8000).

67.3.10.3 MAC and Divide Unit (MDU)

MDU is an autonomous resource in the microengine which can carry out sequential multiply, multiply-accumulate, fractional multiplication and divide operations, selected through the microinstruction fields ALUOP or ALUOPI. The unit supports signed and unsigned multiply and fractional multiplication of any combination of 8, 16 or 24 bit operands[27], and also signed and unsigned 24-bit multiply-accumulate. Divide operation is unsigned, and both operands are always 24-bit wide.

Depending on the size of operands and the type of operation, MDU can take more than one microcycle to execute the operation, but microengine continues to execute microinstructions in parallel. When the microcode issues an END command, any MDU executing operation terminate immediately and is left incomplete. When selecting an operation that uses MDU, the result is always placed in MACH and MACL registers, and the register selected as destination does not have its value changed (Selecting sources and destination). During calculations, MACH and MACL holds temporary values and should not be written, otherwise the result is unspecified. One must not start an MDU operation while MDU is already busy: the result is unspecified for both the ongoing operation and the started one.

MDU Operations update its own set of 5 flags, described in MDU Flags. MDU operations never update C, N, V and Z flags. CIN and BINV microinstruction fields affect MDU operations according to the following table.

Table 417. CIN and BINV with MDU Operations

B-source operand	BINV	CIN	Op. Performed
signed	1	1	AS mdu_op BS
	0	0	AS mdu_op (-BS)
	1	0	reserved
	0	1	reserved
unsigned[1]	1	1	AS mdu_op BS
	1	0	AS mdu_op (BS+1)
	0	x	reserved

1. includes the B-source (unsigned) in fmults (signed) operations.

[27] There is no distinct selection of 24-bit fractional multiplication, for it works exactly as a 24-bit ordinary multiplication.

67.3.10.3.1 Multiply and Multiply-Accumulate Operation Length

MDU needs 2 sources, A source and B source, to perform an operation. The time needed to perform a multiply or multiply-accumulate is:

- on 24-bit x 8 bit multiplies: 2 microcycles (one start-MDU plus one execution microcycle)
- on 24-bit x 16 bit multiplies: 3 microcycles (one start-MDU plus two execution microcycles)
- on 24 bit x 24 bit multiplies/macs: 4 microcycles (one start-MDU plus three execution microcycles)

An internal pipeline in MDU allows multiply-accumulate (or even non-fractional multiply) operations to start one microinstruction before a multiplication or multiply-accumulate (signed or unsigned) has been completed (e.g., one can start one multiply or multiply-accumulate once every three microinstructions). However, by doing that it is not possible to read the result in MACH and MACL (although the MDU flags can be tested), so this is intended to be used in a multiply-accumulate sequence. It is also allowed to mix different sizes in multiply/mac sequences.

Multiply-accumulate operations are similar to multiply operations, except that the contents of MACH and MACL registers are added to the multiplication result.

When multiply or multiply accumulate operations finish, MACL and MACH hold the least and the most significant 24-bit words, respectively.

67.3.10.3.2 Divide Operation Length

The divide operation is always unsigned. The division completes in 13 microcycles, meaning that after the start divide microinstruction, one has to wait for 12 microcycles and then read the result and the remainder in MACH and MACL registers. During the 12 execution microcycles, microengine can execute microinstructions unrelated to the MDU.

67.3.10.3.3 Signed Multiplication (mults)

MDU signed multiplication is defined as follows:

```
(signed) MACH,MACL = (signed) AS * (signed) BS
```

MC and MV flags are reset. MZ is set if result is 0, resets otherwise. MN is set if result is negative.

67.3.10.3.4 Unsigned Multiplication (multu)

MDU unsigned multiplication is defined as follows:

```
(unsigned) MACH|MACL = (unsigned) AS * (unsigned) BS
```

MC and MV flags are reset. MZ is set if result is 0, resets otherwise. MN is a copy of the most significant bit of result.

67.3.10.3.5 Signed Multiply-Accumulate (macs)

MDU signed multiply-accumulate is defined as follows:

```
(signed/unsigned) {MACH,MACL} += (signed) AS * (signed) BS
```

MC is not altered.

MV is set if result can not be represented by a 48-bit signed number. MACS never resets MV flag: it is left as is if no overflow occurs, or set it otherwise. This allows checking the overflow flag only once at the end of a series of multiply-accumulate operations in a scalar product calculation.

```
if (({MACH,MACL} += AS * BS < -2^47) || ({MACH,MACL} += AS * BS > 2^47 - 1))
  MV = 1
```

MZ is set if result is 0, resets otherwise. MN is a copy of the most significant bit of result.

Note that only 24-bit multiply-accumulate is available.

67.3.10.3.6 Unsigned Multiply-Accumulate (macu)

MDU Unsigned Multiply-Accumulate is defined as follows:

```
(signed/unsigned) {MACH,MACL} += (unsigned) AS * (unsigned) BS
```

MC is set if result can not be represented by a 48-bit unsigned non-negative number. MACU never resets MC flag: MC flag is left as is if no carry occurs, or set otherwise. This allows checking the carry flag only once at the end of a series of multiply-accumulate operations in a scalar product calculation.

```
if (({MACH,MACL} += AS * BS < 0) || ({MACH,MACL} += AS * BS > 2^48 - 1))
  MC = 1
```

MV is not altered.

MZ is set if result is 0, resets otherwise. MN is a copy of the most significant bit of result.

Note that only 24-bit multiply-accumulate is available.

67.3.10.3.7 Signed Fractional Multiplication (fmults)

MDU Signed Fractional Multiplication takes the B-Source as an **unsigned** 8- or 16-bit[28] fraction between 0 and $(2^8 - 1)/2^8$ (inclusive) for the 8-bit operation, or between 0 and $(2^{16}-1)/2^{16}$ (inclusive) for the 16-bit operation. Only A-Source is taken as a signed number. The value of B-Source is considered the unsigned numerator of a fraction with denominator 2^8 or 2^{16} for the 8- and 16-bit operations, respectively.

The integer part of the result is stored in MACH, and the fractional part in MACL. The result is signed, so that the concatenation of MACH and MACL form a 48-bit fixed point number with a 24-bit integer part, both for 8- and 16-bit operations. To calculate the unsigned numerator of the fractional part (with denominator 2^{24}) of the result, one must take the absolute value of MACL considering the signal of the result (not MACL alone), i.e.: if flag MN=1, invert MACL and add 1.

MDU flags are updated in the same way as in the Signed Multiplication.

67.3.10.3.8 Unsigned Fractional Multiplication (fmultu)

MDU Unsigned Fractional Multiplication takes both A-Source and B-Source as unsigned operands. B-Source is taken as an 8- or 16-bit[29] fraction between 0 and $(2^8 - 1)/2^8$ (inclusive) for the 8-bit operation, or between 0 and $(2^{16}-1)/2^{16}$ (inclusive) for the 16-bit operation. The value of B-Source is considered the numerator of a fraction with denominator 2^8 or 2^{16} for the 8- and 16-bit operations, respectively.

The integer part of the result is stored in MACH, and the fractional part in MACL. The fractional part in MACL is the numerator of a fraction with denominator 2^{24}. The concatenation of MACH and MACL form a 48-bit fixed point number with a 24-bit integer part, both for 8- and 16-bit operations.

MDU flags are updated in the same way as in the Unsigned Multiplication.

[28] 24-bit fractional signed/unsigned multiplication is equivalent to mults/multu.
[29] 24-bit fractional signed/unsigned multiplication is equivalent to mults/multu.

67.3.10.3.9 Unsigned Divide (div)

At the end of a divide operation MACL holds the result of the division, taking A-source as numerator and B-source as denominator, while MACH holds the remainder. If a divide by 0 is executed, MACL holds the maximum unsigned number (0xFFFFFF) as result and flag MV is set to indicate division by 0 (otherwise reset). The contents of MACH become undetermined.

MC flag is always reset.

MZ flag is set if MACL equals 0, and reset otherwise.

MN receives a copy of MACH bit 23 (msb from the remainder).

Note that signed division is not available.

67.3.10.3.10 MDU Flags

MDU has its own flags to indicate the result and status of an MDU operation. They are: MC, MZ, MV, MN and MB. All MDU flags are updated with the final result at the end of the operation, and do not change until the next operation finishes. Therefore it is possible to start a new MDU operation and test the flags of the previous one in parallel, except for mult/mac with 8-bit operand (takes only 1 microcycle).

67.3.10.3.10.1 MDU Negative Flag - MN

MN flag is always a copy of MACH bit 23 at the end of the operation, either in signed or unsigned ones. Note that MACH holds the rest of a division operation, which is always unsigned.

67.3.10.3.10.2 MDU Carry Flag - MC

MDU carry flag indicates if the result cannot be represented by a 48-bit number, in Signed and Unsigned Multiply Accumulates. It is reset in the other operations.

67.3.10.3.10.3 MDU Zero Flag - MZ

In multiply and multiply-accumulate operations, MDU zero flag is asserted if MACH and MACL are equal to zero at the end of an operation. In divide operations, zero flag is asserted if MACL (result) is equal to 0.

67.3.10.3.10.4 MDU Overflow Flag - MV

In multiply operations, MV flag is negated and keeps negated in the end, because the result of a multiplication can always fit in a 48-bit result (MACH and MACL concatenated). In a multiply-accumulate operation, MV is asserted if the result size is wider than 48 bits. MV flag work in both signed and unsigned operations.

In divide operations it is only asserted if a divide-by-zero operation was executed.

67.3.10.3.10.5 MDU Busy Flag (MB)

MB tests as true at the next microinstruction after the MDU start operation, and as false at the last microcycle of any MDU operation execution.

67.3.10.4 Branch conditions

Microengine allows conditional branch. There are five sets of flags that can be tested in a conditional branch: ALU flags, MDU flags, P flags, Channel flags, and Semaphore flag (flag SMLCK).

When a thread starts to be executed, the values in MDU and ALU flags are not initialized. ALU flags are described in ALU flags, MDU flags are described in MDU Flags. MDU and ALU flags are updated during execution of microinstructions.

P flags are actually the upper byte of P register, which optionally can work as user-defined flags (see P Register).

Channel flags Flags0, Flag1, MRLA, MRLB, TDLA, TDLB, PSS, PRSS and PSTO are obtained from the selected channel (value in CHAN register), while channel flags, LSR, FM[0] and FM[1] are selected by the serviced channel, regardless of the CHAN value[30].

Flags TDLA/B, MRLA/B, LSR, FM and PSS, are sampled at the beginning of a thread. Flag PSS does not change during its execution while CHAN register is not written. When a write in CHAN register is performed, all flags except LSR and FM are updated according to the channel specified by CHAN value. Flags MRLA/B and TDLA/B are reset when their respective latches in channel are cleared by microcode.

Table 418. Channel flags as branch condition

Flag	Description	Service or selected channel
Flag0	State Resolution flag	reflects the selected channel (CHAN)
Flag1	State Resolution flag	reflects the selected channel (CHAN)
MRLA	Match A Recognition Latch	These flags reflect the selected channel (CHAN) (see MRLA/B - Match Recognition Latches and TDLA/B - Transition Detect Latches for more information).
MRLB	Match B Recognition Latch	
TDLA	Transition A Detection Latch	
TDLB	Transition B Detection Latch	
LSR	Link Service Request	reflects the serviced channel.
PRSS	Input Pin state sampled at service request	reflects the selected channel (CHAN). Does not change if CHAN is not changed.
PSS	Sampled Input Pin State	reflects the selected channel (CHAN). Does not change if CHAN is not changed (see Pin Control Registers).
PSTI	Current Input Pin State.	reflects the selected channel (CHAN). Changes any time.
PSTO	Current Output Pin State	reflects the selected channel (CHAN). Changes any time.
FM	Function Mode Bits	reflects the Function Mode for serviced channel (see C*a*SCR_ENG1 and C*a*SCR_ENG2)

Semaphore condition SMLCK always indicates if a semaphore is locked for the Engine, resolving as false before any lock attempt. For each trial, the SMLCK flag is updated. The SMLCK value set in one thread is not meaningful to the other. After a free, the SMLCK condition tests as false until a new lock attempt on the same thread.

Branch conditions are selected through instruction fields BCC and BCF (see Conditional/unconditional branch).

67.3.11 Microinstruction Set

Each microinstruction can execute up to 3 microoperations in parallel. Microinstructions are grouped into formats, and there are four types of microoperations:

- ALU/MDU Operations
- SDM Operations
- Channel Configuration/Control Operations
- Flow Control Operations

[30] Serviced channel does not change during execution of a thread, and it is the channel that requested a service (initial value of CHAN register when a thread starts).

Each microinstruction format is defined by a set of microinstruction fields, which determine the operations, each belonging to one of the groups above (there may be several in one group). Complete microinstruction formats are shown in Microinstruction formats.

Parallelism conflicts may arise when two operations are executed in the same microinstruction. These situations are explained in Microinstruction Parallelism Issues.

67.3.11.1 SDM Microoperations

The access to SDM is made by providing an address and a register to perform a data transfer, except semaphore operations, which are also classified in the SDM group. Only P and DIOB registers can exchange data with SDM. Microengine always addresses SDM in 32-bit boundaries, for 8, 24, or 32 bit wide data.

Direction is determined by the field RW in all addressing modes: RW=0 selects read and RW=1 selects write.

67.3.11.1.1 SDM Addressing Modes

There are 4 addressing modes in eTPU:

- Absolute
- Selected Channel Relative
- Indirect
- Engine Relative

The addressing modes Absolute and Selected Channel Relative use immediate bits to form the physical address of SDM, which is identified in microinstruction as a field called AID. AID field can be 3-, -, or -bit wide depending on the addressing mode.

67.3.11.1.1.1 Absolute Addressing Mode

In Absolute addressing mode, the address range is parameters, addressed by field AID, which in this mode is -bit wide. These parameters are located in SDM addresses from 0 to .

```
physical_address = AID[:0]
```

67.3.11.1.1.2 Selected Channel Relative Addressing Mode

In Selected Channel Relative addressing mode, only the first 8 (with 3-bit AID) or (with 7-bit AID) parameters of the selected channel are accessible, depending on the microinstruction format. Physical address is calculated using the channel parameter base address that is specified in the CPBA field of C*a*CR_ENG1 and C*a*CR_ENG2. AID field is added to channel parameter base address to compose the physical address. The address equation is:

```
physical_address = selected_channel_parameter_base_address + AID[ :0], or
physical_address = selected_channel_parameter_base_address + AID[2:0]
```

67.3.11.1.1.3 Indirect Addressing Mode

In Indirect Addressing mode the physical address is taken from DIOB register. Only DIOB bits 14 to 2 are relevant. Since the SDM word address is shifted two bits up in DIOB, its contents hold the same parameter address value used by Host. The address equation for SDM access is:

```
physical_address = DIOB[13:2], or
physical_address = (truncated to 12 bits) (DIOB / 4)
```

Indirect addressing mode is used to access the Shared Subsystem Area when eTPU_CCCR_C*x*CR_ENG*n*[SSMAE]=1 and DIOB addresses the 16 Kbytes just above the SDM range (DIOB bit 14 = 1) . See Shared subsystems support for more details . If SSMAE=0, accesses with DIOB bit 14 = 1 hit the same SDM addresses as with bit 14 = 0, providing full backwards compatibility with respect to DIOB contents .

Indirect addressing mode can have post-increment or pre-decrement on DIOB, allowing stack operations. See DIOB stack operation for more information.

67.3.11.1.1.4 Engine Relative Addressing Mode

In Engine Relative Addressing mode the physical address is the concatenation of the eTPU_SCR_ECR_ENG*n*[ERBA] field (see eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2)) with the 7-bit AID instruction field. This allows the same function microcode, when running on distinct engines, to access different address spaces, global to the engine only.

The SDM physical word address in Engine Relative Addressing mode is calculated as follows:

```
physical address = (eTPU_SCR_ECR_ENGn[ERBA]<< 7) + AID[6:0]
```

67.3.11.1.2 SDM source/destination registers

When performing an SDM operation, only DIOB or P can be used as data source or destination. P is 32-bit wide, and DIOB is 24-bit wide. Microinstruction field P/D (1 bit) is used to choose between P and DIOB as data the source or destination. When the P/D field is not available in microinstructions that support SDM access, the source/destination is P.

Table 419. SDM source/destination Register Selection

P/D	Meaning
0	P access
1	DIOB access

67.3.11.1.3 SDM Operation Size

When using DIOB register to perform SDM data transfers, the operation size is always 24-bit wide (lower 24 bits of SDM). When using P register, the operation size can be 8-, 24- or 32-bit wide, which is controlled by microcode RSIZ field (2 bits). RSIZ meaning is shown in the following table.

Table 420. SDM P access Size

RSIZ	P access	DIOB access
00	full 32-bit access (i.e. P[31:0]=SDM[addr] [31:0])	RESERVED
01	only upper 8 bits are transferred (i.e. P[31:24] = SDM[addr] [31:24])	RESERVED
10	only lower 24 bits are transferred (i.e. P[23:0] = SDM[addr] [23:0])	DIOB = SDM[addr] [23:0
11	RESERVED	RESERVED

RSIZ is not available in all microinstructions that support SDM access. In microinstructions where RSIZ field is not available, SDM access will be 24 bits by default.

When performing a Zero SDM write operation (see Zero SDM Operation), RSIZ defines the size of operation regardless of the P/D field (SDM source/destination registers).

67.3.11.1.4 SDM access direction

RW field defines the direction of the access in the SDM. The access direction is summarized in the following table.

Table 421. SDM access direction

R/W	Meaning
0	read SDM parameter into P or DIOB registers
1	write SDM parameter from P or DIOB registers

67.3.11.1.5 Zero SDM Operation

Zero SDM operation is controlled by microcode field ZRO (1bit). When ZRO field is 0, the data portion written in SDM or in P/DIOB (SDM read) registers will always be 0x0. When performing a Zero SDM write operation, the RSIZ is relevant regardless of the P/D field (usually RSIZ is meaningful only for P/D = 0), which means that zero SDM write operation can be performed with 32, 24 or 8 bits according to SDM operation size. These conditions are summarized in the following table.

Table 422. Zero SDM Operation

ZRO	RW	P/D	Meaning
0	0	0	Clear P register. Size is determined by RSIZ field. See SDM Operation Size
0	0	1	Clear DIOB (all 24 bits), independently of RSIZ
0	1	x	Clear SDM parameter. Size is determined by RSIZ field. See SDM Operation Size
1	RW	P/D	Regular SDM operation

NOTE

When field STC is present, STC=11 also disables Zero SDM operation (see DIOB stack operation). The conflicts with DIOB operations (see DIOB stack operation) and ALU operations are resolved like a normal SDM operation (see ALU and SDM Operations).

Zero SDM read operations do check memory errors on the read data, however discarded . Zero SDM write operations normally update the ECC of the written data .

67.3.11.1.6 DIOB stack operation

SDM Indirect Addressing Mode (see Indirect Addressing Mode) is used if STC field (2 bits) exists in the microinstruction, controlling automatic increment/decrement of DIOB register, as shown in the following table, thus allowing stack operations. DIOB is incremented and decremented in word addresses, only from bits 15 down to 2, i.e.: the bits 23 to 16 and 1 to 0 are left untouched by STC pre-decrement and post-increment.

Table 423. DIOB Post-Increment / Pre-Decrement - STC

STC	Meaning
00	Post-Increment of DIOB
01	Pre-Decrement of DIOB
10	No Increment/Decrement (normal access)
11	No SDM Access[1]

1. Also disables Zero SDM operation.

67.3.11.1.7 Semaphore Operations

Semaphore lock and free operations are available through eTPU microcode. For more information about semaphores see Hardware Semaphores. There are 2 microinstruction fields that control semaphore operations: FL (1 bit) and SMPR (2 bits). Serviced channel sees 4 semaphores, selected by field SMPR.

Table 424. Semaphore Operations Fields

Field	Meaning
FL	0 = free semaphore, 1 = lock semaphore
SMPR	semaphore number selector

When freeing a semaphore, the field SMPR has no meaning. This is because only one semaphore can be locked at a time by each engine, so when freeing a semaphore it is not necessary to specify its number.

NOTE

If microcode tries to lock a semaphore already locked for the same Engine, the semaphore continues locked for the Engine and the SMLCK branch condition resolves as true.

67.3.11.2 ALU/MDU Operations

ALU/MDU microoperations mostly comprises two sources, one destination and one operation. The operation is generally selected through fields ALUOP, ALUOPI or SHF. In formats where there is no operation selection field (ALUOP, ALUOPI or SHF), the operation performed is always addition; however, it is possible to perform subtraction, increment or decrement using fields BINV (see B-Source Inversion) and CIN (see Carry-in Control).

67.3.11.2.1 Source and Destination Register Set Selection

Microcode field T4ABS allows selection of a source from either one of two register sets, shown in Selecting sources and destination. The same applies to T2ABD, used for ALU destination selection with other two register sets, as shown in Selecting sources and destination. Microinstruction fields ABSE and ABDE control the register set selection for source and destination, respectively, when available at the format. In formats without ABSE/ABDE, the field T4BBS determines the register sets used by T2ABD and T4ABS, as shown in Microinstructions without fields ABSE and ABDE.

67.3.11.2.1.1 Microinstructions With Fields ABSE and ABDE

In microinstructions where ABSE and ABDE fields are available (1 bit each), ABSE controls register set selection for T4ABS and ABDE controls register set selection for T2ABD. The following table shows the meaning of values for ABSE and ABDE fields.

Table 425. Register Set Selection by ABSE or ABDE

ABSE or ABDE	Register Set Selected
0	second
1	first

67.3.11.2.1.2 Microinstructions without fields ABSE and ABDE

When ABSE and ABDE are not available in a microinstruction format, register set is selected by T4BBS field. The following table explains how to select a register set either for T4ABS and T2ABD.

Table 426. Register set selection by T4BBS without ABSE and ABDE

T4BBS	Register set for T2ABD	Register set for T4ABS
0xx	first	first
100	second	second
101	second	first
110	first	second
111	first	first
none[1]	first	first

1. Refers to operations with immediate data as B-source, without ABSE and ABDE.

67.3.11.2.2 Selecting sources and destination

All ALU/MDU operations need 2 sources (called AS and BS) and 1 destination (called AD), except for some of those that use immediate data (see Operations With Immediate Data). Fields T4ABS (4 bits), ABSE (1 bit), T4BBS (3 bits) select sources, while T2ABD (4 bits) and ABDE (1 bit) select the destination. When MDU is used (multiply/divide), T2ABD destination selection is ignored and results are stored in MACH and MACL (see MAC and Divide Unit (MDU)). ABSE and ABDE are not available in some microinstruction formats that support ALU/MDU operations. However, in all formats where ABSE is available, ABDE is also available and vice-versa. The existence of ABSE/ABDE fields changes the meaning of T4BBS field, as shown in the table below. On instructions with immediate data, it is used as B-source (see Operations With Immediate Data).

All sources and destinations have a size associated to it, and these sizes are used to select flag sample position (see Flags Sampling Control). Sizes can be 8, 16 or 24 bits. Registers that are not exactly of one of these sizes are treated as the immediately upper size (e.g., CHAN[4:0] is an 8-bit source). See Flags Sampling Control for more information.

Some parallelism issues arise when selecting P, DIOB, ERTA or ERTB as destination registers, since they can be modified by other microoperations in the same microinstruction (see Microinstruction Parallelism Issues for details).

Table 427. B source selection - T4BBS

T4BBS	Meaning in microinstruction formats with ABSE/ABDE	Meaning in microinstruction formats without ABSE/ABDE[1]
000	BS[23:0] = P[23:0]	
001	BS[23:0] = A[23:0]	
010	BS[23:0] = SR[23:0]	
011	BS[23:0] = DIOB[23:0]	
100	reserved	BS = 0
101	reserved	BS = 0
110	reserved	BS = 0
111	BS=0, or Max const., if CIN=0 and BINV=0 (see Generating "max" constant).	

1. T4BBS also selects A-source and destination register set in this case, according to Microinstructions without fields ABSE and ABDE.

T4ABS selects one source from 2 register sets, shown in the following table. ABSE and T4BBS control which set T4ABS field uses to select the source. For more information about how to select a register set for T4ABS and T2ABD see Source and Destination Register Set Selection. All sources are zero-filled to 24 bits, unless sign-extension is specified (see A-Source Size Override).

Table 428. A source selection - T4ABS

T4ABS	First register set		Second register set	
	Selected register	Size	Selected Register	Size
0000	AS[7:0]=P[7:0]	8	AS[7:0]=0	8
0001	AS[7:0]=P[15:8]	8	AS[23:0]=C[23:0]	24
0010	AS[7:0]=P[31:24]	8	AS[15:0] = TPR[15:0]	16
0011	AS[23:0] = ERTB[23:0]	24	AS[23:0] = B[23:0]	24
0100	AS[23:0] = D[23:0]	24	AS[23:0] = TRR[23:0]	24
0101	AS[15:0] = P[15:0]	16	AS[7:0] = 0, read_match[1]	8
0110	AS[15:0] = P[31:16]	16	AS[13:0] = RAR[13:0]	16
0111	AS[7:0] = P[23:16]	8	AS[23:0] = MACH[23:0]	24
1000	AS[23:0] = P[23:0]	24	AS[23:0] = MACL[23:0]	24
1001	AS[23:0] = A[23:0]	24	AS[4:0]=CHAN[4:0]	8
1010	AS[23:0] = SR[23:0]	24	AS[:2] = CHAN_BASE[2]	16
1011	AS[23:0] = DIOB[23:0]	24	AS[13:0] = ENGINE_BASE[3]	16
1100	AS[23:0] = TCR1[23:0]	24	Reserved	-
1101	AS[23:0] = TCR2[23:0]	24	Reserved	-
1110	AS[23:0] = ERTA[23:0]	24	Reserved	-
1111	AS[23:0] = 0	24	Reserved	-

1. T4ABS=0101 with second register set also reads MatchA/B registers into ERTA/B (see Special T4ABS Source Operation: Read Match Registers).
2. CHAN_BASE is the selected channel's base SDM address in channel relative address mode (see CHAN_BASE as a source).
3. ENGINE_BASE is the eTPU_SCR_ECR_ENG*n*[ERBA] field shifted left 9 positions.

T2ABD selects the destination from 1 of 2 register sets, shown in the following table. ABDE and T4BBS control which set T2ABD field uses to select the destination.

Table 429. Destination selection - T2ABD

T2ABD	First register set		Second register set	
	Selected register	Size	Selected Register	Size
0000	A[23:0] = AD[23:0]	24	C[23:0] = AD[23:0]	24
0001	SR[23:0] = AD[23:0]	24	LINK[7:0] = AD[7:0]	8
0010	ERTA[23:0] = AD[23:0][1]	24	TPR[15:0] = AD[15:0]	16
0011	ERTB[23:0] = AD[23:0][2]	24	B[23:0] = AD[23:0]	24
0100	DIOB[23:0] = AD[23:0]	24	CHAN[4:0] = AD[4:0]	8
0101	P[15:0] = AD[15:0]	16	D[23:0] = AD[23:0]	24
0110	P[31:16] = AD[15:0]	16	RAR[12:0] = AD[12:0]	16
0111	P[23:0] = AD[23:0]	24	MACH[23:0] = AD[23:0]	24
1000	TCR1[23:0] = AD[23:0]	24	MACL[23:0] = AD[23:0]	24
1001	TCR2[23:0] = AD[23:0]	24	Reserved	-
1010	P[31:24] = AD[7:0]	8	Reserved	-
1011	P[23:16] = AD[7:0]	8	Reserved	-
1100	P[15:8] = AD[7:0]	8	Reserved	-
1101	P[7:0] = AD[7:0]	8	Reserved	-
1110	TRR[23:0] = AD[23:0]	24	Reserved	-
1111	no destination selected[3]	24	Reserved	-

1. T2ABD=0010 with first register set also writes to MatchA or UDCM registers of the selected channel if field ERWA=0 (see Write Channel Match and UDCM Registers).
2. T2ABD=0011 with first register set also writes to MatchB register of the selected channel if field ERWB=0.
3. if no destination is selected, ALU flags are updated, although the result is lost.

67.3.11.2.2.1 Max Const Generation With T4BBS=111

When T4BBS = 111, BINV = 0, and CIN = 0, the value assigned to BS will be 0x800000, and not 0x0 as expected. See Generating "max" constant for detailed explanation about this.

67.3.11.2.2.2 Special T4ABS Source Operation: Read Match Registers

When T4ABS = 0101 and the source for T4ABS is selected from the second register set, the constant 0x00 is used as AS (8-bit size) and the following register transfer is performed in parallel as well: match registers of the selected channel (value in CHAN register) are copied to ERTA/ERTB registers, where ERTA receives the value of MatchA register and ERTB receives the value of MatchB register (see ER - Event Registers). Note that ALU destination can still be chosen by T2ABD in parallel. When ERTA or ERTB is selected by T2ABD, a parallelism issue arises (see ALU Operations and Read Match Registers).

67.3.11.2.2.3 CHAN_BASE as a source

Each channel has a parameter base address in SDM, which is configured in C*a*CR_ENG1[CPBA] and C*a*CR_ENG2[CPBA]. CHAN_BASE, which represents a parameter address (CPBA*2), can be used as A-source using T4ABS=1010 when T4ABS selects a source from the second register set. In this case, CHAN_BASE is loaded into AS[13:2] to form the byte address (AS[23:14]=0, AS[1:0]=0). For example, in Indirect addressing mode, where the destination register is DIOB, CHAN_BASE is loaded into DIOB[13:2], which is the parameter address, and DIOB[13:0] represents the byte address. CHAN_BASE is the base address of the selected channel (given by CHAN register).

67.3.11.2.3 Flags Sampling Control

This section explains how the flags Z (zero), C (carry), N (negative) and V (overflow) are updated in an ALU operation. When there are post-ALU shift operations, the ALU Carry Out is not directly sampled in Carry flag, but passed to the post-ALU shifter (see Shift Operations). Since the size of source operands in ALU operations is variable, flags can be sampled as an operation of 8, 16 or 24 bits wide. The operation size selection is automatic, based on defined sizes of sources and destination, using the equation:

```
operation_size = minor(size_of(destination), greater(size_of(A-Source),
size_of(B-Source)))
```

Operation size can also be shown with the following table:

Table 430. Operation Size Determination

A Source	B Source	Destination	Operation Size
x	x	8 bits	8 bits
8 bits	8 bits	x	8 bits
16 or 24 bits	x	16 bits	16 bits
16 bits	8 or 16 bits	24 bits	16 bits
8 or 16 bits	16 bits	24 bits	16 bits
24 bits	x	24 bits	24 bits
x	24 bits	24 bits	24 bits

NOTE

Whenever BS = (constant) 0, its size is considered 8 bits, and all 24 bits in B-bus are set to 0. Therefore, all operations with BS = (constant) 0 have their size determined by AS and Destination only.

CCS field (1 bit) controls whether flags will be updated or not (). When CCS bit exists in a microinstruction, the operation size will be used to sample flags. In some microinstructions CCS field is replaced by CCSV (2 bits,). Flag sampling according to CCSV can be set as defined by the operation size, or fixed as 8 or 16 bit operations.

NOTE

For the post-ALU rotate right operation, CCSV also determines the rotate size: whether 8-bit, 16-bit, or determined by the operation size.

Table 431. Flag Sampling Using CCSV field

CCSV	Meaning
00	sample flags as an 8 bit operation
01	sample flags as a 16 bit operation
10	sample flags as defined by operation size
11	do not sample flags

Table 432. Flag Sampling Using CCS field

CCS	Meaning
0	sample flags as defined by operation size
1	do not sample flags

When neither CCS nor CCSV are present in the microinstruction, flags are not sampled. CCS and CCSV do not affect the Carry update on Exchange Bit operation (see Exchange Bit), but does control the N and Z flags.

67.3.11.2.4 B-Source Inversion

The data selected as second source (T4BBS) can be inverted (bitwise boolean NOT) before operation. This is controlled by microinstruction field BINV (1 bit, in the following table). A zero value for BINV activates B-source inversion.

Table 433. B-Source Inversion - BINV

BINV	Meaning
0	invert B-source[1]
1	keep B-source bus unchanged

1. Except on max-constant selection, see Generating "max" constant.

BINV also selects between *adc* or *sbc* enhanced ALU operation, using inverted C flag as carry-in besides BS inversion for *sbc*. Note that BINV does not invert carry in fixed-carry operations (see Carry-in Control).

When BINV = 0, T4BBS = 111 and CIN = 0, the value assigned to BS is 0x800000, instead of 0x0. See Generating "max" constant for more details.

67.3.11.2.5 Carry-in Control

CIN field (1 bit,) controls the carry-in for addition/subtraction operations. Functionality of CIN field depends on the arithmetic operation selected by ALUOP. When ALUOP is not available in microinstruction, the operation selected is *add*. For carry-in control in MDU operations, see the following table.

Table 434. ALU Carry-In Control

operation	CIN=0	CIN=1
add (addition)	carry-in used is 1[1]	carry-in used is 0

Table continues on the next page...

Table 434. ALU Carry-In Control (continued)

operation	CIN=0	CIN=1
adc (addition with carry)[2]	carry-in used is C flag	
sbc (subtraction with borrow)[3]	carry-in used is inverted C flag	

1. Except on max-constant selection, see Generating "max" constant.
2. Selected by ALUOP=11000 and BINV=1
3. Selected by ALUOP=11000 and BINV=0

67.3.11.2.5.1 Generating "max" constant

When T4BBS = 111, CIN = 0 and BINV = 0, BS is assigned to 0x800000 (called "max constant") instead of 0x000000. This is an exception for CIN and BINV fields: when "max constant" is selected, the carry in is 0 and B-source ("max constant" itself) is not inverted, neither the carry out.

"Max constant" is the value which, added to a time base value minus 1, gives the farthest wrapped time base value that satisfies a channel greater-equal comparison. See Enhanced Channels for more info.

67.3.11.2.6 Shift Operations

There are three types of shift operations: ALU, post-ALU and Shift Register. ALU shift operations are covered in ALU/MDU Operation Selection. Post-ALU and Shift Register are covered in the following sections.

67.3.11.2.6.1 Shift Register Operations

SR can be used as a general purpose register and it can easily shift-right its contents, combined or not to post-ALU shift operations. If field SRC (1 bit) in microcode is 0, SR will shift its contents 1 bit to the right according to the algorithmic description below. SR shifting operation depends also on SHF or ALUOP fields. ALUOP and SHF never exist both on the same microinstruction format.

Table 435. Shift Register Control - SRC

SRC	Meaning
0	shift right SR 1 bit
1	no shift

SR Operation:

```
SR[22:0] = SR[23:1];
if SHF == "01" or ALUOP == "10110" then
 SR[23] = ALU_OUT[0];
else
  SR[23] = 0;
endif;
```

67.3.11.2.6.2 Post-ALU shift operations

Post-ALU shift can be selected by SHF field (2 bits) or by some specific ALUOP field values. SHF and ALUOP fields are never both available in the same microinstruction format. When selecting post-ALU shift operation using ALUOP field, ALU will always add the sources before shifting the result.

Table 436. Post-ALU shift operation

Post ALU operation	SHF[1]	ALUOP
shift left (1 bit)	00	10101
shift right (1 bit)	01	10110
rotate right (1 bit)	10	10111
no shift/rotate	11	any other[2]

1. ALU performs AS+BS before shift/rotate for all SHF values.
2. Some ALUOP combinations perform shift/rotate, but not using the Post-ALU Shifter (see ALU/MDU Operation Selection)

Carry flag is only updated when CCS or CCSV fields allow it (see Flags Sampling Control). Algorithmic descriptions of post-ALU shift operations are presented in ALU ADD operation with and without shifting.

67.3.11.2.7 Conditional ALU/MDU Operation Execution

The 3-bit field AS/CE allows conditional execution of arithmetic operation, as shown in the following table . The same field can also be used for overriding the size of A-Source (see A-Source Size Override).

Table 437. ALU/MDU Conditional Execution

AS/CE	Meaning
000	used for A-Source size override (see A-Source Size Override)
001	
010	execute if C = 1
011	execute if C = 0
100	execute if Z = 1
101	execute if Z = 0
110	execute if N = 1
111	execute unconditionally/no size override

Other operations not related to ALU/MDU in the same microinstruction are not affected by the AS/CE field.

If a conditional operation is selected, there is no A-Source size override; similarly, when size override for A-Source is selected, the ALU/MDU operation executes unconditionally.

When a conditional ALU/MDU operation is not executed:

- the destination register is not updated. If the destination is CHAN, no actions associated with CHAN assignment occur (see Channel Selection Register - CHAN).
- the ALU and MDU flags are not updated.
- MDU does not start any operation, i.e., MACH and MACL are not updated.
- SR does not shift.
- T4ABS-selected read-match does not occur.

67.3.11.2.8 A-Source Size Override

Some values if the AS/CE field are used for A-Source Size Override, as shown in the following table.

Table 438. A-Source Size Override

AS/CE	Meaning
000	A-source size override to 8 bits
001	A-source size override to 16 bits
010	used for conditional execution (see Conditional ALU/MDU Operation Execution)
011	
100	
101	
110	
111	execute unconditionally/no size override

Register size override zero-pads an overridden source to 24-bits (if no sign extension is performed, see A-source Sign Extension) and affects operation size calculation. When register source is wider than size override, most significant bits of selected register are not used as A source (zeros are used instead). When size override is wider than selected register, register value is padded to zeros.

When size override is used with MDU operations, it affects only the operand values, but not the operation size: MDU operation size is fully determined by the operation definition (fields ALUOP, ALUOPI).

Table 439. AS/CE field A source size override functionality

Size Override	Size of Selected Register	AS Value[1]
8 bits	8 bits	reg[7:0]
8-bits	16 bits	reg[7:0]
8bits	24 bits	reg[7:0]
16 bits	8 bits	reg[15:0]
16 bits	16 bits	reg[15:0]
16 bits	24 bits	reg[15:0]

1. All values are zero-padded to 24 bits

67.3.11.2.9 A-source Sign Extension

The SEXT microinstruction field forces sign extension of A source according to the size of A operand, either overridden or not by AS/CE field, according to the following table. The sign is taken from the size-overridden value, not the original one.

Table 440. A source Sign Extension

SEXT	Meaning
0	extends sign of A source from its size to 24-bits
1	does not extend sign of A source

A-source sign is not extended in microinstructions without SEXT field, even if AS/CE field is present.

67.3.11.2.10 ALU/MDU Operation Selection

When field ALUOP is available in microinstruction, enhanced ALU operations shown in the following table can be performed, otherwise addition is performed. The ALU operations are defined in ALU and Post-ALU Shifter. The MDU operations are defined in MAC and Divide Unit (MDU).

Table 441. ALU Operation Selection - ALUOP

ALUOP	Operation	Comment
00000	AS mults BS[7:0]	signed multiplication
00001	AS multu BS[7:0]	unsigned multiplication
00010	AS fmults BS[7:0]	signed fractional multiplication
00011	AS fmultu BS[7:0]	unsigned fractional multiplication
00100	AS mults BS[15:0]	signed multiplication
00101	AS multu BS[15:0]	unsigned multiplication
00110	AS fmults BS[15:0]	signed fractional multiplication
00111	AS fmultu BS[15:0]	unsigned fractional multiplication
01000	AS mults BS[23:0]	signed multiplication
01001	AS multu BS[23:0]	unsigned multiplication
01010	AS macs BS[23:0]	signed multiply-accumulate
01011	AS macu BS[23:0]	unsigned multiply-accumulate
01100	AS div BS[7:0]	unsigned division by 8-bit value
01101	AS div BS[15:0]	unsigned division by 16-bit value
01110	AS div BS [23:0]	unsigned division by 24-bit value
01111	n.a.	RESERVED
10000	AS[23:0] | BS[23:0]	24 bit bitwise OR

Table continues on the next page...

Table 441. ALU Operation Selection - ALUOP (continued)

ALUOP	Operation	Comment
10001	AS[23:0] ^ BS[23:0]	24 bit bitwise XOR
10010	AS[23:0] & BS[23:0]	24 bit bitwise AND
10011	abs(AS)	absolute value of AS
10100	AS + BS	arithmetic addition
10101	(AS + BS) shl 1	arithmetic addition with 1-bit post-ALU shift left. (Post-ALU shift operations)
10110	(AS + BS) shr 1	arithmetic addition with 1-bit post-ALU shift right (Post-ALU shift operations)
10111	(AS + BS) ror 1	arithmetic addition with 1-bit post-ALU rotate right (Post-ALU shift operations)
11000	AS adc/sbc BS[1]	addition/subtraction with C flag (Carry-in Control)
11001	AS shl (2^(BS[1:0]+1))	AS is shifted left: 2 bits for BS=0; 4 for BS=1; 8 for BS=2; 16 for BS=3
11010	AS shr (2^(BS[1:0]+1))	AS is shifted right: 2 bits for BS=0; 4 for BS=1; 8 for BS=2; 16 for BS=3
11011	AS ror (2^(BS[1:0]+1))	AS is rotated right: 2 bits for BS=0; 4 for BS=1; 8 for BS=2; 16 for BS=3
11100	AS exch BS[4:0]	exchange C flag and AS bit determined by BS (Exchange Bit)
11101	AS setb BS[4:0]	set bit in AS determined by BS In setb and clrb operations, the register that drives A source is not changed, unless selected as destination of the operation.
11110	AS clrb BS[4:0]	clear bit in AS determined by BS[2]
11111	n.a.	RESERVED

1. Addition/Subtraction is selected by field BINV (see B-Source Inversion)
2. In setb and clrb operations, the register that drives A source is not changed, unless selected as destination of the operation.

67.3.11.2.11 Operations With Immediate Data

Immediate data can be used with some specific microinstruction formats. eTPU microcode allows 8-, 16- or 24-bit immediate data. Immediate data is loaded as B-source, so T4BBS field is not available. When using 24-bit immediate, an add is performed with A-source = 0 and flags are not updated. ALU operations are available with 8-bit immediate, although the field that selects ALU operation in this case is ALUOPI.

67.3.11.2.11.1 24-bit Immediate Destination

When using 24-bit immediate data, the destination register is selected by T2D field (2 bits), according to the following table.

Table 442. 24-bit Immediate Destination - T2D

T2D	Target Register
00	P[23:0]
01	A
10	SR
11	DIOB

67.3.11.2.11.2 Enhanced ALU Operations With Immediate Data

Enhanced operations with immediate data, selected by ALUOPI (5 bits) are allowed only with an 8 bit immediate operand (see the following table).

Table 443. ALU Operation Selection With Immediate Data - ALUOPI

ALUOPI	Operation	Comment
00000	AS mults #imm8	signed multiplication
00001	AS multu #imm8	unsigned multiplication
00010	AS fmults #imm8	signed fractional multiplication
00011	AS fmultu #imm8	unsigned fractional multiplication
00100	AS div #imm8	unsigned division
00101	n.a.	reserved
00110	n.a.	reserved
00111	n.a.	reserved
01000	AD[7:0] = AS[7:0] | #imm8, AD[23:8] = AS[23:8]	bitwise OR
01001	AD[7:0] = AS[7:0] ^ #imm8, AD[23:8] = AS[23:8]	bitwise XOR
01010	AD[7:0] = AS[7:0] & #imm8, AD[23:8] = AS[23:8]	bitwise AND
01011	AD[7:0] = AS[7:0] & #imm8, AD[23:8] = 0×0	bitwise AND with clear
01100	AD[15:8] = AS[15:8] | #imm8, AD[23:16] = AS[23:16], AD[7:0] = AS[7:0]	bitwise OR

Table continues on the next page...

Table 443. ALU Operation Selection With Immediate Data - ALUOPI (continued)

ALUOPI	Operation	Comment
01101	AD[15:8] = AS[15:8] ^ #imm8, AD[23:16] = AS[23:16], AD[7:0] = AS[7:0]	bitwise XOR
01110	AD[15:8] = AS[15:8] & #imm8, AD[23:16] = AS[23:16], AD[7:0] = AS[7:0]	bitwise AND
01111	AD[15:8] = AS[15:8] & #imm8, AD[23:16] = 0×0, AD[7:0] = 0×0	bitwise AND with clear
10000	AD[23:16] = AS[23:16] | #imm8, AD[15:0] = AS[15:0]	bitwise OR
10001	AD[23:16] = AS[23:16] ^ #imm8, AD[15:0] = AS[15:0]	bitwise XOR
10010	AD[23:16] = AS[23:16] & #imm8, AD[15:0] = AS[15:0]	bitwise AND
10011	AD[23:16] = AS[23:16] & #imm8, AD[15:0] = 0x0	bitwise AND with clear
10100	AS + #imm8	arithmetic addition
10101	(AS + #imm8) shl 1	arithmetic addition with 1-bit shift left.
10110	(AS + #imm8) shr 1	arithmetic addition with 1-bit shift right
10111	(AS + #imm8) ror 1	arithmetic addition with 1-bit rotate right
11000	n.a.	reserved
11001	AS shl (2^(#imm8[1:0]+1))	AS is shifted left: 2 bits for #imm8=0; 4 for #imm8=1; 8 for #imm8=2; 16 for #imm8=3
11010	AS shr (2^(#imm8[1:0]+1))	AS is shifted right: 2 bits for #imm8=0; 4 for #imm8=1; 8 for #imm8=2; 16 for #imm8=3
11011	AS ror (2^(#imm8[1:0]+1))	AS is rotated right: 2 bits for #imm8=0; 4 for #imm8=1; 8 for #imm8=2; 16 for #imm8=3
11100	AS exch #imm8[4:0]	exchange C flag and AS bit determined by #imm8[4:0] (see Exchange Bit)
11101	n.a.	reserved

Table continues on the next page...

Table 443. ALU Operation Selection With Immediate Data - ALUOPI (continued)

ALUOPI	Operation	Comment
11110	n.a.	reserved
11111	n.a.	reserved

67.3.11.3 Channel Control and Configuration Microoperations

Channel Control and Configuration fields set configuration values in the channel logic of the channel selected by the CHAN register, except fields LSR and CIRC.

67.3.11.3.1 Channel flags operations

Each channel has two associated hardware flags, called Channel Flag 0 and Channel Flag 1. Microcode field FLC (3 bits) allows them to be set or cleared, as shown in the following table. These flags can be tested by microcode as a branch condition, and may also influence in the Entry Point taken, allowing fast state decoding. For more details, see Entry Points.

Table 444. P flags operation - FLC

FLC	Meaning
000	Clear flag0
001	Set flag0
010	Clear flag1
011	Set flag1
100	Copy flag1:flag0 from P[25:24]
101	Copy flag1:flag0 from P[27:26]
110	Copy flag1:flag0 from P[29:28]
111	No operation

67.3.11.3.2 Comparator and Time Base Selection

TBSA and TBSB fields (4-bit wide each) are used to configure the type of the comparator and the time bases used for match or capture (see the following tables). TBSA can also be used to control the Output Buffer Enable signal (See Pin Control Registers).

Table 445. Time Base Selection A - TBSA

TBSA[3] = 0	TBSA bit	2	1	0
	bitfield	Comparator selection	Capture selection	Match TB selection
	0	greater or equal	TCR1	TCR1
	1	equal-only	TCR2	TCR2

Table continues on the next page...

Table 445. Time Base Selection A - TBSA (continued)

TBSA[3] = 1	**action**	**2**	**1**	**0**
	set OBE=1	0	0	0
	set OBE=0	0	0	1
	do nothing	1	1	1
	reserved	all other values		

Table 446. Time Base Selection B - TBSB

TBSB[3] = 0	**TBSB bit**	**2**	**1**	**0**
	bitfield	**Comparator selection**	**Capture selection**	**Match TB selection**
	0	greater or equal	TCR1	TCR1
	1	equal-only	TCR2	TCR2
TBSB[3] = 1	action	**2**	**1**	**0**
	do nothing	1	1	1
	reserved	all other values		

67.3.11.3.3 Transition Detection and Pin Action Control

IPACA/B and OPACA/B fields are used to configure transition detection sensitivity (for the channel input signal) or output pin action control (for the channel output signal), as defined in the table below. IPACA and IPACB have the same format, where IPACA is related to Match A and first transition detection, and IPACB to Match B and second transition detection. The same applies in analogue way to OPACA and OPACB.

For the output signal, configuring OPAC registers does not change the current signal state, but defines the action to be done when a match or transition detection occurs. See Match Recognition and Channel Modes on Output Signal Generation for more information.

IPACA/B=1xx also enables assertion of MRLA/B during Time Slot Transition. See Match Recognition.

Table 447. Input and Output Pin Action Control - IPACA/B and OPACA/B

value	IPAC meaning	OPAC meaning
000	Do not detect transitions	Do not change output signal
001	Detect rising edge only	Match sets output signal high
010	Detect falling edge only	Match sets output signal low
011	Detect both edges	Match toggles output signal
100	Detect input signal = 0 on Match	Transition detection sets output signal low

Table continues on the next page...

Table 447. Input and Output Pin Action Control - IPACA/B and OPACA/B (continued)

value	IPAC meaning	OPAC meaning
101	Detect input signal = 1 on Match	Transition detection sets output signal high
110	reserved	Transition detection toggles output signal
111	do not change IPAC	do not change OPAC

67.3.11.3.4 Immediate Pin State Control

It is possible to change output signal state immediately by using PSC (2 bits) and PSCS (1 bit) fields.

Table 448. Immediate Pin State Control - PSC and PSCS

PSC	PSCS	Meaning
00	0	set signal as specified by OPACA (see Transition Detection and Pin Action Control)
00	1	set signal as specified by OPACB (see Transition Detection and Pin Action Control)
01	x	set signal high
10	x	set signal low
11	x	don't change signal state

67.3.11.3.5 Write Channel Match and UDCM Registers

Match registers can have their values changed using ERWA and ERWB fields (1 bit each). They also set their respective MRLE register (see Match Recognition).

ERWA can also be used to program the UDCM register (see UDCM - User Defined Channel Mode) . The field CMW selects where the contents of ERTA is copied when ERWA is active (see the following table).

Table 449. Write MatchA/B - ERWA/B

Field	CMW	Value	Action
ERWA	1	0	write ERTA value in MatchA. Enable matches for MatchA register (MRLEA=1)
	0	0	write ERTA value into UDCM
	1	1	don't change UDCM, MatchA and MRLEA
	0	1	reserved
ERWB	1	0	write ERTB value in MatchB. Enable matches for MatchB register (set MRLEB=1)
	1	1	don't change MatchB and MRLEB

Table continues on the next page...

Table 449. Write MatchA/B - ERWA/B (continued)

Field	CMW	Value	Action
	0		
	0	0	reserved

If ERTA or ERTB is a destination of an ALU operation and, at the same time, the respective ERWA/B field is active, the new ERTA value is the one written into the MatchA/B register or the UDCM register.

67.3.11.3.6 Clear Transition/Match Event Registers

Flags MRLA, MRLB, TDLA and TDLB (see ER - Event Registers) indicate the state of matches and transitions detected in the selected channel, and it is possible to clear those flags using the microcode fields MRLA, MRLB (1 bit each) and TDL (1 or 2 bits, depending on the format). The flags cleared by these microcode fields are the actual channel flags, and also the ones sampled into the branch logic.

TDL can be one or two bits wide, depending on the microinstruction format (see Microinstruction formats) . Two-bit TDL allows independent clearing of TDLA and/or TDLB . defines the two-bit TDL field.

Table 450. Clear Transition/Match Event Registers - MRLA/B, TDL

Field	Meaning
MRLA	0 = clear MRLA event register, 1 = don't change
MRLB	0 = clear MRLB event register, 1 = don't change
TDL (1 bit)	0 = clear TDLA and TDLB flags, 1 = don't change

Table 451. Independent TDLA/B clear - two-bit TDL

value	Meaning
0 0	clear TDLA
0 1	clear TDLB
1 0	clear both TDLA and TDLB
1 1	do not clear TDLA or TDLB

67.3.11.3.7 Disable Matches

Microcode field MRLE (1 bit) allows disabling matches on channel selected by CHAN register, for both MatchA and MatchB registers, by clearing their respective MRLE bits. Matches can be enabled for each Match register using ERWA and ERWB fields (see Write Channel Match and UDCM Registers).

Table 452. Disable Matches - MRLE

MRLE	Meaning
0	Disable matches for Match A and Match B
1	don't change match enabling

Some instruction formats have a two-bit MRLE field (see Microinstruction formats) which allows independent disabling of Matches 1 and 2, as shown in the following table.

Table 453. Two-bit MRLE

MRLE	Meaning
0 0	Disable Match A (clear MRLEA)
0 1	Disable both Matches (clear MRLEA and MRLEB)
1 0	Disable Match B (clear MRLEB)
1 1	nop

67.3.11.3.8 Disable Match and Transition Service Requests

Microcode field MTD (2 bits) disables match and transition service requests for the selected channel. MTD does not disable Link Service Request and Host Service Request. MTD sets or resets register SRI (for more details see SRI - Match/Transition Service Request Inhibit Latch) and TCCEA (see TCCEA - Transition Continuous Capture Enable).

Table 454. Disable Match and Transition Service Request - MTD

MTD	Action on SRI	Action on TCCEA
00	SRI = 0: enable service requests for match and transition	TCCEA = 0: disable transition captures[1] when TDLA = 1
01	SRI = 1: disable service requests for match and transition	
10	SRI = 1: disable service requests for match and transition	TCCEA = 1: enable transition captures[2] when TDLA = 1
11	don't change	

1. Disables only captures on transition events specified by IPACA.
2. Enables only captures into CaptureA register, on transition events specified by IPACA.

67.3.11.3.9 Predefined Channel Modes

Microcode PDCM field (4 bits) defines the channel mode (see Channel Modes).

PDCM coding is shown in the table below. Note that PDCM bit 0 selects between Single Transition (PDCM[0]=0) and Double Transition (PDCM[0]=1) predefined modes.

PDCM is also used to select the user-defined channel mode, defined by the channel register UDCM (see UDCM - User Defined Channel Mode).

Table 455. Predefined Channel Modes

PDCM	Channel mode
0000	em_b_st
0001	em_b_dt
0010	em_nb_st
0011	em_nb_dt
0100	m2_st
0101	m2_dt
0110	bm_st
0111	bm_dt
1000	m2_o_st
1001	m2_o_dt
1010	**user-defined channel mode**
1011	reserved
1100	sm_st
1101	sm_dt
1110	sm_st_e
1111	keep current channel mode

67.3.11.3.10 Channel Interrupt and Data Transfer Requests

Microcode can issue Interrupt Requests, Data Transfer Requests and Global Exception through CIRC field. For more information see Interrupts and data transfer requests.

Table 456. Channel and Data Transfer Requests - CIRC

CIRC	Meaning
000	Channel Interrupt Request from selected channel
001	Data Transfer Request from selected channel
010	Channel Interrupt and Data Transfer requests from selected channel
011	Channel Interrupt and Data Transfer requests from serviced channel
100	Channel Interrupt Request from service channel

Table continues on the next page...

Table 456. Channel and Data Transfer Requests - CIRC (continued)

CIRC	Meaning
101	Data Transfer Request from service channel
110	Global Exception
111	don't request interrupt

67.3.11.3.11 Clear Link Service Request

Microcode LSR field (1 bit) is used to clear the Link Service Request flag of the serviced channel (may not be the one selected by CHAN). The LSR branch condition is always cleared, but not the Link Service Request, if another channel link was received by the serviced channel during the executing thread. See Channel link for more information.

Table 457. Link Service Request Negation Control - LSR

LSR	Meaning
0	clear Link Service Request (flag LSR)
1	don't change

67.3.11.4 Flow Control Microoperations

eTPU has *jump* and *call* microoperations to change microcode flow. Besides, eTPU has *dispatch jump* and *dispatch call* that can be used to implement a jump table. In *call* (or *dispatch call*) microoperation, the return address is saved in RAR register. If nested sub-routine calls are necessary, return address values have to be saved in a stack, usually implemented with DIOB register.

Flow Control microoperations are also provided to repeat a given microinstruction, to finish the current thread execution, and to halt the microengine.

67.3.11.4.1 Ending Current Thread - END

Microcode END field (1 bit) finishes current thread and allows other channels to be serviced. If END field is 0, the current instruction is completed and the thread is finished. END = 1 has no effect, and the next microinstruction is executed Any MDU operation (see MAC and Divide Unit (MDU)) that could be still pending when the thread is finished is left incomplete. END also releases any semaphore locked by the Engine.

67.3.11.4.2 Branch Operations

Branch operations can be **jump** or **call**. The target address of *jump* or *call* microoperations is always immediate and absolute. Branch microoperation is affected by FLS field (refer to Flush pipeline).

67.3.11.4.2.1 Selecting Jump or Call Microoperations

The only difference between *jump* and *call* microoperations is that when a *call* is executed the value of PC or PC+1 (depending on flush, see Flush pipeline) is saved in RAR register. The microcode field J/C (1 bit) selects whether *jump* or a *call* is executed, according to the following table.

Table 458. Jump / Call Selection - J/C

J/C	Meaning
0	jump

Table continues on the next page...

Table 458. Jump / Call Selection - J/C (continued)

J/C	Meaning
1	call

67.3.11.4.2.2 Branch Target Address

Microcode BAF field (14 bits) indicates the absolute address of a *jump*/*call target*.

67.3.11.4.2.3 Conditional/unconditional branch

Jump and *call* can be conditional or unconditional, depending on the BCC (6 bits) and BCF (1 bit) fields, as shown in and . BCF determines whether branch is taken when condition specified by BCC is true or false. When a branch condition uses the channel flags, the channel context is related to the channel number written in CHAN register.

Table 459. Branch Condition Inversion - BCF

BCF	Meaning
0	branch if condition determined by BCC is false
1	branch if condition determined by BCC is true

Table 460. Branch Condition Selection - BCC

BCC	Meaning	BCC	Meaning
001110	Flag 0	001111	Flag 1
100000	V ALU flag	110000	PSS channel flag
100001	N ALU flag	110001	PRSS channel flag
100010	C ALU flag	110010	"Less Than" ALU flag combination (signed) [1]
100011	Z ALU flag	110011	"Lower or Equal" ALU flag combination (unsigned)[2]
100100	MV MDU flag	110100	P[24]
100101	MN MDU flag	110101	P[25]
100110	MC MDU flag	110110	P[26]
100111	MZ MDU flag	110111	P[27]
101000	TDLA channel flag	111000	P[28]
101001	TDLB channel flag	111001	P[29]
101010	MRLA channel flag	111010	P[30]
101011	MRLB channel flag	111011	P[31]

Table continues on the next page...

Table 460. Branch Condition Selection - BCC (continued)

BCC	Meaning	BCC	Meaning
101100	LSR channel flag	111100	PSTO channel flag
101101	MB flag MDU flag	111101	PSTI channel flag
101110	FM[1] channel flag	111110	SMLCK semaphore flag
101111	FM[0] channel flag	111111	false
all other values reserved			

1. "less than" is a signed comparison, equal to the xor between ALU flags V and N; e.g., 0 < 0xFFFFFF tests as false (0 < -1).
2. "lower equal" is an unsigned comparison, equal to Z or C; e.g., 0 < 0xFFFFFF tests as true.

67.3.11.4.3 Dispatch Microoperation

Dispatch microoperation is an unconditional branch where the target address is always PC+P[31:24] (unsigned). Dispatch is affected by FLS field (refer to Flush pipeline). Dispatch microoperation is defined by R/D field (2 bits, see the following table). Field R/D can also be used to define return from sub-routine (see Return from subroutine).

Table 461. Return and Dispatch - R/D

R/D	Meaning
00	return from subroutine (see Return from subroutine)
01	dispatch jump
10	dispatch call
11	don't change microinstruction flow

67.3.11.4.4 Return from subroutine

When a subroutine *call* or a *dispatch call* microoperation is executed, the return address is saved in RAR register. To return from a subroutine a microoperation is available to load the contents of RAR register back to the PC. Fields R/D (2 bits) or RTN (1 bit, see the table below) can be used to return from subroutine. For R/D field, see Dispatch Microoperation.

Return from subroutine microoperation is affected by FLS (see Flush pipeline) when field R/D is used. Return execution through RTN always flushes the pipeline.

Table 462. Return from subroutine - RTN

RTN	Meaning
0	Return with pipeline flush
1	Do not return

67.3.11.4.5 Flush pipeline

When a branch, dispatch or subroutine return microoperation is executed, the next microinstruction can be executed unconditionally before the flow change takes effect, since microengine has a three-stage pipeline. Executing the next microinstruction after a branch maximizes execution performance. This feature is controlled by field FLS (1 bit, see the table

below). When FLS=0 the pipeline is flushed, so the next microinstruction placed after a branch is decoded as NOP if the branch is taken. If FLS=1, the microinstruction placed after the branch is executed, either if the branch is taken or not, as shown in the figure below.

Flush also controls which value is stored in RAR in a call: in case of no flush, it is the address of the branch/dispatch instruction + 2, even if RAR is the ALU destination of the instruction after the call; in case of a flush, it is the address of the instruction following branch/dispatch.

If a branch with no flush is followed by another branch with no flush, the instructions are executed in the following order:

1. first branch
2. second branch
3. first branch's destination instruction
4. second branch's destination instruction, and the flow proceeds normally from then on

The destination of the first branch must not be another flow changing instruction (branch, return or dispatch). Similar flows apply when returns or dispatches are used instead of branches. This scheme can be used to implement quick table look-ups with a dispatch replacing the first branch, for instance.

Table 463. Flush Pipeline - FLS

FLS	Meaning
0	flush pipeline when jump / call / dispatch jump / dispatch call / return is executed
1	do not flush pipeline when jump / call / dispatch jump / dispatch call / return is executed

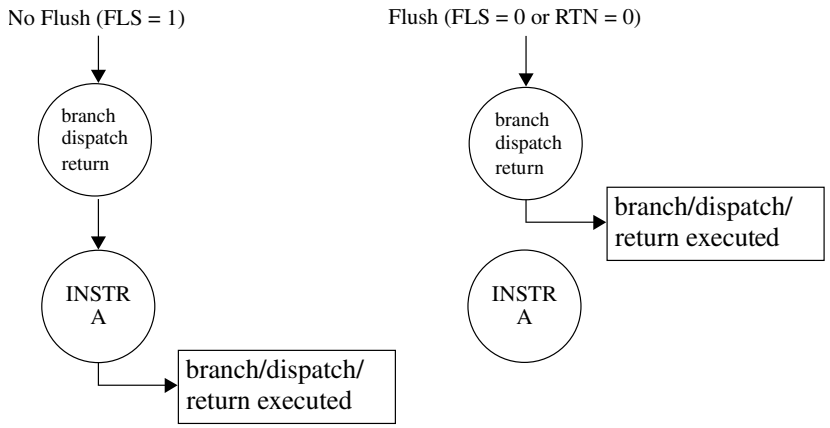


Figure 476. Flush pipeline

67.3.11.4.6 HALT microinstruction

HALT is a microinstruction provided to implement software breakpoints (see Software breakpoints). Note that HALT is coded as a microinstruction format, not a field (see Microinstruction formats). The execution of this instruction puts the microengine in halt state. For more information about the implications of microengine halt state, see Microengine Halt State. HALT is valid only if software breakpoints are enabled at the Debug interface . If software breakpoints are not enabled, HALT executes as a NOP and is treated as an Illegal Instruction (see Illegal instructions).

67.3.11.4.7 NOP microinstruction

There is not a unique microinstruction with an assigned opcode to do No Operation. NOP microinstruction is achieved through any of the formats shown on Microinstruction formats where the user can assign to each individual field the corresponding value

for "No Operation". However, to prevent future impacts of instruction changes on object code compatibility, the instruction value 0x4FFFFFFF should always be used for NOP.

67.3.11.5 Illegal instructions

An instruction is considered illegal if any reserved field value is used, including when the fields marked rsv in the instruction formats (see Microinstruction formats are assigned value 0. A HALT instruction is exceptionally considered illegal when executed with software breakpoints disabled (see HALT microinstruction). Global Exception may be issued up to two microcycles after instruction fetch. The execution results of an illegal instruction on the microengine, channel logic or host interface are unspecified, except for the HALT case.

If the microengine decodes an illegal instruction, the following actions are taken:

- A Global Exception is issued.
- The ILF1/2 flags in eTPU Module Configuration Register (MCR) are set to indicate this occurrence to the Host.
- A breakpoint occurs, if NDEDI is present and configured to do so (see the NDEDI details for more information).

67.3.11.6 Microinstruction Parallelism Issues

This section clarifies parallelism issues that arise when two non-commutative microoperations appear in the same microinstruction.

67.3.11.6.1 ALU Operations and Read Match Registers

ALU operations have only one destination register, but there is one case where source selection determines destination: read Match register in ERTA and ERTB registers. In this case if ALU destination is ERTA or ERTB a conflict arises. The ALU destination value overwrites the value read from the match registers.

67.3.11.6.2 ALU and SDM Operations

P and DIOB registers can be selected as destination by both ALU and SDM (read) microoperations in the same microinstruction. Since P and DIOB update from SDM data happens after P and DIOB update for ALU/MDU microoperations, the data read from SDM remains in P or DIOB after an operation when one of them is specified as destination for both ALU and SDM microoperations. In this case, the value loaded into P or DIOB is the one read from SDM. However, the ALU operation is executed and its flags are updated accordingly.

When P or DIOB is destination of an SDM read and also an ALU source at the same microinstruction, the value before the read is used for the ALU operation.

If DIOB is the ALU destination and P is loaded from SDM or vice-versa, no conflict occurs, and the result is the same as if operations occurred separately.

All the above also applies to Zero SDM operations.

When using P or DIOB as destination for ALU operations and also as source for a SDM write operation, the data written in SDM is the one calculated by ALU, which means it is possible to calculate a value and write it in an SDM address using only one microinstruction.

The old value of DIOB or the old value minus 4 (pre-decrement) is always used when DIOB is selected as address (indirect address mode), no matter if DIOB is selected as destination of either the SDM or ALU. For the value loaded into DIOB, refer to the following table.

Table 464. DIOB load from SDM and ALU

DIOB selected as SDM read destination?	DIOB selected as ALU destination?	DIOB load value
no	no	DIOB, --DIOB (pre-decrement), or DIOB++ (post-increment)
yes	no	SDM read data (post-inc and pre-dec ignored)
yes	yes	SDM read data (post-inc, pre-dec and ALU result ignored)
no	yes	ALU result (post-inc an pre-dec ignored)

When CHAN is the destination of an ALU operation in parallel with a channel-relative SDM access, the CHAN value used to calculate the address is the one before the ALU operation.

67.3.11.6.3 ERTA/B as ALU destination and ERWA/B

The value in ERTA and ERTB registers can be written in match registers of the selected channel by using fields ERWA and ERWB (Write Channel Match and UDCM Registers). If, at the same microinstruction, ERTA or ERTB is destination of an ALU/MDU microoperation, the value written in Match registers is the ALU/MDU result.

The same applies to UDCM when ERTA is the destination of an ALU operation and instruction fields ERWA and CMW are active .

If an ALU operation occurs in parallel with ERWA/B but ERTA/B are not the destination of an ALU/MDU operation, then UDCM and MatchA/B receives the ERTA/B value.

67.3.11.6.4 ERWA/B and MRLE

ERWA/B automatically sets the MRLEA/B channel latch, respectively (see Write Channel Match and UDCM Registers). Microinstruction fields ERWA/B independently sets MRLEA/B channel flags, regardless of MRLE.

67.3.11.6.5 CHAN assignment, Read Match and ERWA/B

When CHAN is a destination of an ALU operation it causes a read of the CaptureA/B register values into ERTA/B. The Capture registers loaded into ERTA/B are selected by the new CHAN value. The value of the CaptureA/B registers overwrites any read-match commanded simultaneously.

If CHAN assignment happens with an ERWA/B operation in the same instruction, the updated Match register(s) belong to the new selected channel.

67.3.11.6.6 Read Match and ERWA/B

If a read match operation is executed with ERWA/B in the same microinstruction, the MatchA/B registers receive the old values of ERTA/B, and the ERTA/B registers receive the old MatchA/B values simultaneously, i.e.: ERTA/B and MatchA/B swap their values.

If ERTA/B is the destination of an ALU operation at the same instruction, MatchA/B gets the ALU result (see ERTA/B as ALU destination and ERWA/B), but the ERTA/B not being written still receives the old MatchA/B values.

NOTE

Read match, ERWA/B and CHAN assignment can be active at the same instruction. Combining rules CHAN assignment, Read Match and ERWA/B and Read Match and ERWA/B, the result is: ERTA/B receives the CaptureA/B values of the new CHAN value, and MatchA/B of the new channel receives the old ERTA/B value(s).

67.3.11.6.7 Stack accesses and ALU operations

Post-increment is ignored in a stack operation (field STC) if DIOB is loaded from SDM: DIOB keeps the value read from SDM. Pre-decrement is ignored in a stack operation (field STC) if DIOB is destination of an ALU operation, for DIOB load value, but not for DIOB as address. Post-increment/pre-decrement remains valid in all other situations. These rules can be summarized in the following equivalent C code, and in ALU and SDM Operations.

```
DIOB = *DIOB[15:2];      // read without posinc/predec
*DIOB[15:2] = DIOB;      // write without posinc/predec
DIOB = *(--DIOB[15:2]);  // read with predec
DIOB = *DIOB[15:2];      // read with posinc (ignored)
*(--DIOB[15:2]) = DIOB;  // write with predec
*DIOB[15:2]++ = DIOB;    // write with posinc (value written is before
increment)
```

67.3.11.6.8 SRC and ALU/MDU operations

If operation SRC is active (field SRC = 0) and register SR is selected as destination of an ALU operation, the value of the ALU operation prevails over the shifted value.

The value of SR used as source in the ALU/MDU operation is the one before the shift.

67.3.11.6.9 Semaphore lock/free and SMLCK branch condition

When the SMLCK branch condition is tested at the same microinstruction of a semaphore lock or free, the condition is evaluated after the semaphore action (either free or lock) is taken.

67.3.11.6.10 Dispatch and SDM Read

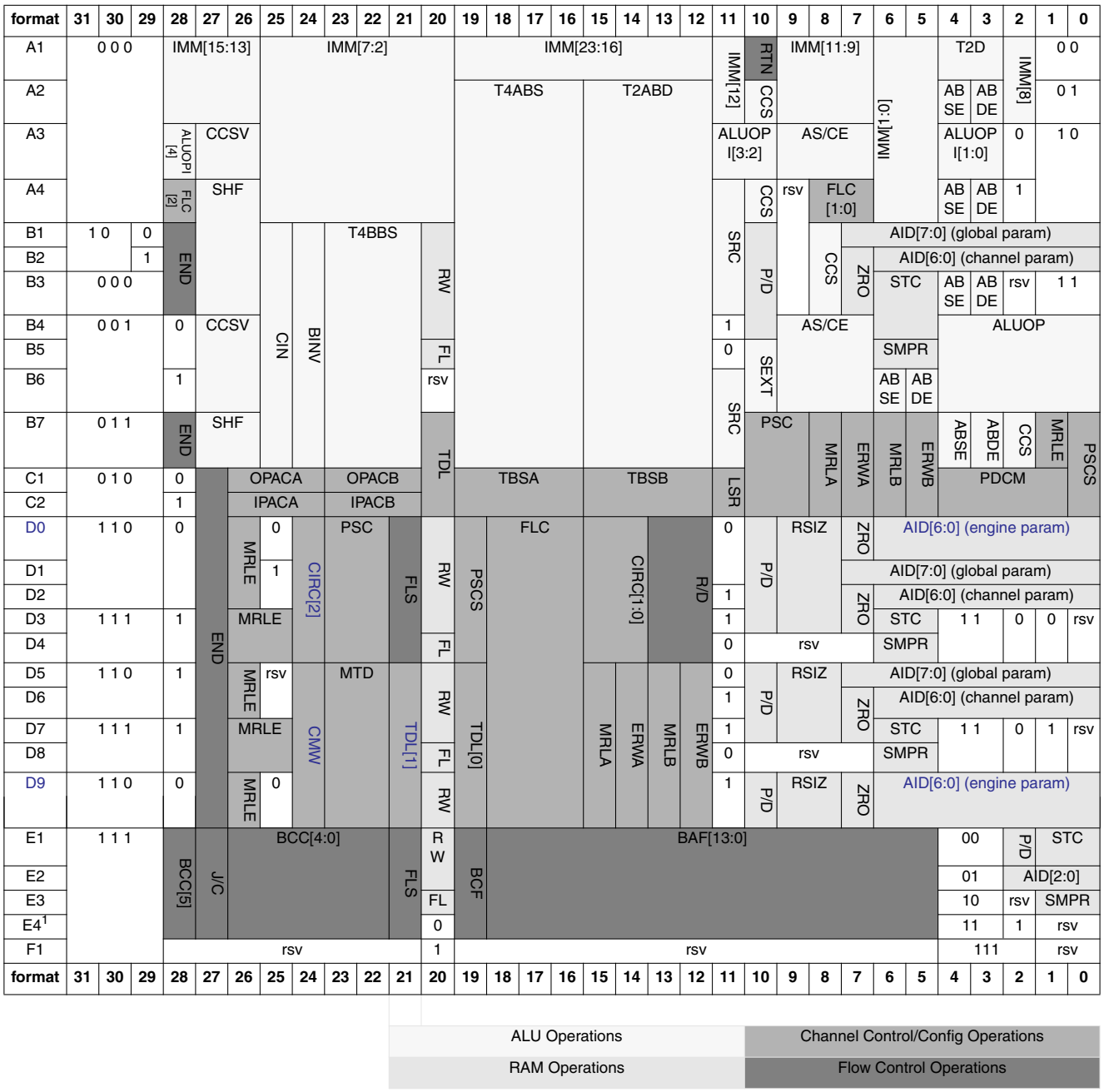
When the most significant byte of P is read from SDM (read 8 msb bits or 32 bits) and a dispatch instruction is executed simultaneously, the dispatch target address is calculated upon the P value before the read.

67.3.11.6.11 CHAN Assignment, PSC/PSCS, and clear MRLEA/B, MRLA/B, TDLA/B

When clear MRLEs, MRLA/B or TDLs is done and a CHAN assignment is done at the same time, the flag selected by the old CHAN value is cleared in the channel, but the branch conditions receive the state of the flags selected by the new CHAN.

When a pin action is commanded through PCS/PSCS and a CHAN assignment is done simultaneously, the output signal affected is selected with the old CHAN value.

67.3.11.7 Microinstruction formats



NOTES:
1 format E4 is deprecated; the same result can be obtained with format E1 with field STC=11

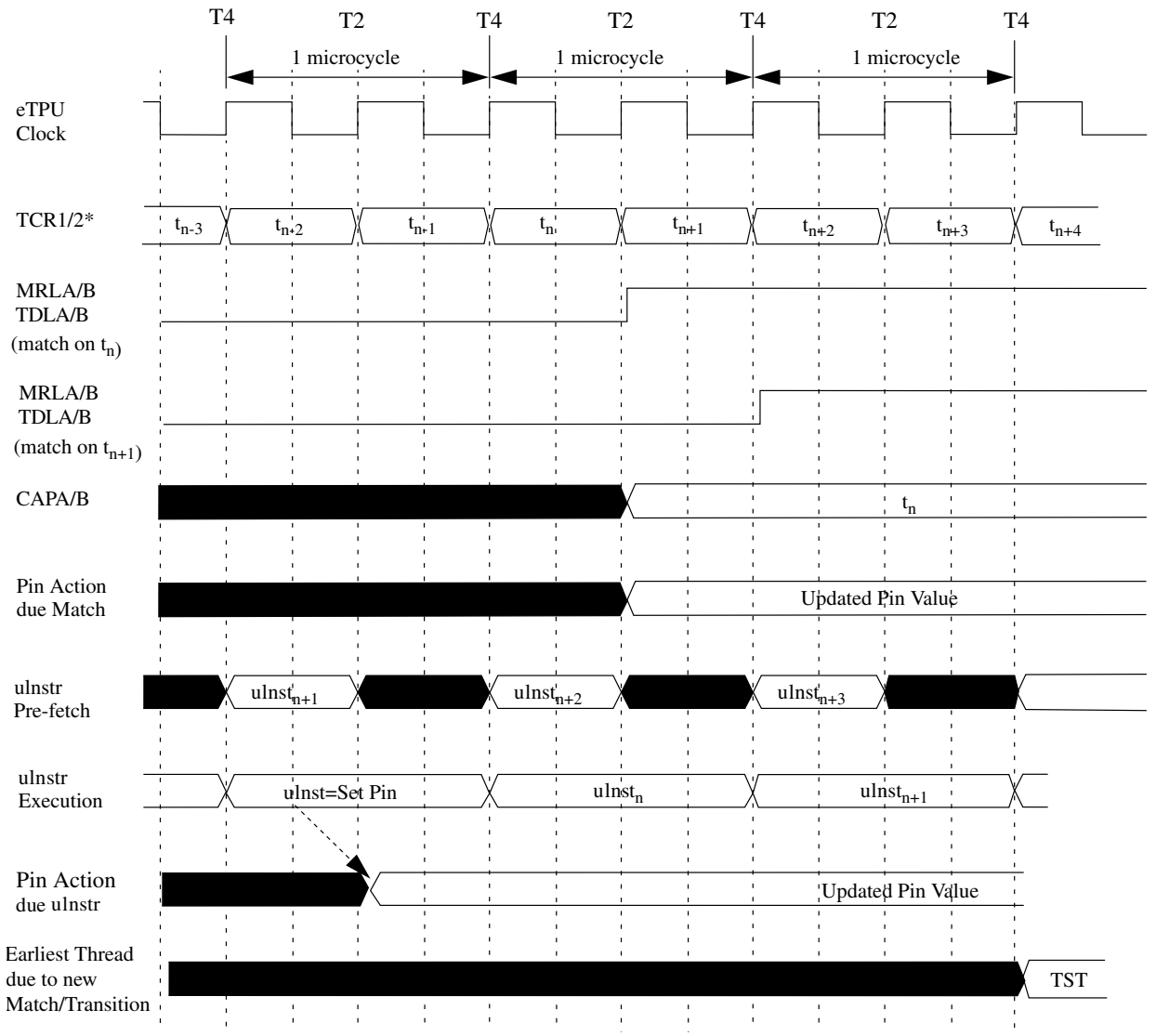
Figure 477. Microinstruction formats

All bits marked "rsvd" are reserved, and must be coded as 1.

67.3.12 Microcycle and I/O timing

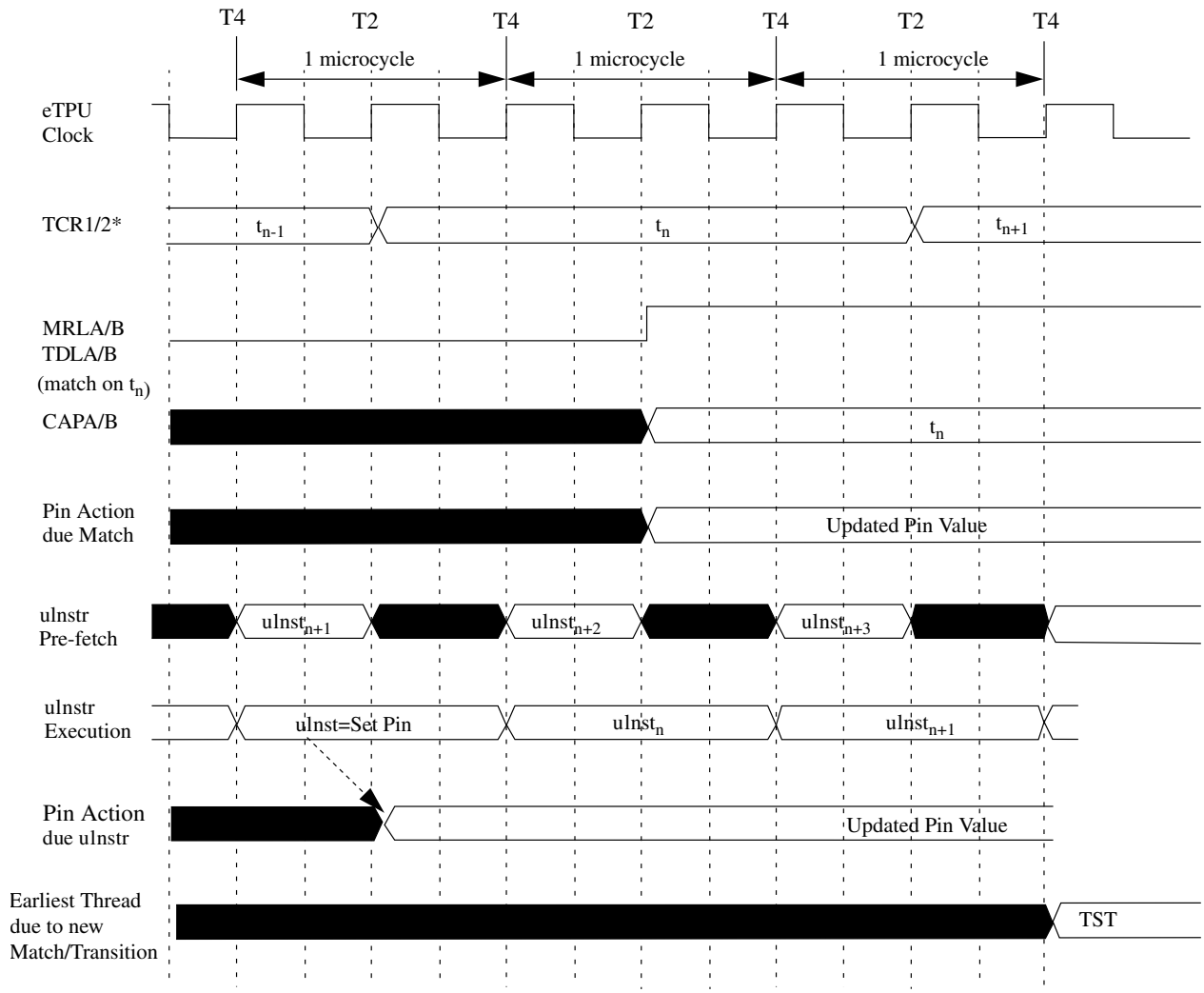
67.3.12.1 Execution and channel timing

The following figure shows the main timings related to microinstruction execution when channels and timebases run on T2 timing.



Note: *TCR clock/prescaler selection = 1 x eTPU clock

Figure 478. Execution timebase and channel T2 timing



Note: *TCR clock/prescaler selection = 4x eTPU clock

Figure 479. Execution timebase and channel T2, T4 timing

The sequential occurrence of the four T states (T1-T4) constitutes a microcycle. Only T2 and T4 are taken as reference for timings, either internal or external. T2 and T4 have the timing of the positive eTPU clock pulses, and are used in most of the eTPU logic in an edge-triggered design style.

Two additional T states are derived from the eTPU clocks: T2 and T4 . T2 occurs when the eTPU loses SDM arbitration to a bus master. T4 occurs in halt state (due to a breakpoint or assertion, for instance), or in stall state (due to an NDEDI queue full); see Development support features for more details.

T2 and T4 states are defined as microcycle timing states (not to be confounded with logic states) of one eTPU clock in which the T clocks continue to run, but the control signals associated with the clocks are unaffected. That is, no operation occurs during these states. Both T2 and T4 states occur in multiples of two eTPU clocks to keep the microengine synchronized with the free running channels, which are unaffected and keep on working as in T2 and T4.

Thus, the eTPU has two types of timing states:

- T2: hold execution for SDM access, from clock pulse T2 until one of the next T2 clock pulses of another microcycle.
- T4: hold execution in debug mode or stall, from clock pulse T4 until one of the next T4 clock pulses of another microcycle.

The two following figures show the timing of T2 and T4 timing states, respectively.

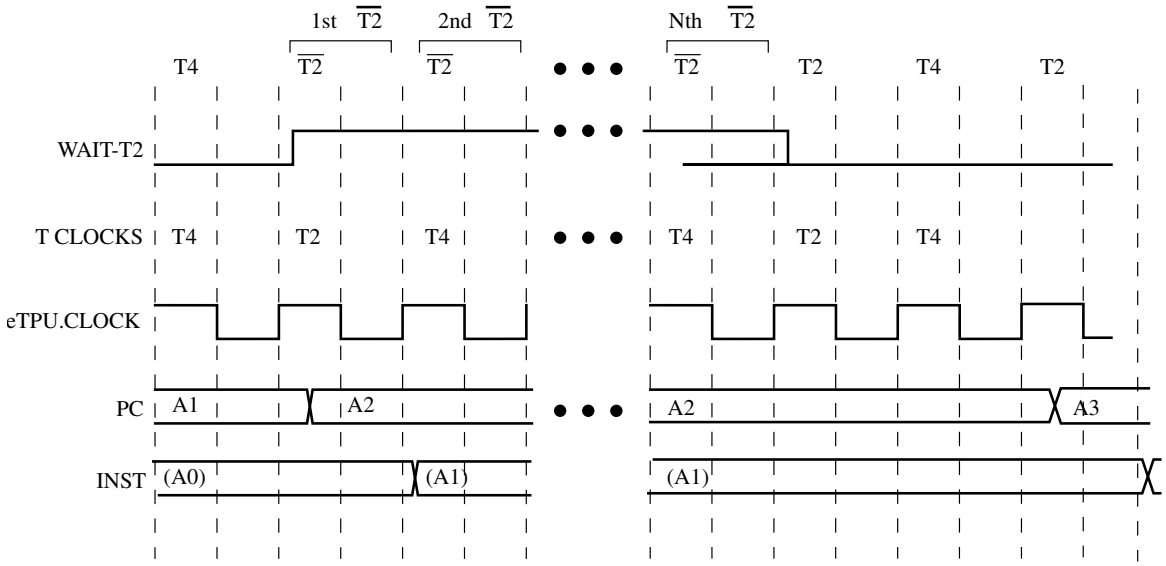


Figure 480. T2 timing

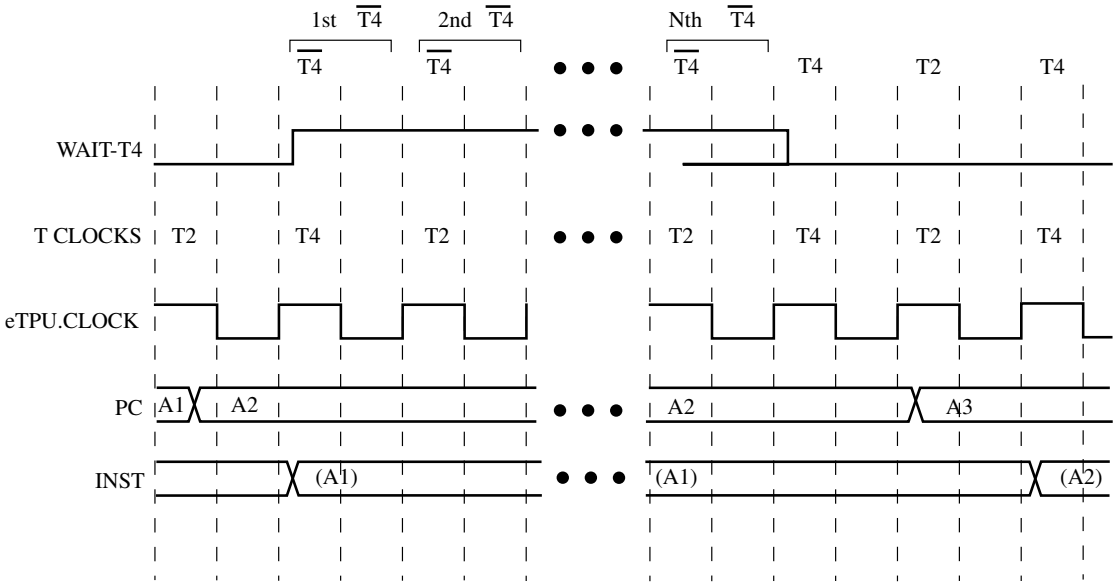


Figure 481. T4 timing

67.3.12.2 Input/output signal delays

The synchronizer, filter and edge detection logic delay the input signal transitions.

The Filter Delay varies with the filter clock (eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2) field FPSCK) and the filter mode used, as shown in the Filter clock prescaler. For any given transition, it depends on the phase of the filter clock when the input transition happens. In integration mode (TCRCLK filtering only), it also depends on the state of the integrator counter. The Total Delay is defined as the number of eTPU clock rising edges between the input transition and the setting of TDLA/B, TCR1/2 incrementing, or EAC tooth sensing (TCRCLK) in angle mode. The synchronizer delay is 2 or 3 eTPU clocks, depending on the phase of the synchronizer when the input transition happens. The edge detection takes 1 more eTPU clock. The total delays are, thus:

```
Min. Total Delay = Min. Synchronizer Delay + Min. Filter Delay + Edge Detection Delay
Min. Total Delay = 3 + Min. Filter Delay
```

```
Max. Total Delay = Max. Synchronizer Delay + Max. Filter Delay + Edge Detection Delay
Max. Total Delay = 4 + Max. Filter Delay
```

The channel filters can be bypassed, so nullifying the filter delays in the equations above.

See the chip-specific eTPU information for connections between eTPU and input glitch filters.

The channel output flip-flops drive the eTPU output signals directly, without any synchronous delays.

67.3.13 Shared subsystems support

Shared Subsystems support allows eTPU to control other modules, either independently or sharing control with the host . A notable example of shared subsystem is the Reaction Module (see the Reaction Module chapter for details), which is connected to the eTPU as shown in the figure below. The host CPU accesses the Reaction Module through the eTPU, which can also access the same registers .

When the SSMAE field in C*a*CR_ENG1 or C*a*CR_ENG2 is 1, the eTPU channel's threads can control shared subsystems by accessing their registers, which are mapped onto the higher 16 KB of the microcode data address space (byte addresses/DIOB values 0x4000 to 0x7FFF, equivalent to parameters 0x1000 to 0x1FFF), as shown in . The shared subsystem registers are accessible by microcode only with the indirect address mode (see SDM Addressing Modes) .

When the SSMAE field in C*a*CR_ENG1 or C*a*CR_ENG2 is 0, the channel's threads can access only the SDM, mirrored throughout the whole DIOB address range .

The same Shared Subsystem register address space is accessible by the host through the Shared Subsystem Area within the eTPU memory map (see and Memory map), allowing shared control and/or supervision between the host and the eTPU . The arbitration mechanism between host and eTPU accesses is the same used for SDM accesses (see SDM arbitration) . The CDC (see Coherent Dual-parameter Controller (CDC)) cannot be used for coherent transfers between SDM and the Shared Subsystem Area, or within the Shared Subsystem Area itself .

NOTE

The detailed register map within the Shared Subsystem Area depends on the subsystem module.

Bus errors coming from the Shared Subsystem cause a Global Exception and are flagged by the MCR[SSAERR] bit on microengine accesses only . In the case of host access, the bus error only propagates to the bus, which also issues a bus error .

A Shared Subsystem may be divided into submodules or channels, hereafter called **Shared Subsystem Units** (or **Shared Units** for short), which can be individually controlled by an eTPU function (see Functions and threads)

NOTE

Shared Unit link service requests are level-sensitive to the eTPU . If it comes from an interrupt source, the link service request stays asserted as long as the interrupt is asserted and enabled, so the interrupt request must be cleared before the clear of the LSR flag in the link service request thread .

The table below summarizes the mapping of Reaction Module resources into Shared Subsystem Support .

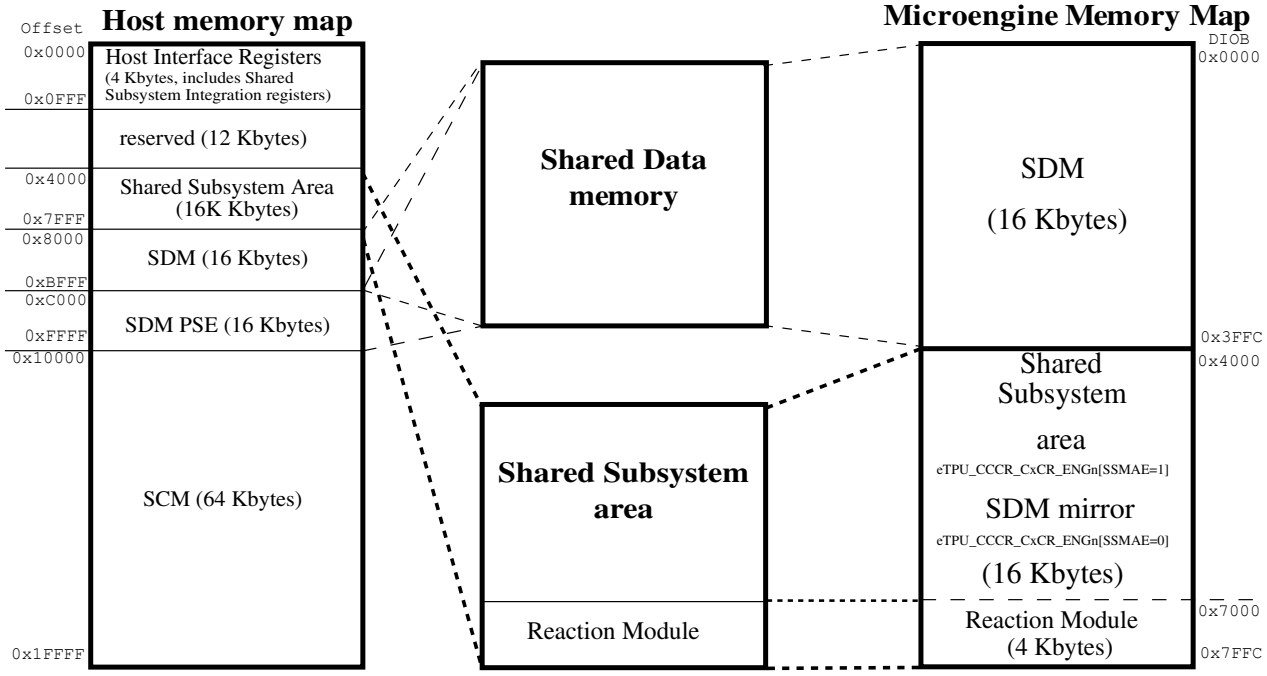


Figure 482. Shared Subsystem memory mapping

Table 465. Reaction Module Shared Subsystem support

Reaction Module resource	Host mapping	eTPU/microengine mapping
Register access	eTPU Base + 0×7000	DIOB address 0×7000 (indirect address mode)
Interrupts	See Interrupts chapter	Link Service Requests mapped through Subsystem Integration registers eTPU_SSIR_ETPUSSSIR*n*
DMA Requests	See eDMA chapter	Not applicable

67.3.14 Development support features

Following sections describe several features available to support development. Most debug features are accessible through a separate debug bus, and are not available through registers in the standard eTPU memory map. The details of the access to this interface are MCU-dependent (see Debug Interface chapter). The microengines can also be put in halt state by a device-level debug request.

NOTE

The behavior of the debug support logic is not specified in the event of a non-correctable memory error on either SCM or SDM (see Memory error support).

67.3.14.1 Nexus Class 3 Support

NDEDI is an IP block designed to support Nexus functionality for the eTPU. It provides a Nexus class 3 or class 1 debug interface, depending on the MCU (see Configuration section). Nexus is a development support external interface defined by the **IEEE standard ISTO 5001-1999**. More details about it can be found in the NDEDI details.

Some of the next subsections describe debug features provided by the eTPU microengine debug support combined with the NDEDI block.

67.3.14.2 Microengine Halt State

Halt is a microengine state where it suspends execution during a thread, or does not start executing a scheduled thread from idle state. While Idle State is entered from END execution without any other scheduled thread, microengine enters Halt State by any of the following events:

- execution of the HALT microinstruction (software breakpoint).
- external halt request through the Debug Interface (includes Nexus breakpoint request via EVTI input pin - see Nexus Class 3 Support).
- the other Engine enters halt state and they are configured to halt simultaneously (bit HTWIN is asserted via Nexus Interface).
- System level device debug request assertion and NDEDI register NDEDIETPUx_DC field CBI=1. If same register's field CBT=1, microengine halts at the next time-slot boundary, if CBT=0 it halts immediately. As a particular case, microengines come halted out of reset if is asserted, since CBI reset value is 1. Microengine does not execute out of reset, either in halt (asserted) or idle state (negated), but halt enables several other features (see below).
- occurrence of any of the hardware breakpoint conditions. See Hardware breakpoints for details.
- execution of a single-step microinstruction: microengine returns to halt state after executing a single microinstruction while in halt state. See Single-step Execution and Forced microinstruction execution for details.

When microengine enters halt state, it automatically triggers the following actions:

- Suspends input signal sampling and filters (respective Engine channels only), if NDEDI_ENGINEx_DC[PINS] = 1 at the Debug Interface.
- Releases the SDM arbitration for Host or CDC accesses, no matter if microengine was halted in the middle of a dual parameter (back-to-back) access.
- Stops TCR1/2 clocks of the respective Engine, if signal ndedi_stop_tcr is asserted at the Debug Interface.
- If the other Engine is also in halt state or stopped, allows turning the eTPU Module Configuration Register (MCR) VIS FIELD to 1.

If all halt conditions are cleared when VIS = 1, microengine(s) keep on halt state until VIS = 0, when it automatically exits halt state, except on single-step (see Single-step Execution), so that single-step execution is ignored while VIS=1.

MDU continues executing until it finishes any ongoing operation even if microengine is in halt state, except when the halted instruction is an END.

There are two kinds of halt state, depending on the previous microengine state when halted:

1. **halt_idle**, if the engine was not executing a thread when halted; the engine cannot leave halt_idle to fetch instructions, so one cannot single-step or follow a program flow; it can, however, execute forced instructions (see Forced microinstruction execution).
2. **halt_exec**, if the engine was executing a thread when halted. The engine can single-step and continue a program flow from halt_exec.

When microengine exits halt state, any dependable action is suspended and, if exiting halt_exec, the instruction pointed by the PC is fetched, while the instruction already fetched before halt is executed. Note that both the PC and the prefetched instructions can be modified during halt state, with a forced execution of a branch instruction (see Forced microinstruction execution).

67.3.14.3 Hardware breakpoints

Microengine can enter halt state through a command from the Debug Interface, configuring a hardware breakpoint. Hardware breakpoints can halt the microengine on specific conditions, listed below. These conditions depend on NDEDI configuration (see the NDEDI details for more information).

- CHAN register assignment (only by microcode, not by time slot transition).

- SDM read and/or write to a given address and/or write data. The breakpoint is always qualified by the SDM address, but the following variations are allowed:
  - break on write only, read only, or read-and-write.
  - break on higher-byte write data value, lower 24-bit write value, full word (32-bit) write value, or regardless of data. Break on read data is not supported.
- PC (program counter) value.
- Beginning of a thread with a Host Service Request pending.
- Beginning of a thread with a Link Service Request pending.
- Beginning of a thread with a Match Service Request pending.
- Beginning of a thread with a Transition Service Request pending.
- End of a thread.
- Illegal instruction execution.

All these conditions can also be qualified by the value of the CHAN register.

NOTE

Data breakpoints are not supported on Shared Subsystem Area accesses (see Shared subsystems support).

Hardware breakpoints halt the microengine before the halted instruction is executed, except on data breakpoints . Data breakpoints allow the instruction that performs the data access to be executed before the microengine is halted .

NOTE

Data breakpoints in eTPU versions before eTPU2 halt the breakpoint instruction before its execution in all cases, including data breakpoints .

On any of these conditions, halt of one microengine does not depend on the halt of the other, unless the other engine is configured to do so, via Nexus Interface. Occurrence of any of these conditions halts the microengine, that is, the conditions are logically ORed together, and they can be individually enabled.

While in halt state, the microengine can also execute any forced microinstruction not in the normal program flow (see Forced microinstruction execution) or, if in halt_exec, in single-step (see Single-step Execution).

There are situations when requests for stopping an engine, breakpoint and service can occur simultaneously. Breakpoint requests always prevails over a stop request (eTPU Engine 1 Configuration Register (ECR_ENG1) or eTPU Engine 2 Configuration Register (ECR_ENG2) bit MDIS = 1 or =1). When the eTPU is idle: stop request prevails over Service Request if there is not a hardware breakpoint request; a hardware breakpoint request leads to Debug mode immediately if there is no Service Request, and after TST if there is Service Request (regardless of stop requests). The rules above are summarized in the following table, showing the destination state of the microengine in each situation.

Table 466. Breakpoint, stop and service requests resolution from idle

Breakpoint request	MDIS	Service request	Final state
no	0	0	Idle
no	1	0	Stop
no	0	1	TST
no	1	1	Stop
Yes	0	0	Halt_idle

Table continues on the next page...

Table 466. Breakpoint, stop and service requests resolution from idle (continued)

Breakpoint request	MDIS	Service request	Final state
Yes	1	0	Halt_idle
Yes	0	1	TST
Yes	1	1	TST

When a thread is ending, it goes to Idle or TST only if there is neither a hardware breakpoint request nor a request to stop (eTPU Engine 1 Configuration Register (ECR_ENG1) or eTPU Engine 2 Configuration Register (ECR_ENG2) bit MDIS = 1 or =1). When thread is ending and there are simultaneous hardware breakpoint and stop (MDIS=1 or =1) requests, hardware breakpoint prevails and the engine enters Debug mode (Halt_idle state).

If the engine entered Debug mode after a thread finished (Halt_idle state) and a "go" command comes from the debug interface, the engine state machine goes to Idle and the rules above apply. It means that if a "go" is issued in Halt_idle state with MDIS=1, the engine goes to Idle for one microcycle and then stops (if MDIS or keeps asserted and there is no other breakpoint request).

NOTE

Hardware breakpoint requests are ignored for the first microinstruction executed when microengine leaves halt.

67.3.14.4 Hardware Watchpoints

Debug Interface allows watchpoints on the same conditions available for hardware breakpoints (see Hardware breakpoints).

NOTE

Data breakpoints are not supported on Shared Subsystem Area accesses (see Shared subsystems support) .

67.3.14.5 Software breakpoints

A software breakpoint occurs when microengine executes a HALT microinstruction. Any number of software breakpoints can be set in code, usually replacing an active microinstruction.

Like any other microinstruction, HALT increments the PC and pre-fetches the next instruction. So, before the halt state is suspended, if the original program flow must be followed, the original instruction at the HALT address must be executed, regardless if the software breakpoint is removed (replacing HALT by the original microinstruction) or not. Follows the procedure to resume execution from a software breakpoint:

1. restore the original instruction in SCM (replace HALT).
2. force a jump with flush to the original instruction (see Forced microinstruction execution).
3. if the software breakpoint must be kept: single-step and replace the original instruction with a HALT.
4. let the flow continue, issuing a GO command (leaving halt state).

Special care must be taken if HALT is followed by another HALT, and the second HALT is removed when microengine was halted by the first one. In this case, replacing the second HALT with the original microinstruction is not enough to remove the second breakpoint, because the second HALT was already prefetched and would be executed anyway when halt was suspended. The debugger must also do a forced execution of unconditional branch with flush to the original microinstruction address. That will clear the pipeline, replacing the prefetched instruction with a NOP, and load PC with the address of the removed breakpoint. So, when halt state is suspended, the original microinstruction will be fetched while NOP is executed, and program flow continues normally from then on.

NOTE

A HALT instruction placed after a no-flushing branch, dispatch or return may be a problem from the debugger application standpoint: after the HALT is executed, the eTPU debug interface informs the address of the branch/dispatch/return destination, and the debugger application has no direct way to identify which HALT instruction was executed, if multiple HALTs lead to the same address. This can be solved if the debug support block (NDEDI) has a register holding the address of the last instruction executed, otherwise one should forbid non-flushed HALT instructions. See the NDEDI details.

Software breakpoint setting and removal is possible only with SCM RAM implementations or ROM implementations with SCM RAM emulation (see SCM Emulation). There is only one way of inserting software breakpoints into SCM RAM: programming VIS=1 in eTPU Module Configuration Register (MCR), and then accessing SCM as an ordinary RAM from the bus. This can be done only if both Engines are halted or stopped.

67.3.14.6 Single-step Execution

When microengine is already in halt_exec state, it can run the next microinstruction in the normal program flow and get back to halt state. PC is incremented, or assigned the BAF value in a branch with satisfied condition. Note that the executed instruction was already prefetched in the instruction pipeline, and a new microinstruction is fetched during its execution. The prefetched instruction may be cleared during halt state by the forced execution of a branch with flush (see Forced microinstruction execution), making single-step execute a NOP instead of the next instruction in the program flow.

Single-step execution is controlled by the debug interface, and is a feature available from Nexus if eTPU is connected to the NDEDI block (see NDEDI details).

The single-step execution of a NOP instruction can be useful to control input signal sampling and filtering, if NDEDI_ENGINEx_DC[PINS] = 1 at the Debug Interface (see NDEDI details). Single-step does not happen if VIS=1.

67.3.14.7 Forced microinstruction execution

When microengine is already in halt state (either halt_idle or halt_exec), it can run forced microinstructions through the debug interface. This feature is available from Nexus if eTPU is connected to the NDEDI block (see NDEDI details). The microinstruction, specified by the user, is not fetched from SCM and comes directly from the debug interface. MDU start commands issued by forced instructions are executed, and the MDU runs the operation until the end, independently of the halt state. The microinstruction field END is ignored.

During forced execution of any instruction except Branches, Returns and Dispatches, the PC does not change, and the prefetched instruction in the pipeline is bypassed, but not discarded. When halt state is suspended, the prefetched instruction is executed and the instruction pointed by the PC is prefetched in parallel (two-stage pipeline).

Forced execution of a Branch, Dispatch or Return loads the PC with the BAF field (if branch condition is satisfied), PC+P or RAR, respectively. If branch condition is not satisfied, PC value stays unaltered. The flush control (field FLS) also works, so that a successful forced branch with flush replaces the prefetched instruction with a NOP. So, to clear the instruction pipeline during halt, all one has to do is an unconditional branch to the desired address with flush. HALT instructions must not be executed as forced.

Forced operations that depend on the serviced channel are unspecified when executed in halt_idle and must be avoided.

NOTE

Forced instructions must not be commanded when MCR[VIS] = 1.

67.3.14.8 Microengine Register Access

eTPU provides no direct access to microengine and channel registers from the bus or any other interface. However, these registers can be read and written in halt state by executing forced microinstructions (see Forced microinstruction execution). Immediate data microinstructions may be used to set register values. Some registers are not selectable for immediate data destination, so intermediary register(s) - notably P - may have to be used to carry the desired new value to the target register in two or more microinstructions. Usually the previous values of intermediary register(s) must be previously saved and restored after the whole operation.

Similar procedures apply for register reads: their contents must be dumped to SDM, where they can be read from the bus.

67.3.14.9 Microengine Flag Access

Microengine halt state allows reading the branch conditions flags through forced microinstructions or, more easily, through the NDEDI register NDEDI_ENGINEx_CFSR (see the NDEDI details). Flag conditions set by the user are seen by microengine for the next microinstruction execution. The flag set options are limited by the possibilities of forced microinstruction execution.

If the eTPU runs (not single-stepping) after exiting the halted state, the conditions modified during halt may remain only for the first microcycle after the halted state. After the first microcycle, branch conditions are altered only according to their regular update scheme.

67.3.14.10 Microengine Stall

Microengine can get into a stall state, attending a request from a debug interface signal assertion. The reason for a Stall request from NDEDI (or from any other debug support block) should be a temporary lack of resources, for instance queue full. During stall the microengine suspends execution, but all the other Engine logic continues operating: time bases, angle logic, channel logic, input sampling and filters. Stall differs from Halt, not enabling any of the debug features that Halt enables (see Microengine Halt State). It also does not break an atomic microengine access, unlike halt.

The Microengine can be stalled when idle and from the moment TST ends, before executing the first thread microinstruction, until just before the last thread microinstruction is executed. Stall requests are ignored in any other occasions. Microengines in a dual engine system can be independently stalled. If a forced end is issued when microengine is in stall coming from execution, the END is executed only when the microengine resumes execution from stall.

67.3.15 SCM Emulation

If SCM is implemented as ROM, an external RAM may be used to replace it, allowing code patching and software breakpoint setting for debugging purposes. SCM ROM replacement by Emulation RAM is MCU-dependent. The SCM may even be divided into a ROM part and a RAM part. In this case, both microengines can run code from both ROM and Emulation RAM. It is possible to make one Engine run code from RAM and the other from ROM, by using different Entry Tables. The SCM visibility conditions also apply to Emulation RAM.

All SCM implementations, either RAM, ROM or Emulation RAM, are external to the eTPU block. eTPU provides a signal to enable the switching between external SCM banks. The conditions for this switching are:

1. Both Engines stopped.
2. VIS bit = 0.

Note that these conditions also stop the clocks of the SCM interface and MISC logic.

67.3.16 Safety features

This section describes embedded safety features: MISC and memory error support.

The Multiple Input Signature Calculator (MISC) is an SCM test feature accessible through eTPU Module Configuration Register (MCR). MISC allows SCM test "on the fly", that is, while eTPU is running, with no impact on eTPU functionality or performance.

Memory Error support features comprise SCM and SDM error detection, correction, report, and soft error.

67.3.16.1 SCM test - multiple input signature calculator

The Multiple Input Signature Calculator (MISC) comprises special hardware that sequentially reads all SCM positions and calculates, in parallel, a 32-bit signature from a 32-input CRC signature calculator with the following polynomial:

$$1 + x^{1} + x^{2} + x^{22} + x^{31}$$

A complete description of the signature calculation procedure can be found in MISC algorithm.

Once started by the Host the MISC runs continuously, restarting after the completion of each cycle, when it sets MCR[SCMMISC]. The average time for a MISC calculation can be measured by checking SCMMISC state at regular intervals, incrementing a counter and clearing SCMMISC if it is set.

MISC accesses to the SCM array are executed if none of the engines is accessing the SCM, to avoid degradation of the microengine performance: it happens while no channel is being serviced. An ongoing MISC operation can be aborted by writing 0 to SCMMISEN.

The Host must load eTPU MISC Compare Register (MISCCMPR) with the expected value to be found at the end of the MISC cycle, and then start the signature calculation by programming field SCMMISEN = 1 in eTPU Module Configuration Register (MCR). MISC zeroes the signature accumulator and starts reading SCM data and calculating the signature. After last SCM position is read, MISC compares the value in signature accumulator against the value in eTPU_SCR_MISCCMPR: if there is a mismatch MISC stops, a Global Exception is issued and MCR[SCMMISF] assumes value 1. If no mismatch is found, MISC repeats the procedure automatically. When signature is being calculated, SCM address starts at the last SCM address and counts down to 0. The conditions for executing a MISC operation are (see also SCM low power):

- Both microengines in idle state (no channel is being serviced) or stopped, in any combination (e.g., engine 1 idle with engine 2 stopped).
- MCR[VIS] = 0.
- MCR[SCMMISEN] = 1.

Note that MISC can run regardless of SCM implementation type (RAM or ROM).

If SCMMISEN=0 or VIS=1, the MISC logic stays at its initial state, with address counter pointing to the last SCM position and accumulator reset.

MISC can also be used to perform single-bit error fixes in the SCM . For more details, see Error fixing .

67.3.16.1.1 MISC algorithm

The MISC generator is based on the following polynomial:

$G(x) = 1 + x^1 + x^2 + x^{22} + x^{31}$ (equivalent to feedback mask = 0x80400007)

The MISC signature generation starts by clearing the MISC Accumulator value to 0 and preloading the MISC Counter with the highest SCM address. It then steps through each address decrementing the counter, reading 32 bit values and following the algorithm below:

```
If the least significant bit in MISC is 1 then
    MISC = MISC right shifted by 1 bit
    MISC = MISC XOR 0x80400007
else
    MISC = MISC right shifted by 1 bit
end if
MISC = MISC XOR RAM data
```

The code example below shows an excerpt of C code that calculates the MISC signature for a given array of data, based on the previous algorithm:

```
#define SCM_size    (MAX_SCM_ADDRESS / 4)    /* last byte address - converted to 32-bit word */
#define POLY        0x80400007               /* G(x) = 1 + x^1 +x^2 + x^22 + x^31 */
/*****************************************************************************
 FUNCTION : void calc_misc()
 PURPOSE : This function calculates the MISC value.
 INPUTS NOTES : none
 RETURNS NOTES : MISC value
 GENERAL NOTES : the array 'unsigned int data[]' represents the actual memory
                 array, organized in 32-bit words.
*****************************************************************************/
unsigned int calc_misc (void)
{
```

```
  int j; /* loop counter */
  unsigned int misc = 0;
  for (j = (SCM_size-1); j >= 0 ; j--) {   /* SCM_size has the number of 32-bit words in SCM */
      if (misc & 0x1) {
          misc >>= 1;
          misc ^= POLY;
      }
      else {
          misc >>= 1;
      }
      misc ^= data[j];          /* data[j] is the actual 32-bit word taken from the SCM array
*/
  }
  return (misc);          /* final signature calculated */

};
```

The value calculated by this algorithm must be loaded into eTPU MISC Compare Register (MISCCMPR) prior to activating the SCM MISC calculator in eTPU. Once the MISC calculator is activated (bit SCMMISEN in register eTPU Module Configuration Register (MCR) is written to 1) eTPU itself will start this procedure[31] reading the SCM whenever allowed by microengine. At the end of the cycle, when all the array has been read and the SCM signature is calculated, the Host CPU can be notified via Global Exception if the MISC Accumulator does not match the value in eTPU_SCR_MISCCMPR.

The average time taken by MISC to complete the signature of the whole SCM can be given by the formula:

```
Average MISC period = S / (4 * F * (1 - L))
```

where f is clock frequency, S is SCM size in bytes and L is eTPU load (as a percentage of execution clocks over a period of time, including TST clocks).

Further detail on MISC calculation can be found on SCM test - multiple input signature calculator. The application note **AN2192 - Detecting Errors in the Dual Port RAM (DPTRAM) Module** is also a good source of information (although it refers to TPU) on MISC signature.

67.3.16.2 Memory error support

Error Correction Code (ECC) support for SDM and SCM provides guaranteed single bit error correction and double bit error detection . Error detection and correction is performed on read accesses and on write accesses less than 32-bit wide to the SCM .

SDM ECC is calculated per byte, 5 bits wide each, totalling 20 ECC bits for each 32-bit word . That allows the ECC to be updated without a read-modify-write operation on writes of any size .

Error is not checked on bytes not selected on SDM read accesses, either by the Host, CDC or microengine . For instance, the most significant byte is not checked for errors on a microengine 24-bit read access .

Error detection also works for host accesses to the PSE area (see Parameter Sign Extension area) . In this case, error is not detected in the most significant byte (bits) . Also, because of sign extension, error is always detected on the bits , regardless if they are selected, whenever the most significant byte is read .

SCM ECC is 7 bits wide, comprising the whole 32-bit word . Read-modify-write is automatically made when 16-bit or 8-bit wide writes are made into the SCM in a host access . SCM errors are also detected on Entry Table accesses during TST (see Time Slot Transition) and on MISC accesses, which are considered microengine accesses with regards to interrupt generation and error reporting .

[31] eTPU MISC hardware is optimized to read 32-bit words from memory and to calculate this CRC in parallel, rather than shifting one bit at a time. The actual implementation inside eTPU, although bringing to the same results, does not match exactly the algorithm shown here.

67.3.16.2.1 Error detection disabling

The error detection logic in SDM and SCM can be disabled by setting the eTPU Memory Error Control Register (MECR) bits DEDD and CEDD, respectively . The disabled state turns ineffective any action due to error detection, including error correction . Note that error detection is always enabled out of reset .

67.3.16.2.2 Memory error flags

SDM single (correctable) and non-correctable bit errors are flagged in eTPU Memory Error Status Register (MESR) fields DCERR and DNCERR, respectively.

SCM correctable and non-correctable errors are flagged in the eTPU_MESR_MESR fields CCERR and CNCERR, respectively .

Double bit errors are guaranteed to be flagged, while three or more simultaneous bit errors in an SDM byte or SCM word are not . An error flagged as non-correctable can be in two or more bits .

Overrun flags DCOVR and CCOVR indicate, for SDM and SCM respectively, when a correctable error occurs when DCERR, CCERR are already asserted . Similarly, overrun flags DNCOVR/CNCOVR assert when a non-correctable error occurs when DNCERR/CNCERR are asserted already .

67.3.16.2.3 Memory error reports

The address, syndrome and data of a non-correctable SDM access can be sampled into eTPU Data Error Report Address Register (DERAR), eTPU Data Error Report Syndrome Register (DERSR), and eTPU Data Error Report Data Register (DERDR), respectively. DERAR also captures the SDM read access originator, whether the host, CDC, or specific eTPU channel service .

Similarly, non-correctable SCM accesses address, syndrome and data are stored in eTPU Code Error Report Address Register (CERAR), eTPU Code Error Report Syndrome Register (CERSR), and eTPU Code Error Report Data Register (CERDR), respectively . eTPU_MESR_CERAR also captures the SCM read access originator, whether the host, MISC, or specific eTPU channel service . The occurrence of a non-correctable error overwrites the report register values from a correctable error, either on SDM (DCERR=1) or SCM (CCERR=1) .

The last address, syndrome and data of a correctable SDM access can also be sampled into eTPU_MESR_DERAR, eTPU_MESR_DERSR, and eTPU_MESR_DERDR, but only if MESR[DNCERR] is 0 . That prevents access address, syndrome and data from a correctable error to overwrite the same information from a non-correctable access .

Similarly, the last address, syndrome and data from a correctable SCM access are stored in eTPU_MESR_CERAR, eTPU_MESR_CERSR, and eTPU_MESR_CERDR only if MESR[CNCERR] is 0 .

For either SDM or SCM, a new correctable error overwrites the report registers' values from an earlier correctable error, but report values from a non-correctable error are not overwritten, as long as bit DNCERR/CNCERR is asserted, neither by a new correctable error nor by a non-correctable one .

The sampling of SDM and SCM error report registers can be disabled through the eTPU_MESR_MECR fields DRDIS and CRDIS, respectively . When DRDIS (CRDIS) is asserted, the update of the SDM (SCM) error report registers is disabled, but not of eTPU_MESR_MESR fields DCERR, DNCERR (CCERR, CNCERR) . DRDIS, CRDIS must be set before reading the respective report registers to assure their coherent reading, preventing them to be updated between reads .

67.3.16.2.4 Error detection and wait states

Microengine SDM accesses do not take any wait state due to ECC support . Host SDM read accesses take two wait-states minimum in MCUs with SDM ECC support, regardless if an error was detected or not, if the SDM error detection is enabled (eTPU Memory Error Control Register (MECR) field DEDD = 0) . Host SDM read accesses take a minimum of one wait state if the SDM error detection is disabled (MECR[DEDD] = 1) . Host SDM write accesses take one wait state minimum, regardless of ECC support presence or enabling .

Host SCM read accesses have two wait-states, regardless if an error was detected or not . Writes from the host to the SCM take one wait state on 32-bit accesses, and one additional wait state (two wait-states total on 16-bit and 8-bit wide accesses . Those figures are not affected by the SCM error detection disabling (eTPU_MESR_MECR[CEDD]) .

[32] One wait-state more, compared with eTPU versions before eTPU2 and previous eTPU2 without ECC support

67.3.16.2.5 Memory error interrupts

For **microengine accesses**, the Global Exception interrupt asserts whenever a non-correctable error is detected, either on SCM or SDM (see Interrupts and data transfer requests) . These errors are flagged by eTPU Module Configuration Register (MCR) fields SCMERR and SDMERR, respectively. Single bit errors are corrected and activate the Memory Error Correction Interrupt if it is enabled (see Interrupt types and sources), but do not generate Global Exceptions .

For **host accesses** a bus error is issued whenever a non-correctable error is detected, either on SCM or SDM (but not through the CDC) and it also generates a Global Exception . Single bit errors are corrected (if the error correction feature is available) and do not cause bus transfer errors, but assert the Memory Error Correction Interrupt if it is enabled (see Interrupt types and sources) .

67.3.16.2.6 Effect of errors on microcode execution

Correctable errors, either on SCM or SDM, do not affect microcode execution if detection/correction is enabled.

The executing thread is affected by a non-correctable SDM error as follows:

- If MECR[DTEND] = 1: on SDM errors due to a read operation, if the instruction is not also an END, the following instruction automatically executes an END, and its operations may be executed, totally or partially. On SDM errors during the TST preload, the thread automatically ends on the first instruction, if the error occurs on a preload parameter selected by the entry point bit PP (see Entry Point Format section.) The first instruction may be executed totally or partially. Data read into P or DIOB may be corrupted in either case.
- If MECR[DTEND] = 0: the TST or thread continues the execution flow normally. Data read into P or DIOB may be corrupted in either case.

The executing thread is affected by a non-correctable SCM error as follows:

- If MECR[CTEND] = 1: on SCM errors, the corrupted instruction is not executed, instead replaced by a simple END. Due to instruction prefetching, an error may be detected and yet not affect the thread execution. However, an error detected in a prefetched instruction may cause error report and global or memory error interrupts, even if not executed. If a non-correctable error occurs on the entry table read during TST (see Time Slot Transition section), the first instruction in the thread is replaced with a simple END, a global exception is issued and the reports and flags are normally updated.
- If MECR[CTEND] = 0: the execution flow continues normally, and the results depend on the particular instruction corruption.

Table 467. Error support summary if CEDD = DEDD = 0

Action		SCM		SDM	
		single bit error	double bit error	single bit error	double bit error
Memory Error Correction Interrupt		Asserts	Not asserted	Asserts	Not asserted
Global Exception		Not asserted	Asserts	Not asserted	Asserts
Bus Error (host reads)		Not issued	Issued	Not issued	Issued
Thread	CTEND = 0	Normal execution	Potential erroneous execution[1]	Normal execution	see DTEND
	CTEND = 1		Terminates before erroneous execution[2]		
	DTEND = 0		see CTEND		Potential erroneous execution
	DTEND = 1				Terminates after erroneous read[3]

Table continues on the next page...

Table 467. Error support summary if CEDD = DEDD = 0 (continued)

Action		SCM		SDM	
		single bit error	double bit error	single bit error	double bit error
Code Error Report Registers	CNCERR = 0	Updates eTPU_MESR_CERAR, eTPU_MESR_CERSR, eTPU_MESR_CERDR		Not related	
	CNCERR = 1	eTPU_MESR_CERAR, eTPU_MESR_CERSR, eTPU_MESR_CERDR not updated			
Data Error Report Registers	DNCERR = 0	Not related		Updates eTPU_MESR_DERAR, eTPU_MESR_DERSR, eTPU_MESR_DERDR	
	DNCERR = 1			eTPU_MESR_DERAR, eTPU_MESR_DERSR, eTPU_MESR_DERDR not updated	

1. The thread executes correctly if the error is detected on an instruction fetched but not executed.
2. The erroneous instruction is not executed at all, and replaced by a simple END.
3. The instruction following the erroneous read may be executed totally or partially.

67.3.16.2.7 Error Correction Code (ECC) and syndrome definition

SDM ECC is composed of 5 Hsiao code[33] bits for each data byte . **SCM ECC** is composed of 7 Hsiao code bits for each 32-bit word .

The following table shows the encoding of the SDM syndrome and global parity fields as they read in eTPU Data Error Report Syndrome Register (DERSR) . There is one syndrome and one global parity for each byte in an SDM word, numbered SYND0 to SYND3 from the least to the most significant .

Table 468. SDM syndrome definition

SYNDn (hex)	Result	SYNDn (hex)	Result
0E	error on data bit 8n+7	10	error on **code** bit 8n+4
15	error on data bit 8n+6	08	error on **code** bit 8n+3
07	error on data bit 8n+5	04	error on **code** bit 8n+2
1A	error on data bit 8n+4	02	error on **code** bit 8n+1
19	error on data bit 8n+3	01	error on **code** bit 8n
13	error on data bit 8n+2		
16	error on data bit 8n+1	00	no error
1C	error on data bit 8n	any other	non-correctable error

[33] Hsiao, M.Y;.A Class of Optimal Minimum Odd-weight-column SEC-DED Codes; IBM Journal of Research and Development http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5391627

The following table shows the definition of the SCM syndrome field as it reads in eTPU Code Error Report Syndrome Register (CERSR).

Table 469. SCM syndrome definition

SYND (hex)	Result	SYND (hex)	Result	SYND (hex)	Result
40	error on **code** bit 6	58	error on data bit 25	46	error on data bit 11
20	error on **code** bit 5	0B	error on data bit 24	4A	error on data bit 10
10	error on **code** bit 4	54	error on data bit 23	52	error on data bit 9
08	error on **code** bit 3	15	error on data bit 22	62	error on data bit 8
04	error on **code** bit 2	16	error on data bit 21	13	error on data bit 7
02	error on **code** bit 1	34	error on data bit 20	29	error on data bit 6
01	error on **code** bit 0	25	error on data bit 19	31	error on data bit 5
		26	error on data bit 18	43	error on data bit 4
49	error on data bit 31	64	error on data bit 17	45	error on data bit 3
0D	error on data bit 30	2C	error on data bit 16	19	error on data bit 2
0E	error on data bit 29	1A	error on data bit 15	51	error on data bit 1
38	error on data bit 28	23	error on data bit 14	61	error on data bit 0
4C	error on data bit 27	2A	error on data bit 13	00	no error
1C	error on data bit 26	32	error on data bit 12	any other	non-correctable error

67.3.16.2.8 Error injection

Errors can be injected into the SDM read data path through eTPU Data Error Injection Address Register (DEIAR), eTPU Data Error Injection Data Pattern Register (DEIDPR) and eTPU Data Error Injection Parity Pattern Register (DEIPPR). They define bit flips on accesses at the specific address specified in eTPU Data Error Injection Address Register (DEIAR).

SDM error injection is enabled independently for host and microengine accesses by the eTPU Memory Error Control Register (MECR) fields HDEIE and MDEIE, respectively. You must program DEIAR, DEIDPR, and DEIPPR with HDEIE = MDEIE = 0, and only then enable error injection by setting HDEIE = 1 and/or MDEIE = 1 to avoid races (see eTPU Memory Error Status Register (MESR)).

Similarly, SCM errors can be injected into the SCM read data path through eTPU Code Error Injection Address Register (CEIAR), eTPU Code Error Injection Data Pattern Register (CEIDPR) and eTPU Code Error Injection Parity Pattern Register (CEIPPR), enabled by the eTPU Memory Error Control Register (MECR) field CEIE. Errors are injected on host accesses to the address specified in CEIAR when MCR[VIS]=1, or on microengine and MISC accesses when VIS=0 .

67.3.16.2.9 Error fixing

Single bit **soft errors** can be fixed by rewriting the right value, as corrected by the ECC logic, into the same address of the erroneous data . eTPU provides means to perform such fixes safely, coherently and concurrently with the normal operation .

SDM fixes can be done using the CDC (see Coherent Dual-parameter Controller (CDC)), limited to the lower 8 KB of SDM . The Host application simply has to program a transfer with both origin and destination positions pointing to the address of the data to be fixed . Because the PBBASE field has an address granularity of 8 bytes, a word adjacent to the one to be fixed must also be rewritten . The CDC transfer is atomic, therefore the fix is done coherently and does not interfere with the application code or data flows .

SCM fixes can be done by programming CEFR[CFIXM] (see eTPU Code Error Fix Register (CEFR)) . The fixes are performed by the MISC logic, which must be enabled (see SCM test - multiple input signature calculator) . The modes available, selected by CEFR[CFIXM], are:

- **Automatic Fix Mode (CFIXM = 11)**: the MISC logic automatically rewrites the contents of an address whenever it finds a correctable error; the CFIXM field keeps its value if a fix is made .

67.3.17 Performance monitoring features

67.3.17.1 Idle Counter

The Idle Counters eTPU Idle Register for Engine 1 (IDLER_ENG1) and eTPU Idle Register for Engine 2 (IDLER_ENG2) continuously count microcycles in which the microengine is not busy with channel service . They can be used to measure the microengine utilization by rating the count measured during a period of time to the number of microcycles contained in the period. The Idle Counters do not count microcycles when the engine is stopped, or is in TST or halt states.

67.3.17.2 Watchdog Monitor Operation

The watchdog mechanism can also be used to monitor, without interfering with the application execution, whether the execution time of any individual thread or a sequence of threads reaches a given limit. This can be achieved by asserting the WMO field in eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1) and eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2).

67.4 Detailed signal descriptions

Detailed signal descriptions are presented in the following sections.

67.4.1 eTPU channel output signals

Each signal is associated with a channel. The microcode may affect the logic level of an output signal[34] by implementing one of two actions:

- Specify the logic level output to the signal when there is a match or a transition.
- Immediately force a logic level.

The output signal may also be forced to a logic level, independently of the output value from the channel logic, by one of the four (each Engine) output disable input signals (see eTPU channel output disable signals).

The output buffer enable signals are not used.

67.4.2 eTPU channel input signals

Each signal is associated with a channel. The microcode can directly control the effect of the transition edge. Each channel can be programmed to sense a transition when a rising and/or falling edge is detected. The channel logic can also process two transition events, and relate these events to each other and to other programmed timer events. The edge sensitivities of the two transition events are configured independently by microcode. For further information refer to Enhanced Channels and Transition Detection and Pin Action Control.

Each channel input signal has an associated synchronizer made of two flip-flops sampling the signal on every other eTPU clock[35], followed by a digital filter. This digital filter can work in three sub-modes, whose purpose is to filter out noise pulses that have width

[34] Note that the minimum pulse width is one microcycle (two eTPU clocks), and slow pads may not be able to transfer it on time. For generation of very short pulses the eTPU pads have to be programmed by the system integration for fast operation mode with the voltage levels defined for fast pad operation in the MCU technology.

less then a programmed value of eTPU clocks, preventing these transitions from being input to the transition detect logic. The synchronizer and digital filter are guaranteed to pass pulses that are greater than a programmed value. All channel input filters in one Engine work on the same mode and sampling clock. For more information on channel input filters, refer to Enhanced digital filter (EDF). In one of the Angle Modes, the output of the digital filter of channel 0 is replaced by the output of TCRCLK signal digital filter (see EAC - eTPU Angle Counter).

67.4.3 Time base clock signal (TCRCLK)

is an input signal used to control the Time Bases TCR1 and TCR2. There is one independent TCRCLK input for each Engine. For pulse accumulator operations TCRCLK can be used as a gate for a counter based on the eTPU clock divided by eight. For Angle operations TCRCLK can be used to get the tooth transition indications in Angle Mode. Further details can be found on Time bases and EAC - eTPU Angle Counter.

Like the channel input signals, the TCRCLK signal has an associated synchronizer followed by a digital filter. This digital filter can work in two submodes, whose purpose is to filter out noise pulses that have width less than a programmed value of eTPU clocks, preventing these transitions from being input to the transition detect logic. The synchronizer and digital filter are guaranteed to pass pulses that are greater than a programmed value. The clock and operation submode of the TCRCLK filter is configured independently of the other channel input filters, through the TCRCF field in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2). For more information on filter submodes, see TCRCLK digital filter. In one of the Angle Modes, the output of the digital filter of channel 0 is replaced with the output of TCRCLK signal digital filter (see EAC - eTPU Angle Counter).

67.4.4 eTPU channel output disable signals

Each of these four input signals are used to force the outputs of a group of 8 channels to an inactive level. When an input is active, all the channels in its group of 8 that have their fields ODIS=1 in C*a*CR_ENG1 and C*a*CR_ENG2 have their outputs forced to the opposite of the value specified in bit OPOL of the same register. Therefore, channels can be individually selected to be affected by the output disable signals, as well as their disabling forced polarity (see 'Pin State Input/Output Logic' figure in Pin Control Registers).

See the chip-specific eTPU information for details on the output channel disable group definition.

In a Dual-engine eTPU there are 8 output disable signals for the 64 channels.

67.4.5 Event in (EVTI)

Event In (EVTI) is used to initiate program and data trace synchronization messages or to generate a breakpoint. EVTI is edge-sensitive for synchronization and breakpoint generation.

67.4.6 Event out (EVTO)

Event Out (EVTO) is an output pin to development tools comprising exact timing for a single watchpoint or breakpoint occurrence. EVTO is asserted for 1 MCKO clock.

67.4.7 Breakout EVTI/O

Break events and event outputs will be generated due to any of the following breakpoint types:

- Exit of System Reset
- DBR assertion
- TWIN Engine
- SW
- MISC Error
- Illegal Instruction

[35] Sampled on the T4 microcycle phase, see Microcycle and I/O timing.

- Single Step
- EVTI
- External (ipg_debug)

The events are namely:

- BCRW (Break on Channel Register Write)
- BHSR (Break on Host Service Request)
- BLINK (Break on Link Service Request)
- BMRL (Break on Match Recognition Request)
- BTDL (Break on Transition Detect Request)
- DBR (Debug Request)
- SS (Single Step)
- SW (Software Breakpoint)
- MISC (MISC Error)
- SRBP (Software Reset Breakpoint)
- TWIN (TWIN Engine)
- EXTE (External Debug)
- EVTI (EVTI Input)
- IIBP (Illegal Instruction Breakpoint)

67.5 Initialization/application information

67.5.1 Configuration sequence

After initial power-on reset the eTPU remains in an idle state, requiring initialization of several registers before any function can begin execution. Also, SCM should be initialized with the eTPU application code prior to configuring the eTPU. Configuration procedures are summarized as follows:

1. Load the eTPU application code into SCM (see SCM access).
2. Initialize SDM (optional if no ECC support is available)
3. Initialize the SCM MISC logic (optional, see SCM test - multiple input signature calculator).
4. Initialize Watchdog (optional).
5. Initialize eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2) to set up:
   - TCR1 and TCR2 prescalers and clock sources.
   - Select digital filtering mode.
   - TCRCLK signal filter control.
   - Angle mode operation (if necessary).
6. Initialize eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2) to set up:
   - Entry table base.

[36] Except when is asserted on power-on reset: in this case, the microengines wake-up in halt state.

- Filter prescaler clock control.

7. Initialize eTPU Engine 1 STAC Configuration Register (STAC_ENG1) and eTPU Engine 2 STAC Configuration Register (STAC_ENG2) if you must set up TCR1/2 resource Client/Server operation.
8. Write to C*a*CR_ENG1 and C*a*CR_ENG2 to choose the function to be performed by each channel, and its parameter base address.
9. Write to C*a*SCR_ENG1 and C*a*SCR_ENG2 to choose among the possible variations within the function flow (FM fields).
10. Write to SDM for parameter initialization of each configured channel.
11. Write to eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1) and eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2) if you must enable and set up the Watchdog(s) mode and timeout.
12. Write to C*a*HSRR_ENG1 and C*a*HSRR_ENG2 to initialize the active channels.
13. Write to eTPU Channel Interrupt Enable Register for Engine 1 (CIER_ENG1) and eTPU Channel Interrupt Enable Register for Engine 2 (CIER_ENG2) if interrupts are to be enabled from the appropriate channels. Likewise for Data Transfer Requests (eTPU Channel Data Transfer Request Enable Register for Engine 1 (CDTRER_ENG1) and eTPU Channel Data Transfer Request Enable Register for Engine 2 (CDTRER_ENG2)). This can also be done through C*a*CR_ENG1 and C*a*CR_ENG2.
14. Write to C*a*CR_ENG1 and C*a*CR_ENG2 to enable each channel by assigning it a high, middle, or low priority (CPR field).
15. Monitor C*a*HSRR_ENG1 and C*a*HSRR_ENG2for completion of initialization.
16. Write #unique_3078/unique_3078_Connect_42_MCR.GTBE = 1 to start TCR1/TCR2 timebase counting at same time in both Engines (may be done before or never, depending on the particular application and use of Red Line bus).

67.5.2 Reset options

67.5.2.1 Hardware reset

Hardware reset is achieved by assertion of device synchronous reset. Both Engines and common logic is reset, and even the System Configuration and Global Channel registers assume their reset values.

NOTE

All eTPU input clocks must pulse during reset so that both engines are reset, even if they are in Module Disable or Stop mode.

67.5.2.2 Software reset

eTPU has no software reset. To abort infinite microcode loops, the Force END mechanism must be used (see field FEND in eTPU Engine 1 Configuration Register (ECR_ENG1) and eTPU Engine 2 Configuration Register (ECR_ENG2)).

67.5.3 Multiple parameter coherency methods

Follows a description of two methods for coherent transfer of multiple parameters between Host and eTPU. Both methods involve the use of two parameter areas: the Transfer Parameter Area (hereafter called TPA), which is the SDM area directly accessed by the Host for reads and writes, and the Permanent Parameter Area (hereafter called PPA), which are the SDM positions where channel parameters are normally accessed by the Function microcode. Note that parameters in either TPA or PPA do not have to be in sequential addresses. TPAs and PPAs allocation are completely defined by the application, and there may be any number of them, independently of the channels.

The methods described here are not the only solutions for the coherent transfer problem, and both can coexist in eTPU and even used in combination. Also note that for transfers of a pair of parameters, the Coherent Dual-parameter Controller is faster and have less impact on both eTPU and Host performance. That said, the methods are:

- **Transfer Service**: a microengine thread transfers, upon Host Service Request, data from/to a TPA to/from a PPA.Coherency is guaranteed by the fact that a thread is atomic with respect to other threads in the same Engine, and so are its transfers. If parameters in PPA are shared by both Engines, hardware semaphores have to be used to access them.
- **Mailbox**: for Host to eTPU transfers, the microcode checks a flag, set by the host, indicating the existence of new parameter data in the TPA. It can, then, either access TPA data directly or copy it to the PPA. For eTPU to Host transfers, when microcode changes PPA, it copies them to the TPA and flags updated TPA data to Host, possibly using an Interrupt or a Data Transfer Request. The Mailbox flag is reset when data is copied: by the eTPU microcode, when it transfers TPA to PPA (possibly followed by an Interrupt); by the Host, when it reads data from the TPA. This indicates that TPA is free for another transfer.

Transfer Service has the advantage of separating the task of data transfer from the functional service thread that accesses the parameters, with less impact to the latter. Compared to the Mailbox method, however, it has bigger average latency, because the Transfer Service thread has to contend for a time slot to execute. This latency can be minimized if Transfer Service thread is assigned to a separate channel with higher priority, but even so it does not guarantee that PPA is updated before the next execution of the functional thread that uses it.

Mailbox method, on the other hand, makes the functional thread check for the existence of new data (Host to eTPU). It does not have to be responsible for the transfer, though: it may access the TPA directly, and a Transfer Service can then be used to copy data from TPA to PPA.

67.5.4 Programming Hints and Caveats

67.5.4.1 Atomic dual access after a call, return

A dual, back-to-back parameter access is not atomic after a call, a jump, or a return if they occurred in parallel with an odd SDM access. It is safer to make a pair of parameter accesses that must be coherent begin at the second instruction after a call/jump/return.

67.5.4.2 Resource polling

The use of polling while waiting for a condition or a resource (except semaphore lock) should be avoided in order not to hang the microengine in long loops. This general programming guideline is greatly enforced in eTPU, as a thread cannot be preempted for any reason. Safer polling, albeit with long and indeterministic latency, can be obtained if a thread issues a channel link to the serviced channel and terminates. The microengine is then free to other tasks, and the next poll happens at the next time the channel is serviced. This mechanism can be combined with finite (timed out) loops for better latency.

67.5.4.3 Changing channel function, parameter base, or entry table scheme

Channel function, parameter base address and entry table scheme are determined by the CFS, CPBA, and ETCS fields in C*a*CR_ENG1 and C*a*CR_ENG2. They cannot be changed when the channel is enabled. If the channel is disabled first, one may still have service requests from the previous function, so before the channel is enabled again one must be sure that:

- the first thread executed in the new function is the initialization one.
- the initialization thread of the new function clears any previously pending service request.

Here is a safe procedure for function changing:

1. Disable the channel (in C*a*CR_ENG1 and C*a*CR_ENG2, write CPR = 00b).
2. Change the function configuration (fields CFS and/or CPBA and/or ETCS in C*a*CR_ENG1 and C*a*CR_ENG2).
3. Request the initialization thread, writing eTPU Channel n Host Service Request Register for Engine 1 (C0HSRR_ENG1 - C31HSRR_ENG1) and eTPU Channel n Host Service Request Register for Engine 2 (C0HSRR_ENG2 - C31HSRR_ENG2)with the initialization HSR (channel still disabled).
4. Enable the channel (in C*a*CR_ENG1 and C*a*CR_ENG2 write CPR > 0); the initialization HSR is serviced before any other formerly pending service requests, clearing them.

67.5.4.4 Checking and Clearing Interrupts of a Stopped Engine

An Engine may be stopped with interrupts (or DMA requests) pending. This includes the case when the Engine's MDIS bit is set and a thread is still running: the thread will complete execution, possibly issuing an interrupt or DMA request before the engine stops, setting the STF bit.

As soon as the engine stops the channel registers become inaccessible, issuing bus errors when accessed. Interrupts and DMA requests can still be checked and cleared through the Global Channel Registers, though. DMA requests can also be cleared by the hardware handshaking with the DMA controller when the engine is stopped.

67.5.5 Estimating Worst Case Latency

Reliable systems are designed to work under worst-case conditions. This section explains how to estimate worst-case latency (WCL) for any eTPU function in any system. The appendix covers the following topics:

- Introduction to Worst-Case Latency
- Using Worst-Case Latency Estimates to Evaluate Performance
- Priority Scheme Details used in WCL Analyses
- First-Pass WCL Analysis
- Second-Pass WCL Analysis

The first-pass WCL analysis is based on a deterministic, generalized formula that is easy to apply. Because of the generalizations in the formula, the first analysis result is almost always much worse than the real worst case. If the desired system performance is within the limits of this first analysis, then no further analysis is required; the system is well within the performance limits of the eTPU. If the desired system performance exceeds that indicated by the first analysis, the second-pass WCL analysis should be applied. The second-pass analysis is not a generalized formula, but rather uses specific system details for a realistic worst-case estimation.

67.5.5.1 Introduction to worst-case latency

NOTE

The latency calculation and examples refer to old TPU functions such as PWM, DIO etc. These functions use single action channels which have single transition and single match functionality. They are not optimized for the eTPU hardware enhancement which support various double action modes. These examples are for reference only. New eTPU functions which are optimized for the new hardware will impose different latency calculations.

Worst-case latency for a channel is the longest amount of time that can elapse between the execution of any two function threads on that channel. For example, if in a particular system, channel 5 is running PWM, the worst-case latency for channel 5 is the longest possible time between the execution of two PWM threads. The worst case time includes the time the execution unit takes to execute threads for other active channels, and other delays described later in this section. Refer to the following figure.

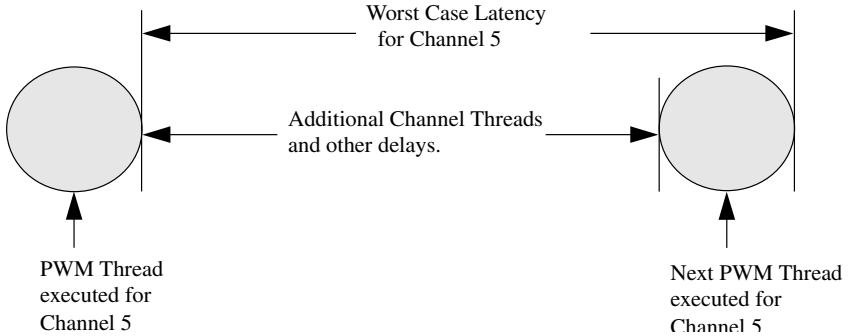


Figure 483. Worst-case latency for PWM

Worst-case latency for a channel depends both on the function running on that channel and on the activity on other channels. Since the 32 eTPU channels must all share the same execution unit, execution speed of a particular function varies with each

system. The PWM thread response is faster if there are no other active channels than if other channels are also active. In addition, changing the priority scheme and channel number assignments can change performance for a function even if the same set of functions are still active.

Each function is divided into treads, as shown in the figure below (see also Functions and threads). The eTPU Microengine executes one thread of a function at a time. For example, the Microengine might execute thread 1 of PWM, then thread 3 of DIO, then thread 2 of PWM, then thread 2 of SM, and so on. The amount of time the eTPU Microengine grants a function to execute a thread varies with the number of microcode instructions in the thread.

Since there is only one eTPU Microengine (in each eTPU Engine), the eTPU cannot actually execute the software for multiple functions simultaneously. However, the hardware for each of the channels is independent. This means that, for example, all 32 channel signals can change thread at the same moment, provided that the function software sets up the channel hardware to do so beforehand.

With Host CPU code, the system designer assigns functions to channels and initializes the functions. After initialization, functions typically run without Host intervention, except for eTPU channel interrupts to the Host to give or receive information. Most functions can run continuously with periodic servicing from the eTPU Microengine. As required, the channels request service from the eTPU Microengine, and the eTPU Scheduler determines the order in which the channels are serviced. Worst-case latency for a channel can be derived from the details of the priority scheme that the scheduler uses (see Scheduler).

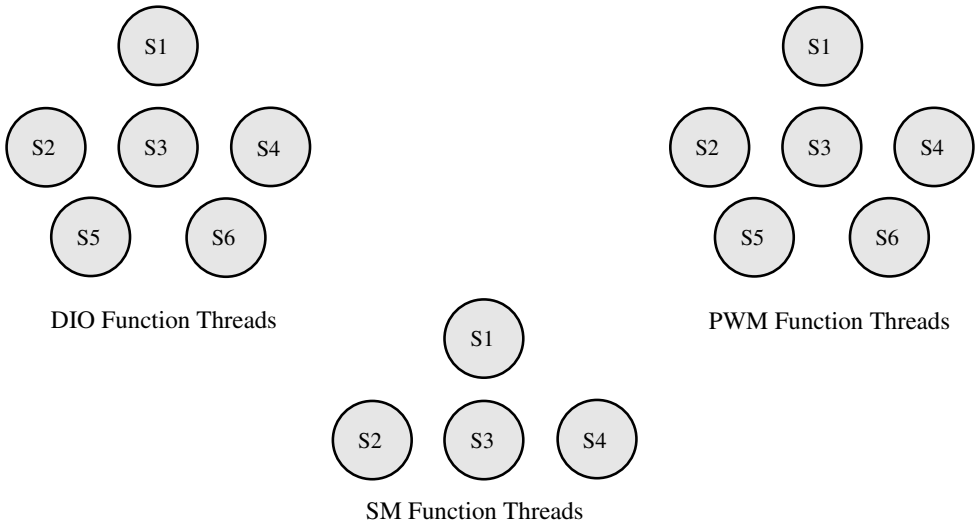


Figure 484. Function threads

67.5.5.2 Using Worst-Case Latency estimates to evaluate performance

Once WCL is found for a channel, the user must determine how to use this number to analyze performance. To analyze the performance of a channel running the PWM function, for example, some information about what happens in each thread is necessary.

The following example refers to old TPU PWM function, which is not optimized to the eTPU enhanced hardware. For PWM, thread 1 is the initialization thread, and threads 2 and 3 are used during normal function execution. (PWM threads 4, 5, and 6 are for special modes and will be assumed to be unused on channel 5). Thread 2 writes a time into the channel 5 match register and performs other operations that will cause the channel 5 signal to go from low to high at the time indicated in the match register (match time). At match time, the signal goes high and channel 5 requests service from the eTPU Microengine to execute thread 3. Thread 3 writes a time into the channel 5 match register and performs other operations that will cause the channel 5 signal to go from high to low at match time. At match time, the signal goes low and channel 5 requests service from the eTPU Microengine to execute thread 2. A PWM wave is kept running on the system by the eTPU executing thread 2, then thread 3, then thread 2, then thread 3, and so on.

Since the definition of worse-case latency assumes a fully loaded running system, initialization threads are not part of worst-case calculations. For the channel 5 example, the two PWM threads in Introduction to worst-case latency are thus the two normal running threads, threads 2 and 3.

Introduction to worst-case latency does not define which thread is thread 2 and which is thread 3. Since the worst-case latency derived from the first-pass analysis is the worst case between any2 threads (not counting initialization threads), it is safe to say that the worst-case latency shown in Introduction to worst-case latency represents both the worst-case high time and the worst-case low time.

Notice in Introduction to worst-case latency that worst-case latency is drawn from the end of the execution of the first PWM thread to the end of the execution of the next PWM thread. It is drawn from end to end because the microcode instructions that make up the threads control the channel hardware. To make sure that all the microcode instructions needed to change the pin thread have been executed, it is necessary to include the execution time of the second thread.

Thread information for each function is found in the programming notes for individual TPU functions. See NXP Programming Note TPUPN00/D, Using the TPU Function Library and TPU Emulation Mode, for a list of available programming notes. Similar documentation will we provided for the eTPU new functions.

67.5.5.3 Priority scheme details used in WCL analysis

The user assigns functions to channel numbers and gives each active channel a priority level of high, middle, or low. The Scheduler uses the channel number and channel priority level to determine the order in which to grant service.

The scheduler allocates time slots to specific priority levels of high, middle, or low. One function thread is executed in each time slot. The length of a time slot varies according to the length of the executing thread. When fully loaded, the scheduler always assigns time slots in a seven-slot sequence (see the following table). After a seven-slot sequence is completed, another seven-slot sequence begins (see). Note that in eTPU, when no service request exists, the scheduler goes to thread 1, but WCL calculation considers full load.

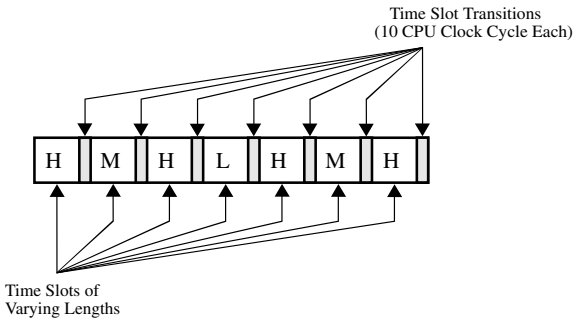


Figure 485. Time-slot sequence

This sequence scheme gives higher-priority channels more service time than lower-priority channels. High-priority channels are allocated four of seven time slots, middle-priority channels are allocated two of seven time slots, and low-priority channels are allocated one of seven time slots.

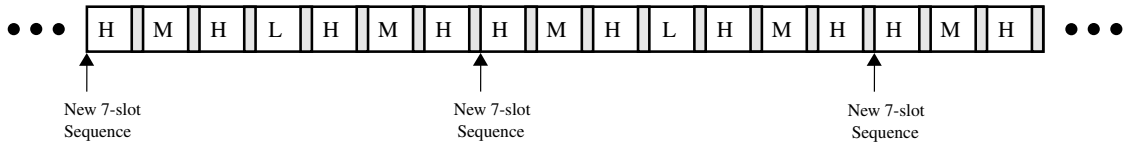


Figure 486. Multiple time-slot sequences

67.5.5.3.1 Priority Passing

If no channel of the priority level assigned to the time slot is requesting service, the eTPU scheduler can pass priority to other levels. If no high-level channel is requesting service during a high level time slot, a middle-level channel is granted service; or, if no middle level-channel is requesting service, a low-level channel is granted service. If no middle-level channel is requesting service

during a middle-level time slot, a high-level channel is granted service; or, if no high-level channel is requesting service, a low-level channel is granted service. If no low-level channel is requesting service during a low-level time slot, a high-level channel is granted service; or, if no high-level channel is requesting service, a middle-level channel is granted service. If no channel is requesting service, the time slot sequence is reset to state 1 and the scheduler idles until a request is received.

Priority passing is implemented in hardware and does not contribute to worst-case latency.

67.5.5.3.2 Time-slot transition

After each time slot, the eTPU must prepare for the next time slot. This preparation time between each time slot is called a time-slot transition. See Time Slot Transition. Time-slot transitions can take from six up to ten eTPU clocks.

67.5.5.3.3 Channel Number Priority

If more than one channel of a priority level is requesting service, the lowest numbered channel is granted service first. For example, if channels 0, 5, and 9 are all high-level channels requesting service during a high time slot, channel 0 is granted service first. Continuing this example, if channel 0 requests service again immediately after being serviced, it is not serviced again until channels 5 and 9 are serviced. This scheme is implemented so that continuously-requesting low numbered channels do not take all the time on the eTPU execution unit and leave no time for other channels.

The scheduler uses registers to keep track of which channels have been serviced and which require servicing. Each channel has two register bit: a service request register (SRR) and a service grant register (SGR). The SRR is set when a channel requests service. After the channel has been granted service, the SGR is set and the SRR is cleared.

SGRs are not cleared individually by channel, but rather as priority level groups. The clearing of a group of SGRs begins a new cycle for that priority level. An SGR group is cleared on the condition that a channel of that priority level has just been serviced, and no other channel of that priority level is requesting service (has a set SRR) and has not been granted service (has a clear SGR).

For example, if a middle-priority channel has just been serviced (either in a middle-priority time slot or a high or low-priority time slot gained by priority passing), the SRRs and SGRs of all middle-priority channels are compared. If there is no middle-priority channel with its SRR set and SGR cleared, the scheduler clears all middle-level SGRs. If there is a middle-level channel with its SRR set and SGR cleared, the scheduler does not clear the SGR group, and the requesting middle-level channel is serviced on the next middle-level time slot (or possibly sooner by priority passing).

67.5.5.3.4 SDM Collision Rate

Most function threads read or write to the eTPU SDM at least once. Because both the eTPU Microengine and Host can access the SDM but not at the same time, the Microengine may suspend execution during the SDM access while waiting for the Host to finish accessing the SDM. At other times the Host may wait for the Microengine. Wait states can take up to two eTPU clocks, when the Host accesses the SDM directly, without using CDC. Microengine(s) wait-states must be added into the worst-case latency calculation. The system designer should estimate the percentage of SDM accesses in the system that will result in Microengine wait-states. This percentage is called the RAM collision rate (RCR). In each collision with direct Host accesses to the SDM the Microengine(s) wait for two eTPU clocks.

In eTPU the Coherent Dual-parameter Controller (CDC) may also access the SDM for atomic transfers of two parameters. eTPU Microengine may wait on this operation (if it is in service time) until the transfer is complete. CDC always transfers two parameters, making four consecutive accesses (read, write, read, write) of one eTPU clock each. The system designer should estimate the percentage of SDM accesses in the system that will result in a Microengine wait due to coherent transfer, and multiply it with the average number of eTPU clocks the Microengine waits for each transfer. This percentage is called Coherent Parameter Collision Rate (CPCR).

In addition, Microengine to Microengine multiple parameter coherent communication, using the hardware semaphores, may hold one Microengine which waits to lock the semaphore while the other Microengine is holding it. This waiting is due to a software loop, not hardware wait-states. Note that single parameter access of one Microengine does not affect the timing of the other Microengine due to SDM time interlace. This implies that single parameter Microengine to Microengine communication does not affect the performance. The Microengine which waits for the semaphore will loop until it is freed by the other Microengine. This time depends on the eTPU application. The system designer should estimate the percentage of Microengine to Microengine coherent parameter communication that will result in eTPU semaphore loops, and multiply it with the average number of eTPU clocks the Microengine loops for each such transfer. This percentage is called CCR (Communication Collision Rate).

A 100% collision rate for a system is the theoretical worst case. In many systems, however, the RCR, CPCR and CCR would be very low, sometimes even near 0%. This is because the eTPU is an independent processor capable of servicing most function needs, so that the Host rarely needs to access the eTPU SDM. Also coherent Microengine to Microengine communication of more than one parameter may be rare. To find a realistic RCR, CPCR the system designer should evaluate the Host code and find the percentage of time it accesses the eTPU SDM with or without using the CDC. This percentage gives a good RCR and CPCR. The eTPU application provides a good estimation of CCR.

NOTE

The programming practice of polling a flag in the eTPU SDM causes a very high RCR and should be avoided in high-performance systems.

After the collision rate for a system is found, it can be applied to the WCL calculations for each channel. The system designer can use the collision percentage and the number of SDM accesses (with and without semaphores) to estimate the eTPU loop time for a function. Note that in old TPU functions CPCR and CCR are both zero.

The estimation of eTPU wait time is as follows:

Variables:

N1 = Number of simple RAM accesses in the longest thread

RCRWait = Maximal eTPU clocks wait time for simple RAM collision = 2

CPCRWait = Average eTPU clocks for Coherent Parameter Transfer (using CDC).

N2 = Number of eTPU-eTPU semaphore RAM accesses in the longest thread

CCRWait = Average eTPU clocks for Microengine-Microengine communication transfer.

Estimated Wait Time:

Function eTPU maximal wait time =

N1 *(RCR * RCRWait + CPCR * CPCRWait) + N2* CCR * CCRWait

67.5.5.4 First-Pass Worst-Case Latency Analysis

Following is the first-pass calculation of worst-case latency for a channel. Remember that this analysis uses generalizations that usually produce a result much worse than the real worst case. If the worst-case result from the first analysis is too long for the desired performance, use the second analysis for a more realistic worst-case analysis.

67.5.5.4.1 Worst-case assumptions and formula

To estimate worst-case latency for a channel, assume this worst-case condition: the channel has just been serviced in a time slot of its priority level, and all other channels in the system are continuously requesting service and have cleared SGRs. The worst-case latency is the time from the end of the channel's service until the end of the channel's next service. See the following figure.

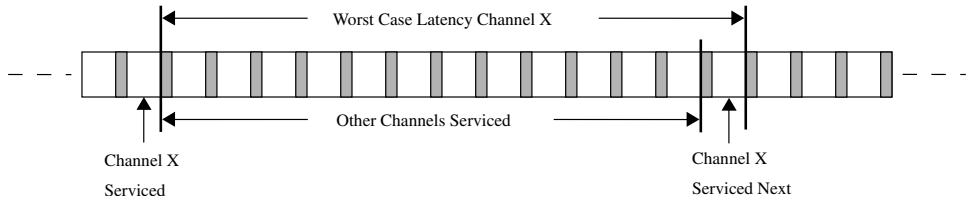


Figure 487. First-pass worst-case latency

To estimate worst-case latency:

- Find the worst-case service time for each active channel.
- Using the H-M-H-L-H-M-H time-slot sequence, map the channels that are granted for each time slot.
- Add time for six-clock time-slot transitions.

67.5.5.4.1.1 Mapping the channels for each time slot

To determine when a channel will be serviced again, it is necessary to determine which other channels will be serviced first. Do this by assuming all channels are continuously requesting service and mapping the channels into the time-slot sequence.

67.5.5.4.1.2 Adding time for time-slot transitions

Add six eTPU clocks for time-slot transitions which occur after each time slot.

67.5.5.4.2 First-pass analysis worst-case latency examples

The examples in this section assume the system configuration shown in the following table.

Table 470. System configuration example

Channel	Priority	Function[1,2]
0	High	PWM (driving a DC motor)
1	Middle	PPWA (Mode 0, measuring the DC motor speed)
2	Low	DIO (Input)

1. 9% RAM Collision Rate (RCR)
2. CPU clock rate = 40 MHz, or 25 ns per clock period

67.5.5.4.2.1 Finding the WCL for PWM on channel 0

The following shows how to find the WCL for PWM on channel 0.

1. Find the worst-case service time for each active channel.
   a. Longest thread of PWM is 24 CPU clocks with four RAM accesses.

      24 + ((4 RAM accesses+1) * 0.09 * 2 CPU clock waits) = 24.9 CPU clocks, rounded up to 25 CPU clocks (since there are no partial clock periods)

      Channel 0 worst-case service time = 25 CPU clocks.

   b. Longest thread of PPWA in mode 0 is 44 CPU clocks with nine RAM accesses.

      44 + ((9 RAM accesses+1) * 0.09 * 2 CPU clock waits) = 45.8 CPU clocks, rounded up to 46 CPU clocks

      Channel 1 worst-case service time = 46 CPU clocks.

   c. Longest thread of DIO is ten CPU clocks with four RAM accesses.

      10 + ((4 RAM accesses+1) * 0.09 * 2 CPU clock waits) = 10.9 CPU clocks, rounded up to 11 CPU clocks

      Channel 2 worst-case service time = 11 CPU clocks.
2. Assume channel 0 has just been serviced and that channels 1 and 2 are continuously requesting service. Using the H-M-H-L-H-M-H time-slot sequence, map the channels that are granted for each time slot. See the following figure.

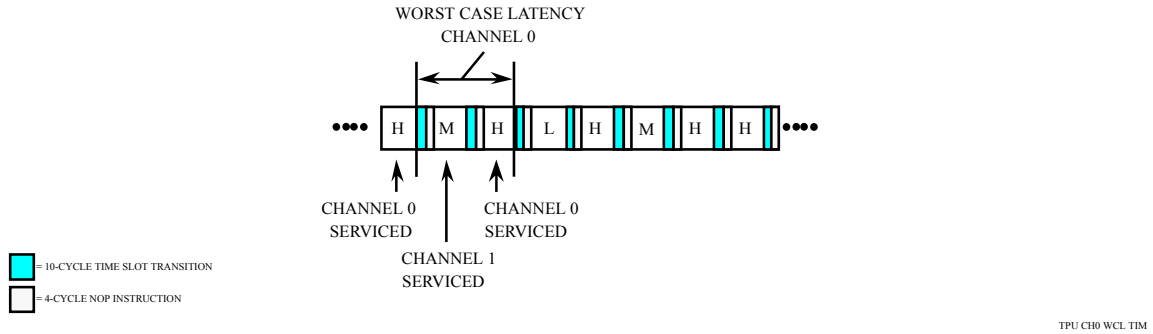


Figure 488. Next servicing for channel 0

Channel 1 will be serviced in the middle-priority time slot before channel 0 is serviced again.

3. Add time for the six-clock CPU time-slot transitions. See the above figure and the following table.

   A four-clock NOP occurs after each channel is serviced since there is one channel in each priority level, i.e., a new cycle for a priority level is started after each channel is serviced. Time-slot transitions occur after each time slot.

Table 471. Worst-case latency for channel 0

Channel 0 worst-case service time	25 clocks
Channel 1 worst-case service time	46 clocks
Two 6-clock time-slot transitions	12 clocks
Total clocks	83 clocks

83 clocks * 25 ns/clock = 2075 ns

Conclusion: in this system configuration PWM can run with a minimum high time or low time of 2075 ns.

Note that in double match eTPU system the PWM can be serviced once in each period, and there is no latency for minimum high time. The latency in eTPU PWM function will represent the minimum PWM period.

67.5.5.4.2.2 Finding the WCL for PPWA on channel 1

The following shows how to find the WCL for PPWA on channel 1.

1. Find the worst-case service time for each active channel. See step 1 of previous example.
2. Assume channel 1 has just been serviced and that channels 0 and 2 are continuously requesting service. Using the H-M-H-L-H-M-H time-slot sequence, map the channels that are granted for each time slot. See the following figure.

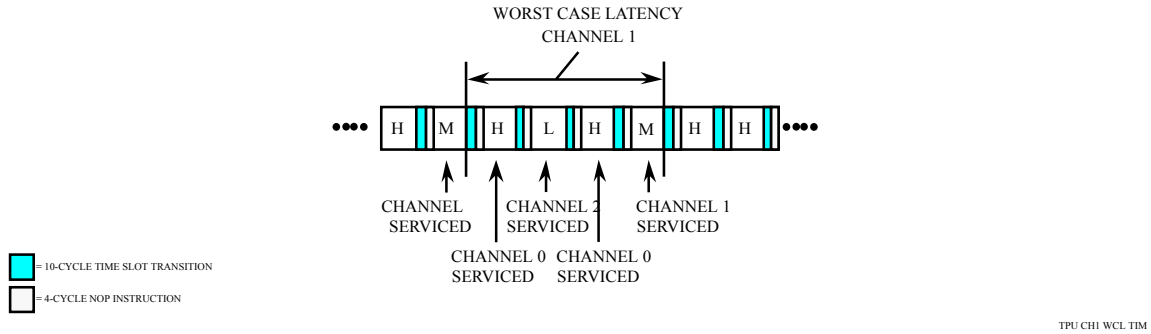


Figure 489. Next servicing for channel 1

Channel 0 will be serviced twice and channel 2 once before channel 1 is serviced again.

3. Add time for the six-clock CPU time-slot transitions. See the above figure and the following table.

Table 472. Worst case latency for channel 1

Two Channel 0 worst-case service times	50 clocks
Channel 1 worst-case service time	46 clocks
Channel 2 worst-case service time	11 clocks
Four 6-clock time-slot transitions	24 clocks
Total clocks	131 clocks

131 clocks * 25 ns/clock = 3275 ns

Conclusion: in this system configuration PPWA can measure a period or pulse of minimum 3275 ns.

Note that PPWA function optimized for eTPU hardware can use double transition mode to measure very narrow pulses with one service after the second transition, and latency will affect only the minimum gap between two input pulses. Also the function threads would have more efficient coding.

67.5.5.4.2.3 Finding the WCL for DIO on channel 2

The following shows how to find the WCL for DIO on channel 2.

1. Find the worst-case service time for each active channel. See step 1 of previous examples.
2. Assume channel 2 has just been serviced and that channels 0 and 1 are continuously requesting service. Using the H-M-H-L-H-M-H time-slot sequence, map the channels that are granted for each time slot. See the following figure.

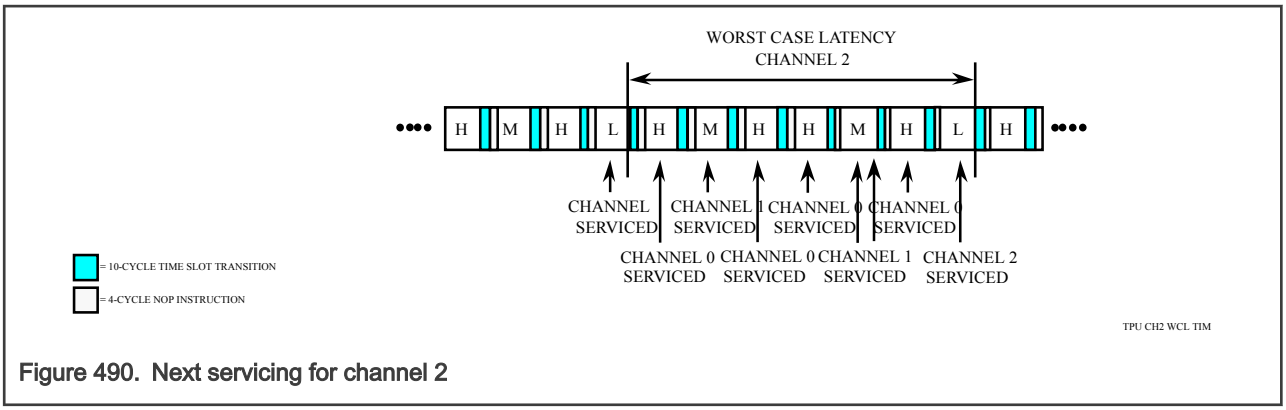


Figure 490. Next servicing for channel 2

Channel 0 will be serviced four times and channel 1 twice before channel 2 is serviced again.

3. Add time for the ten-clock CPU time-slot transitions and the four-clock NOPs. See the above figure and the following figure.

Table 473. Worst case latency for channel 2

Four Channel 0 worst-case service times	100 clocks
Two Channel 1 worst-case service time	92 clocks
Channel 2 worst-case service time	11 clocks
Seven 6-clock time-slot transitions	42 clocks
Total clocks	245 clocks

245 clocks * 25 ns/clock = 6125 ns

Conclusion: in this system configuration DIO can keep track of the input level at a minimum of every 6125 ns.

Note that DIO function optimized for eTPU hardware can use double transition mode to measure two pin transitions at a time and reduce the service time, improving the overall system performance and latency.

67.5.5.5 Second-Pass Worst-Case Latency Analysis

Following is an example of a second-pass analysis for calculating worst-case latency for a channel. The second-pass analysis is useful for higher-performance systems, since it gives a more realistic worst-case latency result than first-pass analysis.

This example uses a relatively simple system in order to illustrate the basic principles of second-pass analysis. For a more complex example of second-pass analysis, refer to Multiphase Motor Commutation TPU Function (COMM)(TPUPN09/ D).

67.5.5.5.1 Second-Pass Analysis Guidelines

Rather than use a fixed formula, a second-pass analysis relies on the application of the following guidelines.

1. The first-pass analysis makes the assumption that all channels in the system are continually requesting service. For many systems this is an unrealistic assumption. For example, if TCR1 is counting at a rate of 2 MHz (500 ns per count) and a channel is running the DIO function with a match rate of 20,000 TCR1 counts, the DIO will request service every 10 ms (20,000 * 500 ns = 10,000,000 ns or 10 ms). It is therefore unrealistic to assume that the channel running this DIO function is continuously requesting service. Figure out a realistic service request rate for each channel. Time slots can then be mapped to each channel at the real rate of request.
2. If a function is active during system initialization but not during the high-speed running mode of the system, then that system does not need to be included in the high-speed worst-case latency calculations.
3. Use a realistic SDM collision rate.

4. Be careful when assigning functions priority levels and channel numbers. Decide which function or functions will be most difficult to make perform at the desired level. Assign those channels high priority and low channel numbers. Try different priority and channel assignments to see how it affects the system.
5. The seven-slot sequence of || H | M | H | L | H | M | H || is asymmetrical when put back-to-back with other seven-slot sequences. Note that in the following sequence there are two high-priority slots next to each other:

   || H | M | H | L | H | M | H |||| H | M | H | L | H | M | H ||
6. Make sure that when mapping out channels to the sequence, you choose a worst-case slot to start the mapping. For example, when estimating WCL for a high-priority channel, do not start the mapping in the last high-priority slot in a seven-slot sequence, as that is a best case for a high-priority channel since another high-priority time slot is next.
7. Instead of always using the longest thread in the function as the worst-case thread, evaluate the threads in the function that will be used in the system and use the appropriate worst-case threads. For example, in the preceding example of first-pass analysis, the PWM was shown to be able to achieve a high time and low time of 2475 ns under worst-case conditions. This was derived using the longest PWM thread of 24 CPU clocks. This longest thread is actually thread 2, the thread that is entered after the pin has just gone high. Thread 3, the thread that is entered after the pin has just gone low, requires only 2 CPU clocks. Therefore, in the first-pass example, the high time was correctly derived, but the low time is actually shorter than was estimated.

67.5.5.5.2 Second-pass analysis example

This example requires three 50% PWM waveforms: one 5 kHz (200 ms/period) and two 50 kHz (20 ms/period), each running DC motors. (Remember that the PWM function requests service from the eTPU after each high time and after each low time, so the eTPU must handle a request every 100 ms for the 5 kHz PWM and every 10 ms for the 50 MHz PWM.)

NOTE

This example uses square waves for simplicity. Notice that to use a PWM waveform in the typical way, in which the pulse is modulated, the pulse must not be modulated in a way that violates the worst-case latency requirements.

This example also uses one DIO channel monitoring a signal level every millisecond and one PPWA channel in mode 0 monitoring the speed of the 5-kHz DC motor. The PPWA must measure periods of 5 kHz (200 ms/period).

The CPU is interrupted by the channel running the PPWA function after measuring 200 periods (every 40 ms). The interrupt service routine performs an averaging of the period accumulation and checks it against a known parameter. The interrupt service time is so short and infrequent that it is a tiny fraction of total system time. The interrupt service routine contains no polling of the SDM. Therefore a realistic RCR = 0%.

67.5.5.5.2.1 First-try system configuration

Try a system configuration that seems likely to work. If it does not, change priority levels or channel numbers.

The 5 kHz and 50 kHz PWMs are the most time-critical functions. Those are assigned high priority. PPWA is assigned middle priority. The DIO is low performance and is assigned low priority. Refer to the following table.

Table 474. First-try system configuration

Channel	Priority	Function[1], [2]
0	High	PWM at 50 kHz (needs a 4-µs WCL)
1	High	PWM at 50 kHz (needs a 4-µs WCL)
2	High	PWM at 5 kHz (needs a 40-µs WCL)
8	Middle	PPWA at 5 kHz (needs a 80-µs WCL)
15	Low	DIO as input at rate of 1 ms

1. 0% RAM collision rate
2. CPU clock rate = 40 MHz, or 60 ns per clock period

With this system configuration, worst-case service time for each active channel is determined as follows:

1. Longest thread of PWM is 24 CPU clocks with four RAM accesses.

   24 + ((4 RAM accesses+1) * 0 * 2 CPU clock waits) = 24 CPU clocks

   Channels 0-2 worst-case service time = 24 CPU clocks.

2. Longest thread of PPWA in mode 0 is 44 CPU clocks with nine RAM accesses.

   44 + ((9 RAM accesses +1)* 0 * 2 CPU clock waits) = 44 CPU clocks

   Channel 8 worst-case service time = 44 CPU clocks.

3. Longest thread of DIO is ten CPU clocks with four RAM accesses.

   10 + ((4 RAM accesses+1) * 0 * 2 CPU clock waits) = 10 CPU clocks

   Channel 15 worst-case service time = 10 CPU clocks.

   To find the WCL for channel 0, assume channel 0 has just finished service.

   Map the channels in the H-M-H-L-H-M-H sequence. See the following figure.

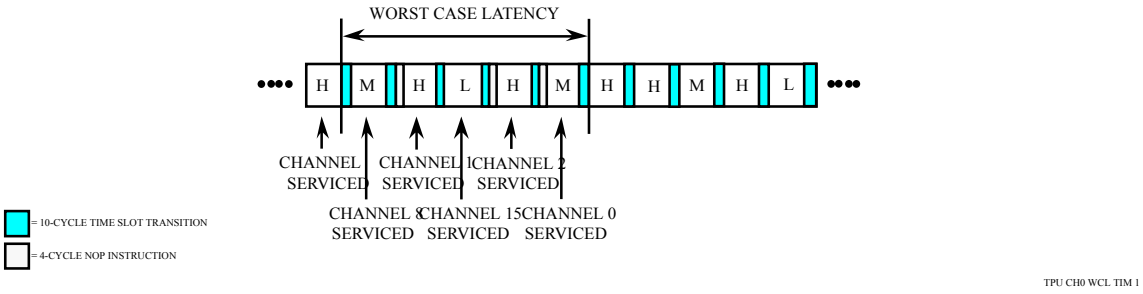


Figure 491. Worst-case latency for channel 0 first try

Conclusion: with this system configuration, worst-case latencies for channels 0 and 1 are too high (WCL for channel 1 is the same as WCL for channel 0). Try a different system configuration.

67.5.5.5.2.2 Second-try system configuration

The second-try system configuration is shown in the following table.

Table 475. Second-try system configuration

Channel	Priority	Function[1], [2]
0	High	PWM at 50 kHz (needs a 4-µs WCL)
1	High	PWM at 50 kHz (needs a 4-µs WCL)
2	Middle	PWM at 5 kHz (needs a 40-µs WCL)
8	Middle	PPWA at 5 kHz (needs a 80-µs WCL)
15	Low	DIO as input at rate of 1 ms

1. 0% RAM collision rate

2. CPU clock rate = 40 MHz, or 60 ns per clock period

To find the WCL for channel 0, assume channel 0 has just finished service. Map the channels in the H-M-H-L-H-M-H sequence. See the following figure.

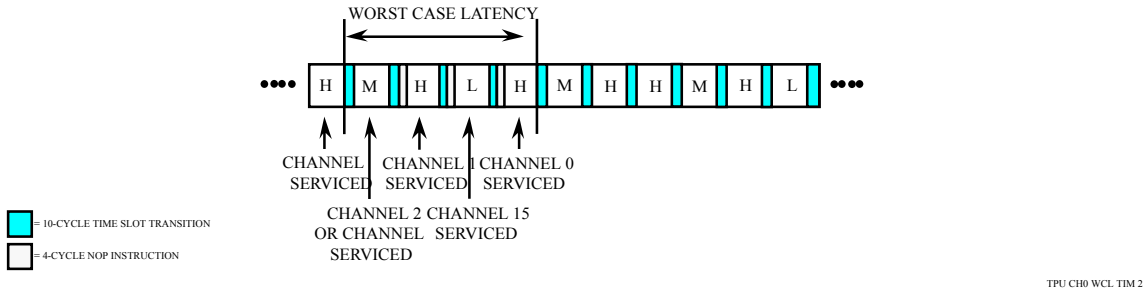


Figure 492. Worst-case latency for channel 0 second try

Conclusion: with this system configuration, the WCL of both channel 0 and channel 1 is 3.85 ms, which is within the limit of 4 ms needed for a 50-kHz PWM.

Next, find the WCL for channel 2. Assume channel 2 has just finished service. Map the channels in the H-M-H-L-H-M-H sequence. See the following figure.

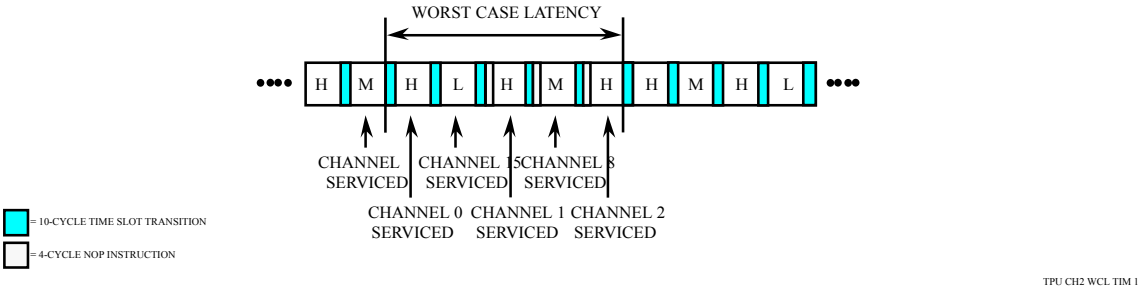


Figure 493. Worst-case latency for channel 2

Conclusion: with this system configuration, the WCL for channels 2 and 8 is 4.7 ms, which is within the 40 and 80 ms WCL requirements.

Notice that channels 2 and 8 are well within their WCL requirements. The system could be reconfigured as shown in the following table to give channels 0 and 1 a larger margin while still keeping channels 2, 8 and 15 within their WCL requirements.

Table 476. Second-try system with channel 0 and 1 reconfigured

Channel	Priority	Function[1,2]
0	High	PWM at 50 kHz (needs a 10-µs WCL)
1	High	PWM at 50 kHz (needs a 10-µs WCL)
2	Middle	PWM at 5 kHz (needs a 40-µs WCL)
8	Low	PPWA at 5 kHz (needs a 80-µs WCL)
15	Low	DIO as input at rate of 1 ms

1. 0% RAM collision rate
2. CPU clock rate = 40 MHz, or 60 ns per clock period

67.5.6 Endianness

The following table shows the parameter addresses for big and little endian machines.

Table 477. Parameter Addresses and Endianness

Parameter	byte address offset (n = word address offset)	
	big endian	little endian
32-bit	4*n	
24-bit	4*n + 1	4*n
32-bit parameter's most significant byte	4*n	4*n + 3
24-bit parameter's most significant byte	4*n + 1	4*n + 2
least significant byte	4*n + 3	4*n

67.5.7 Memory Error Service Procedures

Follows separate procedures for correctable and non-correctable error interrupt service routines. It is assumed that the non-correctable error ISR has higher priority, and cannot be preempted by the correctable error ISR. For memory error support details, see Memory error support .

NOTE

The memory error support hardware does not (and is not intended to) guarantee that no error occurred will go unreported. However, combined with the procedures below, the information loss is minimized to statistical irrelevance on most scenarios.

67.5.7.1 Non-correctable error service procedure

The basic procedure below can be followed in a Global Exception or a bus error machine check service routine. It handles the service for both SCM and SDM errors, as they are symmetrical at this level. However, a real implementation is likely to split the procedure in two, one for each memory.

1. Confirm/identify the error source, checking assertion of the eTPU Module Configuration Register (MCR) fields SCMERR and SDMERR.
2. Save the state(s) of eTPU Memory Error Control Register (MECR) fields CRDIS/DRDIS.
3. Set the eTPU Memory Error Control Register (MECR) CRDIS/DRDIS = 1 to disable further updates to the respective report registers, guaranteeing coherency.
4. Check whether the report registers were updated by a correctable or non-correctable error; to do this, check the eTPU Code Error Report Syndrome Register (CERSR) syndrome (for SCM) and/or the eTPU Data Error Report Syndrome Register (DERSR) syndromes (for SDM, only those with the respective BE flags asserted). If it is a correctable error report, skip the steps 5 and 6 for the respective memory.
5. Identify the error source (host, microengine or MISC/CDC) by checking the field ERR_ACC in the register(s) eTPU Code Error Report Address Register (CERAR) and eTPU Data Error Report Address Register (DERAR); take or schedule the appropriate application-dependent recover actions.
6. Update error statistics as needed; it may include recording the access source, address, data and syndrome from:
   - eTPU Code Error Report Address Register (CERAR)
   - eTPU Data Error Report Address Register (DERAR)

- eTPU Code Error Report Data Register (CERDR)
- eTPU Data Error Report Data Register (DERDR)
- eTPU Code Error Report Syndrome Register (CERSR)
- eTPU Data Error Report Syndrome Register (DERSR)

7. Save the status of non-correctable error overflows flagged in the eTPU Memory Error Status Register (MESR) fields CNCOVR/DNCOVR.
8. Set the eTPU Memory Error Control Register (MECR) fields CRDIS/DRDIS to the state(s) saved in the step 2. That assures the access coherency of a preempted Correctable Error Service Procedure (which may have set CRDIS/DRDIS before this procedure) is not disturbed.
9. Clear the eTPU Memory Error Status Register (MESR) fields CNCOVR/DNCOVR and CNCERR/DNCERR at once, in a single write to eTPU_MESR_MESR.
10. Use the overrun status saved on step 7 to update the error statistics, as needed.
11. Check the other Global Exception flags in eTPU Module Configuration Register (MCR); take or schedule the appropriate (application dependent) recover actions.
12. Clear the Global Exception, programming MCR[GEC] = 1.

67.5.7.2 Correctable error service procedure

The basic procedure below can be followed in a Memory Error Interrupt service routine (see Interrupts and data transfer requests). It handles the service for both SCM and SDM errors, as they are symmetrical at this level. However, a real implementation is likely to split the procedure in two, one for each memory.

1. Confirm/identify the error source, checking assertion of the eTPU Memory Error Status Register (MESR) fields CCERR/DCERR.
2. Program the eTPU Memory Error Control Register (MECR) fields CRDIS = 1 and/or DRDIS = 1, to disable further updates to the respective report registers, guaranteeing coherency.
3. Check whether the report registers were updated by a correctable or non-correctable error; to do this, check the eTPU Code Error Report Syndrome Register (CERSR) syndrome (for SCM) and/or the eTPU Data Error Report Syndrome Register (DERSR) syndromes (for SDM, only those with the respective BE flags asserted). If it is a non-correctable error report, skip the steps 4 and 5 for the respective memory.
4. Identify the error source (host, microengine or MISC/CDC) by checking the field ERR_ACC in eTPU Code Error Report Address Register (CERAR) and eTPU Data Error Report Address Register (DERAR); take or schedule the appropriate application-dependent recover actions, which may include soft-error fixing (see Error fixing).
5. Update error statistics as needed; it may include recording the access source, address, data and syndrome from:
   - eTPU Code Error Report Address Register (CERAR)
   - eTPU Data Error Report Address Register (DERAR)
   - eTPU Code Error Report Data Register (CERDR)
   - eTPU Data Error Report Data Register (DERDR)
   - eTPU Code Error Report Syndrome Register (CERSR)
   - eTPU Data Error Report Syndrome Register (DERSR)
6. Save the status of correctable error overflows flagged in the eTPU Memory Error Status Register (MESR) fields CCOVR/DCOVR.
7. Program the eTPU Memory Error Control Register (MECR) fields CRDIS/DRDIS=0.
8. Clear the eTPU Memory Error Status Register (MESR) fields CCOVR/DCOVR and CCERR/DCERR at once, in a single write to eTPU_MESR_MESR.

9. Use the saved overrun status to update the error statistics, as needed.

67.6 Memory map/register definition

The guideline for the description of all bits and fields throughout the“Memory Map/Register Definition” section is to provide only a brief explanation (without examples or method of use) of the features, since it will be used mainly as a reference for the reader that is studying the “Functional Description" section, where those features are explained in detail.

67.7 Memory map

The eTPU System simplified memory map is shown in table High-level memory map.. Each of the register areas shown may have their own reserved address areas.

There is a table detailed memory map. Offsets are relative to the eTPU Base address, which is MCU-dependent.

See the chip-specific eTPU information about accessing eTPU registers in chip-level Stop mode.

SCM unused area is decoded and returns a fixed opcode, determined by eTPU SCM Off-range Data Register (SCMOFFDATAR).

Table 478. High-level memory map

Offset	Use
0x00 – 0x1F	System Configuration Registers
0x20 – 0x2F	eTPU 1 Time Base Registers
0x30 – 0x3F	Reserved
0x40 – 0x4F	eTPU 2 Time Base Registers
0x50 – 0x5F	Reserved
0x60 – 0x6F	eTPU 1 Extra Engine Registers
0x70 – 0x7F	eTPU 2 Extra Engine Registers
0x80 – 0xFF	
0x100 – 0x13F	Memory Error Support Registers
0x140 – 0x1FF	Reserved
0x200 – 0x2FF	eTPU 1/2 Global Channel Registers
0x300 – 0x3FF	Reserved
0x400 – 0x7FF	eTPU 1 Channel Registers
0x800 – 0xBFF	eTPU 2 Channel Registers
0xC00 – 0xFFF	Shared Subsystems Integration Registers
0x1000 – 0x3FFF	Reserved[1]
0x4000 – 0x7FFF	SSS - Shared Subsystems area
0x8000 – 0xBFFF	SDM - Shared Data Memory
0xC000 – 0xFFFF	SDM PSE mirror[2]
0x10000 – 0x1FFFF	SCM - Shared Code Memory[3]

1. ETPU reserved area space 0x1000 - 0x3FFF does not generate bus errors and reads as 0.
2. Parameter Sign Extension access area, see Parameter Access.
3. SCM access is available only when bit VIS=1 on register eTPU_SCR_MCR, under certain conditions (see eTPU Module Configuration Register (MCR)).

Table 479. Detailed memory map

Offset	Use
System Configuration Registers	
0x00	eTPU_SCR_MCR - eTPU Module Configuration Register
0x04	eTPU_SCR_CDCR - eTPU Coherent Dual-Parameter Controller Register
0x08	Reserved
0x0C	eTPU_SCR_MISCCMPR - eTPU MISC Compare Register
0x10	eTPU_SCR_SCMOFFDATAR - eTPU SCM Off-range Data Register[1]
0x14	eTPU_SCR_ECR_ENG1 - eTPU 1 Engine Configuration Register
0x18	eTPU_SCR_ECR_ENG2 - eTPU 2 Engine Configuration Register
0x1C	Reserved
Time Base Registers	
0x20	eTPU_TBR_TBCR_ENG1 - eTPU 1 Time Base Configuration Register
0x24	eTPU_TBR_TB1R_ENG1 - eTPU 1 Time Base 1
0x28	eTPU_TBR_TB2R_ENG1 - eTPU 1 Time Base 2
0x2C	eTPU_TBR_STAC_ENG1 - eTPU 1 STAC Configuration Register
0x30	Reserved
0x34	Reserved
0x38	Reserved
0x3C	Reserved
0x40	eTPU_TBR_TBCR_ENG2 - eTPU 2 Time Base Configuration Register
0x44	eTPU_TBR_TB1R_ENG2 - eTPU 2 Time Base 1
0x48	eTPU_TBR_TB2R_ENG2 - eTPU 2 Time Base 2
0x4C	eTPU_TBR_STAC_ENG2 - eTPU 2 STAC Configuration Register
0x50	Reserved
0x54	Reserved
0x58	Reserved
0x5C	Reserved
Engine Related Registers	
0x60	eTPU_ER_WDTR_ENG1 - eTPU 1 Watchdog Timer Register
0x64	Reserved
0x68	eTPU_ER_IDLER_ENG1 - eTPU 1 Idle Counter Register
0x6C	Reserved
0x70	eTPU_ER_WDTR_ENG2 - eTPU 2 Watchdog Timer Register

Table continues on the next page...

Table 479. Detailed memory map (continued)

Offset	Use
0x74	Reserved
0x78	eTPU_ER_IDLER_ENG2 - eTPU 2 Idle Counter Register
0x7C	Reserved
Memory Error Support Registers[2]	
0x100	eTPU_MESR_MECR - eTPU Memory Error Control Register
0x104	eTPU_MESR_DEIAR - eTPU Data Error Injection Address Register
0x108	eTPU_MESR_DEIDPR - eTPU Data Error Injection Data Pattern Register
0x10C	eTPU_MESR_DEIPPR - eTPU Data Error Injection Parity Pattern Register
0x110	eTPU_MESR_DERAR - eTPU Data Error Report Address Register
0x114	eTPU_MESR_DERDR - eTPU Data Error Report Data Register
0x118	eTPU_MESR_DERSR - eTPU Data Error Report Syndrome Register
0x11C	Reserved
0x120	eTPU_MESR_MESR - eTPU Memory Error Status Register
0x124	eTPU_MESR_CEIAR - eTPU Code Error Injection Address Register
0x128	eTPU_MESR_CEIDPR - eTPU Code Error Injection Data Pattern Register
0x12C	eTPU_MESR_CEIPPR - eTPU Code Error Injection Parity Pattern Register
0x130	eTPU_MESR_CERAR - eTPU Code Error Report Address Register
0x134	eTPU_MESR_CERDR - eTPU Code Error Report Data Register
0x138	eTPU_MESR_CERSR - eTPU Code Error Report Syndrome Register
0x13C	eTPU_MESR_CEFR - eTPU Code Error Fix Register
0x140 - 0x1FF	Reserved
Global Channel Registers	
0x200	eTPU_GCR_CISR_ENG1 - eTPU 1 Channel Interrupt Status Register
0x204	eTPU_GCR_CISR_ENG2 - eTPU 2 Channel Interrupt Status Register
0x208	Reserved
0x20C	Reserved
0x210	eTPU_GCR_CDTRSR_ENG1 - eTPU 1 Channel Data Transfer Request Status Register
0x214	eTPU_GCR_CDTRSR_ENG2 - eTPU 2 Channel Data Transfer Request Status Register
0x218	Reserved
0x21C	Reserved
0x220	eTPU_GCR_CIOSR_ENG1 - eTPU 1 Channel Interrupt Overflow Status Register
0x224	eTPU_GCR_CIOSR_ENG2 - eTPU 2 Channel Interrupt Overflow Status Register

Table continues on the next page...

Table 479. Detailed memory map (continued)

Offset	Use
0x228	Reserved
0x22C	Reserved
0x230	eTPU_GCR_CDTROSR_ENG1 - eTPU 1 Channel Data Transfer Request Overflow Status Register
0x234	eTPU_GCR_CDTROSR_ENG2 - eTPU 2 Channel Data Transfer Request Overflow Status Register
0x238	Reserved
0x23C	Reserved
0x240	eTPU_GCR_CIER_ENG1 - eTPU 1 Channel Interrupt Enable Register
0x244	eTPU_GCR_CIER_ENG2 - eTPU 2 Channel Interrupt Enable Register
0x248	Reserved
0x24C	Reserved
0x250	eTPU_GCR_CDTRER_ENG1 - eTPU 1 Channel Data Transfer Request Enable Register
0x254	eTPU_GCR_CDTRER_ENG2 - eTPU 2 Channel Data Transfer Request Enable Register
0x258	Reserved
0x25C	Reserved
0x260	eTPU_GCR_WDSR_ENG1 - eTPU 1 Watchdog Status Register
0x264	eTPU_GCR_WDSR_ENG2 - eTPU 2 Watchdog Status Register
0x268-0x27F	Reserved
0x280	eTPU_GCR_CPSSR_ENG1 - eTPU 1 Channel Pending Service Status Register
0x284	eTPU_GCR_CPSSR_ENG2 - eTPU 2 Channel Pending Service Status Register
0x288	Reserved
0x28C	Reserved
0x290	eTPU_GCR_CSSR_ENG1 - eTPU 1 Channel Service Status Register
0x294	eTPU_GCR_CSSR_ENG2 - eTPU 2 Channel Service Status Register
0x298	Reserved
0x29C	Reserved
0x300 - 0x3FF	Reserved
Channel Configuration and Control Registers	
0x400	eTPU_CCCR_C0CR_ENG1 - eTPU 1 Channel 0 Configuration Register
0x404	eTPU_CCCR_C0SCR_ENG1 - eTPU 1 Channel 0 Status and Control Register
0x408	eTPU_CCCR_C0HSRR_ENG1 - eTPU 1 Channel 0 Host Service Request Register
0x40C	Reserved
0x410	eTPU_CCCR_C1CR_ENG1 - eTPU 1 Channel 1 Configuration Register

Table continues on the next page...

Table 479. Detailed memory map (continued)

Offset	Use
0x414	eTPU_CCCR_C1SCR_ENG1 - eTPU 1 Channel 1 Status and Control Register
0x418	eTPU_CCCR_C1HSRR_ENG1 - eTPU 1 Channel 1 Host Service Request Register
0x41C	Reserved
-----	-----
0x5F0	eTPU_CCCR_C31CR_ENG1 - eTPU 1 Channel 31 Configuration Register
0x5F4	eTPU_CCCR_C31SCR_ENG1 - eTPU 1 Channel 31 Status and Control Register
0x5F8	eTPU_CCCR_C31HSRR_ENG1 - eTPU 1 Channel 31 Host Service Request Register
0x5FC - 0x7FF	Reserved
0x800	eTPU_CCCR_C0CR_ENG2 - eTPU 2 Channel 0 Configuration Register
0x804	eTPU_CCCR_C0SCR_ENG2 - eTPU 2 Channel 0 Status and Control Register
0x808	eTPU_CCCR_C0HSRR_ENG2 - eTPU 2 Channel 0 Host Service Request Register
0x80C	Reserved
0x810	eTPU_CCCR_C1CR_ENG2 - eTPU 2 Channel 1 Configuration Register
0x814	eTPU_CCCR_C1SCR_ENG2 - eTPU 2 Channel 1 Status and Control Register
0x818	eTPU_CCCR_C1HSRR_ENG2 - eTPU 2 Channel 1 Host Service Request Register
0x81C	Reserved
-----	-----
0x9F0	eTPU_CCCR_C31CR_ENG2 - eTPU 2 Channel 31 Configuration Register
0x9F4	eTPU_CCCR_C31SCR_ENG2 - eTPU 2 Channel 31 Status and Control Register
0x9F8	eTPU_CCCR_C31HSRR_ENG2 - eTPU 2 Channel 31 Host Service Request Register
0x9FC - 0xBFF	Reserved
Shared Subsystem Support Registers	
0xC00	eTPU_SSIR_SSS0IR - eTPU SSS 0 Integration Register
0xC04	eTPU_SSIR_SSS1IR - eTPU SSS 1 Integration Register
0xC08	eTPU_SSIR_SSS2IR - eTPU SSS 2 Integration Register
0xC0A	eTPU_SSIR_SSS3IR - eTPU SSS 3 Integration Register
0xC0C	eTPU_SSIR_SSS4IR - eTPU SSS 4 Integration Register
0xC10	eTPU_SSIR_SSS5IR - eTPU SSS 5 Integration Register
0xC14	eTPU_SSIR_SSS6IR - eTPU SSS 6 Integration Register
0xC18	eTPU_SSIR_SSS7IR - eTPU SSS 7 Integration Register
0xC1A	eTPU_SSIR_SSS8IR - eTPU SSS 8 Integration Register
0xC1C	eTPU_SSIR_SSS9IR - eTPU SSS 9 Integration Register

Table continues on the next page...

Table 479. Detailed memory map (continued)

Offset	Use
0x1000 - 0x3FFF	Reserved[3]
0x4000 - 0x7FFF	Shared Subsystems area - SSS
0x8000 - 0xBFFF	Shared Data Memory - SDM
0xC000 - 0xFFFF	Shared Data Memory - SDM - PSE mirror [4]
0x10000-1FFFF[5]	Shared Code Memory - SCM[6]

1. This register is not implemented in some MCUs; see eTPU SCM Off-range Data Register (SCMOFFDATAR).
2. These registers are not implemented in some MCUs; see Memory error support .
3. ETPU reserved area space 0x1000 - 0x3FFF does not generate bus errors and reads as 0.
4. Parameter Sign Extension access area, see Parameter Access.
5. The actual SCM size is MCU-dependent (see the chip-specific eTPU information). SCM is allocated from the starting value of the given range of offsets. When the size is not the maximum, the unused SCM address range returns the value of eTPU SCM Off-range Data Register (SCMOFFDATAR).
6. SCM access is available only when eTPU_SCR_MCR[VIS] = 1, under certain conditions (see MCR[VIS]).

67.8 System Configuration memory map and registers

67.8.1 eTPU_SCR register descriptions

67.8.1.1 eTPU_SCR memory map

eTPU_3 base address: 4068_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	eTPU Module Configuration Register (MCR)	32	RW	See section
4h	eTPU Coherent Dual-Parameter Controller Register (CDCR)	32	RW	0000_0000h
Ch	eTPU MISC Compare Register (MISCCMPR)	32	RW	0000_0000h
10h	eTPU SCM Off-range Data Register (SCMOFFDATAR)	32	RW	F377_5FFBh
14h	eTPU Engine 1 Configuration Register (ECR_ENG1)	32	RW	See section
18h	eTPU Engine 2 Configuration Register (ECR_ENG2)	32	RW	See section

67.8.1.2 eTPU Module Configuration Register (MCR)

Offset

Register	Offset
MCR	0h

Function

This register is global to both eTPU engines, and resides in the shared BIU. It gathers global configuration and status in the eTPU system, including global exception. It is also used for configuring the SCM (shared code memory) operation and test.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	SDMERR	WDTO1	WDTO2	MGE1	MGE2	ILF1	ILF2	SSAERR	0	0	SCMSIZE				
W	GEC															
Reset	0	0	0	0	0	0	0	0	0	0	0	u[1]	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	Reserved	0		SCMMISC	SCMMISF	SCMMISEN	SCMERR	0	VIS	0					GTBE
W					W1C											
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1. See the chip-specific eTPU information for this field's reset value.

Fields

Field	Function
31 GEC	Global Exception Clear. This write-only bit negates global exception request and clears global exception status bits SDMERR, SSAERR, SCMERR, WDTO1/2, MGE1/2, ILF1/2, and SCMMISF. GEC works the same way with either one or both Engines in Module Disable Mode. 0b - Keep Global Exception request and status bits SDMERR, SSAERR, SCMERR, WDTO1/2, ILF1/2, MGE1/2, and SCMMISF as is. 1b - Negate Global Exception, clear status bits SDMERR, SSAERR, SCMERR, WDTO1/2, ILF1/2, MGE1/2, and SCMMISF.
30 SDMERR	SDM Read Error This flag indicates that an SDM non-correctable read error occurred on a microengine or host (including CDC) read, generating a Global Exception. This bit is cleared by writing 1 to GEC. 0b - No Global Exception pending because of SDM read error. 1b - Global Exception requested by SDM read error is pending.
29 WDTO1	Watchdog 1 Timeout. Flag WDTO1 indicates that a Watchdog Timeout occurred in engine 1, generating a Global Exception. This bit is cleared by writing 1 to GEC. 0b - No Global Exception pending because of Watchdog timeout. 1b - Global Exception requested by Watchdog timeout.
28 WDTO2	Watchdog 2 Timeout. Flag WDTO2 indicates that a Watchdog Timeout occurred in engine 2, generating a Global Exception. This bit is cleared by writing 1 to GEC. 0b - No Global Exception pending because of Watchdog timeout.

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Field	Function
	1b - Global Exception requested by Watchdog timeout.
27 MGE1	Microcode Global Exception Engine 1. This bit indicates that a global exception was asserted by microcode executed on engine 1. The determination of the reason why the global exception was asserted is application dependent: it can be coded in an SDM status parameter, for instance. This bit is cleared by writing 1 to GEC. 0b - No microcode-requested global exception pending. 1b - Global exception requested by microcode is pending.
26 MGE2	Microcode Global Exception Engine 2. This bit indicates that a global exception was asserted by microcode executed on engine 2. The determination of the reason why the global exception was asserted is application dependent: it can be coded in an SDM status parameter, for instance. This bit is cleared by writing 1 to GEC. 0b - No microcode-requested global exception pending. 1b - Global exception requested by microcode is pending.
25 ILF1	Illegal Instruction Flag for Engine 1. The ILFA1 flag is set by the microengine to indicate that an illegal instruction was decoded in Engine 1. This bit is cleared by host writing 1 to GEC. See Illegal instructions for more details. 0b - Illegal Instruction not detected. 1b - Illegal Instruction detected by Engine 1.
24 ILF2	Illegal Instruction Flag for Engine 2. The ILFA2 flag is set by the microengine to indicate that an illegal instruction was decoded in Engine 2. This bit is cleared by host writing 1 to GEC. See Illegal instructions for more details. 0b - Illegal Instruction not detected. 1b - Illegal Instruction detected by Engine 2.
23 SSAERR	Shared Subsystem Access Error. This flag indicates that a bus error occurred in an microengine access to the Shared Subsystem Area (see Shared subsystems support). This bit is cleared by writing 1 to GEC. **NOTE** Bus errors on host accesses to the Shared Subsystem Area do not set this bit neither asserts the Global Exception, but the bus error is propagated to the host CPU 0b - No bus error returned on a microengine Shared Subsystem Area access. 1b - Bus error returned on a microengine Shared Subsystem Area access.
22 —	Reserved
21	Reserved

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Field	Function
—	
20-16 SCMSIZE	SCM Size = 64 Kbytes. This read-only field holds the number of 2 KB SCM Blocks minus 1. See the chip-specific eTPU information for this field's reset value.
15 —	Reserved
14 —	Reserved
13-12 —	Reserved
11 SCMMISC	SCM MISC Complete flag. Flag SCMMISC indicates that MISC has completed the evaluation of the SCM signature since reset or since the last time it was cleared. SCMMISC is cleared by writing 1 to it, and is not cleared when MISC is disabled (SCMMISEN=0). SCMMISC asserts at the end of the SCM memory scan, either if the signature matches or not. 0b - MISC has not yet completed an SCM signature calculation and compare since the last time SCMMISC was cleared. 1b - MISC completed at least one SCM signature calculation and compare since the last time SCMMISC was cleared.
10 SCMMISF	SCM MISC Flag. The SCMMISF bit is set by the SCM MISC (Multiple Input Signature Calculator) logic to indicate that the calculated signature does not match the expected value in eTPU MISC Compare Register (MISCCMPR), at the end of a MISC iteration. See SCM test - multiple input signature calculator for more details. This bit is cleared when Global Exception is cleared by writing 1 to GEC. 0b - Signature mismatch not detected. 1b - MISC has read entire SCM array and the expected signature does not match the value calculated.
9 SCMMISEN	SCM MISC Enable. The SCMMISEN bit is used for enabling/disabling the operation of the MISC logic. SCMMISEN is readable and writable at any time. The MISC logic will only operate when this bit is set to 1. When the bit is reset, the MISC address counter is set to the initial SCM address. When enabled, the MISC will continuously cycle through the SCM addresses, reading each and calculating a CRC. In order to save power, the MISC can be disabled by clearing the SCMMISEN bit. See SCM test - multiple input signature calculator for more details. SCMMISEN resets automatically when MISC logic detects an error, i.e., when SCMMISF transitions from 0 to 1, disabling the MISC operation.

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Field	Function
	0b - MISC operation disabled. The MISC logic is reset to its initial state. 1b - MISC operation enabled.
8 SCMERR	SCM Read Error. This flag indicates that an SCM non-correctable read error occurred on a host or microengine (including MISC) read, generating a Global Exception. This bit is cleared by writing 1 to GEC. 0b - No Global Exception pending because of SCM read error. 1b - Global Exception requested by SCM read error is pending.
7 —	Reserved
6 VIS	SCM Visibility Bit. VIS bit turns SCM visible to the IP-Bus and resets MISC state (but SCMMISEN keeps its value). This bit is write protected when any of the Engines is not halted or stopped. When VIS=1, the MDIS bits in the eTPU Memory Error Support registers are write protected. 0b - SCM is not visible to the slave bus. Accessing SCM address space issues a bus error, writes are protected and reads are meaningless. 1b - SCM is visible to the slave bus. MISC state is reset.
5-1 —	Reserved
0 GTBE	Global Time Base Enable. GTBE enables time bases in both Engines, allowing them to be started synchronously. **NOTE** Global Time Base Enable action may also depend on other blocks, as explained in Global time base enable (GTBE). **NOTE** When GTBE is turned off with Angle Mode enabled, the EAC must be reinitialized before GTBE is turned on again. The EAC reinitialization procedure is described in Restarting angle logic. 0b - Time bases in both Engines are disabled to run. 1b - Time bases in both Engines are enabled to run.

67.8.1.3 eTPU Coherent Dual-Parameter Controller Register (CDCR)

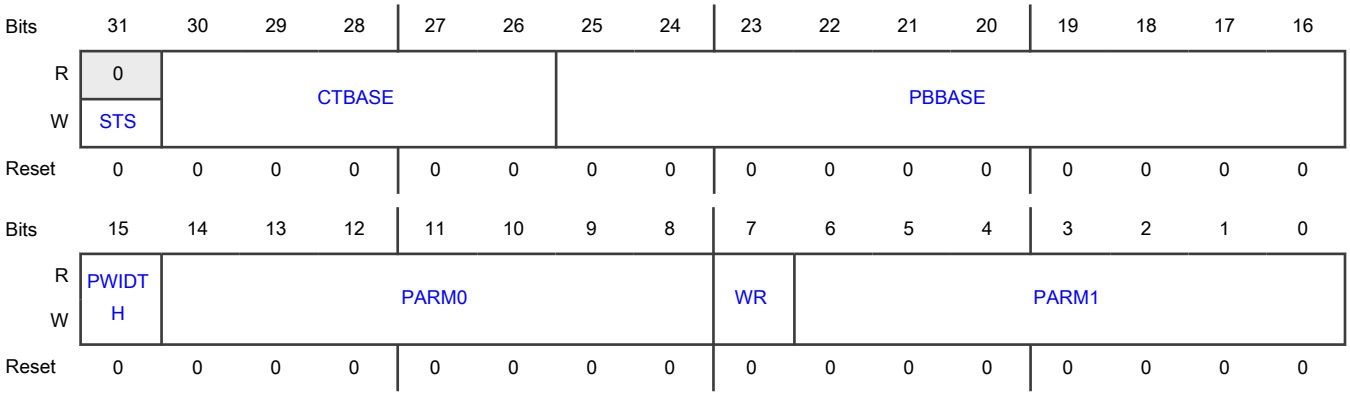
Offset

Register	Offset
CDCR	4h

Function

This register configures and controls dual-parameter coherent transfers. For more information, see Coherent Dual-parameter Controller (CDC).

Diagram



Fields

Field	Function
31 STS	Start Bit. This bit is set by the host in order to start the data transfer between the parameter buffer pointed by PBBASE and the target addresses selected by the concatenation of fields CTBASE and PARM0/1. The host receives wait-states until the data transfer is complete, when this bit is reset by the coherency logic (see Coherent Dual-parameter Controller (CDC)). Therefore, host always reads STS as 0. 0b - Write does not start a coherent transfer. 1b - Write starts a coherent transfer.
30-26 CTBASE	Channel Transfer Base. This field concatenates with fields PARM0 and PARM1 to determine the absolute word offset (from the SDM base) of the parameters to be transferred: Parameter 0 word address = {CTBASE, PARM0} + SDM base word address. Parameter 1 word address = {CTBASE, PARM1} + SDM base word address.
25-16 PBBASE	Parameter Buffer Base Address.

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Field	Function
	This field points to the base address of the parameter buffer location, with granularity of 2 parameters (8 bytes). The host (byte) address of the first parameter in the buffer is PBBASE * 8 + SDM Base Byte Address. The microengine absolute (word) address of the first parameter in the buffer is PBBASE * 2.
15 PWIDTH	Parameter Width Selection. This bit selects the width of the parameters to be transferred between the PB and the target address. 0b - Transfer 24-bit parameters. The upper byte remains unchanged in the destination address. 1b - Transfer 32-bit parameters. All 32 bits of the parameters are written in the destination address.
14-8 PARM0	Channel Parameter number 0. The PARM0 and PARM1 fields in concatenation with CTBASE determine the word address offset (from the SDM base) of the parameters that are destination or source (defined by WR) of the coherent transfer. The word SDM address offset of the parameters are {CTBASE, PARM0/1}. **NOTE** PARM0 and PARM1 allow non-contiguous parameters to be transferred coherently. The parameter pointed by {CTBASE, PARM0} is the first transferred.
7 WR	Read/Write selection. This bit selects the direction of the coherent data transfer. 0b - Read operation. Data transfer is from the selected SDM address to the PB. 1b - Write operation. Data transfer is from the PB to the selected SDM address.
6-0 PARM1	Channel Parameter number 1. The PARM0 and PARM1 fields in concatenation with CTBASE determine the word address offset (from the SDM base) of the parameters that are destination or source (defined by WR) of the coherent transfer. The word SDM address offset of the parameters are {CTBASE, PARM0/1}. **NOTE** PARM0 and PARM1 allow non-contiguous parameters to be transferred coherently. The parameter pointed by {CTBASE, PARM0} is the first transferred.

67.8.1.4 eTPU MISC Compare Register (MISCCMPR)

Offset

Register	Offset
MISCCMPR	Ch

Function

This register holds the 32-bit signature expected from the whole SCM array. This register must be written by the host with the 32-bit word to be compared against the calculated signature at the end of the MISC cycle. This register is global to both eTPU Engines. For more detail, see SCM test - multiple input signature calculator.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	ETPUMISCCMP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ETPUMISCCMP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 ETPUMISCCMP	Expected Multiple Input Signature Register value. For details, see SCM test - multiple input signature calculator.

67.8.1.5 eTPU SCM Off-range Data Register (SCMOFFDATAR)

Offset

Register	Offset
SCMOFFDATAR	10h

Function

This register holds the 32-bit value returned when SCM array is accessed at non-implemented addresses, either by the Host or by the microengine. This register can be written by the host with the 32-bit instruction to be executed by the microengine to recover from runaway code. This register is global to both eTPU Engines. For more detail see SCM off-range data.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	ETPUSCMOFFDATAR															
Reset	1	1	1	1	0	0	1	1	0	1	1	1	0	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ETPUSCMOFFDATAR															
Reset	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1

Fields

Field	Function
31-0 ETPUSCMOFFDATAR	SCM Off-range read data value. See SCM off-range data.

67.8.1.6 eTPU Engine 1 Configuration Register (ECR_ENG1)

Offset

Register	Offset
ECR_ENG1	14h

Function

This register holds configuration and status fields for engine 1.

NOTE

See Register Reset Values in the chip-specific eTPU information.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R		MDIS	0	STF	0				HLTF	0			FCSS	FPSCK		
W	FEND															
Reset	0	u[1]	0	0	0	0	0	0	u[2]	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CDFC		0	ERBA					SPPDIS	0			ETB			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1. Reset value is 1.

2. HLTF field reset value is 1 if, after a reset, the eTPU Nexus debug support is on and a breakpoint request is asserted. Otherwise the reset value is 0.

Fields

Field	Function
31 FEND	Force End. FEND assertion terminates any current running thread as if an END instruction have been executed (see Ending Current Thread - END). This bit is self-negating when the thread ends. **NOTE** Only on rare occasions (e.g., during a long stall, see Microengine Stall) FEND can be read as 1, because it negates as soon as the end begins execution. Writing FEND = 1 is ignored and FEND stays 0 when the microengine is in TST, halted, stopped, or idle (no thread executing). 0b - Normal operation. 1b - Ends any ongoing thread.
30 MDIS	Module Disable Bit. When MDIS is set, the Engine shuts down its internal clocks, going into Module Disable Mode. TCR1 and TCR2 cease to increment, and input sampling stops. The Engine asserts the stop flag (STF) bit to indicate that it has stopped. However, the BIU continues to run, and the Host can access all registers except for the channel registers (see channel registers starting with C*a*CR_ENG1) **NOTE** The Timebase registers can still be read with MDIS=1, but writes are ineffective and a Bus Error is issued. Global Channel Registers and SDM can be accessed normally. After MDIS is set, even before STF asserts, data read from the channel registers is not meaningful and writes are ineffective, issuing a Bus Error. When the MDIS bit is asserted while the microcode is executing, the eTPU will stop when the thread is complete. Stop completes on the next eTPU clock after the stop condition is valid. **NOTE** Once MDIS is switched from 1 to 0 or vice versa, it must not write a different value until STF changes accordingly. The MDIS bit is write-protected when VIS=1. See Register Reset Values in the chip-specific eTPU information. 0b - eTPU Engine runs. 1b - Commands Engine to stop its clocks.
29 —	Reserved
28	Stop Flag Bit.

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Field	Function
STF	Each Engine asserts its stop flag (STF) to indicate that it has stopped. Only then the host can assume that the Engine has actually stopped. The eTPU system is fully stopped when the STF bits of both eTPU Engines are asserted. In case of a stop request, the eTPU responds by acknowledging stop only after both eTPU 1 and eTPU 2 have been stopped. Engine only stops when any ongoing thread is complete also in this case. Summarizing Engine stop conditions, which STF reflects: STF_1 := (after stop completed) MDIS_1 | device stop request. STF_2 := (after stop completed) MDIS_2 | device stop request. STF_1 and STF_2 mean STF bit from engine 1 and STF bit from engine 2, respectively. See Register Reset Values in the chip-specific eTPU information. 0b - Engine is operating. 1b - Engine has stopped (after the local MDIS bit has been asserted, or after the IP-Bus stop line has been asserted).
27-24 —	Reserved
23 HLTF	Halt Mode Flag. If eTPU Engine entered halt state, this flag is asserted. The flag remains asserted while the microengine is in halt state, even during a single-step or forced instruction execution. See Development support features for further details about entering Halt Mode. 0b - eTPU Engine is not halted. 1b - eTPU Engine is halted.
22-20 —	Reserved
19 FCSS	Filter Clock Source Selection Speeds up the filter clock source before the prescaler, allowing more input capture resolution at minimum prescaling. **NOTE** FCSS=1 also makes the channel work on T2/T4 timing mode (see T2/T4 channel timing). 0b - Use eTPU clock / 2 as EDF clock source before prescaler. 1b - Use eTPU clock as EDF clock source before prescaler
18-16 FPSCK	Filter Prescaler Clock Control. FPSCK controls the prescaling of the clocks used in digital filters for the channel input signals and TCRCLK input, as shown in the table below. Filtering can be controlled independently by each engine, but all input digital filters in the same engine have same clock prescaling. For more details, see Filter clock prescaler. A new value written to FPSCK only becomes effective when the filter prescaler finishes the current count.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Filter control</th><th colspan="2">Sample on system clock divided by:</th></tr>
<tr><td></td><td>FCSS = 0</td><td>FCSS = 1</td></tr>
<tr><td>000</td><td>2</td><td>1</td></tr>
<tr><td>001</td><td>4</td><td>2</td></tr>
<tr><td>010</td><td>8</td><td>4</td></tr>
<tr><td>011</td><td>16</td><td>8</td></tr>
<tr><td>100</td><td>32</td><td>16</td></tr>
<tr><td>101</td><td>64</td><td>32</td></tr>
<tr><td>110</td><td>128</td><td>64</td></tr>
<tr><td>111</td><td>256</td><td>128</td></tr>
</table>
</td></tr>
<tr><td>15-14
CDFC</td><td>Channel Digital Filter Control.

These bits select a digital filtering mode for the channels when configured as inputs for improved noise immunity (refer to the table below). The eTPU has three digital filtering modes for the channels which provide programmable trade-off between signal latency and noise immunity (see Enhanced digital filter (EDF)). Changing CDFC during eTPU normal input channel operation is not recommended since it changes the behavior of the transition detection logic while executing its operation.
<table>
<tr><th>CDFC</th><th>Selected digital filter</th></tr>
<tr><td>00</td><td>TPU2/3 Two Sample Mode: Using the filter clock which is the system clock divided by (2, 4, 8,..., 256) as a sampling clock (selected by FPSCK), comparing two consecutive samples which agree with each other sets the input signal state. This is the default reset state.</td></tr>
<tr><td>01</td><td>eTPU bypass mode: the input signal is taken unfiltered, also making the channels work on T2/T4 timing mode.[1]</td></tr>
<tr><td>10</td><td>eTPU Three Sample Mode: Similar to the TPU2/3 two sample mode, but comparing three consecutive samples which agree with each other sets the input signal state.</td></tr>
<tr><td>11</td><td>eTPU Continuous Mode: Signal need to be stable for the whole filter clock period. This mode compares all the values at the rate of eTPU clock (FCSS=1) or eTPU clock divided by two(FCSS=0), between two consecutive filter clock pulses. Signal needs to be continuously stable for the entire period. If all the values agree with each other, input signal state is updated.</td></tr>
</table>
1. See T2/T4 channel timing.</td></tr>
<tr><td>13
—</td><td>Reserved</td></tr>
<tr><td>12-8</td><td>Engine Relative Base Address.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
ERBA	This field value is concatenated with the AID instruction field in engine relative address mode to form the SDM address (see Engine Relative Addressing Mode).
7 SPPDIS	Schedule Priority Passing Disable. SPPDIS is used to disable the priority passing mechanism of the microengine scheduler (see Primary scheme - priority among channels on different levels). **NOTE** SPPDIS bit must not be changed while any channel is enabled. 0b - Scheduler priority passing mechanism enabled. 1b - Scheduler priority passing mechanism disabled.
6-5 —	Reserved
4-0 ETB	Entry Table Base. The field determines the location of the microcode entry table for the eTPU functions in SCM (see Entry Points). The following table shows the entry table base address options.

ETB	Entry Table Base Address for CPU Host Address (byte format)	Entry Table Base Address for Microcode Address (word format)
00000	0x000	0x000
00001	0x800	0x200
00010	0x1000	0x400
--------	----------	---------
11110	0xF000	0x3C00
11111	0xF800	0x3E00

67.8.1.7 eTPU Engine 2 Configuration Register (ECR_ENG2)

Offset

Register	Offset
ECR_ENG2	18h

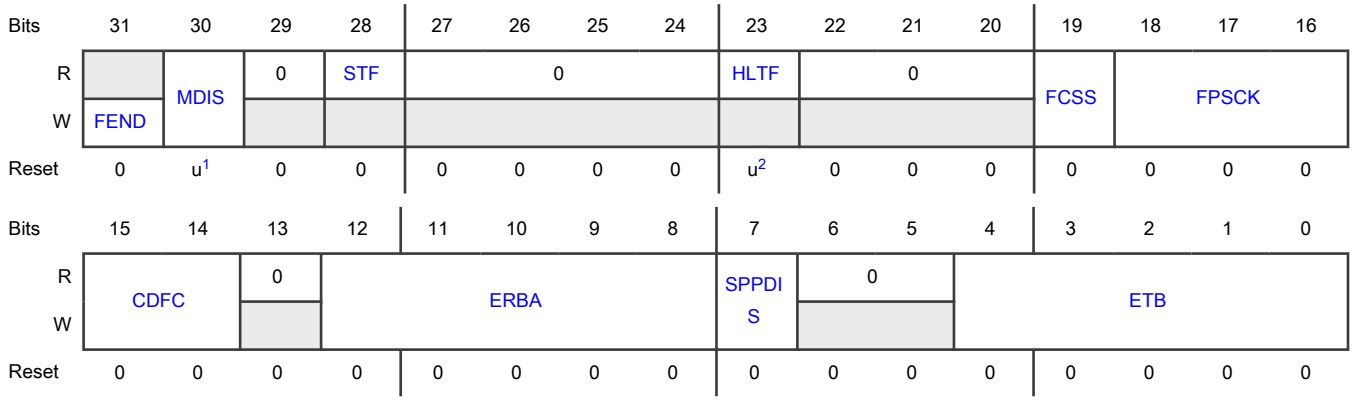
Function

This register holds configuration and status fields for engine 2.

NOTE

See Register Reset Values in the chip-specific eTPU information.

Diagram



1. Reset value is 1.
2. HLTF field reset value is 1 if, after a reset, the eTPU Nexus debug support is on and a breakpoint request is asserted. Otherwise the reset value is 0.

Fields

Field	Function
31 FEND	Force End. FEND assertion terminates any current running thread as if an END instruction have been executed (see Ending Current Thread - END). This bit is self-negating when the thread ends. **NOTE** Only on rare occasions (e.g., during a long stall, see Microengine Stall) FEND can be read as 1, because it negates as soon as the end begins execution. Writing FEND = 1 is ignored and FEND stays 0 when the microengine is in TST, halted, stopped, or idle (no thread executing). 0b - Normal operation. 1b - Ends any ongoing thread.
30 MDIS	Module Disable Bit. When MDIS is set, the Engine shuts down its internal clocks, going into Module Disable Mode. TCR1 and TCR2 cease to increment, and input sampling stops. The Engine asserts the stop flag (STF) bit to indicate that it has stopped. However, the BIU continues to run, and the Host can access all registers except for the channel registers (see channel registers starting with eTPU Channel Configuration-Control registers) **NOTE** The Timebase registers can still be read with MDIS=1, but writes are ineffective and a Bus Error is issued. Global Channel Registers and SDM can be accessed normally. After MDIS is set, even before STF asserts, data read from the channel registers is not meaningful and writes are ineffective, issuing a Bus Error. When the MDIS bit is asserted while the microcode is executing, the eTPU will stop when the thread is complete. Stop completes on the next eTPU clock after the stop condition is valid.

Table continues on the next page...

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Field	Function
	NOTE Once MDIS is switched from 1 to 0 or vice versa, it must not write a different value until STF changes accordingly. The MDIS bit is write-protected when VIS=1. See Register Reset Values in the chip-specific eTPU information. 0b - eTPU Engine runs. 1b - Commands Engine to stop its clocks.
29 —	Reserved
28 STF	Stop Flag Bit. Each Engine asserts its stop flag (STF) to indicate that it has stopped. Only then the host can assume that the Engine has actually stopped. The eTPU system is fully stopped when the STF bits of both eTPU Engines are asserted. In case of IP-Bus stop, the eTPU system responds by acknowledging stop only after both eTPU 1 and eTPU 2 have been stopped. Engine only stops when any ongoing thread is complete also in this case. Summarizing Engine stop conditions, which STF reflects: STF_1 := (after stop completed) MDIS_1 | device stop request. STF_2 := (after stop completed) MDIS_2 | device stop request. STF_1 and STF_2 mean STF bit from engine 1 and STF bit from engine 2, respectively. See Register Reset Values in the chip-specific eTPU information. 0b - Engine is operating. 1b - Engine has stopped (after the local MDIS bit has been asserted, or after the IP-Bus stop line has been asserted).
27-24 —	Reserved
23 HLTF	Halt Mode Flag. If eTPU Engine entered halt state, this flag is asserted. The flag remains asserted while the microengine is in halt state, even during a single-step or forced instruction execution. See Development support features for further details about entering Halt Mode. 0b - eTPU Engine is not halted. 1b - eTPU Engine is halted.
22-20 —	Reserved
19	Filter Clock Source Selection

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>FCSS</td><td>Speeds up the filter clock source before the prescaler, allowing more input capture resolution at minimum prescaling.
NOTE
FCSS=1 also makes the channel work on T2/T4 timing mode (see T2/T4 channel timing).
0b - Use eTPU clock / 2 as EDF clock source before prescaler.
1b - Use eTPU clock as EDF clock source before prescaler</td></tr>
<tr><td>18-16
FPSCK</td><td>Filter Prescaler Clock Control.
FPSCK controls the prescaling of the clocks used in digital filters for the channel input signals and TCRCLK input, as shown in the table below. Filtering can be controlled independently by each engine, but all input digital filters in the same engine have same clock prescaling. For more details, see Filter clock prescaler.
A new value written to FPSCK only becomes effective when the filter prescaler finishes the current count.
<table>
<tr><th>Filter control</th><th>Sample on system clock divided by:</th></tr>
<tr><td>000</td><td>2</td></tr>
<tr><td>001</td><td>4</td></tr>
<tr><td>010</td><td>8</td></tr>
<tr><td>011</td><td>16</td></tr>
<tr><td>100</td><td>32</td></tr>
<tr><td>101</td><td>64</td></tr>
<tr><td>110</td><td>128</td></tr>
<tr><td>111</td><td>256</td></tr>
</table></td></tr>
<tr><td>15-14
CDFC</td><td>Channel Digital Filter Control.
These bits select a digital filtering mode for the channels when configured as inputs for improved noise immunity (refer to the table below). The eTPU has three digital filtering modes for the channels which provide programmable trade-off between signal latency and noise immunity (see Enhanced digital filter (EDF)). Changing CDFC during eTPU normal input channel operation is not recommended since it changes the behavior of the transition detection logic while executing its operation.
<table>
<tr><th>CDFC</th><th>Selected digital filter</th></tr>
<tr><td>00</td><td>TPU2/3 Two Sample Mode: Using the filter clock which is the system clock divided by (2, 4, 8,..., 256) as a sampling clock (selected by FPSCK),"/>), comparing two consecutive samples which agree with each other sets the input signal state. This is the default reset state.</td></tr>
<tr><td>01</td><td>eTPU bypass mode: the input signal is taken unfiltered, also making the channels work on T2/T4 timing mode.[1]</td></tr>
</table></td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>CDFC</th><th>Selected digital filter</th></tr>
<tr><td>10</td><td>eTPU Three Sample Mode: Similar to the TPU2/3 two sample mode, but comparing three consecutive samples which agree with each other sets the input signal state.</td></tr>
<tr><td>11</td><td>eTPU Continuous Mode: Signal need to be stable for the whole filter clock period. This mode compares all the values at the rate of eTPU clock (FCSS=1) or eTPU clock divided by two(FCSS=0), between two consecutive filter clock pulses. Signal needs to be continuously stable for the entire period. If all the values agree with each other, input signal state is updated.</td></tr>
</table>
1. See T2/T4 channel timing.
</td></tr>
<tr><td>13
—</td><td>Reserved</td></tr>
<tr><td>12-8
ERBA</td><td>Engine Relative Base Address.
This field value is concatenated with the AID instruction field in engine relative address mode to form the SDM address (see Engine Relative Addressing Mode).</td></tr>
<tr><td>7
SPPDIS</td><td>Schedule Priority Passing Disable.
SPPDIS is used to disable the priority passing mechanism of the microengine scheduler (see Primary scheme - priority among channels on different levels).
NOTE
SPPDIS bit must not be changed while any channel is enabled.
0b - Scheduler priority passing mechanism enabled.
1b - Scheduler priority passing mechanism disabled.</td></tr>
<tr><td>6-5
—</td><td>Reserved</td></tr>
<tr><td>4-0
ETB</td><td>Entry Table Base.
The field determines the location of the microcode entry table for the eTPU functions in SCM (see Entry Points). The following table shows the entry table base address options.
<table>
<tr><th>ETB</th><th>Entry Table Base Address for CPU Host Address (byte format)</th><th>Entry Table Base Address for Microcode Address (word format)</th></tr>
<tr><td>00000</td><td>0x000</td><td>0x000</td></tr>
<tr><td>00001</td><td>0x800</td><td>0x200</td></tr>
<tr><td>00010</td><td>0x1000</td><td>0x400</td></tr>
<tr><td>--------</td><td>----------</td><td>---------</td></tr>
</table>
</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function		
	ETB	Entry Table Base Address for CPU Host Address (byte format)	Entry Table Base Address for Microcode Address (word format)
	11110	0xF000	0x3C00
	11111	0xF800	0x3E00

67.9 Timebase memory map and registers

67.9.1 eTPU_TBR register descriptions

Time Base registers allows configuration and visibility of internally-generated time bases TCR1 and TCR2. There is one of each of these registers for each eTPU Engine.

NOTE

Writes to these registers issue bus error and are ineffective when MDIS=1. Reads are always allowed.

67.9.1.1 eTPU_TBR memory map

eTPU_6 base address: 4068_0000h

Offset	Register	Width (In bits)	Access	Reset value
20h	eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1)	32	RW	2000_0000h
24h	eTPU Engine 1 Time Base 1 (TCR1) Visibility Register (TB1R_ENG1)	32	R	0000_0000h
28h	eTPU Engine 1 Time Base 2 (TCR2) Visibility Register (TB2R_ENG1)	32	R	0000_0000h
2Ch	eTPU Engine 1 STAC Configuration Register (STAC_ENG1)	32	RW	See section
40h	eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2)	32	RW	2000_0000h
44h	eTPU Engine 2 Time Base 1 (TCR1) Visibility Register (TB1R_ENG2)	32	R	0000_0000h
48h	eTPU Engine 2 Time Base 2 (TCR2) Visibility Register (TB2R_ENG2)	32	R	0000_0000h
4Ch	eTPU Engine 2 STAC Configuration Register (STAC_ENG2)	32	RW	See section

67.9.1.2 eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1)

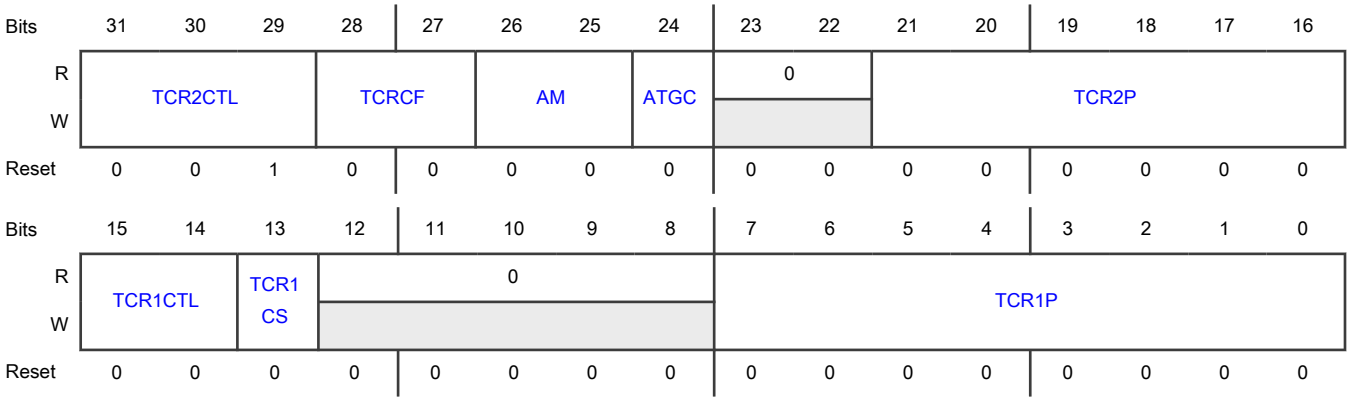
Offset

Register	Offset
TBCR_ENG1	20h

Function

This register configures several timebase options.

Diagram



Fields

Field	Function
31-29 TCR2CTL	TCR2 Clock/Gate Control. These bits are part of the TCR2 clocking system (see Time bases). They determine the clock source for TCR2 before the prescaler. TCR2 can count on any detected edge of the TCRCLK signal or use it for gating eTPU clock divided by 8. After reset - TCRCLK signal rising edge is selected. TCR2 can also be clocked by the eTPU clock divided by 8. TCR2CTL also determines the TCRCLK edge selected for angle tooth detection in angle mode. See the following table.

TCR2CTL	AM = 0 TCR2 Clock before prescaler	AM > 0 Angle Tooth detection
000	Gated DIV8 clock (eTPU clock / 8). In this case, when the external TCRCLK signal is low, the DIV8 clock is blocked, preventing it from incrementing the TCR2 prescaler. When the external TCRCLK signal is high, TCR2 prescaler is incremented at the frequency of the eTPU clock divided by 8.	Do not use with AM > 0
001	Rise transition on TCRCLK signal increments the TCR2 prescaler.	Rising edge
010	Fall transition on TCRCLK signal increments the TCR2 prescaler.	Falling edge
011	Rise or Fall transition on TCRCLK signal increments the TCR2 prescaler.	Both edges

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>TCR2CTL</th><th>AM = 0
TCR2 Clock before prescaler</th><th>AM > 0
Angle Tooth detection</th></tr>
<tr><td>100</td><td>DIV8 clock (eTPU clock / 8)</td><td>Do not use with AM > 0</td></tr>
<tr><td>101</td><td>Do not use with AM=0</td><td>Do not use with AM > 0</td></tr>
<tr><td>110</td><td>Do not use with AM=0</td><td>No edge[1]</td></tr>
<tr><td>111</td><td>TCR2 frozen, except as STAC client</td><td>Do not use with AM > 0</td></tr>
</table>
1. TCRCLK edges are not detected by the EAC logic, but they can still be detected by the channel 0 logic if AM=01.
</td></tr>
<tr><td>28-27
TCRCF</td><td>TCRCLK Signal Filter Control.
This field controls the TCRCLK digital filter (see TCRCLK digital filter), determining whether the TCRCLK signal input (after a synchronizer) is filtered with the same filter clock as the channel input signals (see Enhanced digital filter (EDF)) or uses the eTPU clock divided by 2, and also whether the TCRCLK digital filter works in integrator mode or two sample mode (see the following table).
<table>
<tr><th>TCRCF</th><th>Filter Clock</th><th>Filter Mode</th></tr>
<tr><td>00</td><td>eTPU clock divided by 2</td><td>Two sample</td></tr>
<tr><td>01</td><td>Filter clock of the channels</td><td>Two sample</td></tr>
<tr><td>10</td><td>eTPU clock divided by 2</td><td>Integrator</td></tr>
<tr><td>11</td><td>Filter clock of the channels</td><td>Integrator</td></tr>
</table>
</td></tr>
<tr><td>26-25
AM</td><td>Angle Mode Selection.
This field enables the Enhanced Angle Counter logic to generate angle information (see EAC - eTPU Angle Counter), and also select the tooth signal input and the channel used to process it, as shown in the following table. When EAC is not disabled by AM and neither TCR1 nor TCR2 are STAC Clients, the EAC (eTPU Angle Clock) hardware provides angle information to the channels using the TCR2 bus. When AM is reset (non-angle mode), the EAC operation is disabled, and its internal registers can be used as general purpose. For more information, see EAC - eTPU Angle Counter.
<table>
<tr><th>Value</th><th>TCR2 Value</th><th>Tooth signal</th><th>Tooth processing channel</th></tr>
<tr><td>00</td><td>Timebase (EAC operation disabled)</td><td colspan="2">Not applicable</td></tr>
<tr><td>01</td><td rowspan="2">Angle Ticks</td><td>TCRCLK input</td><td>0</td></tr>
<tr><td>10</td><td>Channel 1 input</td><td>1</td></tr>
</table>
</td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Value</th><th>TCR2 Value</th><th>Tooth signal</th><th>Tooth processing channel</th></tr>
<tr><td>11</td><td></td><td>Channel 2 input</td><td>2</td></tr>
</table>
If TCR1 or TCR2 is a STAC Bus Client (see STAC interface), the EAC operation is not allowed, and AM must be set to 0.
NOTE
Changing AM may cause unexpected transition detections on the channel selected by AM, depending on the channel mode and state (see Transition detection and Time Base Capture). If AM must be changed with GTBE=1, the recommended procedure is described in Restarting angle logic.
</td></tr>
<tr><td>24
ATGC</td><td>Angle Tick Generator Clock.
This bit selects the clock that provides the time interval unit for Angle Tick Generation. For details, see Generating the angle ticks.
0b - TCR1 prescaler output provides time intervals for tick generation.
1b - TCR2 prescaler output provides time intervals for tick generation.</td></tr>
<tr><td>23-22
—</td><td>Reserved</td></tr>
<tr><td>21-16
TCR2P</td><td>Timer Count Register 2 Prescaler Control.
These bits are part of the TCR2 clocking system (see Time bases). TCR2 is clocked from the output of a prescaler. The prescaler divides its input by (TCR2P + 1) allowing frequency divisions from 1 to 64. The prescaler input is the eTPU clock divided by 8 (in gated or non-gated clock mode), or Internal Timebase input, or TCRCLK filtered input. This field has no effect on TCR2 in Angle Mode.</td></tr>
<tr><td>15-14
TCR1CTL</td><td>TCR1 Clock/Gate Control.
TCR1CTL is part of the TCR1 clocking system (see Time bases). It determines, together with TCR1CS, the clock source for TCR1. TCR1 can count on detected rising edge of the TCRCLK signal, the eTPU clock, or the eTPU clock divided by 2 (see the table in the TCR1CS bit description). After reset TCRCLK signal is selected.</td></tr>
<tr><td>13
TCR1CS</td><td>TCR1 Clock Source
TCR1CS provides the option to double the TCR1 incrementing speed, using eTPU clock as its clock source instead of eTPU clock / 2.
NOTE
If ATGC=0, the clock source of the EAC angle tick generator will still be an even division of eTPU clock if TCR1CS=1, obeying to the field TCR1P as if TCR1CS=0 (see Angle Tick Generator).</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>TCR1CTL</th><th>TCR1CS</th><th>TCR1 Clock before prescaler</th></tr>
<tr><td>00</td><td>0</td><td>Selects TCRCLK as clock source for the TCR1 prescaler.[1]</td></tr>
<tr><td>01</td><td>0</td><td>Reserved</td></tr>
<tr><td>01</td><td>1</td><td>Reserved</td></tr>
<tr><td>10</td><td>0</td><td>Selects eTPU clock divided by 2 as clock source for the TCR1 prescaler.</td></tr>
<tr><td>10</td><td>1</td><td>Selects eTPU clock as clock source for the TCR1 prescaler.</td></tr>
<tr><td>11</td><td>0</td><td>TCR1 frozen, except as a STAC client</td></tr>
</table>
1. This selection must not be used in Angle Mode.

0b - Use eTPU clock / 2 as TCR1 clock source before the prescaler, if that clock source is selected by TCR1CTL.

1b - Use eTPU clock as TCR1 clock source before the prescaler; can only be set in specific combinations with TCR1CTL, as shown in the table. TCR1CS=1 also makes the channel work on T2/T4 timing mode.
</td></tr>
<tr><td>12-8
—</td><td>Reserved</td></tr>
<tr><td>7-0
TCR1P</td><td>Timer Count Register 1 Prescaler Control

TCR1 is clocked from the output of a prescaler. T he input to the prescaler is the internal eTPU clock divided by 2, eTPU clock, or the output of TCRCLK filter. The prescaler divides this input by (TCR1P + 1) allowing frequency divisions from 1 up to 256.

NOTE
The TCR1 prescaler counts TCR1P rising edges of TCRCLK on the 1st TCR1 increment. If TCR1CTL selects TCRCLK as TCR1 clock source and TCR1P > 0, the first TCR1 increment happens after TCR1P rising edges of TCRCLK. The second TCR1 increment happens correctly after TCR1P+1 rising edges of TCRCLK.</td></tr>
</table>

67.9.1.3 eTPU Engine 1 Time Base 1 (TCR1) Visibility Register (TB1R_ENG1)

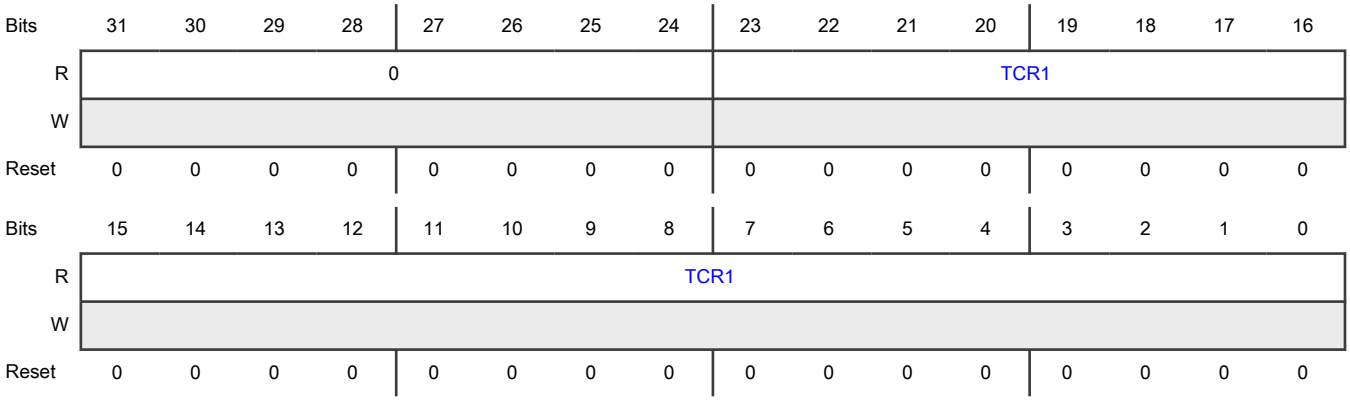
Offset

Register	Offset
TB1R_ENG1	24h

Function

This register provides visibility of the TCR1 time base for host read access (see Time bases). This register is read-only. The value of the TCR1 time base shown can be driven by the TCR1 counter or imported from STAC bus, depending on the configuration set in eTPU Engine 1 STAC Configuration Register (STAC_ENG1).

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 TCR1	TCR1 value. TCR1 value used on matches and captures. See Time bases.

67.9.1.4 eTPU Engine 1 Time Base 2 (TCR2) Visibility Register (TB2R_ENG1)

Offset

Register	Offset
TB2R_ENG1	28h

Function

This register provides visibility of the TCR2 time base for host read access (see Time bases). This register is read-only. The value of the TCR2 time base shown can be driven by the TCR2 counter or imported from the STAC bus, depending on Angle Mode and STAC configurations set in eTPU Engine 1 STAC Configuration Register (STAC_ENG1).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								TCR2							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TCR2															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-0 TCR2	TCR2 value. TCR2 value used on matches and captures. See Time bases.

67.9.1.5 eTPU Engine 1 STAC Configuration Register (STAC_ENG1)

Offset

Register	Offset
STAC_ENG1	2Ch

Function

This register configures the eTPU STAC bus operation as a STAC Server/Client module (see STAC interface).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	REN1	RSC1	0		SERVER_ID1				0				SRV1			
W																
Reset	0	0	0	0	u[1]	u	u	u	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REN2	RSC2	0		SERVER_ID2				0				SRV2			
W																
Reset	0	0	0	0	u[1]	u	u	u	0	0	0	0	0	0	0	0

1. See the chip-specific eTPU information for the reset value.

Fields

Field	Function
31 REN1	TCR1 Resource Client/Server Operation Enable Bit. This bit enables Client/Server operation to eTPU STAC resources. REN1 enables TCR1 STAC bus operations. 0b - Server/Client Operation for TCR1 is disabled. 1b - Server/Client Operation for TCR1 is enabled.
30 RSC1	TCR1 Resource Server/Client Assignment Bits. This bit selects the eTPU data resource assignment to be used as Servers or Clients. For Server mode, MCU-dependent value determines the unique server address assigned to each TCR. See the chip-specific eTPU information for the STAC server IDs. For a Client mode, the SRV1 field determines the Server address to which the Client listens. **NOTE** When TCR1 or TCR2 is configured as a STAC Bus Client (REN1/2 = 1, RSC1/2 = 0) the eTPU Angle Clock hardware cannot be used. **NOTE** RSC1 must not be changed when the REN1 bit is asserted. 0b - Resource Client operation. 1b - Resource Server operation.
29-28 —	Reserved
27-24 SERVER_ID1	Red Line STAC ID 1. STAC Server ID (read-only MCU-dependent values; see the chip-specific eTPU information for the STAC server IDs) used for TCR1 when STAC servers are used.
23-20 —	Reserved
19-16 SRV1	TCR1 Resource Server. This bit selects the address of the specific STAC Server to which the local TCR1 listens when configured as a STAC Client. SRV1 selects the STAC Server of TCR1.
15 REN2	TCR2 Resource Client/Server Operation Enable Bit. This bit enables Client/Server operation to eTPU STAC resources. REN2 enables TCR2 STAC bus operations. 0b - Server/Client Operation for TCR2 is disabled. 1b - Server/Client Operation for TCR2 is enabled.
14	TCR2 Resource Server/Client Assignment Bits.

Table continues on the next page...

Table continued from the previous page...

Field	Function
RSC2	**NOTE** Either time or angle TCR2 values. 0b - Resource Client operation. 1b - Resource Server operation.
13-12 —	Reserved
11-8 SERVER_ID2	Red Line STAC ID 2. STAC Server ID (read-only MCU-dependent values; see the chip-specific eTPU information for the STAC server IDs) used for TCR2 when when STAC servers are used.
7-4 —	Reserved
3-0 SRV2	TCR2 Resource Server. This bit selects the address of the specific STAC Server to which the local TCR2 listens when configured as a STAC Client. SRV2 selects the Red Line STAC Server of TCR2.

67.9.1.6 eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2)

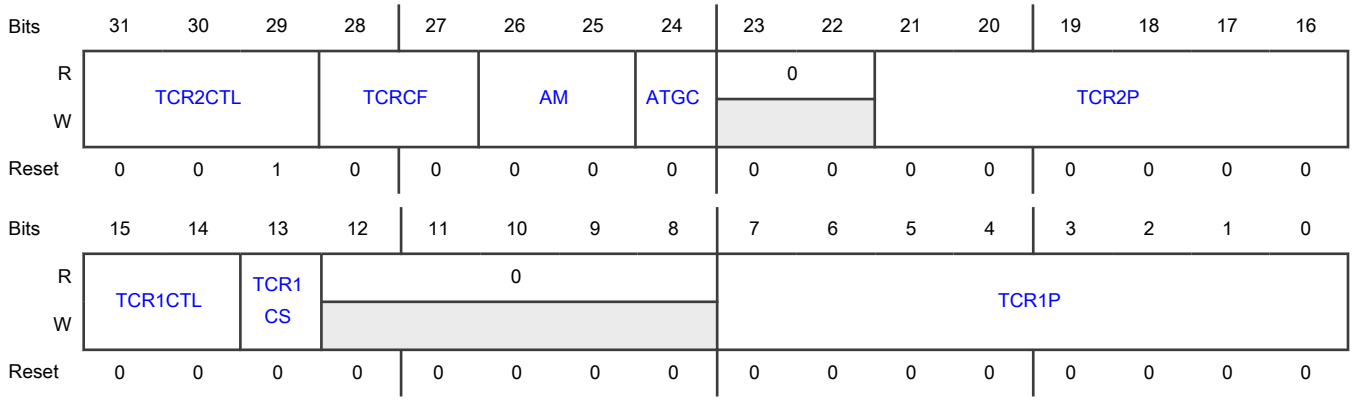
Offset

Register	Offset
TBCR_ENG2	40h

Function

This register configures several timebase options.

Diagram



Fields

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>31-29
TCR2CTL</td><td>TCR2 Clock/Gate Control.
These bits are part of the TCR2 clocking system (see Time bases). They determine the clock source for TCR2 before the prescaler. TCR2 can count on any detected edge of the TCRCLK signal or use it for gating eTPU clock divided by 8. After reset - TCRCLK signal rising edge is selected. TCR2 can also be clocked by the eTPU clock divided by 8. TCR2CTL also determines the TCRCLK edge selected for angle tooth detection in angle mode. See the following table.
<table>
<tr><th>TCR2CTL</th><th>AM = 0
TCR2 Clock before prescaler</th><th>AM > 0
Angle Tooth detection</th></tr>
<tr><td>000</td><td>Gated DIV8 clock (eTPU clock / 8). In this case, when the external TCRCLK signal is low, the DIV8 clock is blocked, preventing it from incrementing the TCR2 prescaler. When the external TCRCLK signal is high, TCR2 prescaler is incremented at the frequency of the eTPU clock divided by 8.</td><td>Do not use with AM > 0</td></tr>
<tr><td>001</td><td>Rise transition on TCRCLK signal increments the TCR2 prescaler.</td><td>Rising edge</td></tr>
<tr><td>010</td><td>Fall transition on TCRCLK signal increments the TCR2 prescaler.</td><td>Falling edge</td></tr>
<tr><td>011</td><td>Rise or Fall transition on TCRCLK signal increments the TCR2 prescaler.</td><td>Both edges</td></tr>
<tr><td>100</td><td>DIV8 clock (eTPU clock / 8)</td><td>Do not use with AM > 0</td></tr>
<tr><td>101</td><td>Do not use with AM=0</td><td>Do not use with AM > 0</td></tr>
<tr><td>110</td><td>Do not use with AM=0</td><td>No edge[1]</td></tr>
<tr><td>111</td><td>TCR2 frozen, except as STAC client</td><td>Do not use with AM > 0</td></tr>
</table>
1. TCRCLK edges are not detected by the EAC logic, but they can still be detected by the channel 0 logic if AM=01.</td></tr>
<tr><td>28-27
TCRCF</td><td>TCRCLK Signal Filter Control.
This field controls the TCRCLK digital filter (see TCRCLK digital filter, determining whether the TCRCLK signal input (after a synchronizer) is filtered with the same filter clock as the channel input signals (see Enhanced digital filter (EDF)) or uses the eTPU clock divided by 2, and also whether the TCRCLK digital filter works in integrator mode or two sample mode (see the following table).
<table>
<tr><th>TCRCF</th><th>Filter Clock</th><th>Filter Mode</th></tr>
<tr><td>00</td><td>eTPU clock divided by 2</td><td>Two sample</td></tr>
<tr><td>01</td><td>Filter clock of the channels</td><td>Two sample</td></tr>
<tr><td>10</td><td>eTPU clock divided by 2</td><td>Integrator</td></tr>
<tr><td>11</td><td>Filter clock of the channels</td><td>Integrator</td></tr>
</table></td></tr>
</table>

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>TCRCF</th><th>Filter Clock</th><th>Filter Mode</th></tr>
</table>
</td></tr>
<tr><td>26-25
AM</td><td>Angle Mode Selection.
This field enables the Enhanced Angle Counter logic to generate angle information (see EAC - eTPU Angle Counter), and also select the tooth signal input and the channel used to process it, as shown in the following table. When EAC is not disabled by AM and neither TCR1 nor TCR2 are STAC Clients, the EAC (eTPU Angle Clock) hardware provides angle information to the channels using the TCR2 bus. When AM is reset (non-angle mode), the EAC operation is disabled, and its internal registers can be used as general purpose. For more information, see EAC - eTPU Angle Counter.
<table>
<tr><th>Value</th><th>TCR2 Value</th><th>Tooth signal</th><th>Tooth processing channel</th></tr>
<tr><td>00</td><td>Timebase (EAC operation disabled)</td><td colspan="2">Not applicable</td></tr>
<tr><td>01</td><td rowspan="3">Angle Ticks</td><td>TCRCLK input</td><td>0</td></tr>
<tr><td>10</td><td>Channel 1 input</td><td>1</td></tr>
<tr><td>11</td><td>Channel 2 input</td><td>2</td></tr>
</table>
If TCR1 or TCR2 is a STAC Bus Client (see STAC interface), the EAC operation is not allowed, and AM must be set to 0.
NOTE
Changing AM may cause unexpected transition detections on the channel selected by AM, depending on the channel mode and state (see Transition detection and Time Base Capture). If AM must be changed with GTBE=1, the recommended procedure is described in Restarting angle logic.</td></tr>
<tr><td>24
ATGC</td><td>Angle Tick Generator Clock.
This bit selects the clock that provides the time interval unit for Angle Tick Generation. For details, see Generating the angle ticks.
0b - TCR1 prescaler output provides time intervals for tick generation.
1b - TCR2 prescaler output provides time intervals for tick generation.</td></tr>
<tr><td>23-22
—</td><td>Reserved</td></tr>
<tr><td>21-16
TCR2P</td><td>Timer Count Register 2 Prescaler Control.
These bits are part of the TCR2 clocking system (see Time bases). TCR2 is clocked from the output of a prescaler. The prescaler divides its input by (TCR2P + 1) allowing frequency divisions from 1 to 64. The prescaler input is the eTPU clock divided by 8 (in gated or non-gated clock mode), or Internal Timebase input, or TCRCLK filtered input. This field has no effect on TCR2 in Angle Mode.</td></tr>
<tr><td>15-14</td><td>TCR1 Clock/Gate Control.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>TCR1CTL</td><td>TCR1CTL is part of the TCR1 clocking system (see Time bases). It determines, together with TCR1CS, the clock source for TCR1. TCR1 can count on detected rising edge of the TCRCLK signal, the eTPU clock, or the eTPU clock divided by 2 (see the table in the TCR1CS bit description). After reset TCRCLK signal is selected.</td></tr>
<tr><td>13
TCR1CS</td><td>TCR1 Clock Source
TCR1CS provides the option to double the TCR1 incrementing speed, using eTPU clock as its clock source instead of eTPU clock / 2.
NOTE
If ATGC=0, the clock source of the EAC angle tick generator will still be an even division of eTPU clock if TCR1CS=1, obeying to the field TCR1P as if TCR1CS=0 (see Angle Tick Generator).
<table>
<tr><th>TCR1CTL</th><th>TCR1CS</th><th>TCR1 Clock before prescaler</th></tr>
<tr><td>00</td><td>0</td><td>Selects TCRCLK as clock source for the TCR1 prescaler.[1]</td></tr>
<tr><td>01</td><td>0</td><td>Reserved</td></tr>
<tr><td>01</td><td>1</td><td>Reserved</td></tr>
<tr><td>10</td><td>0</td><td>Selects eTPU clock divided by 2 as clock source for the TCR1 prescaler.</td></tr>
<tr><td>10</td><td>1</td><td>Selects eTPU clock as clock source for the TCR1 prescaler.</td></tr>
<tr><td>11</td><td>0</td><td>TCR1 frozen, except as a STAC client</td></tr>
</table>
1. This selection must not be used in Angle Mode.
0b - Use eTPU clock / 2 as TCR1 clock source before the prescaler, if that clock source is selected by TCR1CTL.
1b - Use eTPU clock as TCR1 clock source before the prescaler; can only be set in specific combinations with TCR1CTL, as shown in the table. TCR1CS=1 also makes the channel work on T2/T4 timing mode.</td></tr>
<tr><td>12-8
—</td><td>Reserved</td></tr>
<tr><td>7-0
TCR1P</td><td>Timer Count Register 1 Prescaler Control.
TCR1 is clocked from the output of a prescaler. The input to the prescaler is the internal eTPU clock divided by 2, eTPU clock, or the output of TCRCLK filter. The prescaler divides t his input by (TCR1P + 1) allowing frequency divisions from 1 up to 256.
NOTE
The TCR1 prescaler counts TCR1P rising edges of TCRCLK on the 1st TCR1 increment. If TCR1CTL selects TCRCLK as TCR1 clock source and TCR1P > 0, the first TCR1 increment happens after TCR1P rising edges of TCRCLK. The second TCR1 increment happens correctly after TCR1P+1 rising edges of TCRCLK.</td></tr>
</table>

67.9.1.7 eTPU Engine 2 Time Base 1 (TCR1) Visibility Register (TB1R_ENG2)

Offset

Register	Offset
TB1R_ENG2	44h

Function

This register provides visibility of the TCR1 time base for host read access (see Time bases). This register is read-only. The value of the TCR1 time base shown can be driven by the TCR1 counter or imported from STAC bus, depending on the configuration set in eTPU Engine 2 STAC Configuration Register (STAC_ENG2).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								TCR1							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TCR1															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-0 TCR1	TCR1 value. TCR1 value used on matches and captures. See Time bases.

67.9.1.8 eTPU Engine 2 Time Base 2 (TCR2) Visibility Register (TB2R_ENG2)

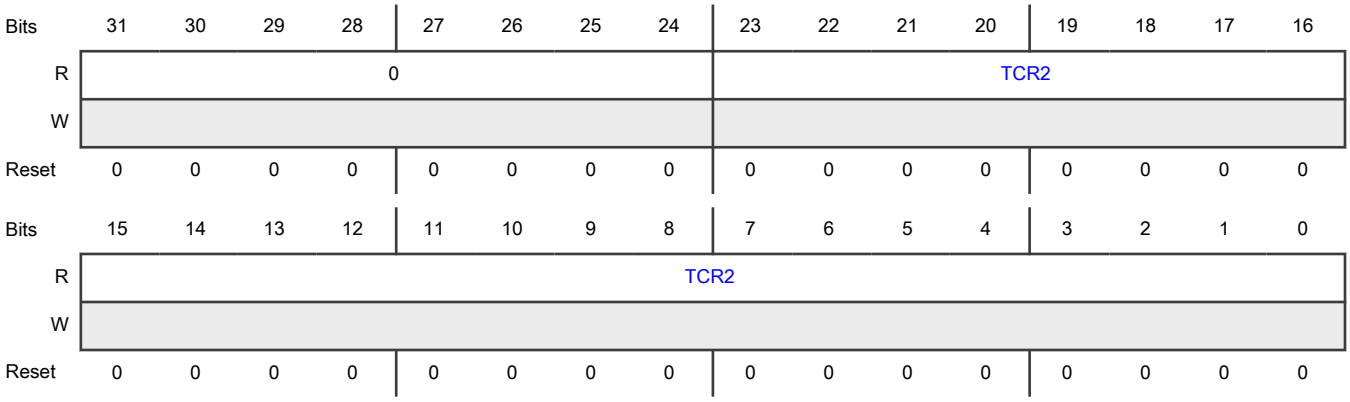
Offset

Register	Offset
TB2R_ENG2	48h

Function

This register provides visibility of the TCR2 time base for host read access (see Time bases). This register is read-only. The value of the TCR2 time base shown can be driven by the TCR2 counter or imported from the STAC bus, depending on Angle Mode and STAC configurations set in eTPU Engine 2 STAC Configuration Register (STAC_ENG2).

Diagram



Fields

Field	Function
31-24 —	Reserved
23-0 TCR2	TCR2 value. TCR2 value used on matches and captures. See Time bases.

67.9.1.9 eTPU Engine 2 STAC Configuration Register (STAC_ENG2)

Offset

Register	Offset
STAC_ENG2	4Ch

Function

This register configures the eTPU STAC bus operation as a STAC Server/Client module (see STAC interface).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	REN1	RSC1	0		SERVER_ID1				0				SRV1			
W																
Reset	0	0	0	0	u[1]	u	u	u	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	REN2	RSC2	0		SERVER_ID2				0				SRV2			
W																
Reset	0	0	0	0	u[1]	u	u	u	0	0	0	0	0	0	0	0

1. See the chip-specific eTPU information for the reset value.

Fields

Field	Function
31 REN1	TCR1 Resource Client/Server Operation Enable Bit. This bit enables Client/Server operation to eTPU STAC resources. REN1 enables TCR1 STAC bus operations. 0b - Server/Client Operation for TCR1 is disabled. 1b - Server/Client Operation for TCR1 is enabled.
30 RSC1	TCR1 Resource Server/Client Assignment Bits. This bit selects the eTPU data resource assignment to be used as Servers or Clients. For Server mode, MCU-dependent value determines the unique server address assigned to each TCR. See the chip-specific eTPU information for the STAC server IDs. For a Client mode, the SRV1 field determines the Server address to which the Client listens. **NOTE** Resource identifies any parameter that changes along the time and can be exported / imported from other device. In eTPU context, a resource can be TCR1 or TCR2 (either Time or Angle values). **NOTE** When TCR1 or TCR2 is configured as a STAC Bus Client (REN2 = 1, RSC2 = 0) the eTPU Angle Clock hardware cannot be used. **NOTE** RSC1 must not be changed when the REN1 bit is asserted. 0b - TCR1 Client operation. 1b - TCR1 Server operation.
29-28 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
27-24 SERVER_ID1	Red Line STAC ID 1. STAC Server ID (read-only MCU-dependent values; see the chip-specific eTPU information for the STAC server IDs) used for TCR1 when STAC servers are used.
23-20 —	Reserved
19-16 SRV1	TCR1 Resource Server. This bit selects the address of the specific STAC Server to which the local TCR1 listens when configured as a STAC Client. SRV1 selects the STAC Server of TCR1.
15 REN2	TCR2 Resource Client/Server Operation Enable Bit. This bit enables Client/Server operation to eTPU STAC resources. REN2 enables TCR2 STAC bus operations. 0b - Server/Client Operation for resource 2 is disabled. 1b - Server/Client Operation for resource 2 is enabled.
14 RSC2	TCR2 Resource Server/Client Assignment Bits. **NOTE** Resource identifies any parameter that changes along the time and can be exported / imported from other device. In eTPU context, a resource can be TCR1 or TCR2 (either Time or Angle values). 0b - Resource Client operation. 1b - Resource Server operation.
13-12 —	Reserved
11-8 SERVER_ID2	Red Line STAC ID 2. STAC Server ID (read-only MCU-dependent values; see the chip-specific eTPU information for the STAC server IDs) used for TCR2 when when STAC servers are used.
7-4 —	Reserved
3-0 SRV2	TCR2 Resource Server. This bit selects the address of the specific STAC Server to which the local TCR2 listens when configured as a STAC Client. SRV2 selects the Red Line STAC Server of TCR2.

67.10 Engine memory map and registers

67.10.1 eTPU_ER register descriptions

This section gathers registers that are engine-related.

67.10.1.1 eTPU_ER memory map

eTPU_4 base address: 4068_0000h

Offset	Register	Width (In bits)	Access	Reset value
60h	eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1)	32	RW	0000_0000h
68h	eTPU Idle Register for Engine 1 (IDLER_ENG1)	32	RW	See section
70h	eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2)	32	RW	0000_0000h
78h	eTPU Idle Register for Engine 2 (IDLER_ENG2)	32	RW	See section

67.10.1.2 eTPU Watchdog Timer Register for Engine 1 (WDTR_ENG1)

Offset

Register	Offset
WDTR_ENG1	60h

Function

This register configures the watchdog timer for the engine.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	WDM		0	WMO	0											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	WDCNT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 WDM	Watchdog Mode. WDM selects the Watchdog operation mode. For more information on the Watchdog operation, see Watchdog).

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE Before a new mode is configured, all conditions below must apply: 1. All channels must be disabled (C*a*CR_ENG1[CPR] = 00b). 2. No thread must be executing (CSSR_ENG1[SSn] reads 0). 3. The watchdog must be disabled (WDM=00). 00b - Disabled 01b - Reserved 10b - Thread length 11b - Busy length
29 —	Reserved
28 WMO	Watchdog Monitor Operation. This bit enables the monitor operation of the watchdog, inhibiting the thread ending and channel disabling in case of a timeout. The Global Exception occurs on a watchdog timeout, independently of WMO. **NOTE** WDSR_ENG1[WDS*n*], MCR[WDTO1], MCR[WDTO2], and the Global Exception always asserts in case of a watchdog timeout, independently of WMO. 0b - Force the end of the running thread and disable the service channel in case of a timeout. 1b - Do not force the end of the running thread, nor disable the service channel in case of a timeout.
27-16 —	Reserved
15-0 WDCNT	Watchdog Count. This field indicates the maximum number of microcycles allowed for a thread (in thread length mode) or a sequence of threads (in busy length mode) before the current running thread is forced to end. For more information on Watchdog operation, see Watchdog . **NOTE** The TST microcycles are also counted by the watchdog. **NOTE** Fields WDCNT and WMO must not be changed when the watchdog is enabled.

67.10.1.3 eTPU Idle Register for Engine 1 (IDLER_ENG1)

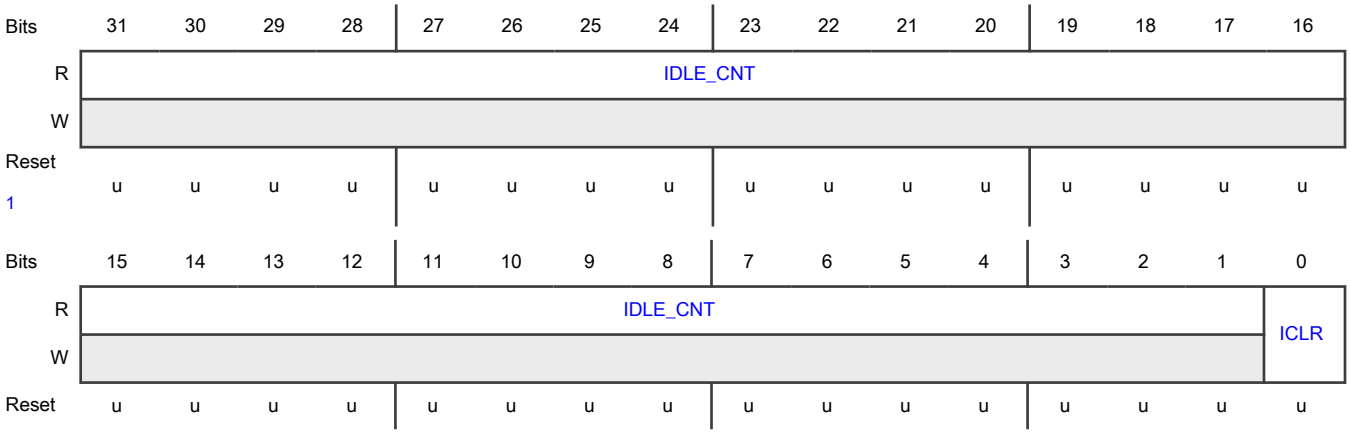
Offset

Register	Offset
IDLER_ENG1	68h

Function

This register counts the microcycles in which the microengine is idle (see Idle Counter

Diagram



1. The reset value is undefined because the counter is free running and the value varies depending on how many cycles have passed after reset before reading the value.

Fields

Field	Function
31-1 IDLE_CNT	Idle Count. This is a free running count of the number of idle microcycles in the microengine. For more information on idle counter operation, see Idle Counter. **NOTE** When the register is read, the ICLR bit is concatenated with the IDLE_CNT field (as the LSB) to form a 32-bit value.
0 ICLR	Idle Clear. Writing a 1 to this bit clears the IDLE_CNT field. **NOTE** When the register is read, the ICLR bit is concatenated with the IDLE_CNT field (as the LSB) to form a 32-bit value. 0b - Do not clear the IDLE_CNT field. 1b - Clear the IDLE_CNT field.

67.10.1.4 eTPU Watchdog Timer Register for Engine 2 (WDTR_ENG2)

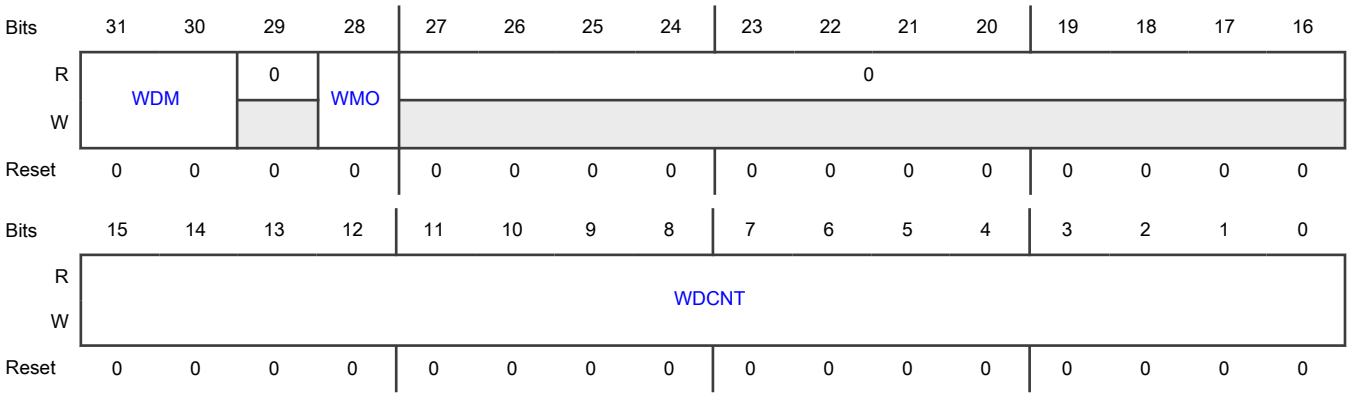
Offset

Register	Offset
WDTR_ENG2	70h

Function

This register configures the watchdog timer for the engine.

Diagram



Fields

Field	Function
31-30 WDM	Watchdog Mode. WDM selects the Watchdog operation mode. For more information on the Watchdog operation, see Watchdog . **NOTE** Before a new mode is configured, all conditions below must apply: 1. All channels must be disabled (CaCR_ENG1[CPR] = 00b). 2. No thread must be executing (eTPU Channel Service Status Register for Engine 2 (CSSR_ENG2) reads 0). 3. The watchdog must be disabled (WDM=00). 00b - Disabled 01b - Reserved 10b - Thread length 11b - Busy length
29 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
28 WMO	Watchdog Monitor Operation. This bit enables the monitor operation of the watchdog, inhibiting the thread ending and channel disabling in case of a timeout. The Global Exception occurs on a watchdog timeout, independently of WMO. **NOTE** WDSR_ENG2[WDS*n*], MCR[WDTO1], MCR[WDTO2], and the Global Exception always assert in case of a watchdog timeout, independently of WMO. 0b - Force the end of the running thread and disable the service channel in case of a timeout. 1b - Do not force the end of the running thread, nor disable the service channel in case of a timeout.
27-16 —	Reserved
15-0 WDCNT	Watchdog Count. This field indicates the maximum number of microcycles allowed for a thread (in thread length mode) or a sequence of threads (in busy length mode) before the current running thread is forced to end.For more information on Watchdog operation, see Watchdog . **NOTE** The TST microcycles are also counted by the watchdog. **NOTE** Fields WDCNT and WMO must not be changed when the watchdog is enabled.

67.10.1.5 eTPU Idle Register for Engine 2 (IDLER_ENG2)

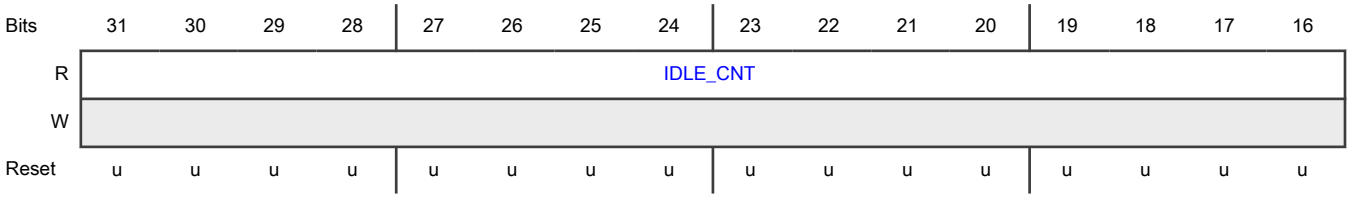
Offset

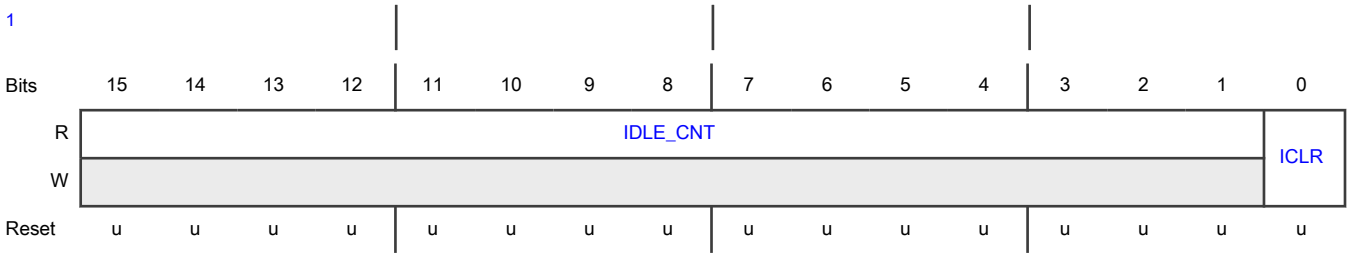
Register	Offset
IDLER_ENG2	78h

Function

This register counts the microcycles in which the microengine is idle (see Idle Counter).

Diagram





1. The reset value is undefined because the counter is free running and the value varies depending on how many cycles have passed after reset before reading the value.

Fields

Field	Function
31-1 IDLE_CNT	Idle Count. This is a free running count of the number of idle microcycles in the microengine. For more information on idle counter operation, see Idle Counter. **NOTE** When the register is read, the ICLR bit is concatenated with the IDLE_CNT field (as the LSB) to form a 32-bit value.
0 ICLR	Idle Clear. Writing a 1 to this bit clears the IDLE_CNT field. **NOTE** When the register is read, the ICLR bit is concatenated with the IDLE_CNT field (as the LSB) to form a 32-bit value. 0b - Do not clear the IDLE_CNT field. 1b - Clear the IDLE_CNT field.

67.11 Memory Error Support memory map and registers

67.11.1 eTPU_MESR register descriptions

67.11.1.1 eTPU_MESR memory map

eTPU_2 base address: 4068_0000h

Offset	Register	Width (In bits)	Access	Reset value
100h	eTPU Memory Error Control Register (MECR)	32	RW	0000_0000h
104h	eTPU Data Error Injection Address Register (DEIAR)	32	RW	0000_0000h
108h	eTPU Data Error Injection Data Pattern Register (DEIDPR)	32	RW	0000_0000h
10Ch	eTPU Data Error Injection Parity Pattern Register (DEIPPR)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
110h	eTPU Data Error Report Address Register (DERAR)	32	R	0000_0000h
114h	eTPU Data Error Report Data Register (DERDR)	32	R	0000_0000h
118h	eTPU Data Error Report Syndrome Register (DERSR)	32	R	0000_0000h
120h	eTPU Memory Error Status Register (MESR)	32	RW	0000_0000h
124h	eTPU Code Error Injection Address Register (CEIAR)	32	RW	0000_0000h
128h	eTPU Code Error Injection Data Pattern Register (CEIDPR)	32	RW	0000_0000h
12Ch	eTPU Code Error Injection Parity Pattern Register (CEIPPR)	32	RW	0000_0000h
130h	eTPU Code Error Report Address Register (CERAR)	32	R	0000_0000h
134h	eTPU Code Error Report Data Register (CERDR)	32	R	0000_0000h
138h	eTPU Code Error Report Syndrome Register (CERSR)	32	R	0000_0000h
13Ch	eTPU Code Error Fix Register (CEFR)	32	RW	0000_0000h

67.11.1.2 eTPU Memory Error Control Register (MECR)

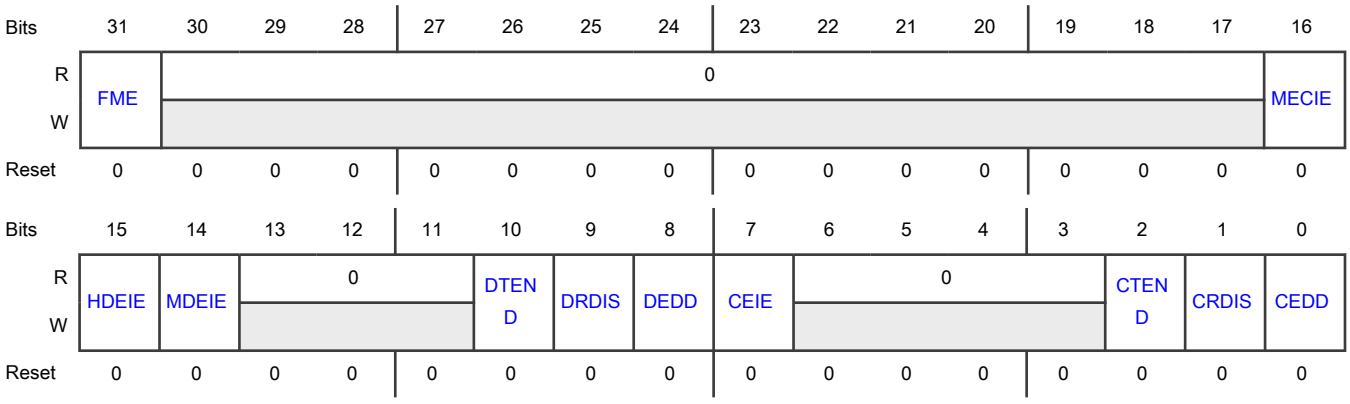
Offset

Register	Offset
MECR	100h

Function

This register gathers control bits of both SCM and SDM error detection and correction support.

Diagram



Fields

Field	Function
31 FME	Field Modification Enable Negation of this bit disables the modification of all fields in the register, except MECIE, DRDIS, CRDIS and FME itself: Write accesses do not cause a bus error, regardless of FME state. 0b - Fields cannot be modified during a write access, except MECIE, DRDIS, CRDIS and FME. 1b - All fields can be modified during a write access.
30-17 —	Reserved
16 MECIE	Memory Error Correction Interrupt Enable. Enables the Memory Error Correction Interrupt (see Interrupt types and sources). 0b - Memory Error Correction Interrupt disabled. 1b - Memory Error Correction Interrupt enabled.
15 HDEIE	Host Data Error Injection Enable Enables error injection into the SDM host read path, including CDC transfers. The eTPU Data Error Injection Address Register (DEIAR) specifies the address where the error is injected, while eTPU Data Error Injection Data Pattern Register (DEIDPR) and eTPU Data Error Injection Parity Pattern Register (DEIPPR) define the bit flips on data and parity, respectively. **NOTE** Data error injection is also performed when data error detection is disabled (DEDD=1). 0b - SDM error injection disabled for host reads. 1b - SDM error injection enabled for host reads.
14 MDEIE	Microengine(s) Data Error Injection Enable. Enables error injection into the SDM microengine read path. The eTPU Data Error Injection Address Register (DEIAR) specifies the address where the error is injected, while eTPU Data Error Injection Data Pattern Register (DEIDPR) and eTPU Data Error Injection Parity Pattern Register (DEIPPR) define the bit flips on data and parity, respectively. **NOTE** Data error injection is also performed when data error detection is disabled (DEDD=1). 0b - SDM error injection disabled for microengine reads. 1b - SDM error injection enabled for microengine reads.
13-11 —	Reserved
10	Thread End on Data Non-correctable Error.

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Field	Function
DTEND	This bit controls the behavior of the microengine when a non-correctable data error occurs. For more details, see Memory error support . **NOTE** DTEND must only be changed when the engine is stopped or halted, or when all channels are disabled. 0b - Thread continues on non-correctable data read access by the microengine. 1b - Thread ends on non-correctable data read access by the microengine.
9 DRDIS	Data Error Report Disable Disables the sampling of SDM error address, data and syndrome into the eTPU Memory Error Support Registers, and eTPU_MESR register descriptions. It does not, however, disable the setting of eTPU_MESR register descriptions bits DCERR and DNCERR. **NOTE** To guarantee coherent reading of eTPU Data Error Report Address Register (DERAR), eTPU Data Error Report Data Register (DERDR), and eTPU Data Error Report Syndrome Register (DERSR), DRDIS must be asserted beforehand if SDM concurrent accesses can happen, by host or microengine. After the registers are read, DRDIS may be negated again to allow new samplings. 0b - SDM error report sampling enabled. 1b - SDM error report sampling disabled.
8 DEDD	Data Error Detection Disable. Disables SDM error detection. The disabled state turns ineffective any action due to error detection, including consequently error correction. 0b - SDM error detection enabled. 1b - SDM error detection disabled.
7 CEIE	Code Error Injection Enable. This bit enables error injection into the SCM read path, either on microengine accesses (see MCR[VIS] = 0) or host accesses (VIS = 1) eTPU Code Error Injection Address Register (CEIAR) specifies the address where the error is injected, while eTPU Code Error Injection Data Pattern Register (CEIDPR) and eTPU Code Error Injection Parity Pattern Register (CEIPPR) define the bit flips on data and parity, respectively. **NOTE** Code error injection is also performed when code error detection is disabled (CEDD = 1). 0b - SCM error injection disabled. 1b - SCM error injection enabled.

Table continues on the next page...

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Field	Function
6-3 —	Reserved
2 CTEND	Thread End on Code Non-Correctable Error. This bit controls the behavior of the microengine when a non-correctable code error occurs. For more details, see Memory error support . **NOTE** CTEND must only be changed when the engine is stopped or halted, or when all channels are disabled. 0b - Thread continues on instruction fetch non-correctable error. 1b - Thread ends on instruction fetch non-correctable error.
1 CRDIS	Code Error Report Disable. Disables sampling of SCM error address, data and syndrome into the eTPU Code Error Report Address Register (CERAR), eTPU Code Error Report Data Register (CERDR), and eTPU Code Error Report Syndrome Register (CERSR). It does not, however, disable the setting of CCERR and CNCERR in eTPU_MESR register descriptions. **NOTE** To guarantee coherent reading of eTPU Code Error Report Address Register (CERAR), eTPU Code Error Report Data Register (CERDR), and eTPU Code Error Report Syndrome Register (CERSR), CRDIS must be asserted beforehand if SCM concurrent accesses can happen, by host or microengine. After the registers are read, CRDIS may be negated again to allow new samplings. 0b - SCM error report sampling enabled. 1b - SCM error report sampling disabled.
0 CEDD	Code Error Detection Disable. This bit disables SCM error detection. The disabled state turns ineffective any action due to error detection, including consequently error correction. 0b - SCM error detection enabled. 1b - SCM error detection disabled.

67.11.1.3 eTPU Data Error Injection Address Register (DEIAR)

Offset

Register	Offset
DEIAR	104h

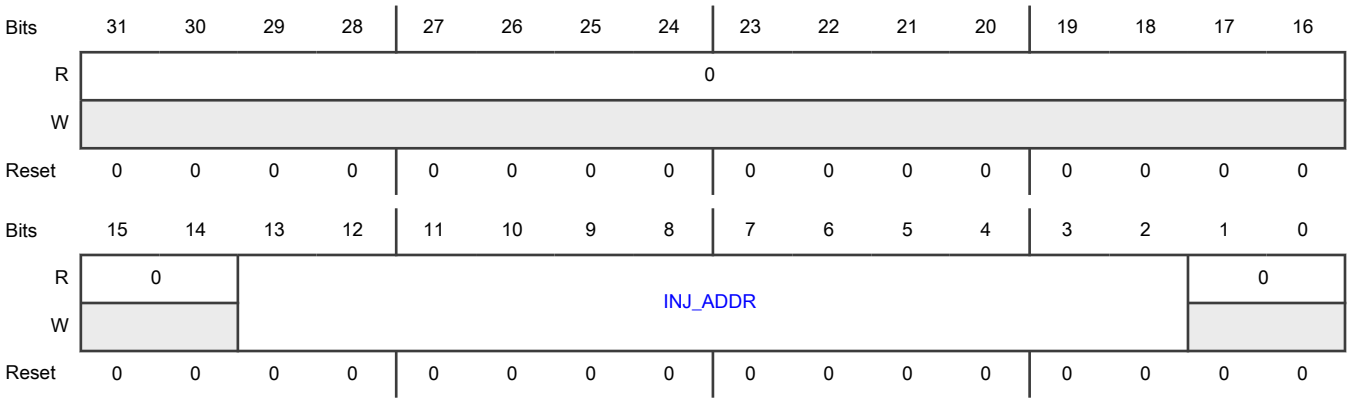
Function

This register holds the address where error is to be injected into the SDM read data path. The two least significant bits are 0 (read-only), so that the address is always word-aligned.

NOTE

This register must only be modified when MECR[HDEIE] and MECR[MDEIE] are both n negated.

Diagram



Fields

Field	Function
31-14 —	Reserved
13-2 INJ_ADDR	Injection Address. This field holds the (word) address where an error is injected into the SDM read data path, as specified by MECR[HDEIE] and MECR[MDEIE]. For more information on error injection, see Error injection.
1-0 —	Reserved

67.11.1.4 eTPU Data Error Injection Data Pattern Register (DEIDPR)

Offset

Register	Offset
DEIDPR	108h

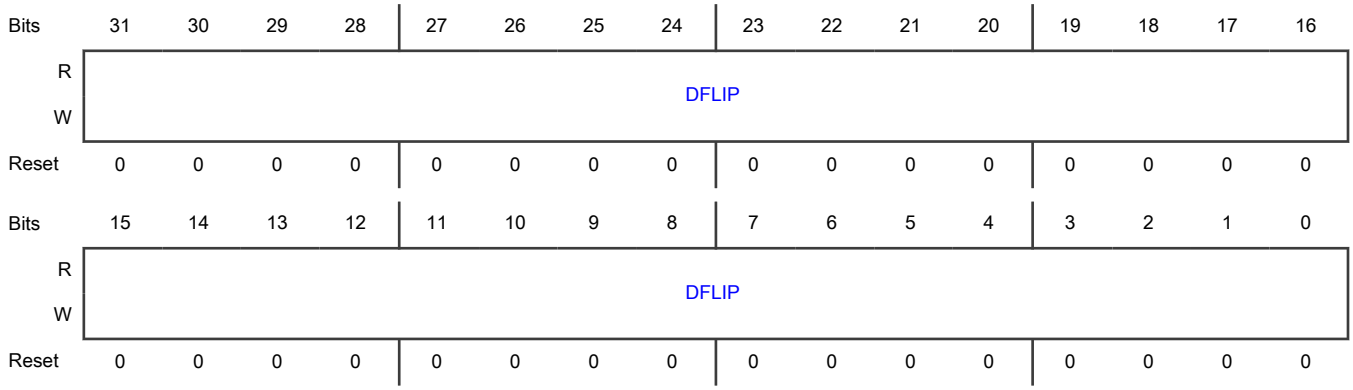
Function

This register is used to specify the bits in which error is injected into the SDM read data path.

NOTE

This register must only be modified when MECR[HDEIE] and MECR[MDEIE] are both negated.

Diagram



Fields

Field	Function
31-0 DFLIP	Data Flip bits. Each bit corresponds to a bit in the actual data read from the SDM address defined in eTPU Data Error Injection Address Register (DEIAR), specifying whether it should be inverted or not. The inversion only occurs if the SDM error injection is enabled by MECR[HDEIE] and/or MECR[MDEIE]. For more information on error injection, see Error injection. 0000_0000_0000_0000_0000_0000_0000_0000b - Read data bit is not inverted. 0000_0000_0000_0000_0000_0000_0000_0001b - Read data bit is inverted.

67.11.1.5 eTPU Data Error Injection Parity Pattern Register (DEIPPR)

Offset

Register	Offset
DEIPPR	10Ch

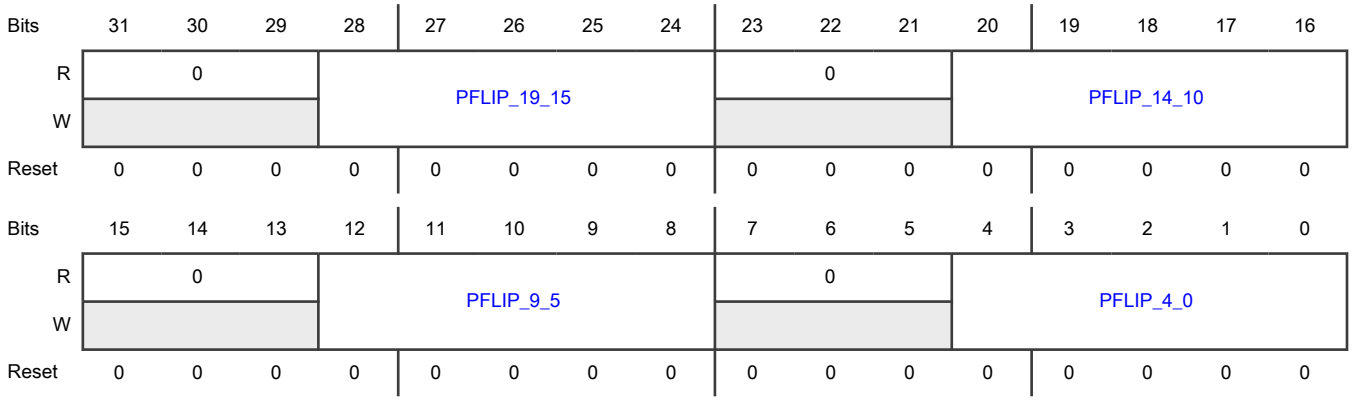
Function

This register is used to specify the bits in which error is injected into the SDM read parity path.

NOTE

This register must only be modified when MECR[HDEIE] and MECR[MDEIE] are both negated.

Diagram



Fields

Field	Function
31-29 —	Reserved
28-24 PFLIP_19_15	Parity Flip bits. Each bit corresponds to a bit in the actual parity read from the SDM address defined in eTPU Data Error Injection Address Register (DEIAR), specifying whether it should be inverted or not. The inversion only occurs if the SDM error injection is enabled by the HDEIE and/or MDEIE fields in eTPU_MESR register descriptions. Bits PFLIP[19:15] corresponds to the parity bits for the most significant byte, PFLIP[14:10] to the next most significant byte and so on until PFLIP[4:0] for the least significant byte. For more information on error injection, see Error injection. 0_0000b - Parity data bit is not inverted. 0_0001b - Parity data bit is inverted.
23-21 —	Reserved
20-16 PFLIP_14_10	Parity Flip bits. Each bit corresponds to a bit in the actual parity read from the SDM address defined in eTPU Data Error Injection Address Register (DEIAR), specifying whether it should be inverted or not. The inversion only occurs if the SDM error injection is enabled by MECR[HDEIE] and/or MECR[MDEIE]. Bits PFLIP[19:15] corresponds to the parity bits for the most significant byte, PFLIP[14:10] to the next most significant byte and so on until PFLIP[4:0] for the least significant byte. For more information on error injection, see Error injection. 0_0000b - Parity data bit is not inverted. 0_0001b - Parity data bit is inverted.
15-13 —	Reserved
12-8	Parity Flip bits.

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Field	Function
PFLIP_9_5	Each bit corresponds to a bit in the actual parity read from the SDM address defined in eTPU Data Error Injection Address Register (DEIAR), specifying whether it should be inverted or not. The inversion only occurs if the SDM error injection is enabled by MECR[HDEIE] and/or MECR[MDEIE]. Bits PFLIP[19:15] corresponds to the parity bits for the most significant byte, PFLIP[14:10] to the next most significant byte and so on until PFLIP[4:0] for the least significant byte. For more information on error injection, see Error injection. 0_0000b - Parity data bit is not inverted. 0_0001b - Parity data bit is inverted.
7-5 —	Reserved
4-0 PFLIP_4_0	Parity Flip bits Each bit corresponds to a bit in the actual parity read from the SDM address defined in eTPU Data Error Injection Address Register (DEIAR), specifying whether it should be inverted or not. The inversion only occurs if the SDM error injection is enabled by MECR[HDEIE] and/or MECR[MDEIE]. Bits PFLIP[19:15] corresponds to the parity bits for the most significant byte, PFLIP[14:10] to the next most significant byte and so on until PFLIP[4:0] for the least significant byte. For more information on error injection, see Error injection. 0_0000b - Parity data bit is not inverted. 0_0001b - Parity data bit is inverted.

67.11.1.6 eTPU Data Error Report Address Register (DERAR)

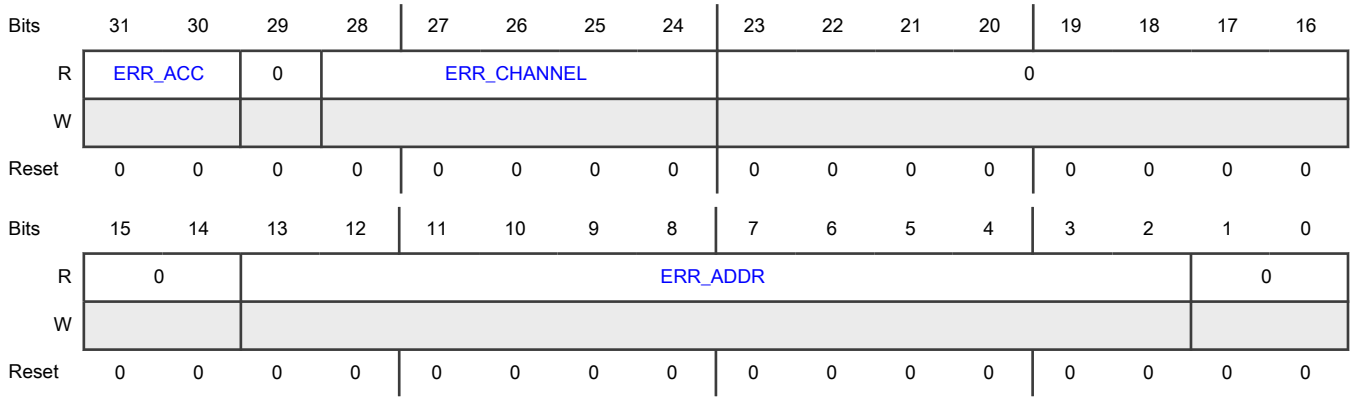
Offset

Register	Offset
DERAR	110h

Function

This register holds the address where the last non-correctable error was detected from the SDM It also captures the address of the last correctable error detected, as long as MESR[DNCERR] is 0. The two least significant bits are 0 (read-only), so that the address is always word-aligned.

Diagram



Fields

Field	Function
31-30 ERR_ACC	Error Access Source Indication. This two-bit field indicates the source of the access when the error occurred. 00b - Host - direct access 01b - Engine 1 10b - Engine 2 11b - CDC
29 —	Reserved
28-24 ERR_CHANNEL	Error Channel Access Indication. This field holds the number of the channel being serviced (not necessarily CHAN) when the error occurred. Its content is meaningful only when the field ERR_ACC indicates Engine 1 or Engine 2.
23-14 —	Reserved
13-2 ERR_ADDR	Error Address. ERR_ADDR holds the (word) address where the last captured SDM read error was detected. The last captured error is a non-correctable one if MESR[DNCERR] = 1, or a correctable one if MESR[DNCERR] = 0 and MESR[DCERR] = 1. The field is meaningless if both MESR[DNCERR] and MESR[DCERR] are 0. For more information on error detection, see Memory error support .
1-0 —	Reserved

67.11.1.7 eTPU Data Error Report Data Register (DERDR)

Offset

Register	Offset
DERDR	114h

Function

This register holds the data read with the last non-correctable error detected from the SDM. It also captures the data of the last correctable error read detection, as long as MESR[DNCERR] is 0. In both cases, the data is captured after the error correction logic. The data is meaningless if both MESR[DNCERR] and MESR[DCERR] are 0. For more information on error detection, see Memory error support .

NOTE

Data is sampled before the error correction logic.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DATA	DATA. **NOTE** Individual data bytes are not meaningful when their respective BE bits in eTPU_MESR register descriptions are not asserted.

67.11.1.8 eTPU Data Error Report Syndrome Register (DERSR)

Offset

Register	Offset
DERSR	118h

Function

This register holds the syndrome read with the last non-correctable error detected from the SDM. It also captures the syndrome of the last correctable error read detection, as long as MESR[DNCERR] is 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BE3	0			SYND3				BE2	0			SYND2			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BE1	0			SYND1				BE0	0			SYND0			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 BE3	Byte Enable 3. Each BE bit corresponds to a report byte in a 32-bit aligned data word. BE3 corresponds to the most significant one. BE qualifies the error report for its respective byte. 0b - Byte was not selected for read, therefore its respective error report fields are not meaningful. 1b - Byte was selected for read, and the error report for the respective byte is meaningful.
30-29 —	Reserved
28-24 SYND3	Error Syndrome 3. SYND3 holds the syndrome of an error detected in the SDM read data path, as defined in Error Correction Code (ECC) and syndrome definition . The field is meaningless if both MESR[DNCERR] and MESR[DCERR] are 0. For more information on error detection, see Memory error support . **NOTE** Syndrome fields which have their respective BE bits negated are not meaningful.
23 BE2	Byte Enable 2. Each BE bit corresponds to a report byte in a 32-bit aligned data word. BE3 corresponds to the most significant one. BE qualifies the error report for its respective byte. 0b - Byte was not selected for read, therefore its respective error report fields are not meaningful. 1b - Byte was selected for read, and the error report for the respective byte is meaningful.
22-21 —	Reserved

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Field	Function
20-16 SYND2	Error Syndrome 2. SYND2 holds the syndrome of an error detected in the SDM read data path, as defined in the “Error Correction Code (ECC) and Syndrome Definition”section. The field is meaningless if both MESR[DNCERR] and MESR[DCERR] are 0. For more information on error detection, see Memory error support . **NOTE** Syndrome fields which have their respective BE bits negated are not meaningful.
15 BE1	Byte Enable 1. Each BE bit corresponds to a report byte in a 32-bit aligned data word. BE3 corresponds to the most significant one. BE qualifies the error report for its respective byte. 0b - Byte was not selected for read, therefore its respective error report fields are not meaningful. 1b - Byte was selected for read, and the error report for the respective byte is meaningful.
14-13 —	Reserved
12-8 SYND1	Error Syndrome 1. SYND1 holds the syndrome of an error detected in the SDM read data path, as defined in the “Error Correction Code (ECC) and Syndrome Definition”section. The field is meaningless if both MESR[DNCERR] and MESR[DCERR] are 0. For more information on error detection, see Memory error support . **NOTE** Syndrome fields which have their respective BE bits negated are not meaningful.
7 BE0	Byte Enable 0. Each BE bit corresponds to a report byte in a 32-bit aligned data word. BE3 corresponds to the most significant one. BE qualifies the error report for its respective byte. 0b - Byte was not selected for read, therefore its respective error report fields are not meaningful. 1b - Byte was selected for read, and the error report for the respective byte is meaningful.
6-5 —	Reserved
4-0 SYND0	Error Syndrome 0. SYND0 holds the syndrome of an error detected in the SDM read data path, as defined in the “Error Correction Code (ECC) and Syndrome Definition”section. The field is meaningless if both MESR[DNCERR] and MESR[DCERR] are 0. For more information on error detection, see Memory error support . **NOTE** Syndrome fields which have their respective BE bits negated are not meaningful.

67.11.1.9 eTPU Memory Error Status Register (MESR)

Offset

Register	Offset
MESR	120h

Function

This register gathers status bits of both SCM and SDM error detection and correction support.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DCERR	0						DCOVR	CCERR	0						CCOVR
W	W1C							W1C	W1C							W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DNCERR	0						DNCOVR	CNCERR	0						CNCOVR
W	W1C							W1C	W1C							W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DCERR	Data Correctable Error flag. When read: 0.....No SDM correctable error occurred. 1.....An SDM correctable error occurred. Writing 1 to this bit clears the DCERR status flag. DCERR asserts even if DNCERR is asserted beforehand, but in this case the address and data of the erroneous access is not captured (see Memory Error Support memory map and registers and following sections). DCERR is cleared by writing a 1 to it. Assertion of this bit can also assert the Memory Error Correction Interrupt (see Interrupt types and sources). **NOTE** A correctable error is not considered for flagging if accompanied of a non-correctable one. Therefore, if both correctable and non-correctable data errors occur on the same access (in distinct bytes), the DNCERR flag asserts, but not the DCERR flag. 0b - Do not clear DCERR flag. 1b - Clears DCERR flag

Table continues on the next page...

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Field	Function
30-25 —	Reserved
24 DCOVR	Data Correctable Overrun flag. Writing 1 to this bit clears the DCOVR status flag. 0b - Data correctable error occurred while DCOVR = 1. 1b - No data correctable error occurred while DCOVR = 1. DCOVR asserts when an SDM correctable error occurs and the DCERR flag is already asserted. Assertion of this bit causes no interrupt. A correctable error is not considered for flagging if accompanied by a non-correctable one. Therefore, if both correctable and non-correctable data errors occur on the same access (in distinct bytes), the DCOVR does not assert, even if DCERR is asserted. The DNCOVR flag, on the other hand, asserts if DNCERR is asserted.
23 CCERR	Code Error flag. When read: 0.....No SCM correctable error occurred. 1.....An SCM correctable error occurred. When written: 0.....Do not clear CCERR flag. 1.....Clears CCERR flag. The CCERR flag asserts even if CNCERR is asserted beforehand, but in this case the address and data of the erroneous access is not captured (see eTPU Code Error Report Address Register (CERAR) and the following sections). CCERR is cleared by writing a 1 at the same position. Assertion of this bit can also assert the Memory Error Correction Interrupt (see Interrupt types and sources).
22-17 —	Reserved
16 CCOVR	Code Correctable Overrun flag This bit asserts when an SCM correctable error occurs and the CCERR flag is already asserted. Assertion of this bit causes no interrupt. When read: 0.....No SCM correctable error overrun occurred. 1.....An SCM correctable error overrun occurred. Writing 1 to this bit clears the CCOVR status flag: 0b - Do not clear CCOVR flag. 1b - Clear CCOVR flag.
15 DNCERR	Data Non-Correctable Error flag DNCERR flags a non-correctable error.

Table continues on the next page...

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Field	Function
	When read: 0.....No SDM non-correctable error occurred. 1.....An SDM non-correctable error occurred; registers eTPU Global Channel Registers are not updated by correctable error detections. DNCERR must be cleared (by writing a 1 to it) to allow correctable error updates to eTPU Data Error Report Address Register (DERAR) and eTPU Data Error Report Data Register (DERDR). 0b - Do not clear DNCERR flag. 1b - Clear DNCERR flag.
14-9 —	Reserved
8 DNCOVR	Data Non-Correctable Overrun flag. DNCOVR asserts when an SDM non-correctable error occurs and the DNCERR flag is already asserted. Assertion of this bit causes no interrupt. When read: 0.....No SDM non-correctable error overrun occurred. 1.....An SDM non-correctable error overrun occurred. DNCOVR is cleared by writing a 1 to it. 0b - Do not clear DNCOVR flag. 1b - Clear DNCOVR flag.
7 CNCERR	Code Non-Correctable Error flag CNCERR flags a non-correctable error: When read: 0.....An SCM non-correctable error occurred; the eTPU Global Channel Registers are not updated by correctable error detections. 1....an SCM non-correctable error occurred; eTPU Code Error Report Address Register (CERAR) and eTPU Code Error Report Data Register (CERDR) are not updated by correctable error detections. CNCERR must be cleared to allow correctable error updates to eTPU Code Error Report Address Register (CERAR) and eTPU Code Error Report Data Register (CERDR). CNCERR is cleared by writing a 1 to it. 0b - Do not clear CNCERR flag. 1b - Clear CNCERR flag.
6-1 —	Reserved
0 CNCOVR	Code Non-Correctable Overrun flag.

Table continues on the next page...

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Field	Function
	CNCOVR asserts when an SCM non-correctable error occurs and the CNCERR flag is already asserted. Assertion of this bit causes no interrupt. When read: 0.....an SCM non-correctable error overrun occurred. 1.....An SCM non-correctable error overrun occurred. When written: 0b - Do not clear CNCOVR flag. 1b - Clear CNCOVR flag.

67.11.1.10 eTPU Code Error Injection Address Register (CEIAR)

Offset

Register	Offset
CEIAR	124h

Function

This register holds the address where error is to be injected into the SCM read data path. The two least significant bits are 0 (read-only), so that the address is always word-aligned.

NOTE

This register must only be modified when MECR[CEIE] is negated.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	INJ_ADDR														0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-2 INJ_ADDR	Injection Address. INJ_ADDR holds the (word) address where an error is injected in the SCM read data path, as specified by eTPU_MESR register descriptions and eTPU_MESR register descriptions. For more information on error injection, see Error injection.
1-0 —	Reserved

67.11.1.11 eTPU Code Error Injection Data Pattern Register (CEIDPR)

Offset

Register	Offset
CEIDPR	128h

Function

This register is used to specify the bits in which error is injected into the SCM read data path.

NOTE

This register must only be modified when MECR[CEIE] is negated.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	DFLIP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DFLIP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DFLIP	Data Flip bits. Each bit corresponds to a bit in the actual data read from the SCM address defined in eTPU Code Error Injection Address Register (CEIAR), specifying whether it should be inverted or not. The inversion only occurs if the SCM error injection is enabled by MECR[CEIE]. For more information on error injection, see Error injection. 0000_0000_0000_0000_0000_0000_0000_0000b - Read data bit is not inverted. 0000_0000_0000_0000_0000_0000_0000_0001b - Read data bit is inverted.

67.11.1.12 eTPU Code Error Injection Parity Pattern Register (CEIPPR)

Offset

Register	Offset
CEIPPR	12Ch

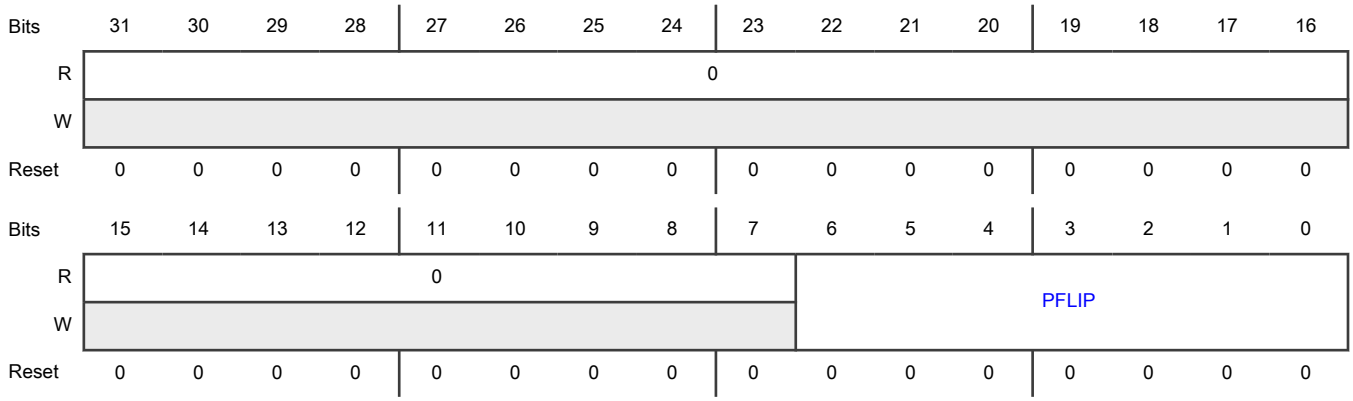
Function

This register is used to specify the bits in which error is injected into the SCM read parity path.

NOTE

This register must only be modified when MECR[CEIE] is negated.

Diagram



Fields

Field	Function
31-7 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
6-0 PFLIP	Parity Flip bits. Each bit corresponds to a bit in the actual parity/code read from the SCM address defined in eTPU Code Error Injection Address Register (CEIAR), specifying whether it should be inverted or not. The inversion only occurs if the SCM error injection is enabled by MECR[CEIE]. For more information on error injection, see Error injection. 000_0000b - Parity data bit is not inverted. 000_0001b - Parity data bit is inverted.

67.11.1.13 eTPU Code Error Report Address Register (CERAR)

Offset

Register	Offset
CERAR	130h

Function

This register holds the address where the last non-correctable error was detected from the SCM. It also captures the address of the last correctable error detected, as long as MESR[CNCERR] is 0. The two least significant bits are 0 (read-only), so that the address is always word-aligned.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ERR_ACC		0		ERR_CHANNEL				0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ERR_ADDR														0	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 ERR_ACC	Error Access Source Indication. This two-bit field indicates the source of the access when the error occurred.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	00b - Host 01b - Engine 1 10b - Engine 2 11b - MISC
29 —	Reserved
28-24 ERR_CHANNEL	Error Channel Access Indication. This field holds the number of the channel being serviced (not necessarily CHAN) when the error occurred. Its content is meaningful only when the field ERR_ACC indicates Engine 1 or Engine 2.
23-16 —	Reserved
15-2 ERR_ADDR	Error Address. ERR_ADDR holds the (word) address where the last captured SCM read error was detected. The last captured error is a non-correctable one if MESR[CNCERR] = 1, or a correctable one if MESR[CNCERR] = 0 and MESR[CCERR] = 1. The field is meaningless if both MESR[CNCERR] and MESR[CCERR] are 0. For more information on error detection, see Memory error support .
1-0 —	Reserved

67.11.1.14 eTPU Code Error Report Data Register (CERDR)

Offset

Register	Offset
CERDR	134h

Function

This register holds the data read with the last non-correctable error detected from the SCM. It also captures the data of the last correctable error read detection, as long as MESR[CNCERR] is 0. In both cases, the data is captured after the error correction logic. The data may be meaningless if both MESR[CNCERR] and MESR[CCERR] are 0. For more information on error detection, see Memory error support .

NOTE

CODE is sampled before the error correction logic.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CODE															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CODE															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CODE	CODE[31-0].

67.11.1.15 eTPU Code Error Report Syndrome Register (CERSR)

Offset

Register	Offset
CERSR	138h

Function

This register holds the syndrome and global parity read with the last non-correctable error detected from the SCM. It also captures the syndrome of the last correctable error read detection, as long as MESR[CNCERR] is 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								SYND							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-7 —	Reserved
6-0 SYND	Error Syndrome. SYND holds the syndrome of an error detected in the SCM read data path, as defined in Error Correction Code (ECC) and syndrome definition . The field is meaningless if both MESR[CNCERR] and MESR[CCERR] are 0. For more information on error detection, see Memory error support .

67.11.1.16 eTPU Code Error Fix Register (CEFR)

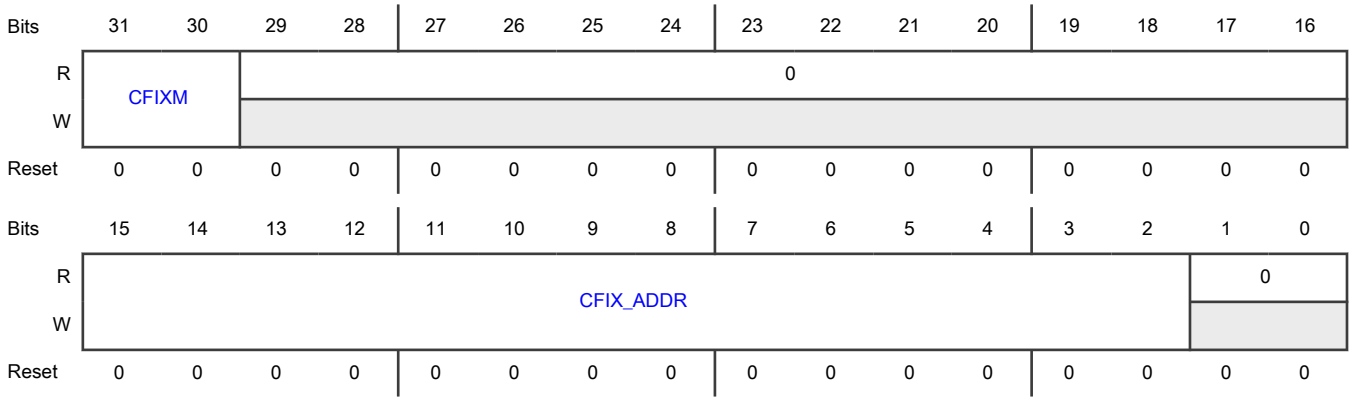
Offset

Register	Offset
CEFR	13Ch

Function

This register is used to fix single-bit error in a specified SCM position. The fix is done automatically, concurrently with code execution, by the MISC logic (see Error fixing).

Diagram



Fields

Field	Function
31-30 CFIXM	Code Fix Mode. This field specifies the SCM MISC fix logic operation mode as shown in the table below. **NOTE** The CFIXM field can only be changed to/from disabled mode.

Table continued from the previous page...

Field	Function
	<table><tr><th>Value</th><th>Mode</th><th>Description</th></tr><tr><td>00</td><td>Disabled</td><td>SCM error fix disabled.</td></tr><tr><td>01</td><td>Reserved</td><td>Reserved value, must not be used.</td></tr><tr><td>10</td><td>Reserved</td><td>Reserved value, must not be used.</td></tr><tr><td>11</td><td>Automatic</td><td>The MISC logic rewrites the code word value read (already fixed by the error correction mechanism) into the same address whenever it finds a correctable error.</td></tr></table>
29-16 —	Reserved
15-2 CFIX_ADDR	Code Fix Address. This field is used for hardware debug purposes. CFIX_ADDR may change its contents and must not be written in automatic mode. For more information on error detection and correction, see Memory error support .
1-0 —	Reserved

67.12 Global Channel memory map and registers

67.12.1 eTPU_GCR register descriptions

The registers in this section group, by type, the interrupt status and enable bits from all the channels. This organization eases management of all channels or groups of channels by a single interrupt handler routine. These bits, except the service and watchdog status, are mirrored in the individual channel registers, grouped by channel.

67.12.1.1 eTPU_GCR memory map

eTPU_1 base address: 4068_0000h

Offset	Register	Width (In bits)	Access	Reset value
200h	eTPU Channel Interrupt Status Register for Engine 1 (CISR_ENG1)	32	RW	0000_0000h
204h	eTPU Channel Interrupt Status Register for Engine 2 (CISR_ENG2)	32	RW	0000_0000h
210h	eTPU Channel Data Transfer Request Status Register for Engine 1 (CDTRSR_ENG1)	32	RW	0000_0000h
214h	eTPU Channel Data Transfer Request Status Register for Engine 2 (CDTRSR_ENG2)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
220h	eTPU Channel Interrupt Overflow Status Register for Engine 1 (CIOSR_ENG1)	32	RW	0000_0000h
224h	eTPU Channel Interrupt Overflow Status Register for Engine 2 (CIOSR_ENG2)	32	RW	0000_0000h
230h	eTPU Channel Data Transfer Request Overflow Status Register for Engine 1 (CDTROSR_ENG1)	32	RW	0000_0000h
234h	eTPU Channel Data Transfer Request Overflow Status Register for Engine 2 (CDTROSR_ENG2)	32	RW	0000_0000h
240h	eTPU Channel Interrupt Enable Register for Engine 1 (CIER_ENG1)	32	RW	0000_0000h
244h	eTPU Channel Interrupt Enable Register for Engine 2 (CIER_ENG2)	32	RW	0000_0000h
250h	eTPU Channel Data Transfer Request Enable Register for Engine 1 (CDTRER_ENG1)	32	RW	0000_0000h
254h	eTPU Channel Data Transfer Request Enable Register for Engine 2 (CDTRER_ENG2)	32	RW	0000_0000h
260h	eTPU Watchdog Status Register for Engine 1 (WDSR_ENG1)	32	RW	0000_0000h
264h	eTPU Watchdog Status Register for Engine 2 (WDSR_ENG2)	32	RW	0000_0000h
280h	eTPU Channel Pending Service Status Register for Engine 1 (CPSSR_ENG1)	32	R	0000_0000h
284h	eTPU Channel Pending Service Status Register for Engine 2 (CPSSR_ENG2)	32	R	0000_0000h
290h	eTPU Channel Service Status Register for Engine 1 (CSSR_ENG1)	32	R	0000_0000h
294h	eTPU Channel Service Status Register for Engine 2 (CSSR_ENG2)	32	R	0000_0000h

67.12.1.2 eTPU Channel Interrupt Status Register for Engine 1 (CISR_ENG1)

Offset

Register	Offset
CISR_ENG1	200h

Function

This register groups the host interrupt status from all channels.These bits are mirrored from the Channel Status Control register (see eTPU_CCCR register descriptions) and the Host must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CISn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CISn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CISn	Channel n Interrupt Status. When read, each bit: 0.....Indicates that channel n has no pending interrupt to the CPU. 1.....Indicates that channel n has a pending interrupt to the CPU. When written: 0.....Keep interrupt status bit unaltered. 1.....Clear interrupt status bit.

67.12.1.3 eTPU Channel Interrupt Status Register for Engine 2 (CISR_ENG2)

Offset

Register	Offset
CISR_ENG2	204h

Function

This register groups the host interrupt status from all channels.These bits are mirrored from the Channel Status Control register (see eTPU_CCCR register descriptions) and the Host must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CISn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CISn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CISn	Channel n Interrupt Status. When read, each bit: 0.....Indicates that channel n has no pending interrupt to the CPU. 1.....Indicates that channel n has a pending interrupt to the CPU. When written: 0.....Keep interrupt status bit unaltered. 1.....Clear interrupt status bit.

67.12.1.4 eTPU Channel Data Transfer Request Status Register for Engine 1 (CDTRSR_ENG1)

Offset

Register	Offset
CDTRSR_ENG1	210h

Function

This register groups data transfer request status from all channels. Their bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions) and Host must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DTRSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DTRSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DTRSn	Channel n Data Transfer Request Status. These bits mimic the corresponding eTPU DMA requests. DTRSn can be cleared by software writing a 1 to it or by the assertion of corresponding DMA completion acknowledge line. When read: 0.....Indicates that channel n has no pending data transfer request. 1.....Indicates that channel x has a pending data transfer request. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.

67.12.1.5 eTPU Channel Data Transfer Request Status Register for Engine 2 (CDTRSR_ENG2)

Offset

Register	Offset
CDTRSR_ENG2	214h

Function

This register groups data transfer request status from all channels.These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions) and Host must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DTRSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DTRSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DTRSn	Channel n Data Transfer Request Status. These bits mimic the corresponding eTPU DMA requests. DTRSn can be cleared by software writing a 1 to it or by the assertion of corresponding DMA completion acknowledge line. When read: 0.....Indicates that channel n has no pending data transfer request. 1.....Indicates that channel x has a pending data transfer request. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.

67.12.1.6 eTPU Channel Interrupt Overflow Status Register for Engine 1 (CIOSR_ENG1)

Offset

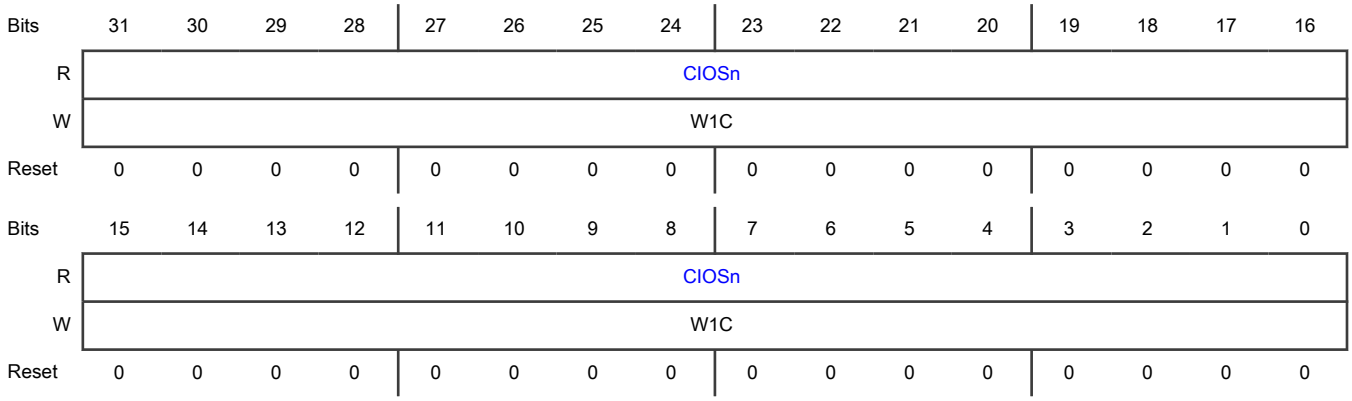
Register	Offset
CIOSR_ENG1	220h

Function

This register groups the interrupt overflow status from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions) and the Host must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram



Fields

Field	Function
31-0 CIOSn	Channel n Interrupt Overflow Status When read: 0.....Indicates that no interrupt overflow occurred in the channel. 1.....Indicates that interrupt overflow occurred in the channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.

67.12.1.7 eTPU Channel Interrupt Overflow Status Register for Engine 2 (CIOSR_ENG2)

Offset

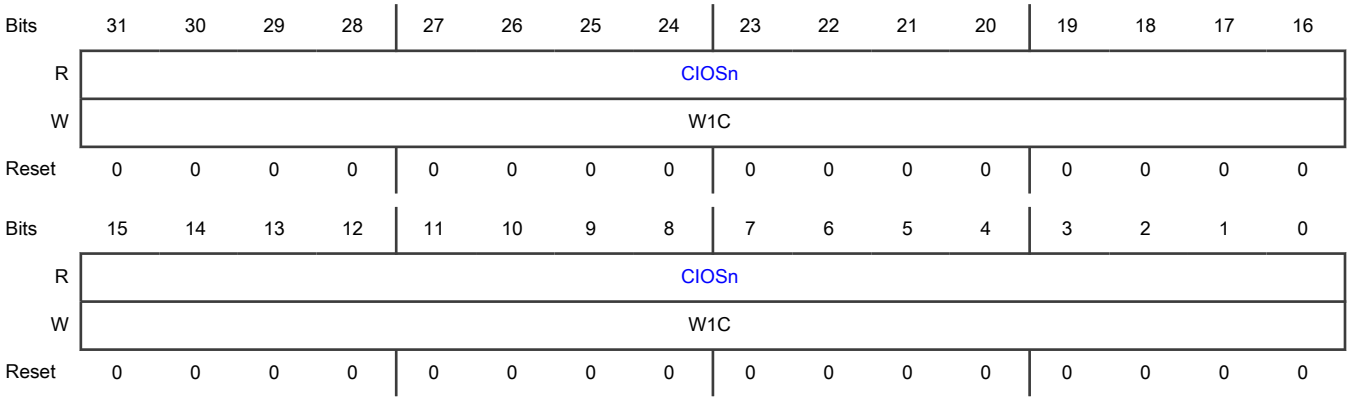
Register	Offset
CIOSR_ENG2	224h

Function

This register groups the interrupt overflow status from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions) and the Host must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram



Fields

Field	Function
31-0 CIOSn	Channel n Interrupt Overflow Status When read: 0.....Indicates that no interrupt overflow occurred in the channel. 1.....Indicates that interrupt overflow occurred in the channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.

67.12.1.8 eTPU Channel Data Transfer Request Overflow Status Register for Engine 1 (CDTROSR_ENG1)

Offset

Register	Offset
CDTROSR_ENG1	230h

Function

This register groups the data transfer request overflow status from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions) and the CPU must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DTROSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DTROSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DTROSn	Channel n Data Transfer Request Overflow Status. When read: 0.....Indicates that no data transfer request overflow occurred in the channel. 1.....Indicates that data transfer request overflow occurred in the channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.

67.12.1.9 eTPU Channel Data Transfer Request Overflow Status Register for Engine 2 (CDTROSR_ENG2)

Offset

Register	Offset
CDTROSR_ENG2	234h

Function

This register groups the data transfer request overflow status from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions) and the CPU must write 1 to clear a status bit.

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DTROSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DTROSn															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DTROSn	Channel n Data Transfer Request Overflow Status. When read: 0.....Indicates that no data transfer request overflow occurred in the channel. 1.....Indicates that data transfer request overflow occurred in the channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.

67.12.1.10 eTPU Channel Interrupt Enable Register for Engine 1 (CIER_ENG1)

Offset

Register	Offset
CIER_ENG1	240h

Function

This register groups the data transfer request overflow status from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions).

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CIEn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CIEn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CIEn	Channel n Interrupt Enable. 0000_0000_0000_0000_0000_0000_0000_0000b - Interrupt disabled for channel n. 0000_0000_0000_0000_0000_0000_0000_0001b - Interrupt enabled for channel n.

67.12.1.11 eTPU Channel Interrupt Enable Register for Engine 2 (CIER_ENG2)

Offset

Register	Offset
CIER_ENG2	244h

Function

This register groups the data transfer request overflow status from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions).

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CIEn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CIEn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CIEn	Channel n Interrupt Enable. 0000_0000_0000_0000_0000_0000_0000_0000b - Interrupt disabled for channel n. 0000_0000_0000_0000_0000_0000_0000_0001b - Interrupt enabled for channel n.

67.12.1.12 eTPU Channel Data Transfer Request Enable Register for Engine 1 (CDTRER_ENG1)

Offset

Register	Offset
CDTRER_ENG1	250h

Function

This register groups the data transfer request enable from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions).

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	DTREn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DTREn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DTREn	Channel n Data Transfer Request Enable. 0000_0000_0000_0000_0000_0000_0000_0000b - Data Transfer request disabled for channel n. 0000_0000_0000_0000_0000_0000_0000_0001b - Data Transfer request enabled for channel n.

67.12.1.13 eTPU Channel Data Transfer Request Enable Register for Engine 2 (CDTRER_ENG2)

Offset

Register	Offset
CDTRER_ENG2	254h

Function

This register groups the data transfer request enable from all channels. These bits are mirrored from the Channel Status Control registers (see eTPU_CCCR register descriptions).

For details about interrupts, see Interrupts and data transfer requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	DTREn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DTREn															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DTREn	Channel n Data Transfer Request Enable. 0000_0000_0000_0000_0000_0000_0000_0000b - Data Transfer request disabled for channel n. 0000_0000_0000_0000_0000_0000_0000_0001b - Data Transfer request enabled for channel n.

67.12.1.14 eTPU Watchdog Status Register for Engine 1 (WDSR_ENG1)

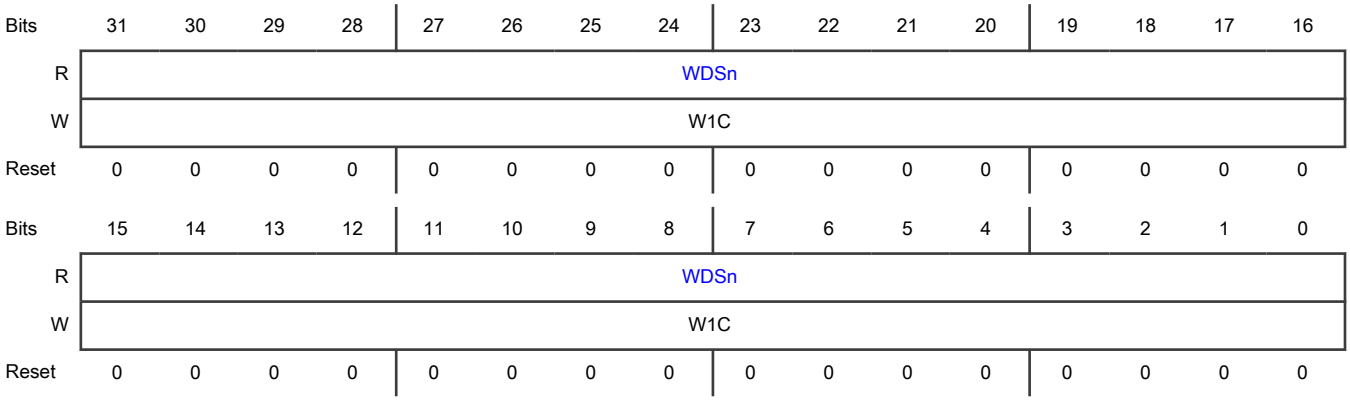
Offset

Register	Offset
WDSR_ENG1	260h

Function

This register indicates the watchdog influence on each of the engine channels.

Diagram



Fields

Field	Function
31-0 WDSn	Channel n Watchdog Status. For details about Watchdog mechanism, see . **NOTE** The WDSn bits set in case of a watchdog timeout independently of #unique_3074/unique_3074_Connect_42_WDTR_ENG1.WMO. When read: 0.....Watchdog did not expire during execution of a channel x thread since reset or last WDSn clear. 1.....Watchdog expired during execution of a channel n thread. When written: 0.....Keep watchdog status bit unaltered. 1.....Clear watchdog status bit.

67.12.1.15 eTPU Watchdog Status Register for Engine 2 (WDSR_ENG2)

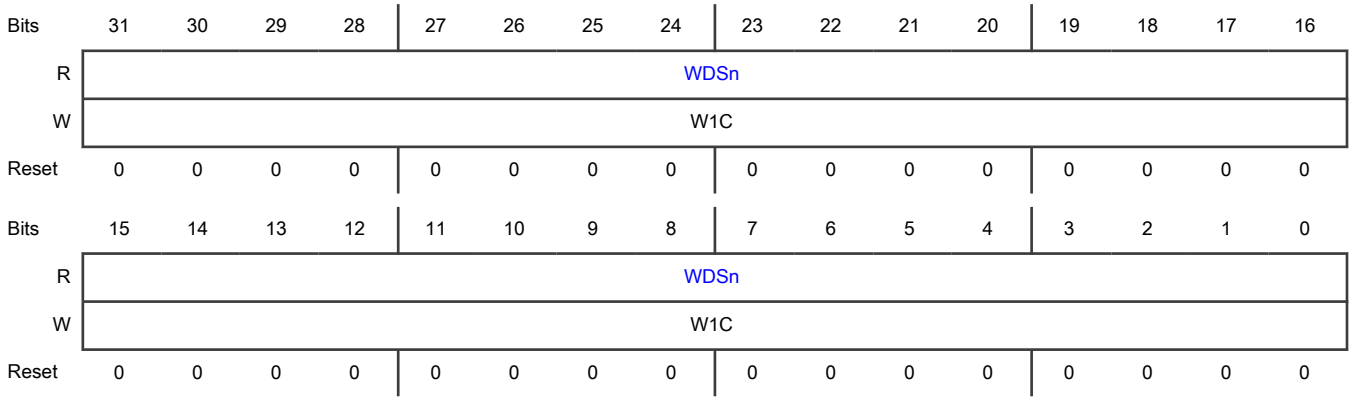
Offset

Register	Offset
WDSR_ENG2	264h

Function

This register indicates the watchdog influence on each of the engine channels.

Diagram



Fields

Field	Function
31-0 WDSn	Channel n Watchdog Status. For details about Watchdog mechanism, see . **NOTE** The WDSn bits set in case of a watchdog timeout independently of #unique_3075/unique_3075_Connect_42_WDTR_ENG2.WMO. When read: 0.....Watchdog did not expire during execution of a channel x thread since reset or last WDSn clear. 1.....Watchdog expired during execution of a channel n thread. When written: 0.....Keep watchdog status bit unaltered. 1.....Clear watchdog status bit.

67.12.1.16 eTPU Channel Pending Service Status Register for Engine 1 (CPSSR_ENG1)

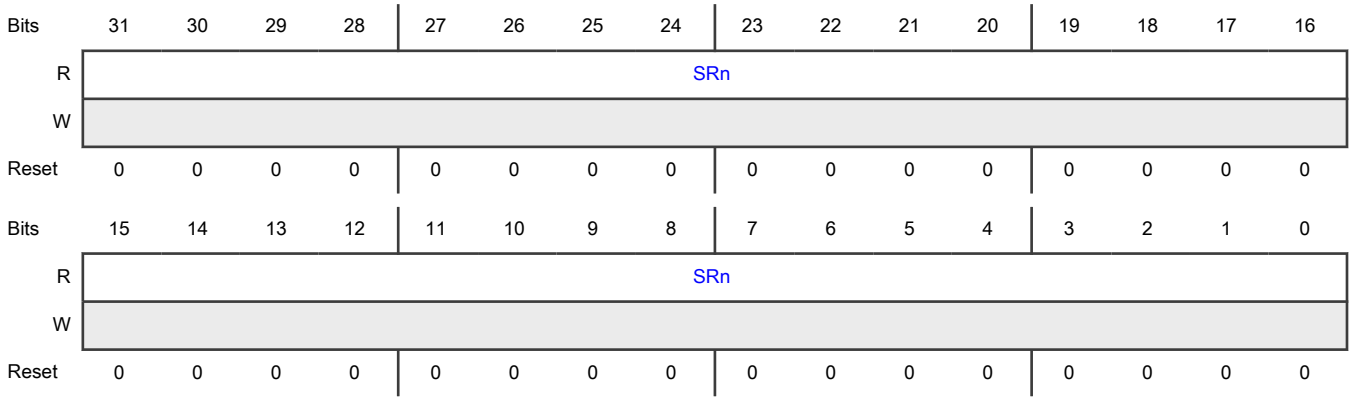
Offset

Register	Offset
CPSSR_ENG1	280h

Function

This register holds the status of the pending Channel Service Requests (see Functions and threads).

Diagram



Fields

Field	Function
31-0 SRn	Pending Service Request n. Indicates a pending Service Request for channel n. Pending SR status is a logic OR of all service requests pending: if only HSR is active, SRn clears only at the end of the thread. SRn clear due to the other request sources is microcode dependent. **NOTE** The pending service status bit for a channel is 1 when a Service Request is pending, even if the Channel is disabled (CPRn = 0). **NOTE** There can be a delay of one clock between writing HSR greater than 0 in C*n*HSRR_ENG1 of a channel and its respective bit being asserted in eTPU_GCR_CPSSR_ENG1. 0000_0000_0000_0000_0000_0000_0000_0000b - No Service Request pending for channel n. 0000_0000_0000_0000_0000_0000_0000_0001b - Pending Service Request for channel n.

67.12.1.17 eTPU Channel Pending Service Status Register for Engine 2 (CPSSR_ENG2)

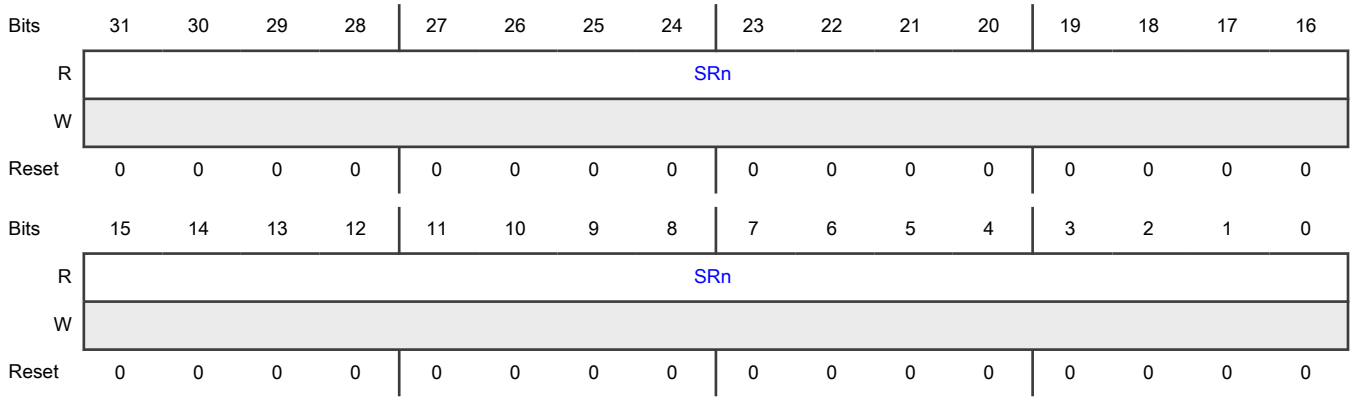
Offset

Register	Offset
CPSSR_ENG2	284h

Function

This register is a read-only register that holds the status of the pending Channel Service Requests (see Functions and threads).

Diagram



Fields

Field	Function
31-0 SRn	Pending Service Request n. Indicates a pending Service Request for channel n. Pending SR status is a logic OR of all service requests pending: if only HSR is active, SRn clears only at the end of the thread. SRn clear due to the other request sources is microcode dependent. **NOTE** The pending service status bit for a channel is 1 when a Service Request is pending, even if the Channel is disabled (CPRn = 0). **NOTE** There can be a delay of one clock between writing HSR greater than 0 in C*n*HSRR_ENG2 of a channel and its respective bit being asserted in eTPU_GCR_CPSSR_ENG2. 0000_0000_0000_0000_0000_0000_0000_0000b - No Service Request pending for channel n. 0000_0000_0000_0000_0000_0000_0000_0001b - Pending Service Request for channel n.

67.12.1.18 eTPU Channel Service Status Register for Engine 1 (CSSR_ENG1)

Offset

Register	Offset
CSSR_ENG1	290h

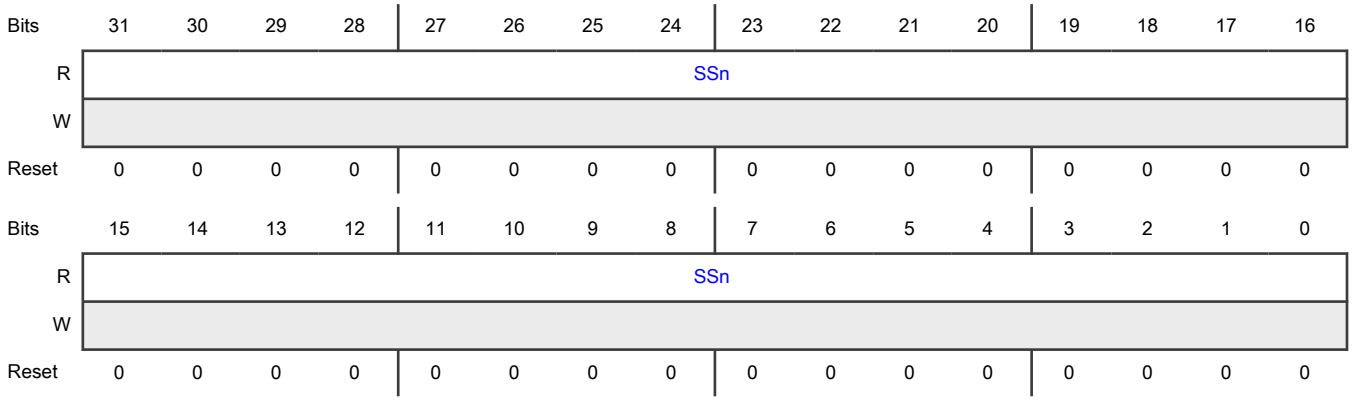
Function

This register holds the current channel service status on whether it is being serviced or not (see Functions and threads). Only one bit may be asserted in this register at a given time. When no channel is being serviced, the register read value is 0x0000_0000. This register is read-only and can be read during normal eTPU operation for monitoring the scheduler activity.

NOTE

Channel Service Status does not always reflect decoding of the CHAN register (see CHAN Register), since the latter can be changed by the service thread microcode.

Diagram



Fields

Field	Function
31-0 SSn	Service Status n. Indicates that channel n is currently being serviced. It is updated at the 1st microcycle of a Time Slot Transition (see Time Slot Transition), or when the microengine ends the thread. 0000_0000_0000_0000_0000_0000_0000_0000b - Channel n is not currently being serviced. 0000_0000_0000_0000_0000_0000_0000_0001b - channel n is currently being serviced.

67.12.1.19 eTPU Channel Service Status Register for Engine 2 (CSSR_ENG2)

Offset

Register	Offset
CSSR_ENG2	294h

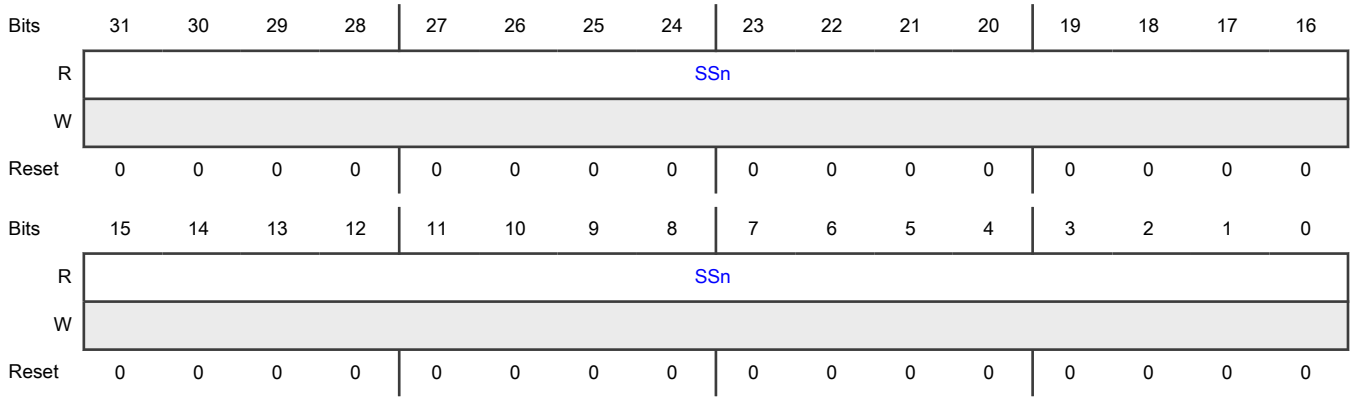
Function

This register holds the current channel service status on whether it is being serviced or not (see Functions and threads). Only one bit may be asserted in this register at a given time. When no channel is being serviced, the register read value is 0x0000_0000. This read-only register can be read during normal eTPU operation for monitoring the scheduler activity.

NOTE

Channel Service Status does not always reflect decoding of the CHAN register (see CHAN Register), since the latter can be changed by the service thread microcode.

Diagram



Fields

Field	Function
31-0 SSn	Service Status n. Indicates that channel n is currently being serviced. It is updated at the 1st microcycle of a Time Slot Transition (see Time Slot Transition), or when the microengine ends the thread. 0000_0000_0000_0000_0000_0000_0000_0000b - Channel n is not currently being serviced. 0000_0000_0000_0000_0000_0000_0000_0001b - channel n is currently being serviced.

67.13 Channel Configuration Control memory map and registers

67.13.1 eTPU_CCCR register descriptions

Each channel has a group of 3 registers used to control, configure and check status of that channel as shown in the following table. This organization eases individual channel management.

Table 480. Channel registers structure

Channel offset	Register name
0x00	eTPU_CCCR_C*n*CR_ENG*m* - eTPU Channel Configuration Register
0x04	eTPU_CCCR_C*n*SCR_ENG*m* - eTPU Channel Status/Control Register
0x08	eTPU_CCCR_C*n*HSRR_ENG*m* - eTPU Channel Host Service Request Register
0x0C	Reserved

One contiguous area is used to map all channel registers of each eTPU engine as shown in the following table.

Table 481. Channel registers mMap

Offset	Registers structure
0x400	eTPU 1 Channel 0 Registers Structure
0x410	eTPU 1 Channel 1 Registers Structure
0x420	eTPU 1 Channel 2 Registers Structure

Table continues on the next page...

Table 481. Channel registers mMap (continued)

Offset	Registers structure
0x430	-----
0x5E0	eTPU 1 Channel 30 Registers Structure
0x5F0	eTPU 1 Channel 31 Registers Structure
0x600	RESERVED
0x800	eTPU 2 Channel 0 Registers Structure
0x810	eTPU 2 Channel 1 Registers Structure
0x820	-----
0x9E0	eTPU 2 Channel 30 Registers Structure
0x9F0	eTPU 2 Channel 31 Registers Structure
0xA00	RESERVED

There are 64 structures defined, one for each available channel in the eTPU System (32 for each Engine). The base address for the structure presented can be calculated by using the following equation:

Channel_Register_Base = eTPU_Engine_Channel_Base + (channel_number * 0x10), where:

- eTPU_Engine_Channel_Base = eTPU_Base + 0x400 for Engine 1.
- eTPU_Engine_Channel_Base = eTPU_Base + 0x800 for Engine 2.

67.13.1.1 eTPU_CCCR memory map

eTPU_0 base address: 4068_0000h

Offset	Register	Width (In bits)	Access	Reset value
400h	eTPU Channel n Configuration Register for Engine 1 (C0CR_ENG1)	32	RW	0000_0000h
404h	eTPU Channel n Status Control Register for Engine 1 (C0SCR_ENG1)	32	RW	0000_0000h
408h	eTPU Channel n Host Service Request Register for Engine 1 (C0HSRR_ENG1)	32	RW	0000_0000h
410h	eTPU Channel n Configuration Register for Engine 1 (C1CR_ENG1)	32	RW	0000_0000h
414h	eTPU Channel n Status Control Register for Engine 1 (C1SCR_ENG1)	32	RW	0000_0000h
418h	eTPU Channel n Host Service Request Register for Engine 1 (C1HSRR_ENG1)	32	RW	0000_0000h
420h	eTPU Channel n Configuration Register for Engine 1 (C2CR_ENG1)	32	RW	0000_0000h
424h	eTPU Channel n Status Control Register for Engine 1 (C2SCR_ENG1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
428h	eTPU Channel n Host Service Request Register for Engine 1 (C2HSRR_ENG1)	32	RW	0000_0000h
430h	eTPU Channel n Configuration Register for Engine 1 (C3CR_ENG1)	32	RW	0000_0000h
434h	eTPU Channel n Status Control Register for Engine 1 (C3SCR_ENG1)	32	RW	0000_0000h
438h	eTPU Channel n Host Service Request Register for Engine 1 (C3HSRR_ENG1)	32	RW	0000_0000h
440h	eTPU Channel n Configuration Register for Engine 1 (C4CR_ENG1)	32	RW	0000_0000h
444h	eTPU Channel n Status Control Register for Engine 1 (C4SCR_ENG1)	32	RW	0000_0000h
448h	eTPU Channel n Host Service Request Register for Engine 1 (C4HSRR_ENG1)	32	RW	0000_0000h
450h	eTPU Channel n Configuration Register for Engine 1 (C5CR_ENG1)	32	RW	0000_0000h
454h	eTPU Channel n Status Control Register for Engine 1 (C5SCR_ENG1)	32	RW	0000_0000h
458h	eTPU Channel n Host Service Request Register for Engine 1 (C5HSRR_ENG1)	32	RW	0000_0000h
460h	eTPU Channel n Configuration Register for Engine 1 (C6CR_ENG1)	32	RW	0000_0000h
464h	eTPU Channel n Status Control Register for Engine 1 (C6SCR_ENG1)	32	RW	0000_0000h
468h	eTPU Channel n Host Service Request Register for Engine 1 (C6HSRR_ENG1)	32	RW	0000_0000h
470h	eTPU Channel n Configuration Register for Engine 1 (C7CR_ENG1)	32	RW	0000_0000h
474h	eTPU Channel n Status Control Register for Engine 1 (C7SCR_ENG1)	32	RW	0000_0000h
478h	eTPU Channel n Host Service Request Register for Engine 1 (C7HSRR_ENG1)	32	RW	0000_0000h
480h	eTPU Channel n Configuration Register for Engine 1 (C8CR_ENG1)	32	RW	0000_0000h
484h	eTPU Channel n Status Control Register for Engine 1 (C8SCR_ENG1)	32	RW	0000_0000h
488h	eTPU Channel n Host Service Request Register for Engine 1 (C8HSRR_ENG1)	32	RW	0000_0000h
490h	eTPU Channel n Configuration Register for Engine 1 (C9CR_ENG1)	32	RW	0000_0000h
494h	eTPU Channel n Status Control Register for Engine 1 (C9SCR_ENG1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
498h	eTPU Channel n Host Service Request Register for Engine 1 (C9HSRR_ENG1)	32	RW	0000_0000h
4A0h	eTPU Channel n Configuration Register for Engine 1 (C10CR_ENG1)	32	RW	0000_0000h
4A4h	eTPU Channel n Status Control Register for Engine 1 (C10SCR_ENG1)	32	RW	0000_0000h
4A8h	eTPU Channel n Host Service Request Register for Engine 1 (C10HSRR_ENG1)	32	RW	0000_0000h
4B0h	eTPU Channel n Configuration Register for Engine 1 (C11CR_ENG1)	32	RW	0000_0000h
4B4h	eTPU Channel n Status Control Register for Engine 1 (C11SCR_ENG1)	32	RW	0000_0000h
4B8h	eTPU Channel n Host Service Request Register for Engine 1 (C11HSRR_ENG1)	32	RW	0000_0000h
4C0h	eTPU Channel n Configuration Register for Engine 1 (C12CR_ENG1)	32	RW	0000_0000h
4C4h	eTPU Channel n Status Control Register for Engine 1 (C12SCR_ENG1)	32	RW	0000_0000h
4C8h	eTPU Channel n Host Service Request Register for Engine 1 (C12HSRR_ENG1)	32	RW	0000_0000h
4D0h	eTPU Channel n Configuration Register for Engine 1 (C13CR_ENG1)	32	RW	0000_0000h
4D4h	eTPU Channel n Status Control Register for Engine 1 (C13SCR_ENG1)	32	RW	0000_0000h
4D8h	eTPU Channel n Host Service Request Register for Engine 1 (C13HSRR_ENG1)	32	RW	0000_0000h
4E0h	eTPU Channel n Configuration Register for Engine 1 (C14CR_ENG1)	32	RW	0000_0000h
4E4h	eTPU Channel n Status Control Register for Engine 1 (C14SCR_ENG1)	32	RW	0000_0000h
4E8h	eTPU Channel n Host Service Request Register for Engine 1 (C14HSRR_ENG1)	32	RW	0000_0000h
4F0h	eTPU Channel n Configuration Register for Engine 1 (C15CR_ENG1)	32	RW	0000_0000h
4F4h	eTPU Channel n Status Control Register for Engine 1 (C15SCR_ENG1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
4F8h	eTPU Channel n Host Service Request Register for Engine 1 (C15HSRR_ENG1)	32	RW	0000_0000h
500h	eTPU Channel n Configuration Register for Engine 1 (C16CR_ENG1)	32	RW	0000_0000h
504h	eTPU Channel n Status Control Register for Engine 1 (C16SCR_ENG1)	32	RW	0000_0000h
508h	eTPU Channel n Host Service Request Register for Engine 1 (C16HSRR_ENG1)	32	RW	0000_0000h
510h	eTPU Channel n Configuration Register for Engine 1 (C17CR_ENG1)	32	RW	0000_0000h
514h	eTPU Channel n Status Control Register for Engine 1 (C17SCR_ENG1)	32	RW	0000_0000h
518h	eTPU Channel n Host Service Request Register for Engine 1 (C17HSRR_ENG1)	32	RW	0000_0000h
520h	eTPU Channel n Configuration Register for Engine 1 (C18CR_ENG1)	32	RW	0000_0000h
524h	eTPU Channel n Status Control Register for Engine 1 (C18SCR_ENG1)	32	RW	0000_0000h
528h	eTPU Channel n Host Service Request Register for Engine 1 (C18HSRR_ENG1)	32	RW	0000_0000h
530h	eTPU Channel n Configuration Register for Engine 1 (C19CR_ENG1)	32	RW	0000_0000h
534h	eTPU Channel n Status Control Register for Engine 1 (C19SCR_ENG1)	32	RW	0000_0000h
538h	eTPU Channel n Host Service Request Register for Engine 1 (C19HSRR_ENG1)	32	RW	0000_0000h
540h	eTPU Channel n Configuration Register for Engine 1 (C20CR_ENG1)	32	RW	0000_0000h
544h	eTPU Channel n Status Control Register for Engine 1 (C20SCR_ENG1)	32	RW	0000_0000h
548h	eTPU Channel n Host Service Request Register for Engine 1 (C20HSRR_ENG1)	32	RW	0000_0000h
550h	eTPU Channel n Configuration Register for Engine 1 (C21CR_ENG1)	32	RW	0000_0000h
554h	eTPU Channel n Status Control Register for Engine 1 (C21SCR_ENG1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
558h	eTPU Channel n Host Service Request Register for Engine 1 (C21HSRR_ENG1)	32	RW	0000_0000h
560h	eTPU Channel n Configuration Register for Engine 1 (C22CR_ENG1)	32	RW	0000_0000h
564h	eTPU Channel n Status Control Register for Engine 1 (C22SCR_ENG1)	32	RW	0000_0000h
568h	eTPU Channel n Host Service Request Register for Engine 1 (C22HSRR_ENG1)	32	RW	0000_0000h
570h	eTPU Channel n Configuration Register for Engine 1 (C23CR_ENG1)	32	RW	0000_0000h
574h	eTPU Channel n Status Control Register for Engine 1 (C23SCR_ENG1)	32	RW	0000_0000h
578h	eTPU Channel n Host Service Request Register for Engine 1 (C23HSRR_ENG1)	32	RW	0000_0000h
580h	eTPU Channel n Configuration Register for Engine 1 (C24CR_ENG1)	32	RW	0000_0000h
584h	eTPU Channel n Status Control Register for Engine 1 (C24SCR_ENG1)	32	RW	0000_0000h
588h	eTPU Channel n Host Service Request Register for Engine 1 (C24HSRR_ENG1)	32	RW	0000_0000h
590h	eTPU Channel n Configuration Register for Engine 1 (C25CR_ENG1)	32	RW	0000_0000h
594h	eTPU Channel n Status Control Register for Engine 1 (C25SCR_ENG1)	32	RW	0000_0000h
598h	eTPU Channel n Host Service Request Register for Engine 1 (C25HSRR_ENG1)	32	RW	0000_0000h
5A0h	eTPU Channel n Configuration Register for Engine 1 (C26CR_ENG1)	32	RW	0000_0000h
5A4h	eTPU Channel n Status Control Register for Engine 1 (C26SCR_ENG1)	32	RW	0000_0000h
5A8h	eTPU Channel n Host Service Request Register for Engine 1 (C26HSRR_ENG1)	32	RW	0000_0000h
5B0h	eTPU Channel n Configuration Register for Engine 1 (C27CR_ENG1)	32	RW	0000_0000h
5B4h	eTPU Channel n Status Control Register for Engine 1 (C27SCR_ENG1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
5B8h	eTPU Channel n Host Service Request Register for Engine 1 (C27HSRR_ENG1)	32	RW	0000_0000h
5C0h	eTPU Channel n Configuration Register for Engine 1 (C28CR_ENG1)	32	RW	0000_0000h
5C4h	eTPU Channel n Status Control Register for Engine 1 (C28SCR_ENG1)	32	RW	0000_0000h
5C8h	eTPU Channel n Host Service Request Register for Engine 1 (C28HSRR_ENG1)	32	RW	0000_0000h
5D0h	eTPU Channel n Configuration Register for Engine 1 (C29CR_ENG1)	32	RW	0000_0000h
5D4h	eTPU Channel n Status Control Register for Engine 1 (C29SCR_ENG1)	32	RW	0000_0000h
5D8h	eTPU Channel n Host Service Request Register for Engine 1 (C29HSRR_ENG1)	32	RW	0000_0000h
5E0h	eTPU Channel n Configuration Register for Engine 1 (C30CR_ENG1)	32	RW	0000_0000h
5E4h	eTPU Channel n Status Control Register for Engine 1 (C30SCR_ENG1)	32	RW	0000_0000h
5E8h	eTPU Channel n Host Service Request Register for Engine 1 (C30HSRR_ENG1)	32	RW	0000_0000h
5F0h	eTPU Channel n Configuration Register for Engine 1 (C31CR_ENG1)	32	RW	0000_0000h
5F4h	eTPU Channel n Status Control Register for Engine 1 (C31SCR_ENG1)	32	RW	0000_0000h
5F8h	eTPU Channel n Host Service Request Register for Engine 1 (C31HSRR_ENG1)	32	RW	0000_0000h
800h	eTPU Channel n Configuration Register for Engine 2 (C0CR_ENG2)	32	RW	0000_0000h
804h	eTPU Channel n Status Control Register for Engine 2 (C0SCR_ENG2)	32	RW	0000_0000h
808h	eTPU Channel n Host Service Request Register for Engine 2 (C0HSRR_ENG2)	32	RW	0000_0000h
810h	eTPU Channel n Configuration Register for Engine 2 (C1CR_ENG2)	32	RW	0000_0000h
814h	eTPU Channel n Status Control Register for Engine 2 (C1SCR_ENG2)	32	RW	0000_0000h
818h	eTPU Channel n Host Service Request Register for Engine 2 (C1HSRR_ENG2)	32	RW	0000_0000h
820h	eTPU Channel n Configuration Register for Engine 2 (C2CR_ENG2)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
824h	eTPU Channel n Status Control Register for Engine 2 (C2SCR_ENG2)	32	RW	0000_0000h
828h	eTPU Channel n Host Service Request Register for Engine 2 (C2HSRR_ENG2)	32	RW	0000_0000h
830h	eTPU Channel n Configuration Register for Engine 2 (C3CR_ENG2)	32	RW	0000_0000h
834h	eTPU Channel n Status Control Register for Engine 2 (C3SCR_ENG2)	32	RW	0000_0000h
838h	eTPU Channel n Host Service Request Register for Engine 2 (C3HSRR_ENG2)	32	RW	0000_0000h
840h	eTPU Channel n Configuration Register for Engine 2 (C4CR_ENG2)	32	RW	0000_0000h
844h	eTPU Channel n Status Control Register for Engine 2 (C4SCR_ENG2)	32	RW	0000_0000h
848h	eTPU Channel n Host Service Request Register for Engine 2 (C4HSRR_ENG2)	32	RW	0000_0000h
850h	eTPU Channel n Configuration Register for Engine 2 (C5CR_ENG2)	32	RW	0000_0000h
854h	eTPU Channel n Status Control Register for Engine 2 (C5SCR_ENG2)	32	RW	0000_0000h
858h	eTPU Channel n Host Service Request Register for Engine 2 (C5HSRR_ENG2)	32	RW	0000_0000h
860h	eTPU Channel n Configuration Register for Engine 2 (C6CR_ENG2)	32	RW	0000_0000h
864h	eTPU Channel n Status Control Register for Engine 2 (C6SCR_ENG2)	32	RW	0000_0000h
868h	eTPU Channel n Host Service Request Register for Engine 2 (C6HSRR_ENG2)	32	RW	0000_0000h
870h	eTPU Channel n Configuration Register for Engine 2 (C7CR_ENG2)	32	RW	0000_0000h
874h	eTPU Channel n Status Control Register for Engine 2 (C7SCR_ENG2)	32	RW	0000_0000h
878h	eTPU Channel n Host Service Request Register for Engine 2 (C7HSRR_ENG2)	32	RW	0000_0000h
880h	eTPU Channel n Configuration Register for Engine 2 (C8CR_ENG2)	32	RW	0000_0000h
884h	eTPU Channel n Status Control Register for Engine 2 (C8SCR_ENG2)	32	RW	0000_0000h
888h	eTPU Channel n Host Service Request Register for Engine 2 (C8HSRR_ENG2)	32	RW	0000_0000h
890h	eTPU Channel n Configuration Register for Engine 2 (C9CR_ENG2)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
894h	eTPU Channel n Status Control Register for Engine 2 (C9SCR_ENG2)	32	RW	0000_0000h
898h	eTPU Channel n Host Service Request Register for Engine 2 (C9HSRR_ENG2)	32	RW	0000_0000h
8A0h	eTPU Channel n Configuration Register for Engine 2 (C10CR_ENG2)	32	RW	0000_0000h
8A4h	eTPU Channel n Status Control Register for Engine 2 (C10SCR_ENG2)	32	RW	0000_0000h
8A8h	eTPU Channel n Host Service Request Register for Engine 2 (C10HSRR_ENG2)	32	RW	0000_0000h
8B0h	eTPU Channel n Configuration Register for Engine 2 (C11CR_ENG2)	32	RW	0000_0000h
8B4h	eTPU Channel n Status Control Register for Engine 2 (C11SCR_ENG2)	32	RW	0000_0000h
8B8h	eTPU Channel n Host Service Request Register for Engine 2 (C11HSRR_ENG2)	32	RW	0000_0000h
8C0h	eTPU Channel n Configuration Register for Engine 2 (C12CR_ENG2)	32	RW	0000_0000h
8C4h	eTPU Channel n Status Control Register for Engine 2 (C12SCR_ENG2)	32	RW	0000_0000h
8C8h	eTPU Channel n Host Service Request Register for Engine 2 (C12HSRR_ENG2)	32	RW	0000_0000h
8D0h	eTPU Channel n Configuration Register for Engine 2 (C13CR_ENG2)	32	RW	0000_0000h
8D4h	eTPU Channel n Status Control Register for Engine 2 (C13SCR_ENG2)	32	RW	0000_0000h
8D8h	eTPU Channel n Host Service Request Register for Engine 2 (C13HSRR_ENG2)	32	RW	0000_0000h
8E0h	eTPU Channel n Configuration Register for Engine 2 (C14CR_ENG2)	32	RW	0000_0000h
8E4h	eTPU Channel n Status Control Register for Engine 2 (C14SCR_ENG2)	32	RW	0000_0000h
8E8h	eTPU Channel n Host Service Request Register for Engine 2 (C14HSRR_ENG2)	32	RW	0000_0000h
8F0h	eTPU Channel n Configuration Register for Engine 2 (C15CR_ENG2)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
8F4h	eTPU Channel n Status Control Register for Engine 2 (C15SCR_ENG2)	32	RW	0000_0000h
8F8h	eTPU Channel n Host Service Request Register for Engine 2 (C15HSRR_ENG2)	32	RW	0000_0000h
900h	eTPU Channel n Configuration Register for Engine 2 (C16CR_ENG2)	32	RW	0000_0000h
904h	eTPU Channel n Status Control Register for Engine 2 (C16SCR_ENG2)	32	RW	0000_0000h
908h	eTPU Channel n Host Service Request Register for Engine 2 (C16HSRR_ENG2)	32	RW	0000_0000h
910h	eTPU Channel n Configuration Register for Engine 2 (C17CR_ENG2)	32	RW	0000_0000h
914h	eTPU Channel n Status Control Register for Engine 2 (C17SCR_ENG2)	32	RW	0000_0000h
918h	eTPU Channel n Host Service Request Register for Engine 2 (C17HSRR_ENG2)	32	RW	0000_0000h
920h	eTPU Channel n Configuration Register for Engine 2 (C18CR_ENG2)	32	RW	0000_0000h
924h	eTPU Channel n Status Control Register for Engine 2 (C18SCR_ENG2)	32	RW	0000_0000h
928h	eTPU Channel n Host Service Request Register for Engine 2 (C18HSRR_ENG2)	32	RW	0000_0000h
930h	eTPU Channel n Configuration Register for Engine 2 (C19CR_ENG2)	32	RW	0000_0000h
934h	eTPU Channel n Status Control Register for Engine 2 (C19SCR_ENG2)	32	RW	0000_0000h
938h	eTPU Channel n Host Service Request Register for Engine 2 (C19HSRR_ENG2)	32	RW	0000_0000h
940h	eTPU Channel n Configuration Register for Engine 2 (C20CR_ENG2)	32	RW	0000_0000h
944h	eTPU Channel n Status Control Register for Engine 2 (C20SCR_ENG2)	32	RW	0000_0000h
948h	eTPU Channel n Host Service Request Register for Engine 2 (C20HSRR_ENG2)	32	RW	0000_0000h
950h	eTPU Channel n Configuration Register for Engine 2 (C21CR_ENG2)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
954h	eTPU Channel n Status Control Register for Engine 2 (C21SCR_ENG2)	32	RW	0000_0000h
958h	eTPU Channel n Host Service Request Register for Engine 2 (C21HSRR_ENG2)	32	RW	0000_0000h
960h	eTPU Channel n Configuration Register for Engine 2 (C22CR_ENG2)	32	RW	0000_0000h
964h	eTPU Channel n Status Control Register for Engine 2 (C22SCR_ENG2)	32	RW	0000_0000h
968h	eTPU Channel n Host Service Request Register for Engine 2 (C22HSRR_ENG2)	32	RW	0000_0000h
970h	eTPU Channel n Configuration Register for Engine 2 (C23CR_ENG2)	32	RW	0000_0000h
974h	eTPU Channel n Status Control Register for Engine 2 (C23SCR_ENG2)	32	RW	0000_0000h
978h	eTPU Channel n Host Service Request Register for Engine 2 (C23HSRR_ENG2)	32	RW	0000_0000h
980h	eTPU Channel n Configuration Register for Engine 2 (C24CR_ENG2)	32	RW	0000_0000h
984h	eTPU Channel n Status Control Register for Engine 2 (C24SCR_ENG2)	32	RW	0000_0000h
988h	eTPU Channel n Host Service Request Register for Engine 2 (C24HSRR_ENG2)	32	RW	0000_0000h
990h	eTPU Channel n Configuration Register for Engine 2 (C25CR_ENG2)	32	RW	0000_0000h
994h	eTPU Channel n Status Control Register for Engine 2 (C25SCR_ENG2)	32	RW	0000_0000h
998h	eTPU Channel n Host Service Request Register for Engine 2 (C25HSRR_ENG2)	32	RW	0000_0000h
9A0h	eTPU Channel n Configuration Register for Engine 2 (C26CR_ENG2)	32	RW	0000_0000h
9A4h	eTPU Channel n Status Control Register for Engine 2 (C26SCR_ENG2)	32	RW	0000_0000h
9A8h	eTPU Channel n Host Service Request Register for Engine 2 (C26HSRR_ENG2)	32	RW	0000_0000h
9B0h	eTPU Channel n Configuration Register for Engine 2 (C27CR_ENG2)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
9B4h	eTPU Channel n Status Control Register for Engine 2 (C27SCR_ENG2)	32	RW	0000_0000h
9B8h	eTPU Channel n Host Service Request Register for Engine 2 (C27HSRR_ENG2)	32	RW	0000_0000h
9C0h	eTPU Channel n Configuration Register for Engine 2 (C28CR_ENG2)	32	RW	0000_0000h
9C4h	eTPU Channel n Status Control Register for Engine 2 (C28SCR_ENG2)	32	RW	0000_0000h
9C8h	eTPU Channel n Host Service Request Register for Engine 2 (C28HSRR_ENG2)	32	RW	0000_0000h
9D0h	eTPU Channel n Configuration Register for Engine 2 (C29CR_ENG2)	32	RW	0000_0000h
9D4h	eTPU Channel n Status Control Register for Engine 2 (C29SCR_ENG2)	32	RW	0000_0000h
9D8h	eTPU Channel n Host Service Request Register for Engine 2 (C29HSRR_ENG2)	32	RW	0000_0000h
9E0h	eTPU Channel n Configuration Register for Engine 2 (C30CR_ENG2)	32	RW	0000_0000h
9E4h	eTPU Channel n Status Control Register for Engine 2 (C30SCR_ENG2)	32	RW	0000_0000h
9E8h	eTPU Channel n Host Service Request Register for Engine 2 (C30HSRR_ENG2)	32	RW	0000_0000h
9F0h	eTPU Channel n Configuration Register for Engine 2 (C31CR_ENG2)	32	RW	0000_0000h
9F4h	eTPU Channel n Status Control Register for Engine 2 (C31SCR_ENG2)	32	RW	0000_0000h
9F8h	eTPU Channel n Host Service Request Register for Engine 2 (C31HSRR_ENG2)	32	RW	0000_0000h

67.13.1.2 eTPU Channel n Configuration Register for Engine 1 (C0CR_ENG1 - C31CR_ENG1)

Offset

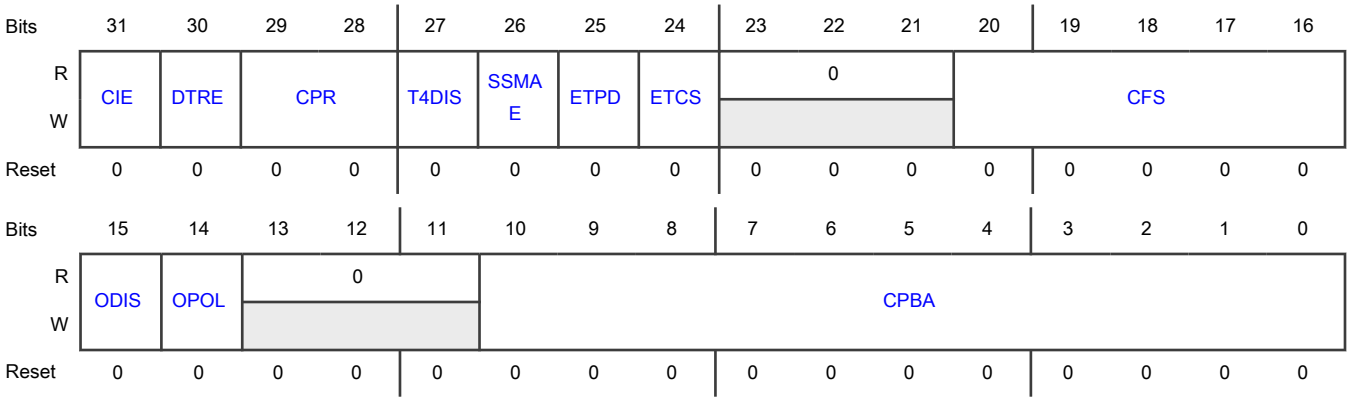
For a = 0 to 31:

Register	Offset
CaCR_ENG1	400h + (a × 10h)

Function

This register gathers configurations set individually per channel.

Diagram



Fields

Field	Function
31 CIE	Channel Interrupt Enable. This bit is mirrored from eTPU Channel Interrupt Enable Register for Engine 1 (CIER_ENG1) (see Channel Interrupt and Data Transfer Requests). 0b - Disable interrupt for this channel. 1b - Enable interrupt for this channel.
30 DTRE	Channel Data Transfer Request Enable. This bit is mirrored from eTPU Channel Data Transfer Request Enable Register for Engine 1 (CDTRER_ENG1) (see Interrupts and data transfer requests). 0b - Disable data transfer request for this channel. 1b - Enable data transfer request for this channel.
29-28 CPR	Channel Priority. This field defines the priority level for the channel, used by the Hardware Scheduler (see Scheduler). 00b - Disabled 01b - Low 10b - Middle 11b - High
27 T4DIS	T4 channel action Disable. This bit forces the channel to work on T2 timing mode, regardless of the FCSS and CDFC fields in eTPU Engine 1 Configuration Register (ECR_ENG1), or of the TCR1CS field in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1). For more details, see Channel timing modes.

Table continues on the next page...

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Field	Function
	0b - Channel works either in T2 or T2/T4 timing modes, depending on the TCR1CS field in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) and the FCSS and CDFC fields in eTPU Engine 1 Configuration Register (ECR_ENG1). 1b - Channel works in T2 timing mode, regardless of the TCR1CS field in eTPU Engine 1 Time Base Configuration Register (TBCR_ENG1) or the FCSS and CDFC fields in eTPU Engine 1 Configuration Register (ECR_ENG1).
26 SSMAE	Shared Subsystem Microengine Access Enable. This bit enables the microengine access to the Shared Subsystem Area (see Shared subsystems support). When this bit is negated, DIOB address values pointing to the Shared Subsystem Area actually access SDM mirrors, in legacy mode. **NOTE** SSMAE value must only be changed when the engine is either stopped or halted. 0b - An SDM mirror is accessed when the Shared Subsystem Area is addressed by the microengine. 1b - Enables microengine access to the Shared Subsystem Area.
25 ETPD	Entry Table Pin Direction. This bit selects which channel signal, input or output, is used in the Entry Point selection. The ETPD value has to be compatible with the function chosen for the channel, selected in the field CFS. For details about Entry Table and condition encoding schemes, see Entry Points. 0b - Use PSTI for Entry Point selection. 1b - Use PSTO for Entry Point selection.
24 ETCS	Entry Table Condition Select. This bit determines the channel condition encoding scheme that selects, according to channel conditions, the Entry Point to be taken in an Entry Table. ETCS value has to be compatible with the function chosen for the channel, selected in field CFS. Two condition encoding schemes are available. For details about Entry Table and condition encoding schemes, see Entry Points. 0b - Select Standard Entry Table Condition encoding scheme. 1b - Select Alternate Entry Table Condition encoding scheme.
23-21 —	Reserved
20-16 CFS	Channel Function Select. This field defines the function to be performed by the channel (see Functions and threads). The Function assigned to the channel has to be compatible with the channel condition encoding scheme, selected by field ETCS.
15 ODIS	Output Disable.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This bit enables the channel to have its output forced to the value opposite to OPOL when the output disable input signal corresponding to the channel group that it belongs is active (see eTPU channel output disable signals and OBE - Output Buffer Enable control latch). 0b - Turns off the output disable feature for the channel. 1b - Turns on the output disable feature for the channel.
14 OPOL	Output Polarity. Determines the output signal polarity. The activation of the output disable signal forces, when enabled by the ODIS bit, the channel output signal to the opposite of this polarity (see OBE - Output Buffer Enable control latch). 0b - Output active low (output disable drives output to high). 1b - Output active high (output disable drives output to low).
13-11 —	Reserved
10-0 CPBA	Channel n Parameter Base Address. The value of this field times 8 specifies the SDM parameter base host (byte) address for channel n (2-parameter granularity; see SDM organization). As seen by the Host, the channel parameter base (byte) address is (without parameter sign extension) eTPU_Base + 0x8000 + CPBA * 8 or (with parameter sign extension), eTPU_Base + 0xC000 + CPBA*8.

67.13.1.3 eTPU Channel n Status Control Register for Engine 1 (C0SCR_ENG1 - C31SCR_ENG1)

Offset

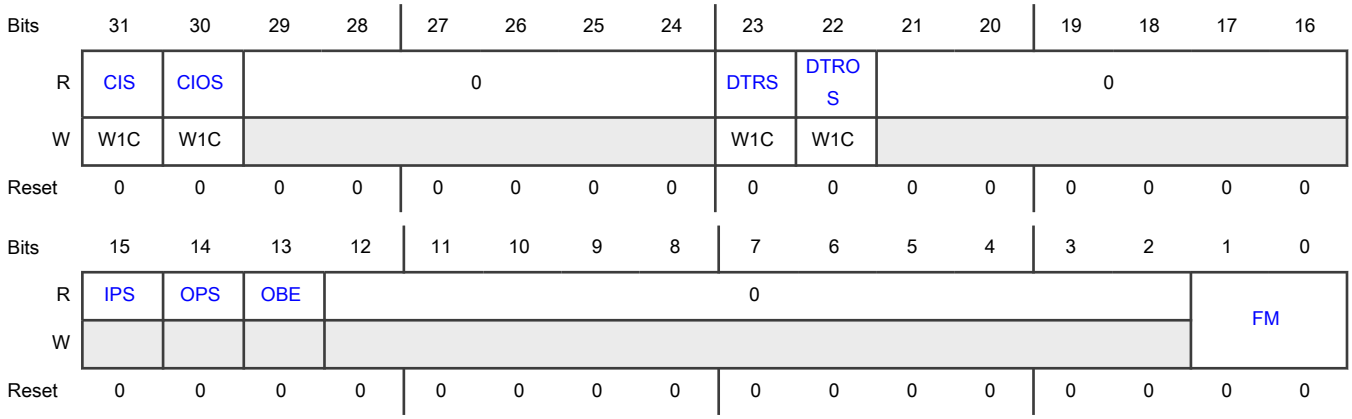
For a = 0 to 31:

Register	Offset
CaSCR_ENG1	404h + (a × 10h)

Function

This register gathers the interrupt status bits of the channel and the Function Mode definition (read-write). Bits CIS, CIOS, and DTRS for each channel can be also accessed from eTPU Channel Interrupt Status Register for Engine 1 (CISR_ENG1), eTPU Channel Interrupt Overflow Status Register for Engine 1 (CIOSR_ENG1), and eTPU Channel Data Transfer Request Status Register for Engine 1 (CDTRSR_ENG1). Host must write 1 to clear a status bit.

Diagram



Fields

Field	Function
31 CIS	Channel Interrupt Status. These bits are mirrored in eTPU Channel Interrupt Status Register for Engine 1 (CISR_ENG1). Also, see Channel Interrupt and Data Transfer Requests. When read: 0.....Channel has no pending interrupt to the Host CPU. 1.....Channel has a pending interrupt to the Host CPU. When written: 0.....Keep interrupt status bit unaltered. 1.....Clear interrupt status bit.
30 CIOS	Channel Interrupt Overflow Status. These bits are mirrored in eTPU Channel Interrupt Overflow Status Register for Engine 1 (CIOSR_ENG1). Also, see Interrupt and Data Transfer Request overflow. When read: 0.....Interrupt overflow negated for this channel. 1.....Interrupt overflow asserted for this channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.
29-24 —	Reserved
23 DTRS	Data Transfer Request Status. These bits are mirrored in eTPU Channel Data Transfer Request Status Register for Engine 1 (CDTRSR_ENG1). Also, see Channel Interrupt and Data Transfer Requests.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When read: 0.....Channel has no pending data transfer request. 1.....Channel has a pending data transfer request. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.
22 DTROS	Data Transfer Request Overflow Status. These bits are mirrored in eTPU Channel Data Transfer Request Overflow Status Register for Engine 1 (CDTROSR_ENG1). Also, see Interrupt and Data Transfer Request overflow. When read: 0.....Data transfer request overflow negated for this channel. 1.....Data transfer request overflow asserted for this channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.
21-16 —	Reserved
15 IPS	Channel Input Pin State. This bit shows the current value of the filtered channel input signal state.
14 OPS	Channel Output Pin State. This bit shows the current value driven in the channel output signal, including the effect of the external output disable feature (see eTPU channel output disable signals). If the channel input and output signals are connected to the same pad, OPS reflects the value driven to the pad (if OBE=1). This is not necessarily the actual pad value, which drives the value in the bit IPS.
13 OBE	Output Buffer Enable. This bit shows the state of the channel output buffer enable signal, controlled by microcode.
12-2 —	Reserved
1-0 FM	Channel Function Mode. Each function uses this field for a specific configuration. These bits can be tested by microengine code (see Conditional/unconditional branch).

67.13.1.4 eTPU Channel n Host Service Request Register for Engine 1 (C0HSRR_ENG1 - C31HSRR_ENG1)

Offset

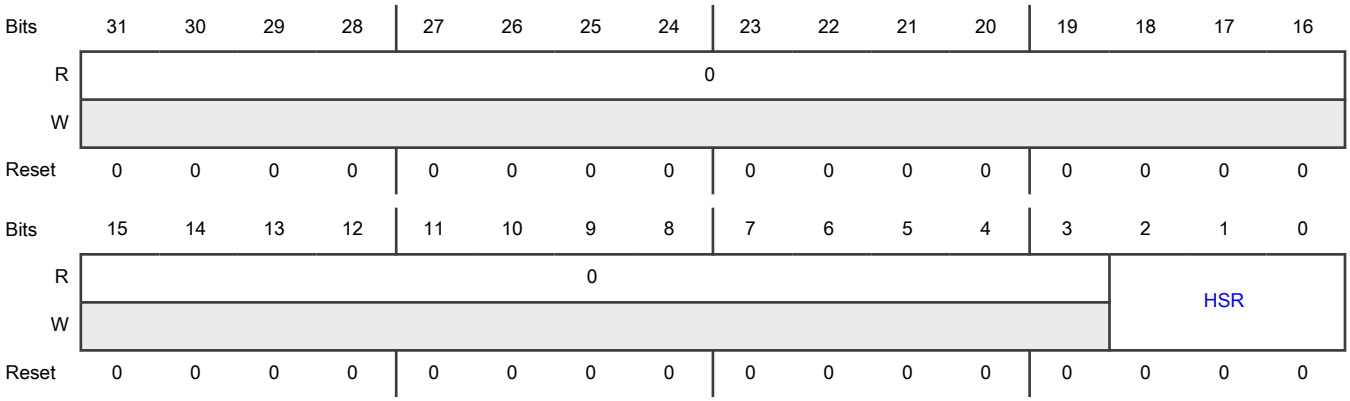
For a = 0 to 31:

Register	Offset
CaHSRR_ENG1	408h + (a × 10h)

Function

This register is used by the Host to issue service requests to the channel.

Diagram



Fields

Field	Function
31-3 —	Reserved
2-0 HSR	Host Service Request This field is used by the Host CPU to request service to the channel (see Host Service Requests). HSR value turns to 000 automatically at the end of microengine service for that channel, but only if the thread started due to an HSR. Host should write HSR greater than 0 only when HSR=0. Writing HSR=000 withdraws a pending request if scheduler did not begin to resolve the Entry Point yet, but it does not abort the service thread from that point on. For more details, see Entry Points and Host Service Requests. 000b - No Host Service Request pending. 001b - Function-dependent Host Service Request pending. 111b - Function-dependent Host Service Request pending.

67.13.1.5 eTPU Channel n Configuration Register for Engine 2 (C0CR_ENG2 - C31CR_ENG2)

Offset

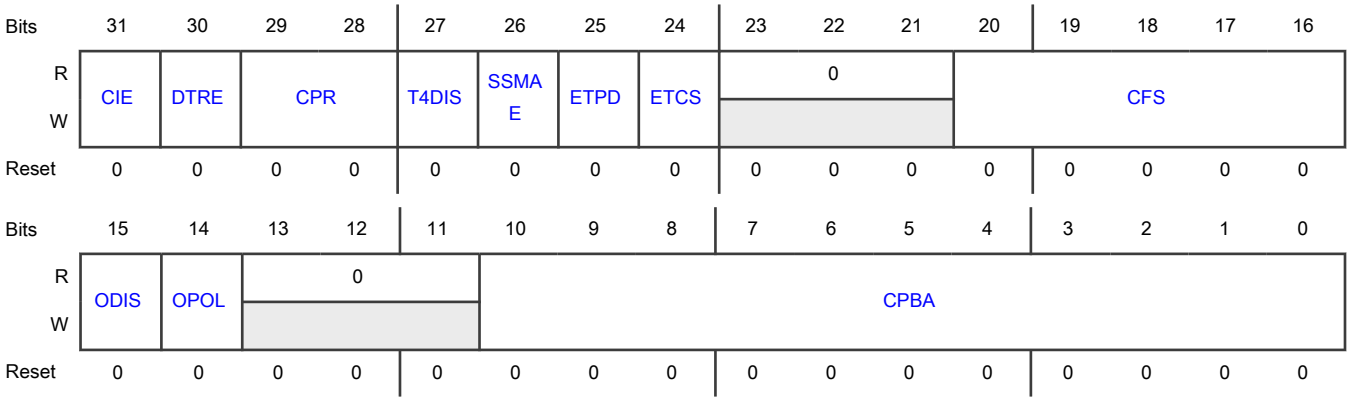
For a = 0 to 31:

Register	Offset
CaCR_ENG2	800h + (a × 10h)

Function

This register gathers configurations set individually per channel.

Diagram



Fields

Field	Function
31 CIE	Channel Interrupt Enable. This bit is mirrored from eTPU Channel Interrupt Enable Register for Engine 2 (CIER_ENG2) (see Channel Interrupt and Data Transfer Requests). 0b - Disable interrupt for this channel. 1b - Enable interrupt for this channel.
30 DTRE	Channel Data Transfer Request Enable. This bit is mirrored from eTPU Channel Data Transfer Request Enable Register for Engine 2 (CDTRER_ENG2) (see Channel Interrupt and Data Transfer Requests). 0b - Disable data transfer request for this channel. 1b - Enable data transfer request for this channel.
29-28 CPR	Channel Priority. This field defines the priority level for the channel, used by the Hardware Scheduler (see Scheduler). 00b - Disabled 01b - Low 10b - Middle 11b - High
27	T4 channel action Disable.

Table continues on the next page...

Table continued from the previous page...

Field	Function
T4DIS	This bit forces the channel to work on T2 timing mode, regardless of the FCSS and CDFC fields in eTPU Engine 2 Configuration Register (ECR_ENG2), or of the TCR1CS field in eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2). For more details, see Channel timing modes. 0b - Channel works either in T2 or T2/T4 timing modes, depending on the TCR1CS field in eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2) and the FCSS and CDFC fields in eTPU Engine 2 Configuration Register (ECR_ENG2). 1b - Channel works in T2 timing mode, regardless of the TCR1CS field in eTPU Engine 2 Time Base Configuration Register (TBCR_ENG2) or the FCSS and CDFC fields in eTPU Engine 2 Configuration Register (ECR_ENG2).
26 SSMAE	Shared Subsystem Microengine Access Enable. This bit enables the microengine access to the Shared Subsystem Area (see Shared subsystems support). When this bit is negated, DIOB address values pointing to the Shared Subsystem Area actually access SDM mirrors, in legacy mode. **NOTE** SSMAE value must only be changed when the engine is either stopped or halted. 0b - An SDM mirror is accessed when the Shared Subsystem Area is addressed by the microengine. 1b - Enables microengine access to the Shared Subsystem Area.
25 ETPD	Entry Table Pin Direction. This bit selects which channel signal, input or output, is used in the Entry Point selection. The ETPD value has to be compatible with the function chosen for the channel, selected in the field CFS. For details about Entry Table and condition encoding schemes, see Entry Points. 0b - Use PSTI for Entry Point selection. 1b - Use PSTO for Entry Point selection.
24 ETCS	Entry Table Condition Select. This bit determines the channel condition encoding scheme that selects, according to channel conditions, the Entry Point to be taken in an Entry Table. ETCS value has to be compatible with the function chosen for the channel, selected in field CFS. Two condition encoding schemes are available. For details about Entry Table and condition encoding schemes, see Entry Points. 0b - Select Standard Entry Table Condition encoding scheme. 1b - Select Alternate Entry Table Condition encoding scheme.
23-21 —	Reserved
20-16 CFS	Channel Function Select. This field defines the function to be performed by the channel (see Functions and threads). The Function assigned to the channel has to be compatible with the channel condition encoding scheme, selected by field ETCS.

Table continues on the next page...

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Field	Function
15 ODIS	Output Disable. This bit enables the channel to have its output forced to the value opposite to OPOL when the output disable input signal corresponding to the channel group that it belongs is active (see eTPU channel output disable signals and OBE - Output Buffer Enable control latch). 0b - Turns off the output disable feature for the channel. 1b - Turns on the output disable feature for the channel.
14 OPOL	Output Polarity. Determines the output signal polarity. The activation of the output disable signal forces, when enabled by the ODIS bit, the channel output signal to the opposite of this polarity (see OBE - Output Buffer Enable control latch). 0b - Output active low (output disable drives output to high). 1b - output active high (output disable drives output to low).
13-11 —	Reserved
10-0 CPBA	Channel n Parameter Base Address. The value of this field times 8 specifies the SDM parameter base host (byte) address for channel n (2-parameter granularity; see SDM organization). As seen by the Host, the channel parameter base (byte) address is (without parameter sign extension) eTPU_Base + 0x8000 + CPBA * 8 or (with parameter sign extension), eTPU_Base + 0xC000 + CPBA*8.

67.13.1.6 eTPU Channel n Status Control Register for Engine 2 (C0SCR_ENG2 - C31SCR_ENG2)

Offset

For a = 0 to 31:

Register	Offset
CaSCR_ENG2	804h + (a × 10h)

Function

This register gathers the interrupt status bits of the channel and the Function Mode definition (read-write). Bits CIS, CIOS, and DTRS for each channel can be also accessed from eTPU Channel Interrupt Status Register for Engine 2 (CISR_ENG2), eTPU Channel Interrupt Overflow Status Register for Engine 2 (CIOSR_ENG2), and eTPU Channel Data Transfer Request Status Register for Engine 2 (CDTRSR_ENG2). Host must write 1 to clear a status bit.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CIS	CIOS	0						DTRS	DTROS	0					
W	W1C	W1C							W1C	W1C						
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	IPS	OPS	OBE	0											FM	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 CIS	Channel Interrupt Status. These bits are mirrored in eTPU Channel Interrupt Status Register for Engine 2 (CISR_ENG2). Also, see Channel Interrupt and Data Transfer Requests. When read: 0.....Channel has no pending interrupt to the Host CPU. 1.....Channel has a pending interrupt to the Host CPU. When written: 0.....Keep interrupt status bit unaltered. 1.....Clear interrupt status bit.
30 CIOS	Channel Interrupt Overflow Status. These bits are mirrored in eTPU Channel Interrupt Overflow Status Register for Engine 2 (CIOSR_ENG2). Also, see Interrupt and Data Transfer Request overflow. When read: 0.....Interrupt overflow negated for this channel. 1.....Interrupt overflow asserted for this channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.
29-24 —	Reserved
23 DTRS	Data Transfer Request Status. These bits are mirrored in eTPU Channel Interrupt Status Register for Engine 2 (CISR_ENG2). Also, see Channel Interrupt and Data Transfer Requests.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When read: 0.....Channel has no pending data transfer request. 1.....Channel has a pending data transfer request. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.
22 DTROS	Data Transfer Request Overflow Status. These bits are mirrored in eTPU Channel Data Transfer Request Overflow Status Register for Engine 2 (CDTROSR_ENG2). Also, see Channel Interrupt and Data Transfer Requests. When read: 0.....Data transfer request overflow negated for this channel. 1.....Data transfer request overflow asserted for this channel. When written: 0.....Keep status bit unaltered. 1.....Clear status bit.
21-16 —	Reserved
15 IPS	Channel Input Pin State. This bit shows the current value of the filtered channel input signal state.
14 OPS	Channel Output Pin State. This bit shows the current value driven in the channel output signal, including the effect of the external output disable feature (see eTPU channel output disable signals). If the channel input and output signals are connected to the same pad, OPS reflects the value driven to the pad (if OBE=1). This is not necessarily the actual pad value, which drives the value in the bit IPS.
13 OBE	Output Buffer Enable. This bit shows the state of the channel output buffer enable signal, controlled by microcode.
12-2 —	Reserved
1-0 FM	Channel Function Mode. Each function uses this field for a specific configuration. These bits can be tested by microengine code (see Conditional/unconditional branch).

67.13.1.7 eTPU Channel n Host Service Request Register for Engine 2 (C0HSRR_ENG2 - C31HSRR_ENG2)

Offset

For a = 0 to 31:

Register	Offset
CaHSRR_ENG2	808h + (a × 10h)

Function

This register is used by the Host to issue service requests to the channel.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0														HSR	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-3 —	Reserved
2-0 HSR	Host Service Request This field is used by the Host CPU to request service to the channel (see Host Service Requests). HSR value turns to 000 automatically at the end of microengine service for that channel, but only if the thread started due to an HSR. Host should write HSR greater than 0 only when HSR=0. Writing HSR=000 withdraws a pending request if scheduler did not begin to resolve the Entry Point yet, but it does not abort the service thread from that point on. For more details, see Entry Points and Host Service Requests. 000b - No Host Service Request pending. 001b - Function-dependent Host Service Request pending. 111b - Function-dependent Host Service Request pending.

67.14 Shared Subsystem Integration memory map and registers

67.14.1 eTPU_SSIR register descriptions

Shared Subsystems Integration Registers configure aspects of how the shared modules interface with the eTPU. There is one integration register for each subsystem unit, which can be, depending on the specific subsystem, a whole IP module, a sub-module, or a channel within a module. For more details, see Shared subsystems support .

67.14.1.1 eTPU_SSIR memory map

eTPU_5 base address: 4068_0000h

67.15 Glossary

channel	The dedicated hardware that, with a selected timebase, performs input signal processing and output signal generation for a specific I/O signal pair.
function	A set of microengine routines that implement a specific channel application. See Functions and threads.
microengine	A single eTPU internal processing core. Also called an eTPU engine. Typically, there are two microengines in an eTPU module.
SCM	Shared code memory
SDM	Shared data memory
SSS	Shared Subsystem area. A memory map region used by both the host and eTPU to access registers of a reaction channel, giving you the option to control them by the host, the eTPU code, or a combination of both.
STAC bus	Shared time and counter bus. Used for sharing real-time data between multiple peripherals.
thread	A service routine of a function, or its execution. See Functions and threads.

Chapter 68
Sine Wave Generator (SGEN)

68.1 Chip-specific SGEN information

68.1.1 SGEN configuration

This device has 2 sine wave generators modules: SGEN_0 and SGEN_1[37].

The 2 sine wave generators modules share dedicated Power and ground pads.

NOTE

Each instance have one trigger signal which comes through TRGMUX.

NOTE

SWG and SGEN terms are used interchangeably in this document.

68.2 Introduction

The Sine Wave Generator (SGEN) generates a high-quality sinusoidal voltage signal. It can be programmed with the desired oscillation frequency and amplitude voltage. A wide frequency range (1 kHz–50 kHz in 16 Hz steps) is easily programmable through a simple register interface. The linearity and noise performance are carefully optimized through digital processing.

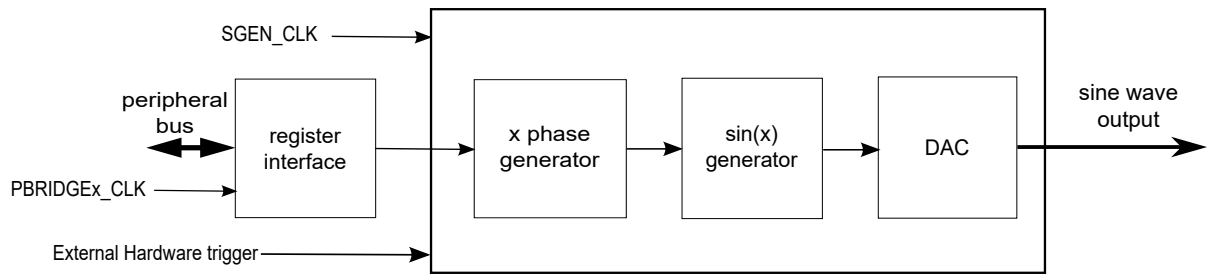


Figure 494. SGEN block diagram

68.3 Features

- Input clock frequency range: 12 MHz–20 MHz
- Output sinusoidal signal:
  - Frequency range: 1 kHz–50 kHz
  - Peak-to-peak amplitude: user adjustable. See Output sine wave amplitude

68.4 SGEN register descriptions

[37] SGEN_1 is not available in S32K36x.

68.4.1 SGEN memory map

SGEN_0 base address: 406C_8000h

SGEN_1 base address: 406C_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Control Register (CTRL)	32	RW	0001_0000h
4h	Status Register (STAT)	32	RW	0000_0000h

68.4.2 Control Register (CTRL)

Offset

Register	Offset
CTRL	0h

Function

This register enables the following operations:

- Control and read the output sine wave frequency.
- Control and read the output sine wave amplitude.
- Input phase align trigger mode selection for the sine wave output.
- Control acceptance window width.
- Select the input trigger mode to align the phase of the sine wave output.

NOTE

Changes made to the SGEN_CTRL register must be preserved for at least 50 SGEN clock cycles. Failure to do so might cause unexpected output from the SGEN

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LDOS	0	IOAMPL				WINDOW		SEMASK	0			0	TRIG_MO...	Reserved	PDS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	IOFREQ															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LDOS	Load sine wave frequency CTRL[IOFREQ] is loaded by waiting until LDOS = 0 and then setting LDOS to 1. **NOTE** LDOS bit toggling to be done before the Power Down bit is cleared. 0b - Wait for I/O sine wave frequency 1b - Load I/O sine wave frequency
30 —	Reserved
29-26 IOAMPL	IO sine wave amplitude Controls the sine wave voltage amplitude on the output pin. See Output sine wave amplitude for further information.
25-24 WINDOW	Phase alignement acceptance window width These bits controls the size of the acceptance window for the phase alignment. 00b - +- 1% from the zero crossing 01b - +- 10% from the zero crossing 10b - +- 15% from the zero crossing 11b - +- 25% from the zero crossing
23 SEMASK	Sine wave generator error mask interrupt register 0b - Mask the SGEN error interrupt source 1b - Enable the SGEN error interrupt source
22-20 —	Reserved
19 —	Reserved
18 TRIG_MODE	Input phase align trigger mode selection bit The sine wave appears at the output after the first active trigger occurs. Its frequency is determined by IOFREQ. 0b - Software trigger mode is selected. 1b - Hardware trigger mode is selected.
17 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
16 PDS	Enter/exit Power Down mode 0b - Force SGEN to exit Power Down mode. 1b - Force SGEN to enter Power Down mode.
15-0 IOFREQ	Output sine wave frequency See Output sine wave frequency to determine value for this field.

68.4.3 Status Register (STAT)

Offset

Register	Offset
STAT	4h

Function

This register provides information about error status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								SERR	0			FERR	PHERR	0	
W									W1C							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23 SERR	Error interrupt status This field is set by chip and it can be also set by the SGEN_STAT[FERR] or SGEN_STAT[PHERR] field. It can be cleared in software by writing a 1 to it. During an STAT[SERR] clear operation, the hardware set is not allowed to set this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE This field is set on either of the following conditions: • There is an error in the demodulator block. • The input trigger's phase is out of the acceptance window of the current sine wave output. 0b - No error interrupt pending 1b - Error interrupt pending
22-20 —	Reserved
19 FERR	Software generated demodulator error interrupt **NOTE** Because this field is set in the bus clock domain and the SGEN digital block operates in the SGEN clock domain, both clocks must be present to set the STAT[SERR] field. Also, due to the synchronization between two asynchronous clocks, the setting of STAT[SERR] will occur, at maximum, 4 bus clock and 4 SGEN clock cycles after the setting of STAT[FERR]. 0b - An error interrupt will not be forced. 1b - An error interrupt will be forced.
18 PHERR	Software generated phase error interrupt SERR will be set when this field transistions from 0 to 1. This field can be reset to 0 by software.
17-0 —	Reserved

68.5 Functional description

68.5.1 Operation after a power-on reset

After a power-on reset, the SGEN produces a DC value (no sinusoidal fluctuations).

68.5.2 Output sine wave frequency

The output sine wave frequency *f* is controlled by CTRL[IOFREQ] according to Figure 495 where frequencies *f* and Input frequency are in Hz, and IOFREQ is in decimal format. IOFREQ must be chosen to ensure that *f* remains between 1 kHz and 50 kHz.

$$f = \frac{\text{InputFrequency}}{16777216} \times \text{IOFREQ}$$

Figure 495. Equation 1: Output sine wave frequency

68.5.3 Output sine wave amplitude

The amplitude of the output sine wave is controlled by CTRL[IOAMPL] as described in the following table.

Table 482. Resulting sine wave amplitude for each IOAMPL value

IOAMPL value (decimal)	Sine wave amplitude (V)	Sine wave amplitude step (V)
0	0.423	0.064
1	0.487	0.064
2	0.550	0.063
3	0.613	0.063
4	0.675	0.062
5	0.737	0.062
6	0.797	0.060
7	0.857	0.060
8	0.987	0.130
9	1.136	0.149
10	1.284	0.148
11	1.430	0.146
12	1.575	0.145
13	1.719	0.144
14	1.861	0.142
15	2.00	0.139

68.6 Software trigger mode

The software trigger mode is selected when the SGEN_CTRL[TRIG_MODE] is set to 0. It is possible to update the output signal every time when the new frequency is programmed into the SGEN_CTRL and the bit SGEN_CTRL[LDOS] is toggled (software trigger - see section Initialization and application information for correct sequence of steps).

The figure below shows how the SGEN works in software trigger mode. The software trigger signal is generated by the toggle of the SGEN_CTRL[LDOS] bit. The SGEN OUT signal is not generated until the first software trigger comes.

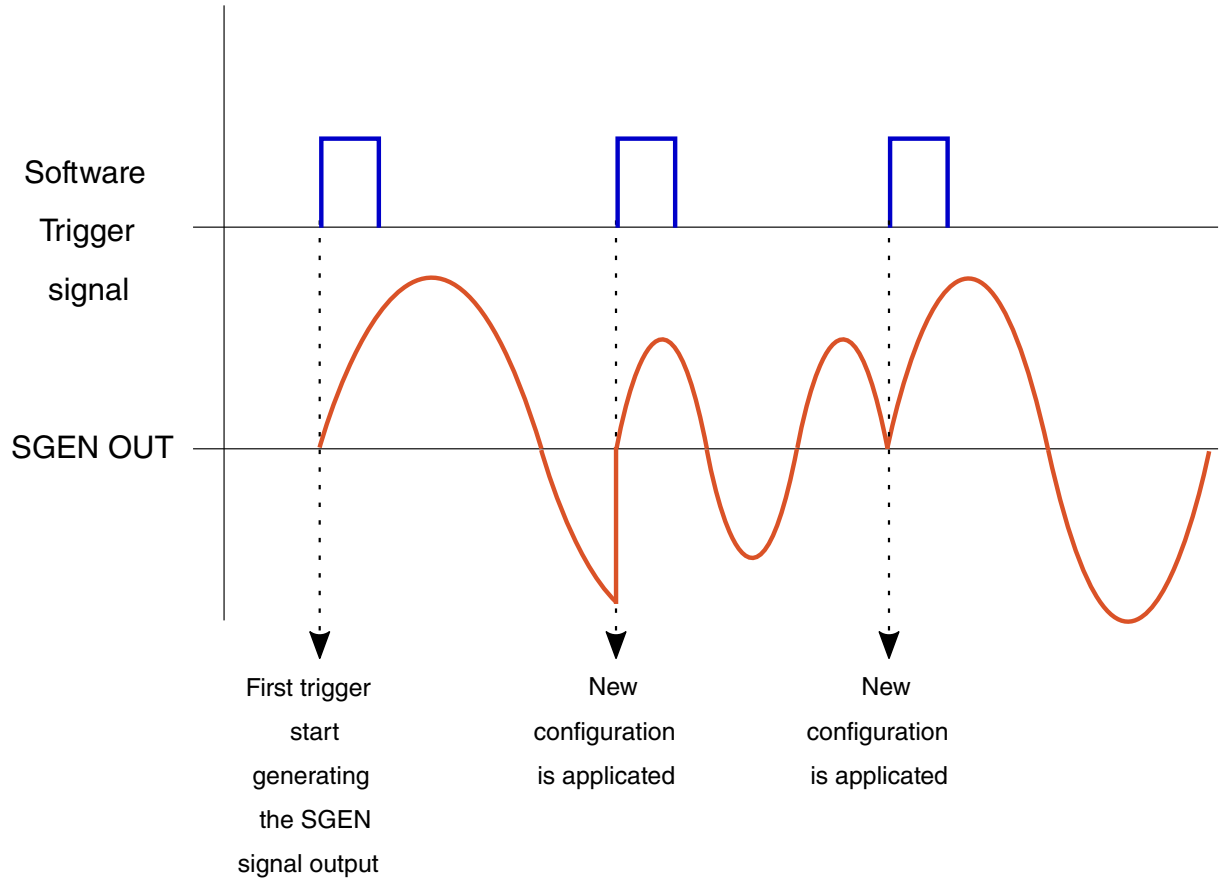


Figure 496. Software trigger mode

68.6.1 Initialization and application information

Bring SWG out of power down by making PDS = 0.

NOTE

A glitch can be observed on the SWG output during the initialization before the output settles on the common voltage level (CV). This glitch is not affecting the SWG functionality.

68.6.2 Change the output frequency

To change the output frequency do the following steps:

1. Determine the required value of the output frequency by using Figure 495.
2. Ensure that CTRL[LDOS] = 0.
3. Write the new value of the CTRL[IOFREQ] field.
4. Set CTRL[LDOS].

The SGEN will begin producing the new sine wave frequency two SGEN clock cycles after this procedure is completed.

68.6.3 Change the output amplitude

Write the new value of the amplitude into SGEN_CTRL[IOAMPL] field using Equation 1Output sine wave amplitude. The amplitude is updated immediately.

68.6.4 Phase control of the sine wave output

To align the SGEN OUT phase with some internal process it is needed to generate the software trigger which will start the SGEN from phase 0 by the following steps:

1. Clear the SGEN_CTRL[LDOS] field.
2. Set SGEN_CTRL[LDOS].

68.7 Hardware trigger mode

The hardware trigger mode is selected when the SGEN_CTRL[TRIG_MODE] is set to 1.

The SGEN OUT signal is not generated until the first hardware trigger arrives.

The SGEN OUT signal frequency and phase are updated when the hardware trigger is inside the acceptance window, which is configurable by the SGEN_CTRL[WINDOW] to +/-1%, +/-10%, +/- 15%, and +/-25%. When the trigger is out of the acceptance window the phase error is generated SGEN_STAT[SERR] = 1.

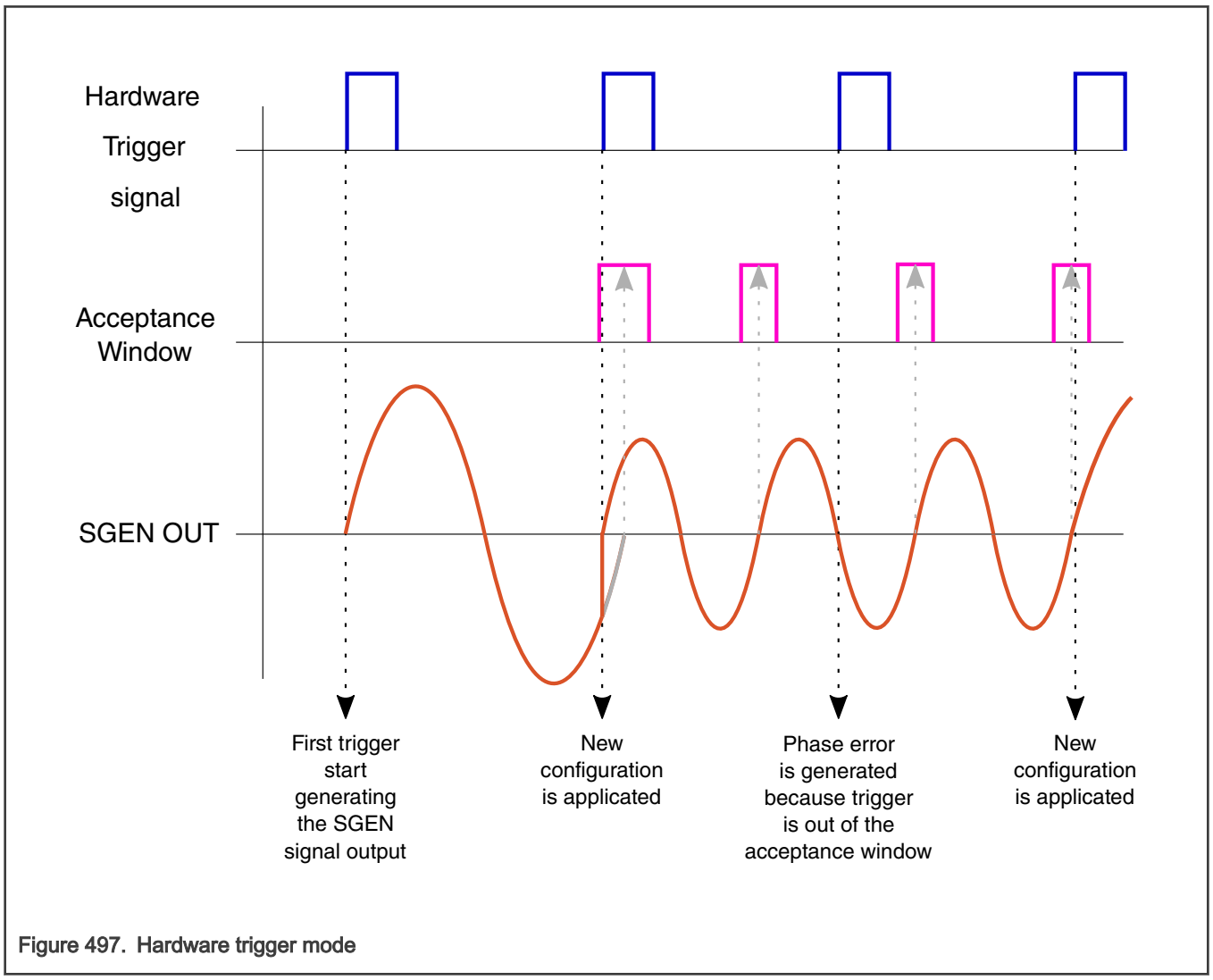


Figure 497. Hardware trigger mode

68.7.1 Acceptance window generation

It is done in the digital part of the SGEN module. When the hardware trigger for reconfiguration is generated (received) the IP checks the value of the pointer which show sample of the SGEN that is sent to the DAC. When the pointer is in the acceptance window (+/-1%, +/-10%, +/-15%, or +/-25%) the trigger is applied, if not the phase error is generated (SGEN_STA[SERR] = 1).

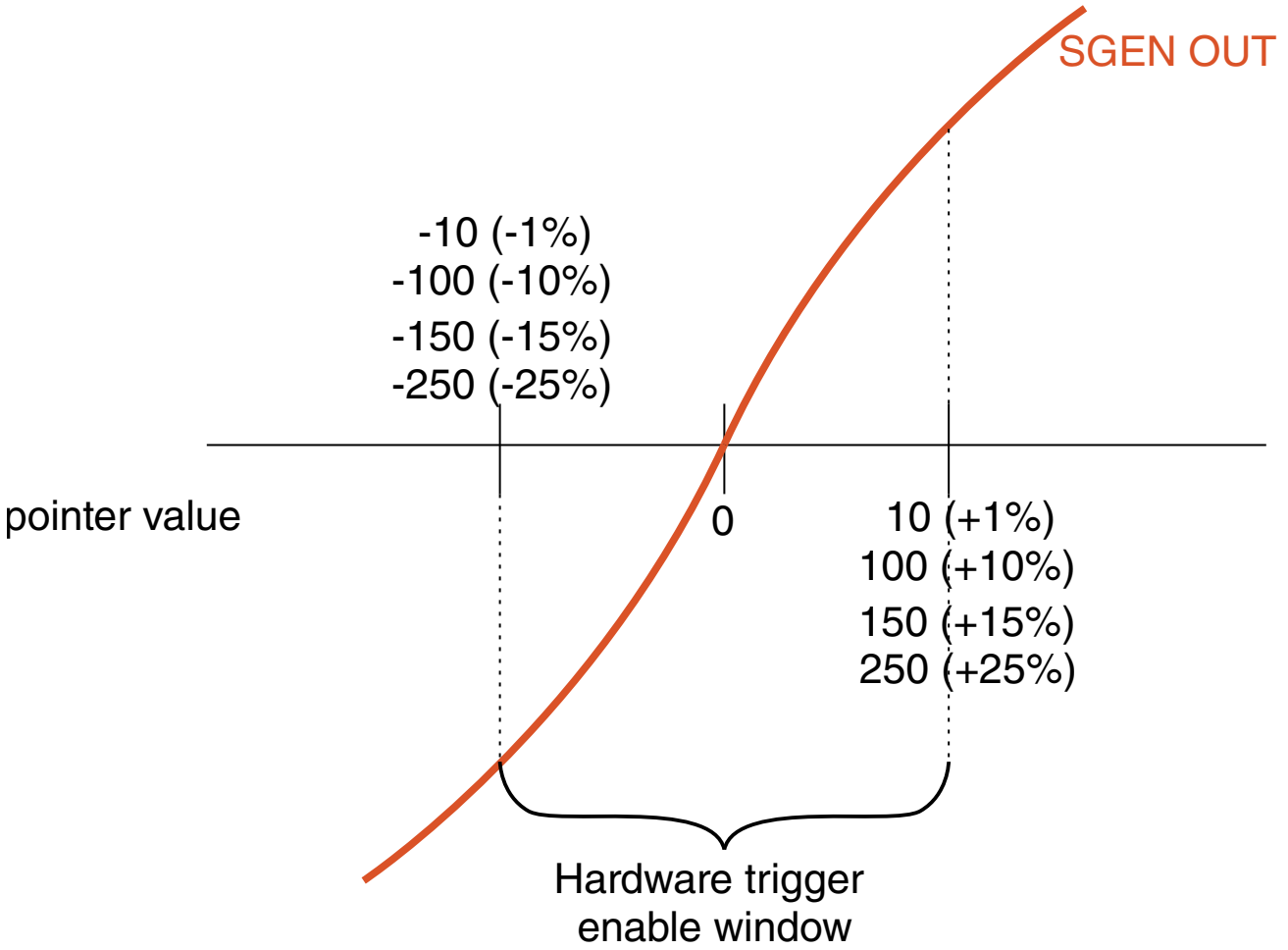


Figure 498. Hardware trigger acceptance window

68.7.2 Initialization and application information

Bring SWG out of power down by making PDS = 0.

NOTE

A glitch can be observed on the SWG output during the initialization before the output settles on the common voltage level (CV). This glitch is not affecting the SWG functionality.

68.7.3 Change the output frequency

To change the output frequency:

1. Determine the required value of the output frequency by using equation 1. Figure 495.
2. Write the new value of the SGEN_CTRL[IOFREQ] field.
3. Generate hardware trigger in the configured acceptance window.
4. When the HW trigger is in the acceptance window the new value of the frequency is applied to SGEN OUT.

68.7.4 Change the output amplitude

Write the new value of the amplitude into the SGEN_CTRL[IOAMPL] field using Output sine wave amplitude. The amplitude is updated immediately.

68.7.5 Phase/Frequency control of the sine wave output

The normal output of the sine wave generator is a free-running sine wave with the amplitude and frequency determined by the SGEN_CTRL register settings.

SGEN_CTRL[TRIG_MODE] selects the hardware phase/frequency align of the sine wave output

The trigger input is a periodic signal which has the same frequency as the sine wave output but might have a different phase (either leading or lagging) or periodical signal with similar frequency as sine wave output which is not reachable by SGEN (this is a limitation by equation Figure 495).

When the HW trigger arrives within the acceptance window the output signal is restarted. If the HW trigger arrives outside of the acceptance window a phase error is generated (SGEN_STAT[SERR] is set).

For additional details refer to the figure below:

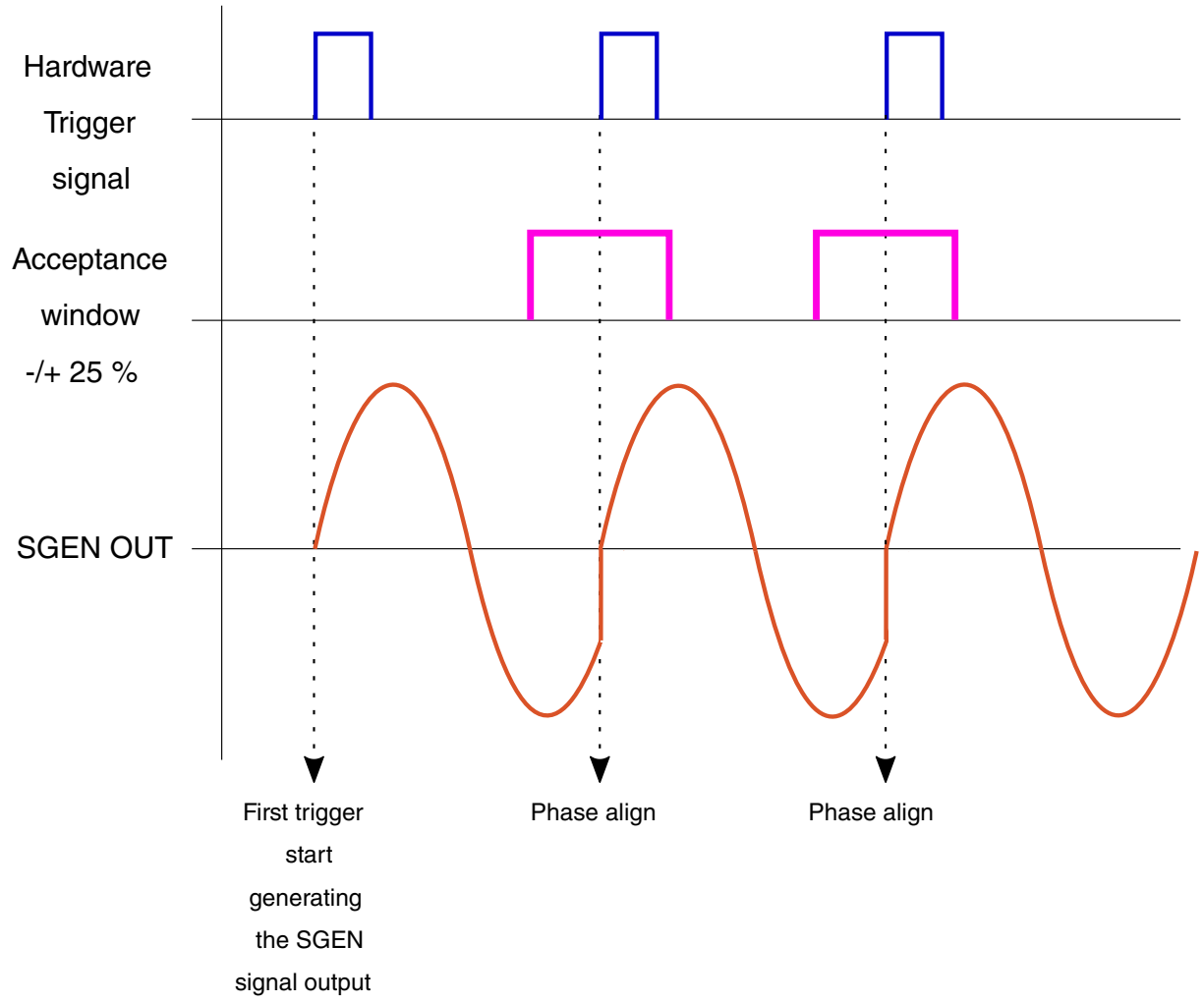


Figure 499. Phase/Frequency control of the sine wave output

NOTE

Because the trigger input is an asynchronous signal, it must be held high for at least 2 SGEN clock cycles to capture the input trigger.

This requirement must be guaranteed by the module generating the trigger input signal. If this requirement is not met, the phase alignment will not function as expected.

Chapter 69
Software Watchdog Timer (SWT)

69.1 Chip-specific SWT information

69.1.1 SWT instances and configuration

This chip supports 3 instances of SWT, one for each Cortex-M7 core.

Table 483. SWT configuration

Instance	Core	Reset type	Clock Source	SWT_MIN_TO (100µs)	SWT_TO_RST (25ms)
SWT_0[1]	Cortex-M7_0	Functional Reset - RAM retention	SIRC (32K)	3	320h
SWT_1	Cortex-M7_1	Functional Reset - RAM retention	SIRC (32K)	3	320h
SWT_2	Cortex-M7_2	Functional Reset - RAM retention	SIRC (32K)	3	320h

1. SWT_0 supports operation in STANDBY mode.

NOTE

When using SWT as a wakeup source from standby, software should ensure proper value of timeout such that SWT timeout doesn't get expired again (after wakeup till standby exit is completed). The timeout should be programmed to a value greater than the time till standby exit is complete (sum of standby exit time and the time till software disables padkeeping).

NOTE

The "Reset only the SWT" feature using SWT_RRR[RRF] is supported only when SWT reset reaction is demoted to interrupt within MC_RGM.

Protect SWT from service by non-core masters

You must program protection for the SWT registers so that only core masters can service SWT.

When an SWT timeout takes place, the logic generating a reset to the system runs off the slow internal RC oscillator (32KHz). It could therefore take the SWT almost 31.25µs to reset the system, after timeout, leaving more time for runaway code to execute. The register interface clock of SWT is running from AIPS_SLOW_CLK, see Clocking chapter for more details. The register interface clock is responsible for generating the abort for invalid access while the counter clock is responsible for generating the SWT reset request. Since there is a synchronization happening between the register interface clock and counter clock domains before generating the SWT reset request, thus the generation of the reset request can take a number of register interface clock cycles after an invalid access is done.

Clock source

SWT is clocked by SIRC only.

69.2 Overview

The Software Watchdog Timer (SWT) is a 32-bit window watchdog timer that enables the system to recover from situations such as:

- Software trapped in a loop

- A bus transaction failing to terminate

In regular operation, SWT requires periodic execution of a watchdog servicing operation. The servicing operation resets the timer to a specified timeout period. If this servicing action does not occur before the timer expires, SWT generates an interrupt or a hardware reset request.

You can configure SWT to generate a reset request or an interrupt on the initial timeout. SWT always generates a reset request on a second consecutive timeout.

69.2.1 Block diagram

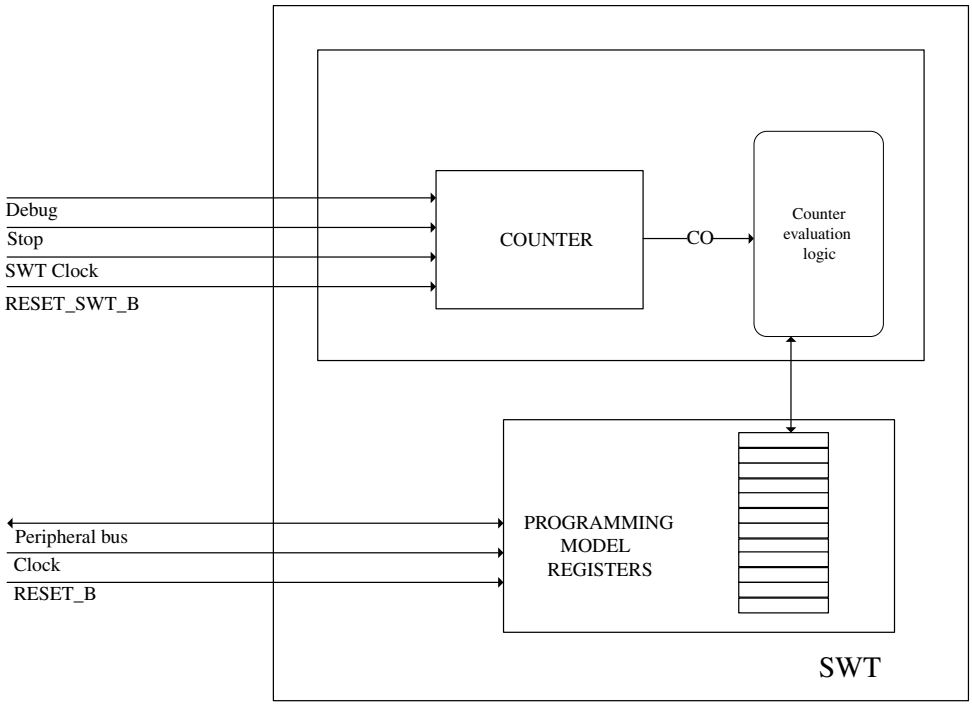


Figure 500. SWT block diagram

69.2.2 Features

SWT has the following features:

- 32-bit countdown timer
- Selection of regular or window servicing
- Selection of reset request or interrupt on an initial timeout
- Selection of fixed or keyed service sequence
- Master access protection
- Hard and soft configuration lock bits

69.3 Functional description

69.3.1 Behavior in different chip and core modes

SWT supports the core modes of operation as follows:

Core mode	SWT behavior
Normal	When SWT is enabled (CR[WEN] = 1), the SWT timer counts down continuously.
Debug	If CR[FRZ] = 1, SWT stops the timer; otherwise, the timer continues to run.
Stop or Standby	If CR[STP] = 1, SWT stops the timer; otherwise, the timer continues to run.

69.3.2 Register access latency

Accesses to SWT registers occur with no peripheral bus wait states. The peripheral bus bridge may add 1 or more system wait states. However, due to synchronization logic in the SWT design, recognition of the service sequence or configuration changes may require up to three system clock cycles plus seven counter clock cycles.

69.3.3 Service key generation

SWT generates service keys with the pseudorandom key generator defined by the following equation.

$$SK_{n+1} = (17 \times SK_n + 3) \bmod 2^{16}$$

Figure 501. Pseudorandom key generator

This algorithm generates a sequence of 2^{16} different key values before repeating. In keyed service sequence mode, each time you write a valid key to SR[WSC], SWT updates SK[SK] with the next key.

For example, if the previous service key (SK[SK]) is 100h, then the next service sequence keys are 1103h followed by 2136h.

69.3.4 Clocking

The SWT has two clock domains, one for the IPS interface and the other for the counter and reset request logic. The two clocks can be asynchronous to each other and have independent resets.

See the chip-specific SWT information to find the clock source that drives the countdown timer.

69.3.5 Reset

The following table describes the SWT resets:

Table 484. SWT resets

Reset	Description
RESET_B	It is used to reset the programming model registers.
RESET_SWT_B	It is used to reset the functional domain of the SWT.

69.3.6 Interrupts

The SWT generates one interrupt:

- Timeout interrupt: it is asserted when the watchdog timer count exceeds the timeout period in the TO register.

69.3.7 Reset only the SWT

When a timeout triggers a reset request and the application does not require a system reset, you can make the SWT instance reset itself rather than the whole system.

To make a timeout reset request trigger only an SWT reset (rather than the whole system), write 1 to the Reset Request Flag (RRR[RRF]).

This action causes SWT to:

- Clear the reset request.
- If an interrupt request also occurred, clear the interrupt request (IR[TIF]).
- Reset and restart the SWT.

For systems with multiple SWT instances, this feature allows you to reset an individual SWT instance, avoiding the widespread impact of a system reset.

69.3.8 Test SWT operation

When you disable SWT, it loads the current countdown timer into CO[CNT]. When you enable SWT, it clears this register. You can use CO[CNT] to perform a software self-test of SWT.

To test SWT operation:

1. Enable the SWT (CR[WEN] = 1).
2. Do not service SWT for a fixed period of time that is less than the timeout value.
3. Disable the SWT (CR[WEN] = 0).
4. Read the value in CO[CNT] to determine whether the internal countdown timer is working properly.

NOTE

The value shown in CO[CNT] can lag behind the actual internal timer up to six system clock cycles plus eight counter clock cycles.

69.4 External signals

This module has no external signals.

69.5 Initialization

69.5.1 Initialize the SWT

To initialize the SWT, you must do the following:

- Set the timeout period.
- Control timeout behavior. There are two options:
  - Select reset request on timeout, or
  - Select interrupt on initial timeout.

You must initialize all registers before enabling SWT (CR[WEN]). You can initialize the registers in any sequence.

69.5.1.1 Set the timeout period

When you enable SWT, it loads the greater of the specified watchdog timeout period or the minimum timeout period into an internal 32-bit countdown timer every time you perform a valid service operation.

To set the watchdog timeout period:

- Write the desired timeout period to TO[WTO].

The minimum timeout period is 3 clock cycles.

69.5.1.2 Control timeout behavior

SWT can respond to a timeout in one of two ways:

- Generate an immediate reset request on any timeout.

- Generate an interrupt and load the countdown timer on an initial timeout, then generate a reset request on a subsequent timeout.

69.5.1.2.1 Select reset request on timeout

To configure SWT to generate an immediate reset request on any timeout:

- Write 0 to CR[ITR].

69.5.1.2.2 Select interrupt on initial timeout

To configure SWT to generate an interrupt on an initial timeout:

- Write 1 to CR[ITR].

In this configuration, on the initial timeout:

- SWT loads the countdown timer with the timeout period (TO[WTO]).
- SWT indicates the interrupt with the timeout interrupt flag (IR[TIF]).
- If a second consecutive timeout occurs before writing the service sequence for the first timeout, SWT generates a reset request.

You clear the interrupt flag by writing 1 to IR[TIF].

69.5.1.3 Configure locking and unlocking

You can lock the SWT configuration with either a hard lock or a soft lock. When either lock is in effect, CR, TO, WN, and SK are read-only.

69.5.1.3.1 Enable the hard lock

To enable the hard lock:

- Write 1 to CR[HLK].

Hard lock is disabled only by a reset.

69.5.1.3.2 Enable the soft lock

To enable the soft lock:

- Write 1 to CR[SLK].

69.5.1.3.3 Unlock the soft lock

To unlock the soft lock:

1. Write C520h to SR[WSC].
2. Write D928h to SR[WSC].

This unlock sequence:

- Ignores service sequence writes.
- Recognizes the unlock sequence regardless of previous writes.
- Recognizes the unlock sequence regardless of the time between writes.
- Does not require CR[WEN] to be 1.

You can write this unlock sequence at any time.

NOTE

It is possible for a keyed service sequence to unlock soft lock. See Avoid soft unlock for the procedure to handle this situation.

69.5.1.3.4 Avoid soft unlock

When SWT operates in keyed sequence service, the sequence of service keys generated by the pseudorandom generator includes the unlock keys for soft lock. If one or more service routines use both unlock keys in the proper order, 0xC520 followed at any future time by 0xD928, SWT unlocks soft lock (CR[SLK] = 0). The unlock sequence logic ignores any service keys other than the unlock keys, so the unlock keys don't have to be inserted consecutively. If the second unlock key is also the second key of a service operation, unlock occurs before the service operation completes.

To avoid unlock:

If the service routine writes a key value of C520h to SR[WSC] as a key of the service operation, then do the following:

1. Complete the service operation.
2. Complete the unlock sequence by writing the second unlock key, D928h, to SR[WSC].
3. Reinitiate the soft lock (CR[SLK] = 1).

69.5.1.4 Select behavior on an invalid access

SWT can respond to an invalid access one of two ways:

- Generate a bus error.
- Generate a bus error and, if SWT is enabled, a reset request.

To select how SWT responds to an invalid access:

- Write the appropriate value to CR[RIA].

69.5.2 Initiate service operations

When enabled, SWT requires periodic execution of a servicing operation.

SWT can operate in one of the following service sequence modes:

- Fixed service sequence
- Keyed service sequence

69.5.2.1 Initiate a fixed service sequence

To initiate the fixed service sequence:

1. Select the fixed servicing mode (write 00b to CR[SMD]).
2. Write A602h to SR[WSC].
3. Write B480h to SR[WSC].

There is no timing requirement between the two writes. The service sequence logic ignores unlock-sequence writes.

69.5.2.2 Initiate a keyed service sequence

To initiate the keyed service sequence:

1. Select the keyed servicing mode (write 01b to CR[SMD]).
2. Read the initial service key from SK[SK].
3. Calculate the next service key using the provided equation.
4. Write that service key to SR[WSC].

5. Repeat steps 2 through 4 one time.

See Service key generation for information about service keys.

69.5.2.3 Select window service mode

In window service mode, you must write the service sequence only when the watchdog timer is less than the window start value (WN[WST]). If you write the service sequence outside of this window, the access is invalid and generates a bus error or reset request depending on the Reset on Invalid Access setting (CR[RIA]).

For example, if the timeout period is 5000 and the window start value is 1000, you must write the service sequence during the last 20% of the timeout period.

Synchronization logic in SWT causes a slight delay in the opening of the window. This delay can be up to three system clock cycles plus four counter clock cycles.

To select window service mode:

- Write 1 to (CR[WND]).

69.6 SWT register descriptions

The SWT programming model allows only 32-bit (word) accesses.

Any of the following attempted accesses are invalid:

- Non-32-bit accesses
- Writes to read-only registers
- Writes of incorrect values to SR when SWT is enabled
- Accesses to reserved addresses
- Accesses by masters without permission

You control how SWT responds to an invalid access with CR[RIA].

69.6.1 SWT memory map

SWT_0 base address: 4027_0000h

SWT_1 base address: 4046_C000h

SWT_2 base address: 4047_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Control (CR)	32	RW	FF00_010Ah
4h	Interrupt (IR)	32	RW	0000_0000h
8h	Timeout (TO)	32	RW	0000_0320h
Ch	Window (WN)	32	RW	0000_0000h
10h	Service (SR)	32	RW	0000_0000h
14h	Counter Output (CO)	32	R	0000_0000h
18h	Service Key (SK)	32	RW	0000_0000h
1Ch	Event Request (RRR)	32	RW	0000_0000h

69.6.2 Control (CR)

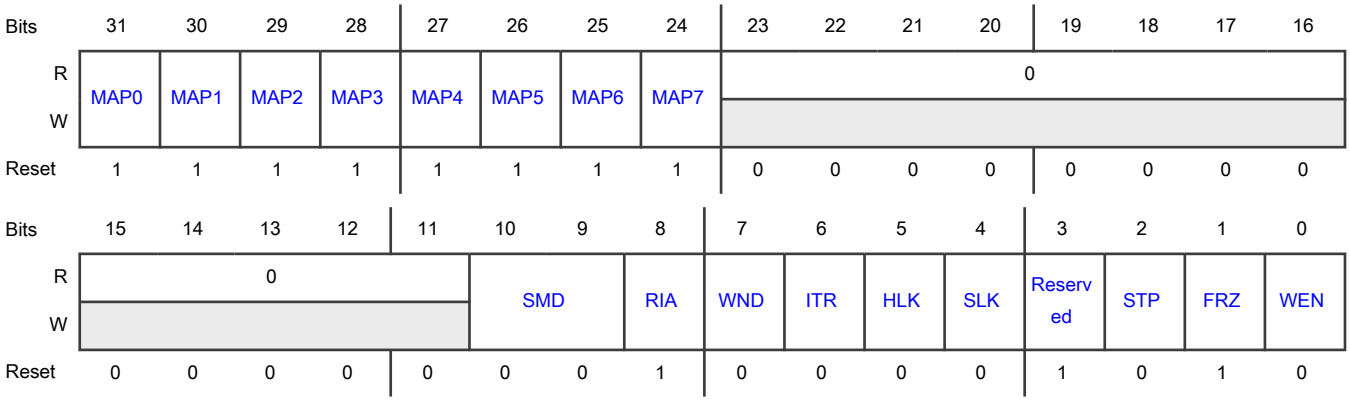
Offset

Register	Offset
CR	0h

Function

Contains fields for configuring and controlling SWT. The register is read-only if either hard lock or soft lock is enabled (either HLK or SLK is 1).

Diagram



Fields

Field	Function
31 MAP0	Master Access Protection 0 The platform bus master assignments are chip-specific. The number of this field corresponds to the XRDC DIDs of the bus master. MAP0 corresponds to XRDC DIDs 0 and 8. 0b - Access disabled 1b - Access enabled
30 MAP1	Master Access Protection 1 See the description for MAP0. MAP1 corresponds to XRDC DIDs 1 and 9. 0b - Access disabled 1b - Access enabled
29 MAP2	Master Access Protection 2 See the description for MAP0. MAP2 corresponds to XRDC DIDs 2 and 10. 0b - Access disabled

Table continues on the next page...

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Field	Function
	1b - Access enabled
28 MAP3	Master Access Protection 3 See the description for MAP0. MAP3 corresponds to XRDC DIDs 3 and 11. 0b - Access disabled 1b - Access enabled
27 MAP4	Master Access Protection 4 See the description for MAP0. MAP4 corresponds to XRDC DIDs 4 and 12. 0b - Access disabled 1b - Access enabled
26 MAP5	Master Access Protection 5 See the description for MAP0. MAP5 corresponds to XRDC DIDs 5 and 13. 0b - Access disabled 1b - Access enabled
25 MAP6	Master Access Protection 6 See the description for MAP0. MAP6 corresponds to XRDC DIDs 6 and 14. 0b - Access disabled 1b - Access enabled
24 MAP7	Master Access Protection 7 See the description for MAP0. MAP7 corresponds to XRDC DIDs 7 and 15. 0b - Access disabled 1b - Access enabled
23-11 —	Reserved
10-9 SMD	Service Mode 00b - Fixed Service Sequence. To service the watchdog, write the fixed sequence 0xA602, 0xB480 to SR. 01b - Keyed Service Sequence. To service the watchdog, write two pseudorandom key values to SR. 10b - Reserved. Do not use this value. Writing this value can cause the watchdog to not be serviced. 11b - Reserved. Do not use this value. Writing this value can cause the watchdog not to be serviced.

Table continues on the next page...

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Field	Function
8 RIA	Reset on Invalid Access Controls how SWT responds to an invalid access. **NOTE** For a description of how this chip implements SWT reset requests resulting from SWT invalid accesses, see the chip-specific SWT information. 0b - Generate a bus error 1b - Generate a bus error and reset request. If SWT is enabled (WEN = 1), generate a bus error and a reset request; otherwise, generate a bus error.
7 WND	Window Mode Specify regular or window mode operation. 0b - Regular mode. Can execute service sequence at any time 1b - Window mode. Can execute service sequence only when the timeout counter is less than the value in WN
6 ITR	Interrupt Then Reset Request **NOTE** For a description of how this chip implements SWT reset requests and interrupt requests resulting from SWT timeouts, see the chip-specific SWT information. 0b - Generate a reset request on a timeout 1b - Generate an interrupt on an initial timeout; generate a reset request on a second consecutive timeout
5 HLK	Hard Lock Indicates that the hard lock is enabled. You cannot directly write 0 to this field. This field becomes 0 only after a reset. 0b - CR, TO, WN, and SK are read/write registers if SLK is also 0 1b - CR, TO, WN, and SK are read-only registers
4 SLK	Soft Lock Indicates that the soft lock is enabled. You cannot directly write 0 to this field. Clear this field by writing the unlock sequence to the service register. 0b - CR, TO, WN, and SK are read/write registers if HLK is also 0 1b - CR, TO, WN, and SK are read-only registers
3 —	Reserved
2	Stop Mode Control

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>STP</td><td>Controls the watchdog timer when the chip enters Stop or Standby mode.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>SWT_0</td><td>CR</td><td>—</td></tr><tr><td>SWT_1</td><td>—</td><td>CR</td></tr><tr><td>SWT_2</td><td>—</td><td>CR</td></tr></table>0b - Timer continues
1b - Timer stops</td></tr>
<tr><td>1
FRZ</td><td>Debug Mode Control
Controls the watchdog timer when the core enters Debug mode.
0b - Timer continues
1b - Timer stops</td></tr>
<tr><td>0
WEN</td><td>Watchdog Enable
Enables or disables SWT.
The reset value is 0. Therefore, after reset, you must enable SWT to start the countdown timer.
0b - Disabled
1b - Enabled</td></tr>
</table>

69.6.3 Interrupt (IR)

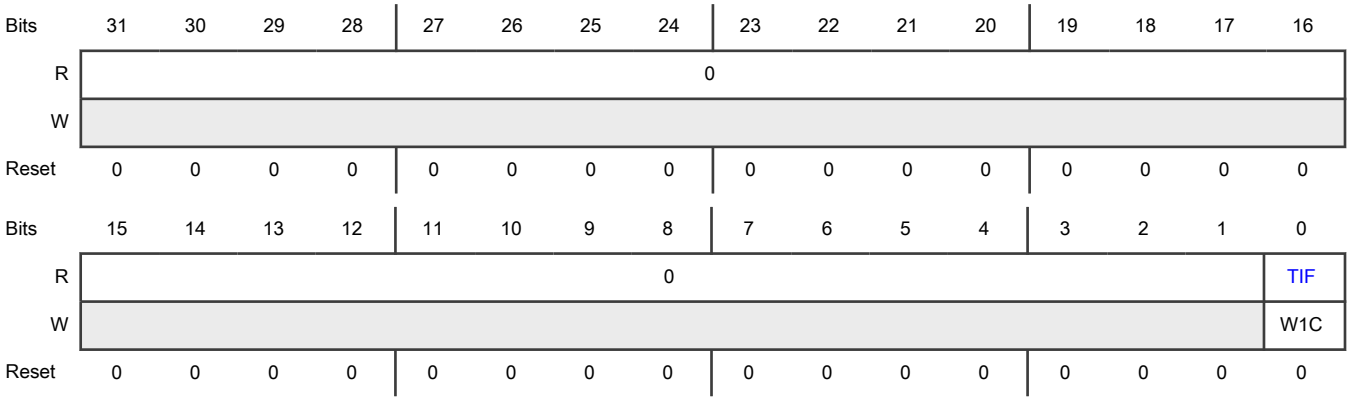
Offset

Register	Offset
IR	4h

Function

The timeout interrupt flag.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 TIF	Timeout Interrupt Flag Write 1 to this field to clear the flag and interrupt. Writing a 0 has no effect. 0b - No interrupt request 1b - Interrupt request due to an initial timeout

69.6.4 Timeout (TO)

Offset

Register	Offset
TO	8h

Function

Contains the 32-bit timeout period. The register is read-only if either hard lock or soft lock is enabled (CR[HLK] or CR[SLK] is 1).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	WTO															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	WTO															
Reset	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0

Fields

Field	Function
31-0 WTO	Watchdog Timeout Watchdog timeout period in clock cycles. When software writes a service sequence or enables SWT, SWT loads the internal 32-bit countdown timer with this value or 3h, whichever is greater.

69.6.5 Window (WN)

Offset

Register	Offset
WN	Ch

Function

Contains the 32-bit window start value. SWT clears this register on reset. The register is read-only if either hard lock or soft lock is enabled (CR[HLK] or CR[SLK] is 1).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	WST															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	WST															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 WST	Window Start Value When you enable window mode (CR[WND]), you can write the service sequence only when the internal timer is less than this value.

69.6.6 Service (SR)

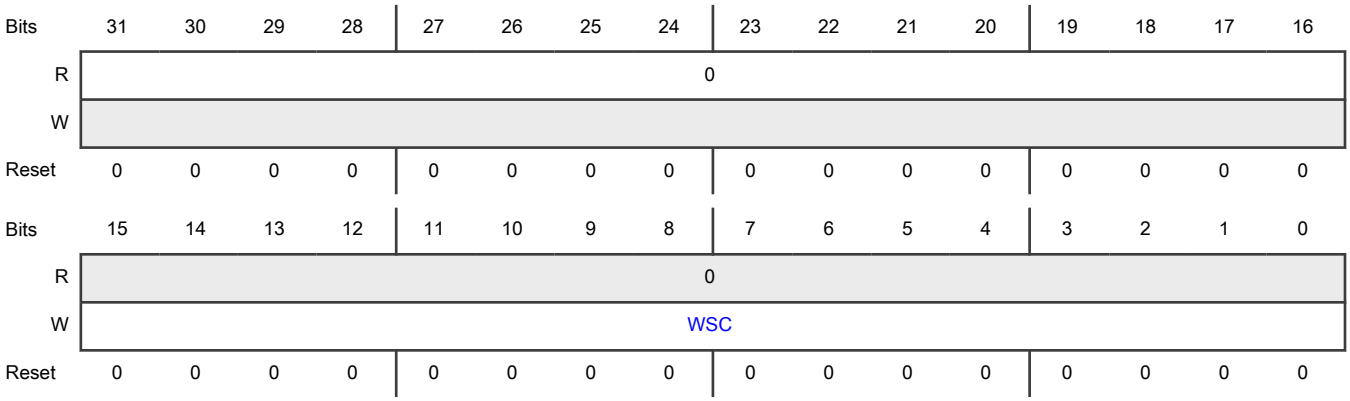
Offset

Register	Offset
SR	10h

Function

Initiates the service operation and resets the watchdog timer.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 WSC	Watchdog Service Code Use this field to service the watchdog and to unlock the Soft Lock (CR[SLK]). To service the watchdog: If SWT is in keyed service mode (CR[SMD]), write two pseudorandom key values to WSC (see Service key generation for details). Otherwise, write the following values to WSC, in the order shown:

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1. A602h 2. B480h To unlock the Soft Lock (CR[SLK]), write the following values to WSC, in the order shown: 1. C520h 2. D928h When read, WSC always returns zero.

69.6.7 Counter Output (CO)

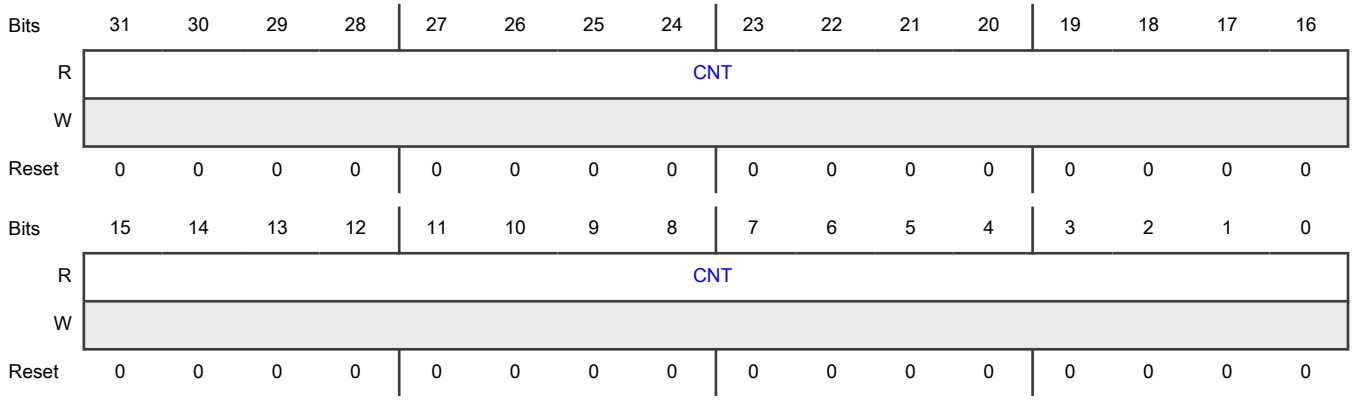
Offset

Register	Offset
CO	14h

Function

Shows the value of the internal timer when SWT is disabled.

Diagram



Fields

Field	Function
31-0 CNT	Watchdog Count When SWT is disabled (CR[WEN] is 0), CNT shows the value of the internal timer. When SWT is enabled (CR[WEN] is 1), it writes 0 to CNT. Values in this field can lag behind the internal timer value up to six system clock cycles plus eight counter clock cycles. Therefore, the CNT value that is read immediately after disabling SWT may be higher than the actual value of the internal timer.

69.6.8 Service Key (SK)

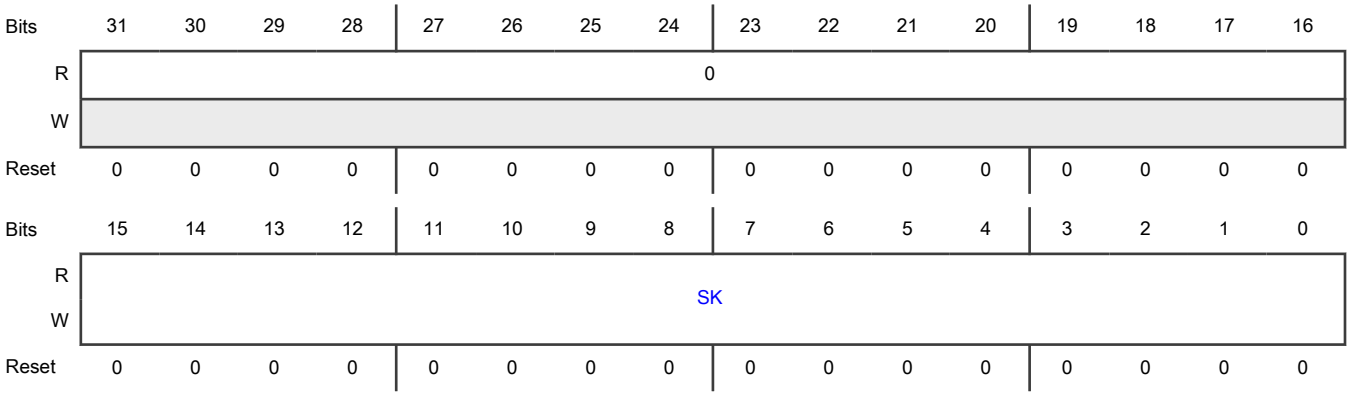
Offset

Register	Offset
SK	18h

Function

Holds the previous (or initial) service key value. This register is read-only if either hard lock or soft lock is enabled (CR[HLK] or CR[SLK] is 1).

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 SK	Service Key Holds the previous (or initial) service key value used in Initiate a keyed service sequence. If CR[SMD] is 01b, the next key value to write to SR is (17 * SK + 3) mod 2^{16}.

69.6.9 Event Request (RRR)

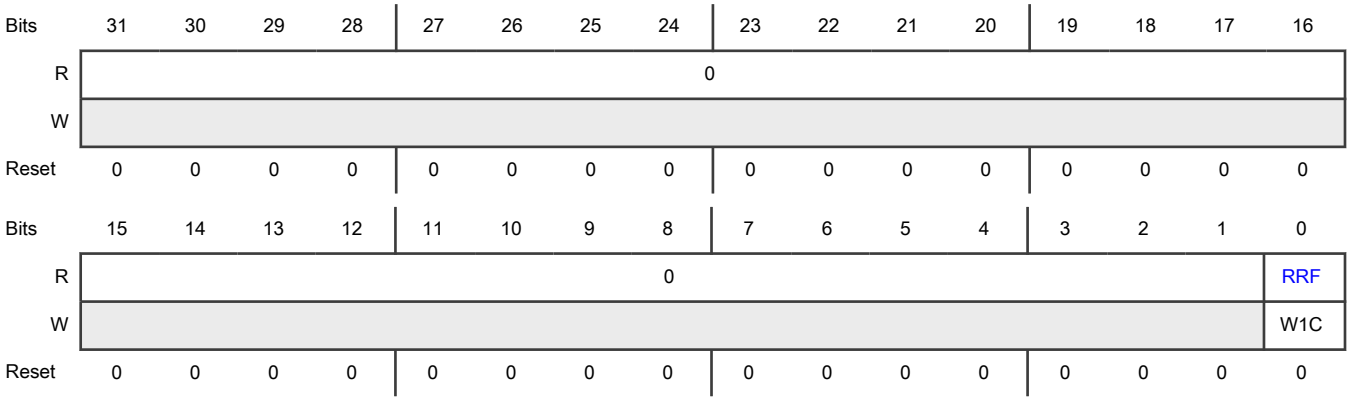
Offset

Register	Offset
RRR	1Ch

Function

Contains the timeout reset request flag. See the chip-specific information for the specific event associated with this flag.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 RRF	Reset Request Flag Write 1 to clear the flag and request. Writing 0 has no effect. 0b - No reset request 1b - Any reset request initiated

Chapter 70
System Timer Module (STM)

70.1 Chip-specific STM information

70.1.1 STM instances and configuration

This chip has 3 instances of STM, one for each Cortex-M7 core. The STM counter increments at the STM module clock frequency divided by a pre-scaled value.

Table 485. STM instances and configuration

Instance	Description	Number of Channels	Number of Registers (32-bit)
STM_0	Intended for Cortex-M7_0 core	4	14
STM_1	Intended for Cortex-M7_1 core	4	14
STM_2	Intended for Cortex-M7_2 core	4	14

70.2 Overview

STM supports commonly required system and application software timing functions. STM includes a 32-bit count-up timer and four 32-bit compare channels with a separate interrupt source for each channel. The timer is driven by the STM module clock divided by an 8-bit prescale value (1 to 256).

70.2.1 Block diagram

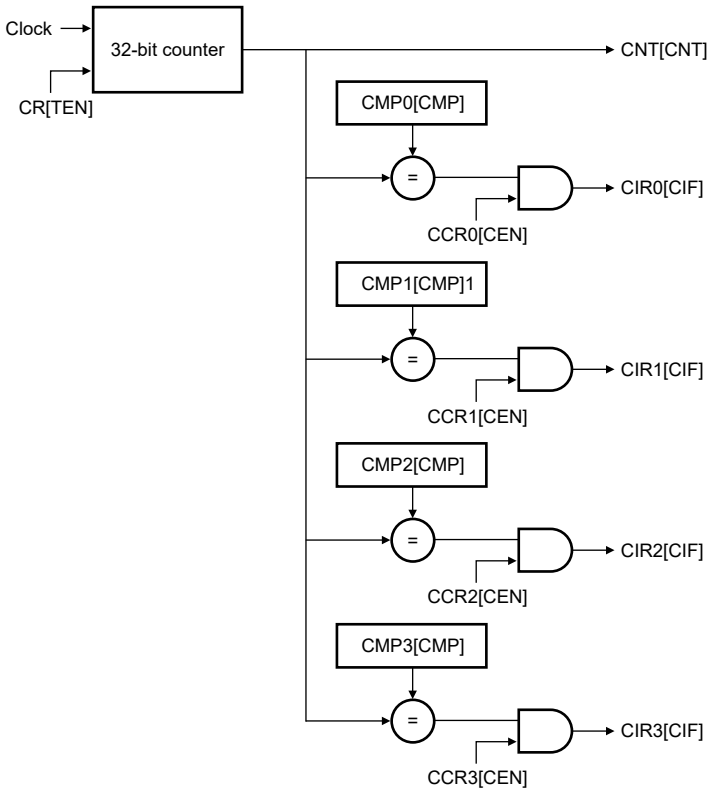


Figure 502. Block diagram

70.2.2 Features

STM has the following features:

- One 32-bit count-up timer with an 8-bit prescaler
- Four 32-bit compare channels
- An independent interrupt source for each channel
- Ability to stop the timer in Debug mode

70.3 Functional description

70.3.1 Count-up timer

STM has one 32-bit count-up timer that serves as the time base for four compare channels. When enabled, the counter increments at the module clock frequency divided by a prescaler value in the range from 1 to 256. When enabled in Normal mode, the timer increments continuously. The counter rolls over at FFFF_FFFFh to 0000_0000h with no restrictions at this boundary.

70.3.2 Compare channels

STM has four identical compare channels. Each channel includes a channel control register (CCR*n*), a channel interrupt register (CCR*n*), and a channel compare register (CMP*n*). When the channel is enabled and its channel compare value matches the timer count, STM sets the channel interrupt flag and generates an IRQ on that channel.

70.3.3 Behavior in different chip modes

STM supports the chip modes of operation as follows:

Chip mode	STM behavior
Normal	When the timer is enabled (CR[TEN] = 1), the timer counts up continuously.
Debug	If CR[FRZ] = 1, STM stops the timer. Otherwise, when the timer is enabled (CR[TEN] = 1), the timer counts up continuously.

70.3.4 Clocking

This module has no clocking considerations.

70.3.5 Interrupts

STM can generate a channel interrupt. For information, see:

- Compare channels
- Respond to compare channel events
- Channel Interrupt (CIR0 - CIR3)

70.4 External signals

This module has no external signals.

70.5 Initialization

This module does not require initialization.

70.6 Application information

70.6.1 Configure the timer

1. Set the initial timer count (CNT[CNT]).
2. Specify STM behavior in chip Debug mode (CNT[FRZ]).
3. Set the counter prescaler (CR[CPS]).
4. Start the timer (CR[TEN]).

70.6.2 Configure the compare channels

For each compare channel:

1. Set the channel compare value (CMP*n*[CMP]).
2. Enable the compare channel (CCR*n*[CEN]).

70.6.3 Respond to compare channel events

For each compare channel:

1. Check the channel interrupt flag (CIR*n*[CIF]).
2. If the channel interrupt flag is set, respond to the interrupt request.
3. When the channel interrupt has been handled, clear the channel interrupt flag (CIR*n*[CIF]).

70.7 STM register descriptions

The STM programming model allows only 32-bit (word) accesses. An attempted reference using a different size or to a reserved address generates a bus error termination.

70.7.1 STM memory map

STM_0 base address: 4027_4000h

STM_1 base address: 4047_4000h

STM_2 base address: 4047_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Control (CR)	32	RW	0000_0000h
4h	Count (CNT)	32	RW	0000_0000h
10h	Channel Control (CCR0)	32	RW	0000_0000h
14h	Channel Interrupt (CIR0)	32	RW	0000_0000h
18h	Channel Compare (CMP0)	32	RW	0000_0000h
20h	Channel Control (CCR1)	32	RW	0000_0000h
24h	Channel Interrupt (CIR1)	32	RW	0000_0000h
28h	Channel Compare (CMP1)	32	RW	0000_0000h
30h	Channel Control (CCR2)	32	RW	0000_0000h
34h	Channel Interrupt (CIR2)	32	RW	0000_0000h
38h	Channel Compare (CMP2)	32	RW	0000_0000h
40h	Channel Control (CCR3)	32	RW	0000_0000h
44h	Channel Interrupt (CIR3)	32	RW	0000_0000h
48h	Channel Compare (CMP3)	32	RW	0000_0000h

70.7.2 Control (CR)

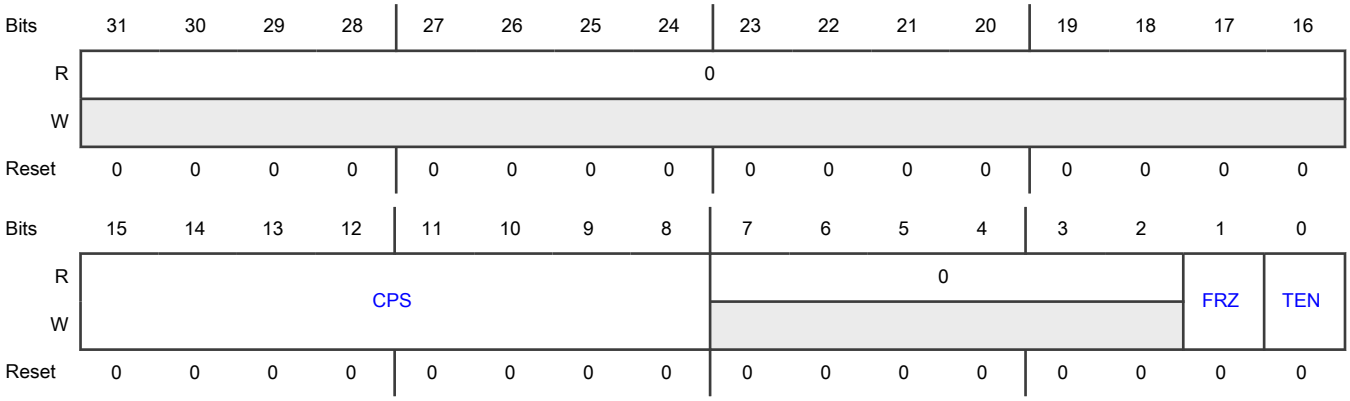
Offset

Register	Offset
CR	0h

Function

Contains fields for the prescale value, freeze control, and timer enable.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-8 CPS	Counter Prescaler Selects the module clock divide value for the prescaler (1–256). • 00h - Divide module clock by 1 • 01h - Divide module clock by 2 • ... • FFh - Divide module clock by 256
7-2 —	Reserved
1 FRZ	Freeze Stops the timer when the chip enters Debug mode. **NOTE** When the chip enters Debug mode, it notifies STM, which in turn uses this field to determine timer operation. 0b - Timer runs in Debug mode 1b - Timer stops in Debug mode
0 TEN	Timer Enable Enables the module timer. 0b - Disabled 1b - Enabled

70.7.3 Count (CNT)

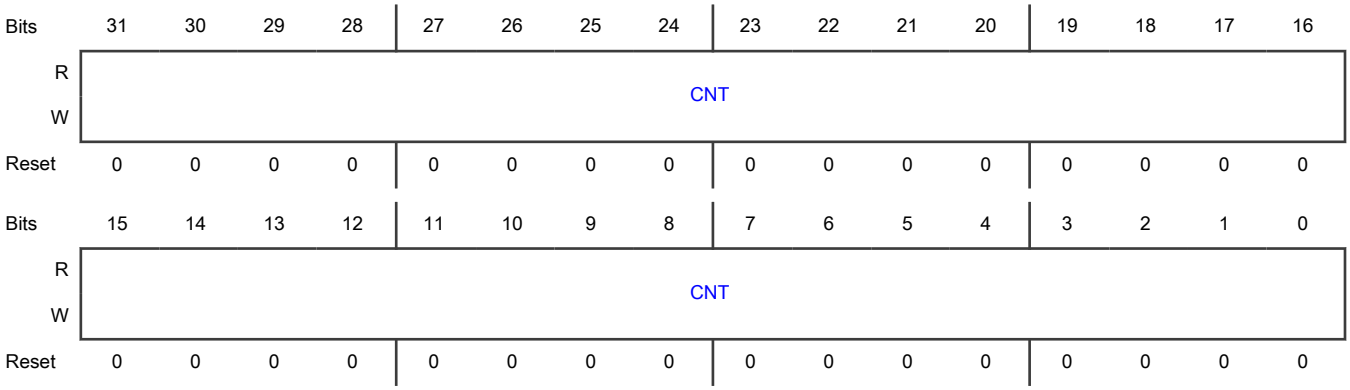
Offset

Register	Offset
CNT	4h

Function

Holds the timer count value.

Diagram



Fields

Field	Function
31-0 CNT	Timer Count The time base for all compare channels. When enabled, the timer count increments at the rate of the module clock divided by the prescale value.

70.7.4 Channel Control (CCR0 - CCR3)

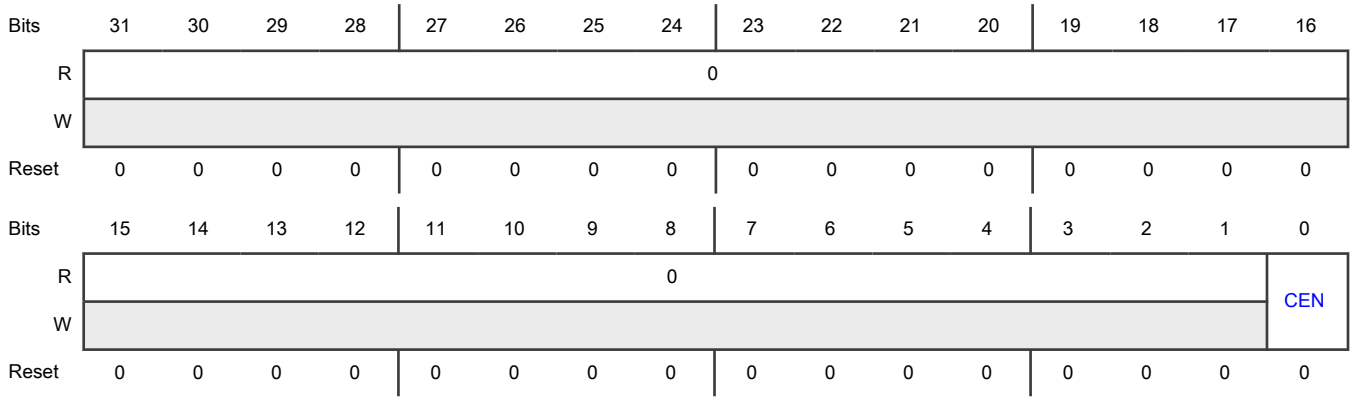
Offset

Register	Offset
CCR0	10h
CCR1	20h
CCR2	30h
CCR3	40h

Function

Enables channel n of the timer.

Diagram



Fields

Field	Function
31-1 —	Reserved
0 CEN	Channel Enable 0b - Disabled 1b - Enabled

70.7.5 Channel Interrupt (CIR0 - CIR3)

Offset

Register	Offset
CIR0	14h
CIR1	24h
CIR2	34h
CIR3	44h

Function

Indicates and clears the interrupt flag for channel n of the timer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															CIF
W																W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1 —	Reserved
0 CIF	Channel Interrupt Flag Indicates the channel IRQ is asserted due to a match on the channel. 0b - Read: IRQ is not asserted. Write: No effect. 1b - Read: IRQ is asserted. Write: Clear the flag.

70.7.6 Channel Compare (CMP0 - CMP3)

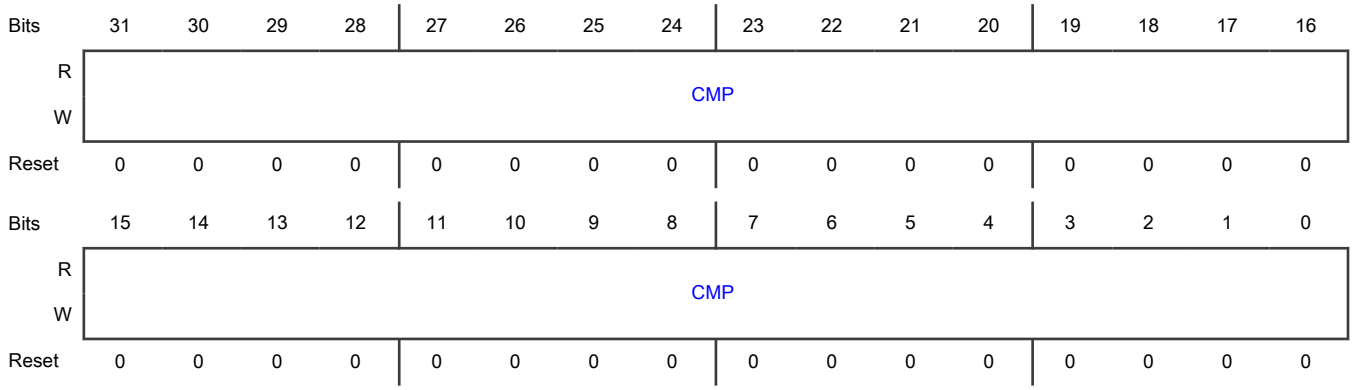
Offset

Register	Offset
CMP0	18h
CMP1	28h
CMP2	38h
CMP3	48h

Function

The compare value for channel n.

Diagram



Fields

Field	Function
31-0 CMP	Channel Compare If the channel is enabled (CCR*n*[CEN]), when the timer count (CNT) matches this value, STM asserts the channel IRQ and sets the channel interrupt flag (CIR*n*[CIF]).

70.8 Glossary

IRQ Interrupt request

Chapter 71
Periodic Interrupt Timer (PIT)

71.1 Chip-specific PIT information

71.1.1 PIT instances and configuration

This chip has 3 instances of the PIT each with 4 PIT timers/channels, each channel being 32 bits in length.

Table 486. PIT instances and features

Feature	PIT_0	PIT_1	PIT_2
Real time interrupt (RTI)	Yes (32-bit)[1]	No	No
Lifetime Timer	Yes	No	No
Timer chaining to create a 64-bit timer	Yes	No	No
Number of 32-bit timer channels	4	4	4
Timer value unchanged by a non-destructive reset	No	No	No

1. The RTI on PIT_0 supports operation in STANDBY mode

The RTI shall be possible to set the timer resolution to 1us independently to other timers. The interrupt can be generated by programming LDVAL0, LDVAL1, LDVAL2 and LDVAL3 to 48 in case of 48 MHz FIRC as system clock and 40 in case of 40 MHz system clock to generate an interrupt after 1us.

71.1.2 Input Output

All the PIT instances are capable of generating periodic triggers. PIT triggers are routed to motor control IPs such as eMIOS, LCU, BCTU, ADC etc. via TRGMUX. See the TRGMUX connectivity file attached to this document for details.

71.2 Overview

PIT includes:

- An array of timers that can be used to raise interrupts and triggers.
- A dedicated RTI timer that runs on a separate oscillator clock and can be used for system wakeup

71.2.1 Block diagram

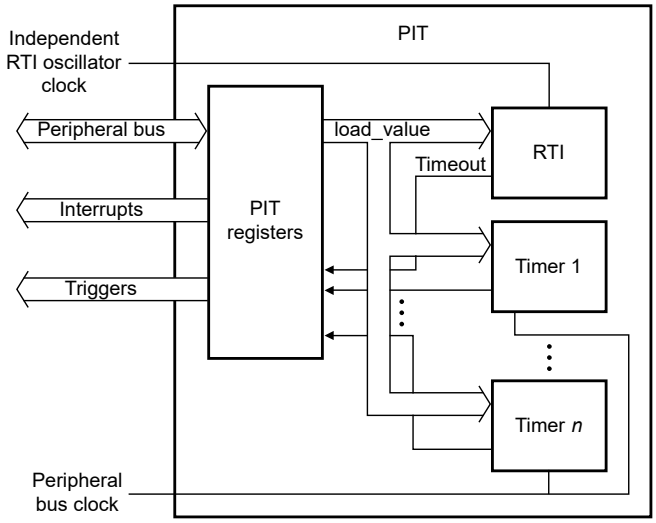


Figure 503. Block diagram

71.2.2 Features

The key features of the module are:

- 4 32-bit countdown timers
- Independent timeout periods for each timer
- Ability to chain two timers into a 64-bit lifetimer
- Ability of timers to generate interrupts
- Ability of timers to generate trigger pulses
- Maskable interrupts
- One RTI countdown timer to wake up the CPU
- Option to generate the RTI even when the bus clock is off
- Power saving with a separate input clock for the RTI timer. All other timers share a common core clock.

71.3 Functional description

See the chip-specific PIT information for the number of PIT modules and their channel configuration on this chip.

71.3.1 Modes of operation

Mode	Description
Run	All functional parts of the PIT operate normally.
Debug	Timers run or stop depending on the Freeze setting (MCR[FRZ]). See Debug mode.

71.3.2 Timer operation

When you enable a timer (write 1 to TCTRL*n*[TEN] or RTI_TCTRL[TEN]), the timer counts down (one count per clock cycle) from its initial start value (LDVAL*n*[TSV] or RTI_LDVAL[TSV]). When the timer period expires (CVAL*n*[TVL] or RTI_CVAL[TVL] reaches 0), PIT sets the Timer Interrupt Flag (writes 1 to TFLG*n*[TIE] or RTI_TFLG[TIE]). It then reloads the timer start value and starts the timer counting down again.

If the timer interrupt is enabled (TCTRL*n*[TIE] or RTI_TCTRL[TIE] = 1), it generates an interrupt when it sets the Timer Interrupt Flag. The timer cannot generate a new interrupt until you clear the flag from the previous interrupt. Because clearing the RTI crosses clock domains, you should use a minimum RTI timer load value of 32.

You can read the current counter value of any timer (CVAL*n*[TVL] or RTI_CVAL[TVL]). Because the RTI timer is synchronized to the RTI clock domain, the value of the RTI counter may be several cycles old when read.

See these related topics:

- Stop and start a timer
- Change timer period
- Change timer period dynamically

NOTE

- If Freeze is enabled (MCR[FRZ] = 1) when the timer nears 0, the Debug mode command may not reach PIT before the timer expires and generates a trigger.
- If a timer is at zero when Debug mode is asserted, the interrupt trigger remains asserted until the device exits Debug mode. Clear the Timer Interrupt Flag (write 1 to TFLG*n*[TIF] or RTI_TFLG[TIF]) upon Debug exit.
- If Freeze is enabled (MCR[FRZ] = 1), sufficient time must be ensured for the IP to react.

71.3.2.1 Stop and start a timer

To restart a running timer:

1. Disable the timer (write 0 to TCTRL*n*[TEN] or RTI_TCTRL[TEN]).
2. Enable the timer (write 1 to TCTRL*n*[TEN] or RTI_TCTRL[TEN]).

   Enabling the timer reloads the start value and starts the timer counting down again. See Restart counter period.

71.3.2.2 Restart counter period

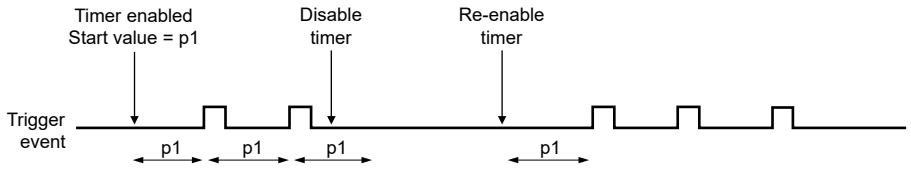


Figure 504. Restart counter period

71.3.2.3 Change timer period

To change the counter period of a running timer:

1. Disable the timer (write 0 to TCTRL*n*[TEN] or RTI_TCTRL[TEN]).
2. Specify a new start value (LDVAL*n*[TSV] or RTI_LDVAL[TSV]).
3. Enable the timer (write 1 to TCTRL*n*[TEN] or RTI_TCTRL[TEN]).

   Enabling the timer loads the new start value and starts the timer counting down again. See Change current timer period.

71.3.2.4 Change current timer period

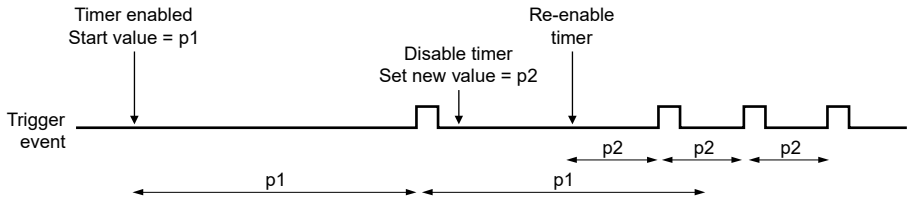


Figure 505. Change timer period dynamically timing

71.3.2.5 Change timer period dynamically

To change the counter period of a running timer:

- Specify a new start value (LDVAL*n*[TSV] or RTI_LDVAL[TSV])

  The next time the timer expires, it loads the new start value. See Dynamically setting a new timer period.

71.3.2.6 Dynamically setting a new timer period

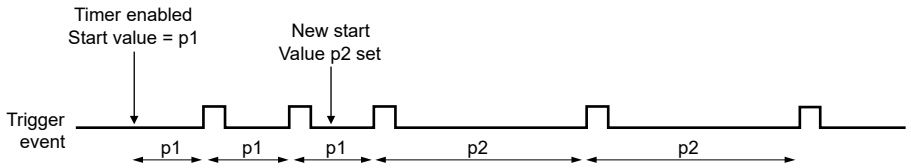


Figure 506. Dynamically setting a new timer period

71.3.3 Chained timers

PIT supports chaining two timers together to support timer periods greater than FFFFFFFFh. When a timer *n* has chain mode enabled, it decrements each time timer *n* - 1 expires. The chained timer sets its Timer Interrupt Flag when it expires (CVAL*n* = 0).

For example, assume you need to configure a timer period of 6,000,000,000 cycles. You could specify a start value of 10 for timer *n* and 599,999,999 for timer *n* - 1. With these values, the chained timer expires after timer *n* - 1 has expired ten times.

You cannot chain timer 0 or the RTI timer to another timer.

For an example configuration of a chained timer, see Example configuration using chained timers.

71.3.4 Lifetimer

PIT supports a 64-bit lifetimer. You configure the lifetimer by chaining timer 1 to timer 0 and populating the start values for both timers with the maximum value of FFFFFFFFh. You read the lifetimer in the LTMR64H and LTMR64L registers. LTMR64H returns the upper 32 bits of the lifetimer value and LMTR64L returns the lower 32 bits. When a timer 1 has chain mode enabled, it decrements each time timer 0 expires. The lifetimer expires when CVAL1 expires.

When you chain timer 1 to timer 0, timer 1 decrements every time timer 0 expires. To obtain the correct lifetimer value, read LTMR64H first and then read LTMR64L. When you read LTMR64H, it returns the value in CVAL1 (the chained timer value), and immediately latches the value from CVAL0 into LTMR64L. This latching eliminates the carryover effects of the running counter.

For an example configuration of the lifetimer, see Example configuration using the lifetimer.

71.3.5 Debug mode

If Freeze is enabled (MCR[FRZ] = 1), the timers stop if the device enters Debug mode. This freeze allows the software developer to halt the processor, investigate the current state of the system, including the PIT timer values, and then continue operation.

71.3.6 Clocking

The PIT general-purpose timers are driven by the peripheral bus clock.

The RTI timer is driven by an independent oscillator clock. This clock input continues running when the device is in Stop mode. Driving the RTI timer with an independent clock allows the RTI to trigger periodic wake-up from Stop mode.

71.3.7 Interrupts

All of the timers support interrupt generation.

You enable interrupt generation for each individual timer (TCTRL*n*[TIE]). Each interrupt is available on a separate interrupt output.

When a timer expires (CVAL*n*[TVL] = 0), it sets the Timer Interrupt Flag (TFLG*n*[TIF]) regardless of whether the interrupt is enabled. To enable generation of an interrupt when the Timer Interrupt Flag is set, write 1 to TCTRL*n*[TIE]. To clear the Timer Interrupt Flag, write 1 to it.

When the RTI timer expires (RTI_CVAL*n*[TVL] = 0), PIT sets the RTI Timer Interrupt Flag (RTI_TFLG*n*[TIF]) regardless of whether the RTI is enabled. To enable generation of an RTI when the RTI Timer Interrupt Flag is set, write 1 to TCTRL*n*[TIE]. To clear the RTI Timer Interrupt Flag, write 1 to it.

The RTI is typically used for periodic wake-up from Standby mode, but it can also be used to generate a general-purpose interrupt.

71.4 External signals

PIT has no external inputs.

71.5 Initialization

To initialize PIT:

1. For each timer *n* you plan to use:
    a. Specify the timer period (LDVAL*n*[TSV]).

       To calculate the load value for a timer:

       Start value = (timer period / clock period) - 1

    b. If you want the timer to generate an interrupt each time it expires, enable the timer interrupt (write 1 to TCTRL*n*[TIE]).
    c. If you want to use this timer as the divisor of a pair of chained timers, chain this timer to the next lower-numbered timer (write 1 to TCTRL*n*[CHN]). You cannot chain timer 0. If you want to use the lifetimer, chain timer 1 to timer 0.
    d. Enable the timer (write 1 to TCTRL*n*[TEN]).
2. If you want to use the RTI feature:
    a. Specify the RTI timer period (RTI_LDVAL*n*[TSV]).
    b. Enable the RTI timer interrupt (write 1 to RTI_TCTRL*n*[TIE]).
    c. Enable the RTI timer (write 1 to RTI_TCTRL*n*[TEN]).
3. Activate, or enable, PIT (write 0 to MCR[MDIS]).

   All enabled timers load their start values and begin counting down.

For example configurations, see Application information.

71.6 Application information

71.6.1 Example configuration for general timers

In this example configuration:

- The PIT clock frequency is 50 MHz, which equates to a clock cycle of 20 ns.
- The RTI clock frequency is 10 MHz, which equates to a clock cycle of 100 ns.
- The RTI timer needs to generate a wake-up interrupt every 500 ms.
- Timer 1 needs to generate an interrupt every 5.12 ms.
- Timer 3 needs to generate a trigger event every 30 ms.

To configure PIT for this example:

1. Disable PIT (write 1 to MCR[MDIS]).
2. Use the formula in Initialization to calculate the load value for the RTI timer:

   (500 ms/100 ns) - 1 = 4,999,999 cycles, or 004C4B3Fh.
3. Specify the RTI timer load value (write 004C4B3Fh to RTI_LDVAL[TSV]).
4. Enable the RTI (write 1 to RTI_TCTRL[TIE])
5. Enable the RTI timer (write 1 to RTI_TCTRL*n*[TEN]).
6. Use the formula in Initialization to calculate the load value for timer 1:

   (5.12 ms/20 ns) - 1 = 255,999 cycles, or 0003E7FFh.
7. Disable timer 1 (write 0 to TCTRL1[TEN]).
8. Specify the timer 1 value (write 0003E7FFh to LDVAL1[TSV]).
9. Enable the timer 1 interrupt (write 1 to TCTRL1[TIE])
10. Enable timer 1 (write 1 to TCTRL1[TEN]).
11. Calculate the load value for timer 3:

    (30 ms/20 ns) - 1 = 1,499,999 cycles, or 0016E35Fh.
12. Disable timer 3 (write 0 to TCTRL3[TEN]).
13. Specify the timer 3 value (write 0016E35Fh to LDVAL3[TSV]).
14. Enable timer 3 (write 1 to TCTRL3[TEN]).
15. Activate, or enable, PIT (write 0 to MCR[MDIS]).

NOTE

You can configure timers without first disabling PIT or the timer itself. However, if PIT is running, be aware that when a timer begins using a new start value depends on whether the timer is running or disabled when you specify the new start value. For more information, see Timer operation.

The following example code provides the described configuration:

```
// Disable PIT (see note above)
PIT_MCR = 0x02;
```

```
// RTI
PIT_RTI_LDVAL = 0x004C4B3F; // Configure RTI for 5000000 cycles
```

```
    PIT_RTI_TCTRL = PIT_TIE;    // Enable RTI
    PIT_RTI_TCTRL |= PIT_TEN;   // Start RTI timer
```

```
    // Timer 1
    PIT_LDVAL1 = 0x0003E7FF;    // Configure timer 1 for 256000 cycles
    PIT_TCTRL1 = TIE;           // Enable Timer 1 interrupts
    PIT_TCTRL1 |= TEN;          // Start Timer 1
```

```
    // Timer 3
    PIT_LDVAL3 = 0x0016E35F;    // Configure timer 3 for 1500000 cycles
    PIT_TCTRL3 = TEN;           // Enable Timer 3
```

```
     // Enable PIT
     PIT_MCR = 0x00;
```

71.6.2 Example configuration using chained timers

In this example configuration:

- The PIT clock frequency is 100 MHz, which equates to a clock cycle of 10 ns.
- Timers 1 and 2 are available.
- An interrupt is needed every minute. Using the formula in Initialization, a 1 minute timer period requires:

  (60 s/10 ns) - 1 = 5,999,999,999 cycles, or 165A0BBFFh

  This value requires more than 32 bits.

To configure PIT for this example:

1. Disable PIT (write 1 to MCR[MDIS]).
2. Disable timer 1 (write 0 to TCTRL1[TEN]).
3. Disable timer 2 (write 0 to TCTRL2[TEN]).
4. Chain timer 2 to timer 1 (write 1 to TCTRL2[CHN]).
5. For the timer 2 start value, select a value that divides evenly into the desired period. For this example, we are using 10. For the timer 1 value, divide the full timer period by the selected divisor: 6,000,000,000/10 = 600,000,000.
6. Specify the timer 2 value as the selected divisor (write 00000009h to LDVAL2[TSV]).
7. Specify the timer 1 value as the quotient minus 1, or 599,999,999 (write 0x23C345FFh to LDVAL1[TSV]).
8. Enable the timer 2 interrupt (write 1 to TCTRL2[TIE])
9. Enable timer 2 (write 1 to TCTRL2[TEN]).
10. Enable timer 1 (write 1 to TCTRL1[TEN]).
11. Activate, or enable, PIT (write 0 to MCR[MDIS]).

The following example code matches the described configuration:

```
// Disable PIT
PIT_MCR = 0x02;
```

```
// Timer 2
PIT_LDVAL2 = 0x00000009; // Configure Timer 2 to the divisor (10)
PIT_TCTRL2 = TIE;        // Enable Timer 2 interrupt
PIT_TCTRL2 |= CHN;       // Chain Timer 2 to Timer 1
PIT_TCTRL2 |= TEN;       // Enable Timer 2
```

```
// Timer 1
PIT_LDVAL1 = 0x23C345FF; // Configure Timer 1 to 600,000,000 cycles
PIT_TCTRL1 = TEN;        // Enable Timer 1
```

```
 // Enable PIT
 PIT_MCR = 0x00;
```

71.6.3 Example configuration using the lifetimer

To configure the lifetimer:

1. Disable PIT (write 1 to MCR[MDIS]).
2. Disable timer 0 (write 0 to TCTRL0[TEN]).
3. Disable timer 1 (write 0 to TCTRL1[TEN]).
4. Chain timer 1 to timer 0 (write 1 to TCTRL1[CHN]).
5. Specify the maximum start value for timer 1 (write FFFFFFFFh to LDVAL1[TSV]).
6. Specify the maximum start value for timer 0 (write FFFFFFFFh to LDVAL0[TSV]).
7. Enable timer 1 (write 1 to TCTRL1[TEN]).
8. Enable timer 0 (write 1 to TCTRL0[TEN]).
9. Activate, or enable, PIT (write 0 to MCR[MDIS]).

To access the lifetimer, first read LTMR64H and then LTMR64L. For more information, see Lifetimer.

The following example code matches the described setup:

```
// Disable PIT
PIT_MCR = 0x02;
```

```
// Timer 1
PIT_LDVAL1 = 0xFFFFFFFF; // setup timer 1 for maximum counting period
PIT_TCTRL1 = 0x0; // disable timer 1 interrupts
PIT_TCTRL1 |= CHN; // chain timer 1 to timer 0
PIT_TCTRL1 |= TEN; // start timer 1
```

```
// Timer 0
```

```
PIT_LDVAL0 = 0xFFFFFFFF; // setup timer 0 for maximum counting period
PIT_TCTRL0 = TEN; // start timer 0
```

```
// Read lifetimer
current_uptime = PIT_LTMR64H<<32;
current_uptime = current_uptime + PIT_LTMR64L;
```

```
 // Enable PIT
 PIT_MCR = 0x00;
```

71.7 PIT register descriptions

This section provides a detailed description of all PIT registers.

Program RTI registers only when the RTI clock is running.

71.7.1 PIT memory map

PIT_0 base address: 400B_0000h

PIT_1 base address: 400B_4000h

PIT_2 base address: 402F_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	PIT Module Control (MCR)	32	RW	See section
E0h	PIT Upper Lifetimer (LTMR64H)	32	R	0000_0000h
E4h	PIT Lower Lifetimer (LTMR64L)	32	R	0000_0000h
ECh	RTI Timer Load Value Sync Status (RTI_LDVAL_STAT)	32	RW	0000_0000h
F0h	RTI Timer Load Value (RTI_LDVAL)	32	RW	0000_0000h
F4h	Current RTI Timer Value (RTI_CVAL)	32	R	0000_0000h
F8h	RTI Timer Control (RTI_TCTRL)	32	RW	0000_0000h
FCh	RTI Timer Interrupt Flag (RTI_TFLG)	32	RW	0000_0000h
100h	Timer Load Value (LDVAL0)	32	RW	0000_0000h
104h	Current Timer Value (CVAL0)	32	R	0000_0000h
108h	Timer Control (TCTRL0)	32	RW	0000_0000h
10Ch	Timer Flag (TFLG0)	32	RW	0000_0000h
110h	Timer Load Value (LDVAL1)	32	RW	0000_0000h
114h	Current Timer Value (CVAL1)	32	R	0000_0000h
118h	Timer Control (TCTRL1)	32	RW	0000_0000h
11Ch	Timer Flag (TFLG1)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
120h	Timer Load Value (LDVAL2)	32	RW	0000_0000h
124h	Current Timer Value (CVAL2)	32	R	0000_0000h
128h	Timer Control (TCTRL2)	32	RW	0000_0000h
12Ch	Timer Flag (TFLG2)	32	RW	0000_0000h
130h	Timer Load Value (LDVAL3)	32	RW	0000_0000h
134h	Current Timer Value (CVAL3)	32	R	0000_0000h
138h	Timer Control (TCTRL3)	32	RW	0000_0000h
13Ch	Timer Flag (TFLG3)	32	RW	0000_0000h

71.7.2 PIT Module Control (MCR)

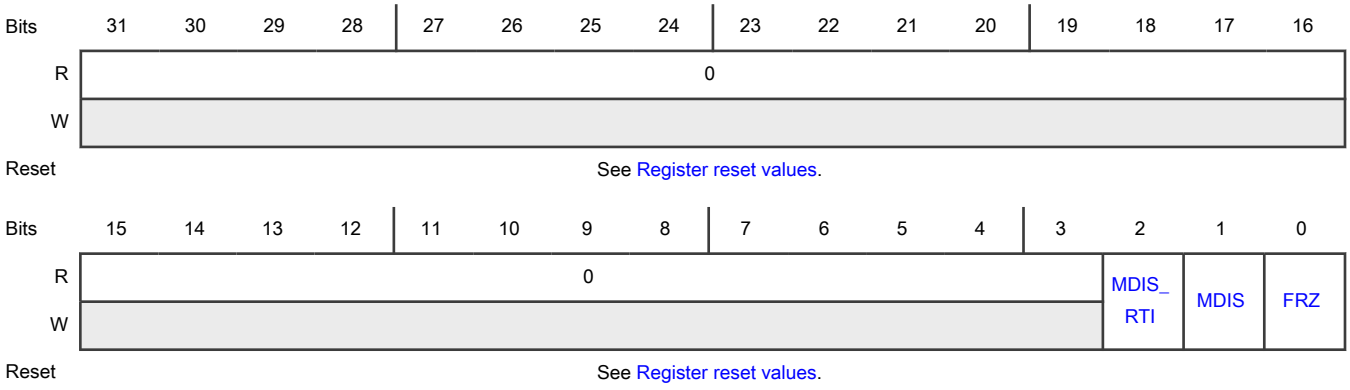
Offset

Register	Offset
MCR	0h

Function

Enables the PIT timer clocks and specifies the behavior of the timers when PIT enters Debug mode.

Diagram



Register reset values

Register	Reset value
MCR	PIT_0: 0000_0006h PIT_1,PIT_2: 0000_0002h

Fields

Field	Function
31-3 —	Reserved
2 MDIS_RTI	Module Disable for RTI Disables the RTI timer. You must write 1 to this field before setting up an RTI. **NOTE** This field is not supported in every instance. The following table includes only supported registers. 0b - Enables 1b - Disables
1 MDIS	Module Disable for PIT Disables the standard timers. This field does not affect the RTI timer. You must disable the clock (write 1 to MDIS) before configuring PIT. After configuration, you must enable the clock (write 0 to MDIS). 0b - Enables 1b - Disables
0 FRZ	Freeze Stops the timers when the device enters Debug mode. 0b - Timers run in Debug mode 1b - Timers stop in Debug mode

Instance	Field supported in	Field not supported in
PIT_0	MCR	—
PIT_1	—	MCR
PIT_2	—	MCR

71.7.3 PIT Upper Lifetimer (LTMR64H)

Offset

Register	Offset
LTMR64H	E0h

Function

Combined with LTMR64L, provides a 64-bit lifetimer constructed from the values in two chained PIT timers.

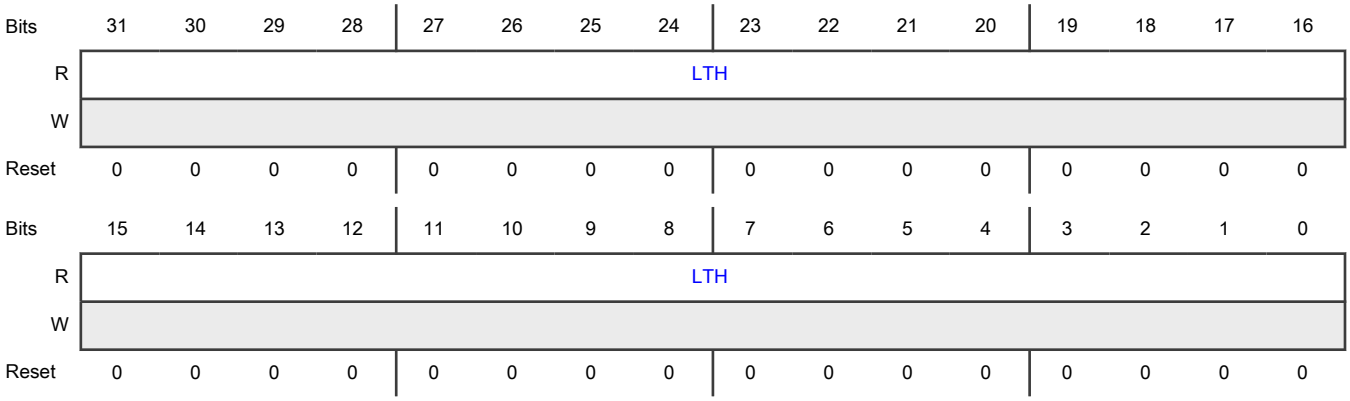
For more information, see Lifetimer.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
PIT_0	LTMR64H	—
PIT_1	—	LTMR64H
PIT_2	—	LTMR64H

Diagram



Fields

Field	Function
31-0 LTH	Lifetimer Value Indicates the timer value of timer 1. This value is the upper 32 bits of the 64-bit lifetimer value. When you read this register at t1, the value of timer 0 at t1 is latched into LTMR64L.

71.7.4 PIT Lower Lifetimer (LTMR64L)

Offset

Register	Offset
LTMR64L	E4h

Function

Combined with LTMR64H, provides a 64-bit lifetimer.

For more information, see Lifetimer.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
PIT_0	LTMR64L	—
PIT_1	—	LTMR64L
PIT_2	—	LTMR64L

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LTL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LTL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 LTL	Lifetimer Value Indicates the timer value of timer 0 at the moment LTMR64H was last read. This value is the lower 32 bits of the 64-bit lifetimer value. This field updates only when LTMR64H is read.

71.7.5 RTI Timer Load Value Sync Status (RTI_LDVAL_STAT)

Offset

Register	Offset
RTI_LDVAL_STAT	ECh

Function

Indicates whether the RTI timer start value has been loaded (RTI_LDVAL). This status is necessary because it takes several cycles for the RTI start value to synchronize into the RTI clock domain.

NOTE

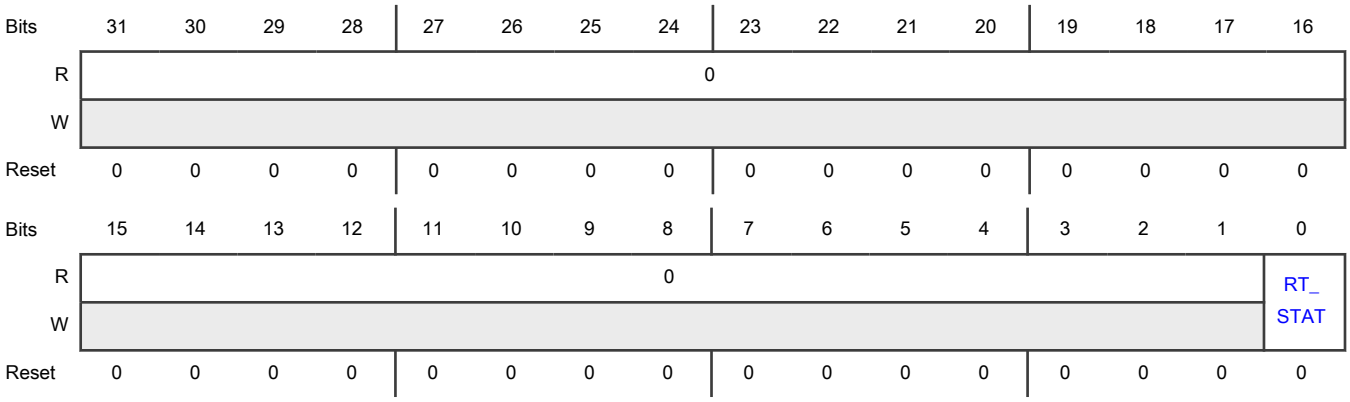
In the case of dynamic loading (Figure 506) of the RTI timer, this status may be unreliable .

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
PIT_0	RTI_LDVAL_STAT	—
PIT_1	—	RTI_LDVAL_STAT
PIT_2	—	RTI_LDVAL_STAT

Diagram



Fields

Field	Function
31-1 —	Reserved
0 RT_STAT	Sync Status Indicates whether the RTI start value is loaded. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not loaded 1b - Loaded When writing 0b - Clears status 1b - Clears status

71.7.6 RTI Timer Load Value (RTI_LDVAL)

Offset

Register	Offset
RTI_LDVAL	F0h

Function

Specifies the length of the RTI timeout period in clock cycles.

It takes several cycles for this value to synchronize into the RTI clock domain.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
PIT_0	RTI_LDVAL	—
PIT_1	—	RTI_LDVAL
PIT_2	—	RTI_LDVAL

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSV															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSV															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSV	Timer Start Value Specifies the starting RTI timer value. The timer counts down until it reaches 0, then sets the interrupt flag and reloads this value. When you write a new value to this register, the timer does not restart with the new value until the current timing period expires. To terminate the current period and start a new period with the new value, you must disable the timer (write 0 to RTI_TCTRL*n*[TEN]) and then enable it again (write 1 to RTI_TCTRL*n*[TEN]).

Table continues on the next page...

Field	Function
	NOTE Because it may take several cycles to clear the RTI interrupt, setting the value to something less than 32 cycles may result in a lost interrupt.

71.7.7 Current RTI Timer Value (RTI_CVAL)

Offset

Register	Offset
RTI_CVAL	F4h

Function

Indicates the current RTI timer value. Because this timer might be driven from a different clock domain from the other timers, the value may be several cycles old.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
PIT_0	RTI_CVAL	—
PIT_1	—	RTI_CVAL
PIT_2	—	RTI_CVAL

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TVL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TVL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TVL	Current Timer Value Indicates the current RTI timer value. **NOTE** • If the timer is disabled (RTI_TCTRL*n*[TEN] = 0), this value has no meaning. • If PIT is frozen in Debug mode (MCR[FRZ] = 1), timer values are frozen when the device is in Debug mode.

71.7.8 RTI Timer Control (RTI_TCTRL)

Offset

Register	Offset
RTI_TCTRL	F8h

Function

Controls RTI timer behavior.

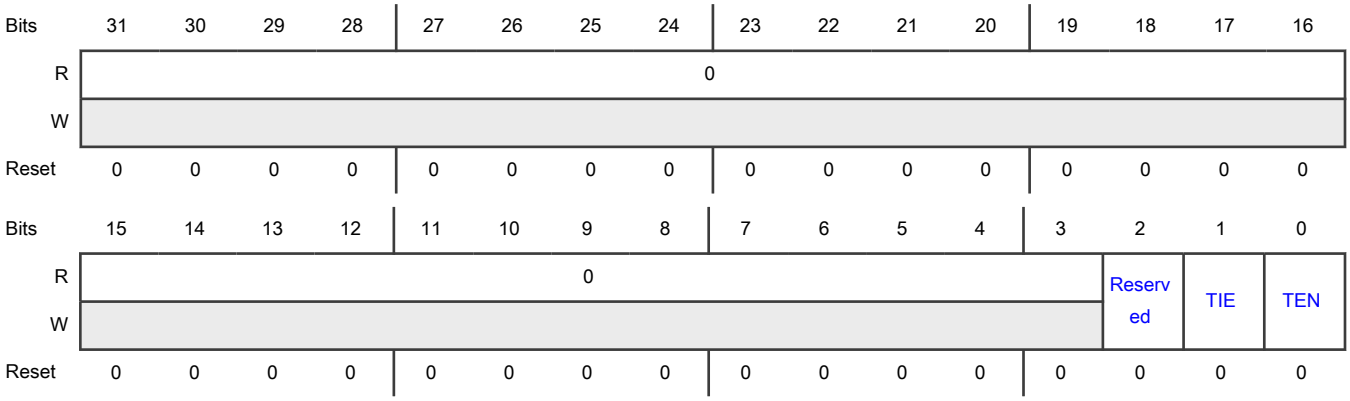
The RTI may take several RTI clock cycles to enable or update. Therefore, you must wait for at least three RTI clock cycles after RTI configuration before relying on the RTI timer.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
PIT_0	RTI_TCTRL	—
PIT_1	—	RTI_TCTRL
PIT_2	—	RTI_TCTRL

Diagram



Fields

Field	Function
31-3 —	Reserved
2 —	Reserved
1 TIE	Timer Interrupt Enable Enables the RTI timer interrupt. If the interrupt is enabled, when an interrupt is pending or the Timer Interrupt Flag is set (RTI_TFLG*n*[TIF] = 1), PIT generates an interrupt. To avoid an interrupt when you first enable the interrupt, clear the Timer Interrupt Flag (write 1 to RTI_TFLG*n*[TIF]) before you enable the interrupt. 0b - Disables 1b - Enables
0 TEN	Timer Enable Bit Enables the RTI timer. 0b - Disables 1b - Enables. The RTI timer begins counting down.

71.7.9 RTI Timer Interrupt Flag (RTI_TFLG)

Offset

Register	Offset
RTI_TFLG	FCh

Function

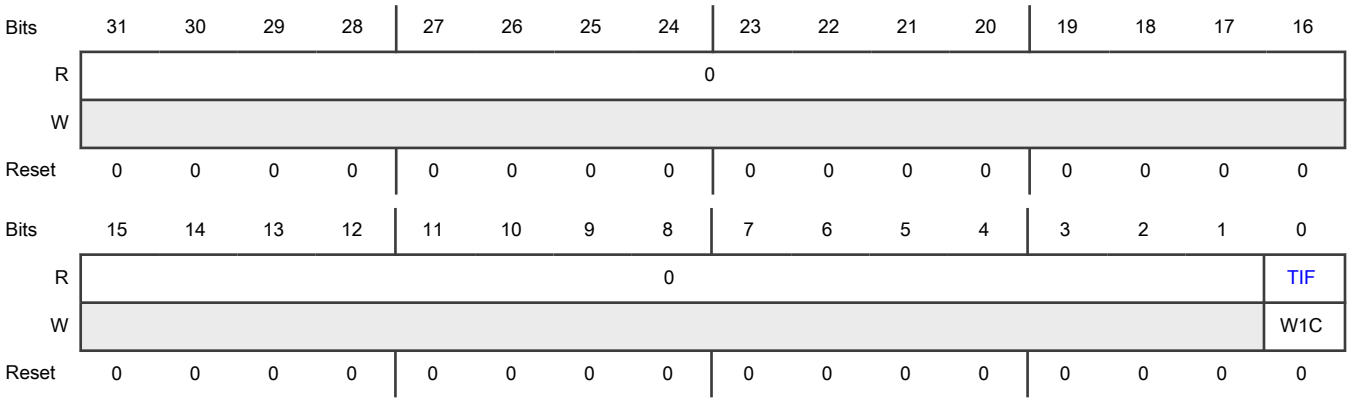
Indicates the RTI timer has expired.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
PIT_0	RTI_TFLG	—
PIT_1	—	RTI_TFLG
PIT_2	—	RTI_TFLG

Diagram



Fields

Field	Function
31-1 —	Reserved
0 TIF	Timer Interrupt Flag Indicates the RTI timer period has expired (CVAL*n*[TVL] = 0). If interrupts are enabled (RTI_TCTRL*n*[TIE] = 1), TIF triggers an interrupt request. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Timer still counting down 1b - Timer has expired When writing 0b - No effect 1b - Clears the flag

71.7.10 Timer Load Value (LDVAL0 - LDVAL3)

Offset

Register	Offset
LDVAL0	100h
LDVAL1	110h
LDVAL2	120h
LDVAL3	130h

Function

Specifies the length of the timeout period in clock cycles.

The value change is visible immediately. The synchronization mechanism allows 0 wait states in this case.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSV															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSV															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSV	Timer Start Value Specifies the starting timer value. The timer counts down until it reaches 0, then sets the interrupt flag and reloads this value. When you write a new value to this register, the timer does not restart with the new value until the current timing period expires. To terminate the current period and start a new period with the new value, you must disable the timer (write 0 to TCTRL*n*[TEN]) and then enable it again (write 1 to TCTRL*n*[TEN]). **NOTE** Because the CPU requires several cycles to service an interrupt, there is a practical limit to the lowest start value for a timer. Setting the value too low may result in a lost interrupt.

71.7.11 Current Timer Value (CVAL0 - CVAL3)

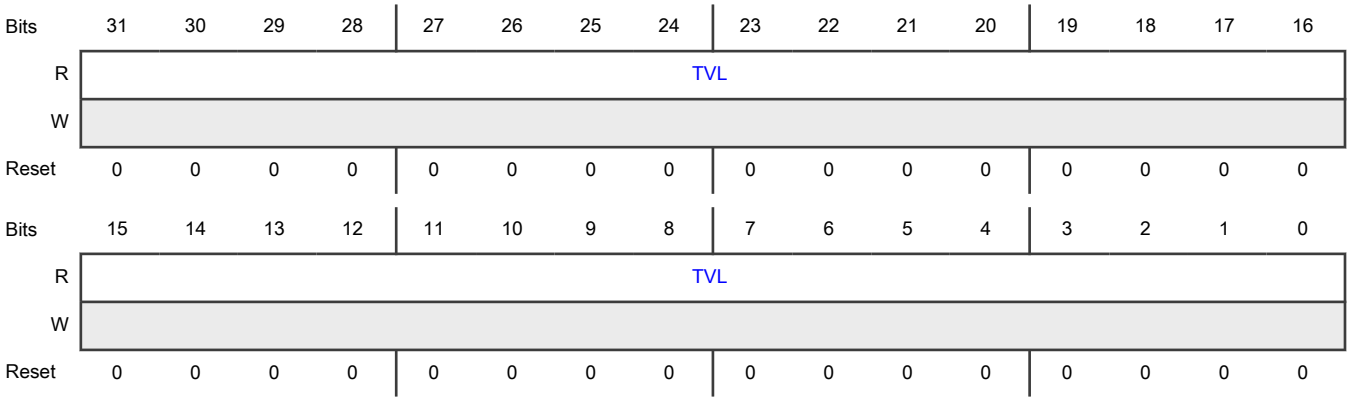
Offset

Register	Offset
CVAL0	104h
CVAL1	114h
CVAL2	124h
CVAL3	134h

Function

Indicates the current timer value.

Diagram



Fields

Field	Function
31-0 TVL	Timer Value Indicates the current timer value. **NOTE** • If the timer is disabled (TCTRL*n*[TEN] = 0), this value has no meaning. • If PIT is frozen in Debug mode (MCR[FRZ] = 1), timer values are frozen when the device is in Debug mode.

71.7.12 Timer Control (TCTRL0 - TCTRL3)

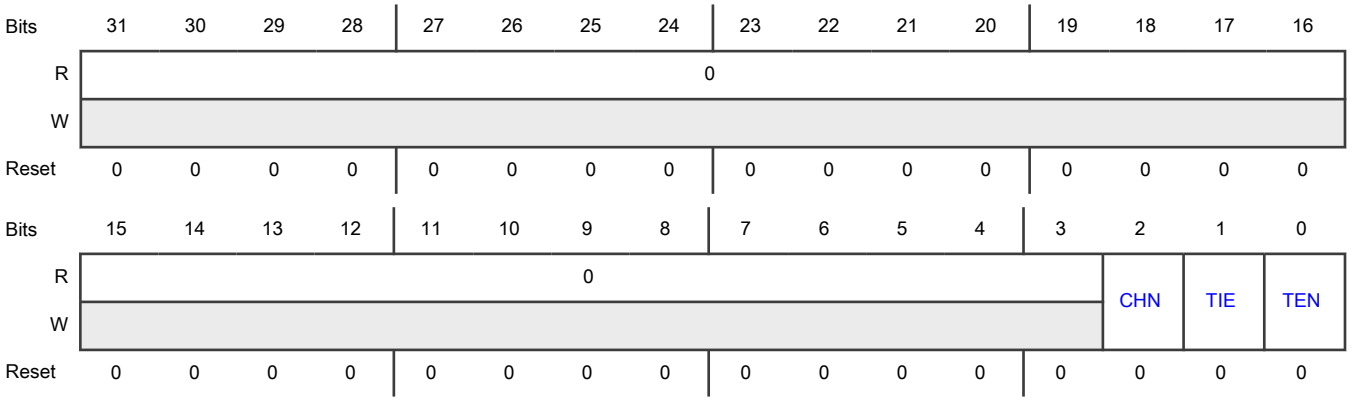
Offset

Register	Offset
TCTRL0	108h
TCTRL1	118h
TCTRL2	128h
TCTRL3	138h

Function

Controls timer behavior.

Diagram



Fields

Field	Function
31-3 —	Reserved
2 CHN	Chain Mode Chains this timer (timer *n*, where *n* is > 0) to the next lower numbered timer (timer *n* - 1) to create a 64-bit lifetimer. When chained, timer *n* decrements when timer *n* - 1 expires. See LTMR64H and LTMR64L. You cannot chain timer 0 or the RTI timer. 0b - Unchains 1b - Chains
1 TIE	Timer Interrupt Enable Enables the timer interrupt. If the interrupt is enabled, when an interrupt is pending or the Timer Interrupt Flag is set (TFLG*n*[TIF] = 1), PIT generates an interrupt. To avoid an interrupt when you first enable the interrupt, clear the Timer Interrupt Flag (write 1 to TFLG*n*[TIF]) before you enable the interrupt.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disables 1b - Enables
0 TEN	Timer Enable Enables the timer. 0b - Disables 1b - Enables. The timer begins counting down.

71.7.13 Timer Flag (TFLG0 - TFLG3)

Offset

Register	Offset
TFLG0	10Ch
TFLG1	11Ch
TFLG2	12Ch
TFLG3	13Ch

Function

Indicates the PIT timer has expired.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															TIF
W																W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-1	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
0 TIF	Timer Interrupt Flag Indicates the timer period has expired (CVAL*n*[TVL] = 0). If interrupts are enabled (TCTRL*n*[TIE] = 1), TIF triggers an interrupt request. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Timer has not expired 1b - Timer expired When writing 0b - No effect 1b - Clears flag

71.8 Glossary

RTI Real-time interrupt

Chapter 72
Real Time Clock (RTC)

72.1 RTC instances and configuration

The chip contains one instance of RTC (Real Time Clock) timer and API (Autonomous Periodic Interrupt) timer, where both can perform 32-bit comparisons.

The RTC is present in always ON domain, hence available in RUN mode as well as in STANDBY mode. Both RTC and API timers can generate interrupts as well as wakeup from low power modes.

RTC supports a resolution of 1µs with high speed internal oscillator clock (1/48MHz (FIRC) * 48 (RTC counter) = 1µs)

This chip supports seamless RTC operation across functional reset with the clock sources SIRC.

API has the capability to change the Timer compare value (APIVAL) independently without stopping the timer.

API can also be used in conjunction with the Comparator module. In STANDBY mode configuration, the API is configured to generate a START / NEXT type signal to inform the Comparator module that a 'compare' must be carried out.

72.2 Overview

The Real-Time Clock (RTC) is a free-running counter used for time keeping applications. The RTC can be configured to generate an interrupt at a pre-defined interval independent of the mode of operation (run mode or low power mode). If in a low power mode, the RTC interval is reached, the RTC first generates a wakeup and then asserts the interrupt request. The RTC also supports an API function used to generate a periodic wakeup request to exit a low-power mode or an interrupt request.

72.2.1 Block diagram

The following figure shows clock gating for RTC clocks.

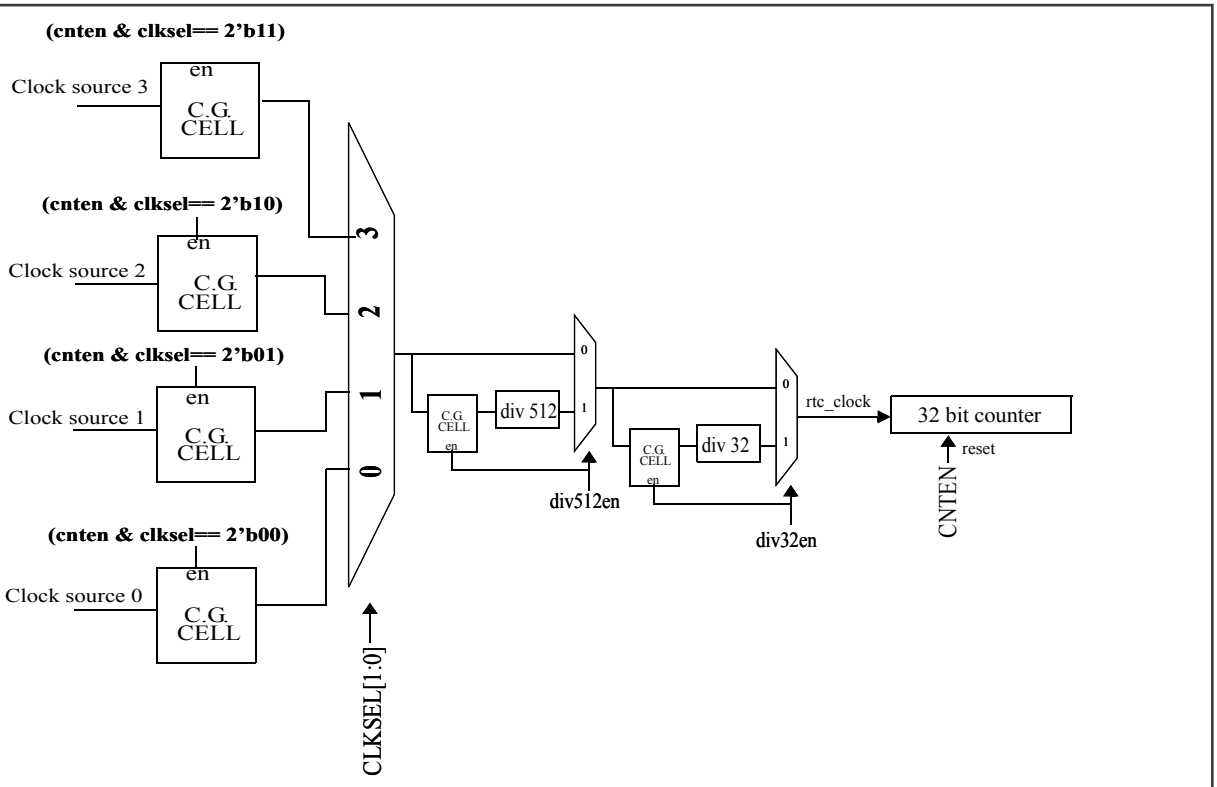


Figure 507. Clock gating for RTC clocks

The following figure shows the block diagram of RTC.

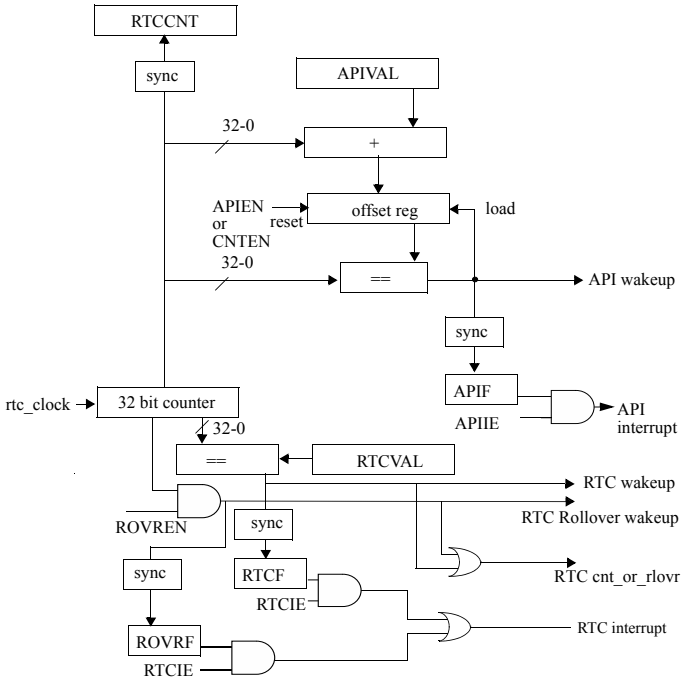


Figure 508. Block diagram

72.2.2 Features

RTC features include:

- 32-bit counter
- Selectable counter clock sources (IRCs and OSCs)
  - Clock source 0
  - Clock source 1
  - Clock source 2
  - Clock source 3
- Optional 512 prescaler and optional 32 prescaler to run the 32 bit counter.
- RTC interrupt with interrupt enable.
- Counter runs in all modes of operation.
- RTC counter is reset when the counter is disabled by software and by reset to RTC block.
- Autonomous periodic interrupt support includes:
  - 32-bit compare value to support range of wakeup intervals/interrupts
  - API logic has a separate enable to support changing compare value while RTC is running
  - API interrupt with interrupt enable
  - Operates in all modes
  - API compare value can be modified while RTC is running
- Optional interrupt for RTC match, API match, and RTC rollover.

72.3 Functional description

72.3.1 RTC

The RTC consists of a 32-bit free running counter enabled with the CNTEN bit (CNTEN, when negated, asynchronously resets the counter and synchronously enables the counter when enabled). After disabling CNTEN, RTCVAL, APIVAL, needs to be written again for desired functionality. The value of the counter may be read via the RTC Count (RTCCNT) register. Note that because of clock synchronization, the RTC Count (RTCCNT) value may represent a previous counter value. The difference between the counter and the read value depends on the ratio of counter clock and bus clock. Maximum possible difference between the two is 6 count values.

The clock source to the counter is selected with the CLKSEL field, which gives four options for clocking the RTC/API. The four clock sources are assumed to be on these:Clock source 0, Clock source 1, Clock source 2, and Clock source 3. The output of the clock mux can be optionally divided by a combination of 512 and 32 to give various count periods for different clock sources. Note that the CNTEN bit should be disabled when the RTC/API clock source is switched.

When the RTC Count (RTCCNT) counter value for counter bits 31-0 match the 32-bit value in the RTCVAL field, then the RTCF interrupt flag bit is set (after proper clock synchronization). If the RTCIE interrupt enable bit is set, then the RTC interrupt request is generated. RTC Compare value register (RTCVAL) register can be written only when INV_RTC bit is clear. Initially INV_RTC=0, and hence RTC Compare value register (RTCVAL) can be written once and hence INV_RTC gets set. This bit can now be cleared only by enabling the RTC counter. After the counter is enabled, RTC Compare value register (RTCVAL) can be written anytime, until RTC is disabled again. RTC Compare value register (RTCVAL) is first synchronized to the RTC clock domain, therefore, if RTC Compare value register (RTCVAL) is updated at the point where a counter match is due to happen in the next 2-3 RTC clocks because of previous RTC Compare value register (RTCVAL), the RTCF flag is set. However, if the RTC Compare value register (RTCVAL) is updated at the point where no counter match is due as per the previous RTC Compare value register (RTCVAL), the RTCF flag is set when the counter matches the new RTC Compare value register (RTCVAL). If there is a match when in the low-power mode, then the RTC first generates a wakeup request to force a wakeup to run mode,and then the RTCF flag is set.

If RTC Compare value register (RTCVAL) is updated just after counter match, new RTC Compare value register (RTCVAL) value should not be within next 6 RTC counter values.

A rollover wakeup and/or interrupt can be generated when the RTC transitions from a count of 0xFFFF_FFFF to 0x0000_0000. The rollover flag is enabled by setting the ROVREN bit. If RTCIE is enabled, an interrupt request is generated for an RTC counter rollover. If system is in low power mode, RTC counter rollover with this bit causes a wakeup from the low-power mode.

Both rollover wakeup and RTC wakeup gets asynchronously de-asserted with disabling of CNTEN.

All the flags and counter values are synchronized with the Bus clock. It is assumed that the Bus clock and RTC clock selected through CLKSEL follows the below relation:

Bus clock >= (1.5 * RTC clock)/(div_factor)

- if both DIV32EN and DIV512EN bits are disabled, div_factor = 1
- if DIV32EN=1 and DIV512EN=0, div_factor = 32
- if DIV32EN=0 and DIV512EN=1, div_factor = 512
- if both DIV32EN and DIV512EN bits are enabled, div_factor = 512*32 = 16384

In case, RTC wakeup's are used as a wakeup source, bus clock (system clock or register interface clock of RTC) should be disabled (to save power in standby mode) after enabling the required wakeup and ensuring sufficient time gap (3-6 bus clock or RTC clock (rtc_clock) cycles, whichever is slower) between bus clock disabling and wakeup event. To ensure writing the register to enable the wakeup, the bus clock must be active, hence it should not be disabled before enabling wakeup. Correct operation is not guaranteed if the specification is not followed.

72.3.2 API functional description

Setting APIEN bit enables the autonomous interrupt function. The 32-bit APIVAL field selects the time interval for triggering an interrupt and/or wakeup event. Because the RTC is a free-running counter, the APIVAL is added to the current count to calculate an offset. When the counter reaches the offset count, an interrupt and/or wakeup request is generated. Then the offset value is

recalculated and again re-triggers a new request when the new value is reached. API function is enabled only when CNTEN and APIEN bits are asserted and APIVAL is non-zero. Also APIVAL can be updated anytime. After APIVAL is updated, the first API interrupt is generated according to the previous value. From the second interrupt onwards, the API interrupt is generated with the new APIVAL. When a compare is reached, the APIF interrupt flag bit is set (after proper clock synchronization). If the APIIE interrupt enable bit is set, then the API interrupt request is generated. If there is a match while being in the low-power mode, then the API first generates a wakeup request to force a wakeup into normal operation, and then the APIF flag is set.

When the CNTEN is de-asserted, the API function is reset , though wakeup API is not asynchronously de-asserted with CNTEN. If APIEN is disabled when counter matches the offset APIF can be missed.

72.3.3 Modes of operation

72.3.3.1 Functional mode

There are two functional modes of operation for RTC, normal operation and low-power mode. In normal operation, all RTC registers can be read or written . The RTC/API and associated interrupts are optionally enabled. In low-power mode, the bus interface is disabled. The RTC/API is enabled (if enabled prior to entry into low-power mode).

72.3.3.2 Debug mode

On entering into the debug mode, the RTC counter freezes on the last valid count if the FRZEN is set. On exit from debug mode, counter continues from the frozen value.

72.4 Initialization

Recommended programming flow as follow

1. Program RTCVAL register with the value greater than 4 if RTCF related functionality is required.
2. Program APIVAL register with the value greater than 4 if API functionality is required.
3. Program all fields (as required) of RTC Control (RTCC) register with CNTEN=1. After setting CNTEN field, counter starts running and RTC/API functionality will be active as per the configurations.
4. If RTCVAL or APIVAL needs to be updated during run, check corresponding INV_RTC or INV_API bit is cleared before writing and do meet all the restrictions of the corresponding register.
5. If CLKSEL or DIV32EN or DIV512EN needs to be updated, first update RTC Control (RTCC) register with CNTEN=0 (when all INV_RTC or INV_API are 0) keeping other field values same. Wait for minimum 3 RTC clock cycles so that CNTEN will be synchronized to RTC clock domain. Then write the RTC Control (RTCC) register with new configuration required with CNTEN=1.

72.5 RTC register descriptions

The RTC registers are listed in this section.

NOTE

Address offset - 0x18h should not be accessed by application as corresponding feature/s are not available. Therefore, transfer error will not be generated at this offset.

NOTE

XFR error will be generated when RTCSUPV is accessed in user mode, any other register is accessed in user mode when SUPV bit is set, write attempt is made for RTCCNT register and any register accessed out of address range.

72.5.1 RTC memory map

RTC base address: 4028_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	RTC Supervisor control register (RTCSUPV)	32	RW	8000_0000h
4h	RTC Control (RTCC)	32	RW	0000_0000h
8h	RTC Status register (RTCS)	32	RW	0000_0000h
Ch	RTC Count (RTCCNT)	32	R	0000_0000h
10h	API Compare value register (APIVAL)	32	RW	0000_0000h
14h	RTC Compare value register (RTCVAL)	32	RW	0000_0000h

72.5.2 RTC Supervisor control register (RTCSUPV)

Offset

Register	Offset
RTCSUPV	0h

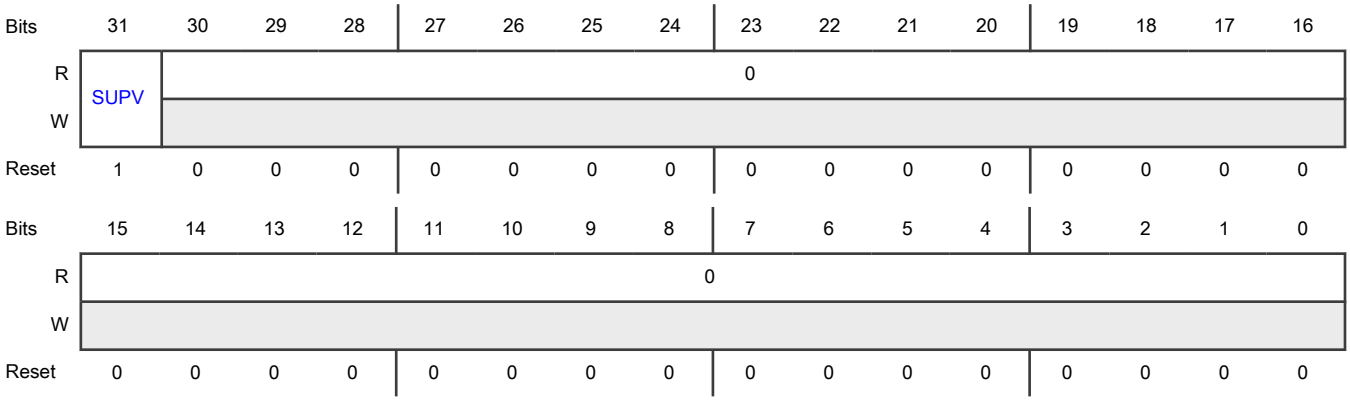
Function

The RTCSUPV register contains the SUPV bit that determines whether other registers are accessible in supervisor mode or user mode.

NOTE

You can access this register only in Supervisor mode, and you must write a value only to the SUPV field of the register.

Diagram



Fields

Field	Function
31	RTC Supervisor Bit

Table continues on the next page...

Table continued from the previous page...

Field	Function
SUPV	0b - All registers are accessible in both user as well as supervisor mode 1b - All other registers are accessible in the supervisor mode only
30-0 —	Reserved

72.5.3 RTC Control (RTCC)

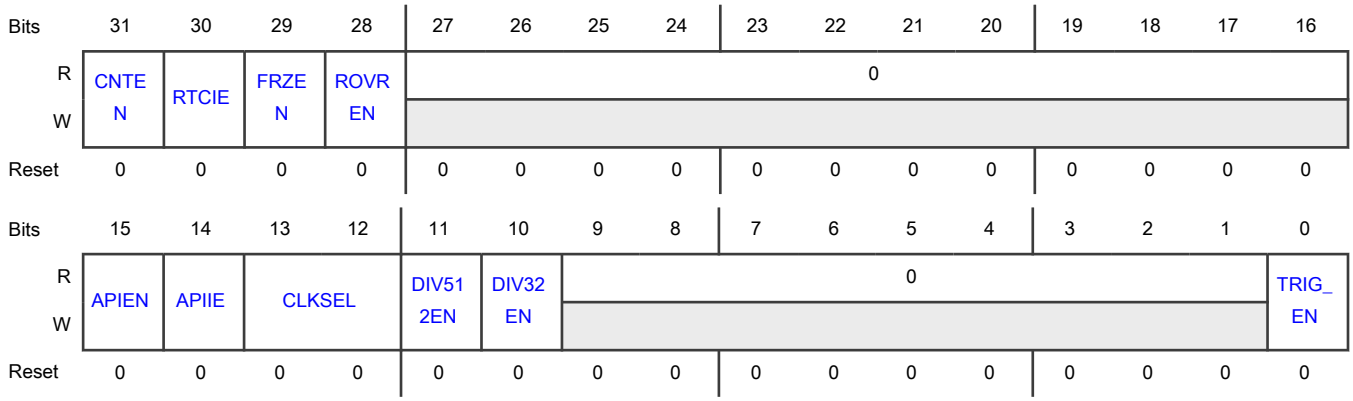
Offset

Register	Offset
RTCC	4h

Function

RTC Control register

Diagram



Fields

Field	Function
31 CNTEN	Counter Enable The CNTEN bit enables the RTC counter. Setting CNTEN bit to 0b has the effect of asynchronously resetting (synchronous reset negation) all the RTC and API logic. This allows RTC configuration and clock source selection to be updated without causing synchronization issues. **NOTE** CNTEN should be disabled when INV_RTC, INV_API are cleared.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Counter disabled 1b - Counter enabled
30 RTCIE	RTC Interrupt Enable The RTCIE bit enables interrupts requests to the system if RTCF is asserted. 0b - RTC interrupts disabled 1b - RTC interrupts enabled
29 FRZEN	Freeze Enable Bit The counter freezes on entering the debug mode on the last valid count value if the FRZEN bit is set. After passing of the debug mode counter starts from the frozen value. This bit should not be changed when debug mode is enabled. 0b - Counter does not freeze in debug mode 1b - Counter freezes in debug mode
28 ROVREN	Counter Roll Over wakeup/Interrupt Enable The ROVREN bit enables wakeup and interrupt requests when the RTC has rolled over from 0xFFFF_FFFF to 0x0000_0000. The RTCIE bit must also be set in order to generate an interrupt from a counter rollover. 0b - RTC rollover wakeup/interrupt disabled 1b - RTC rollover wakeup/interrupt enabled
27-16 —	Reserved
15 APIEN	Autonomous Periodic Interrupt Enable The APIEN bit enables the autonomous periodic interrupt function. Setting this bit to 0b, asynchronously disables API wakeup output of RTC as well. 0b - API disabled 1b - API enabled
14 APIIE	API Interrupt Enable The APIIE bit enables interrupts requests to the system if APIF is asserted. 0b - API interrupts disabled 1b - API interrupts enabled
13-12 CLKSEL	Clock select The CLKSEL[1:0] bits select the clock source for the RTC. CLKSEL may only be updated when CNTEN is 0. The user should ensure that oscillator is enabled before selecting it as a clock source for RTC.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE See the RTC-clocking and resolution information in the clocking chapter elsewhere in this document. 00b - Clock source 0 01b - Clock source 1 10b - Clock source 2 11b - Clock source 3
11 DIV512EN	Divide by 512 enable The DIV512EN bit enables the 512 clock divider. DIV512EN may only be updated when CNTEN is 0. 0b - Divide by 512 is disabled 1b - Divide by 512 is enabled
10 DIV32EN	Divide by 32 enable The DIV32EN bit enables the 32 clock divider. DIV32EN may only be updated when CNTEN is 0. 0b - Divide by 32 is disabled 1b - Divide by 32 is enabled
9-1 —	Reserved
0 TRIG_EN	Trigger enable for Analog Comparator This bit (TRIG_EN) when set will de-assert the wakeup_api on the next RTC clock (required for CMP when bus clock is disabled). **NOTE** If API wakeup is asserted with TRIG_EN set, and bus clock enabled, setting of RTCS[APIF] may be missed.

72.5.4 RTC Status register (RTCS)

Offset

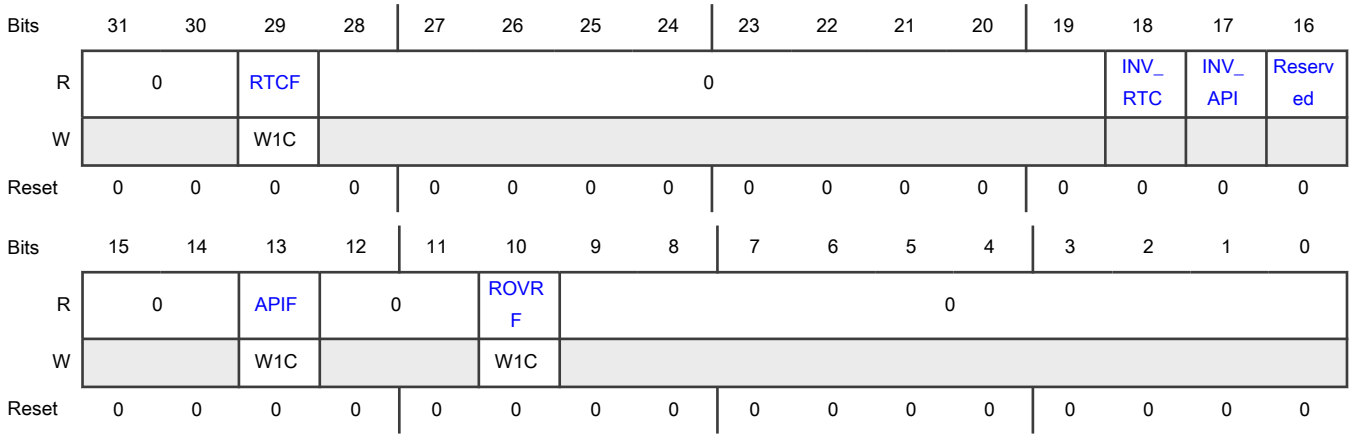
Register	Offset
RTCS	8h

Function

NOTE

W1C has priority over setting of the RTCF, APIF and ROVRF bits, in case both clearing and setting occurs at the same time.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 RTCF	RTC Interrupt Flag The RTCF bit indicates that the RTC counter has reached the counter value matching RTC Compare value register (RTCVAL). RTCF is cleared by writing a 1 to RTCF. Writing a 0 to RTCF has no effect. 0b - RTC counter is not equal to RTCVAL 1b - RTC counter matches RTCVAL
28-19 —	Reserved
18 INV_RTC	Invalid RTC write This bit returns value 1 after a value is written to the RTCVAL register and the synchronization process is in progress. During this synchronization period, any attempt to write to the RTCVAL register again is ignored. Synchronization will complete only when CNTEN is set.
17 INV_API	Invalid APIVAL write This bit returns value 1 after a value is written to the APIVAL register and the synchronization process is in progress. During this synchronization period, any attempt to write to the APIVAL register again is ignored. Synchronization will complete only when CNTEN is set.
16 —	Reserved
15-14 —	Reserved
13	API Interrupt Flag

Table continues on the next page...

Table continued from the previous page...

Field	Function
APIF	The APIF bit indicates that the RTC counter has reached the counter value matching API offset value. APIF is cleared by writing a 1 to APIF. Writing a 0 to APIF has no effect. 0b - Counter is not equal to API offset value 1b - Counter matches the API offset value
12-11 —	Reserved
10 ROVRF	Counter Roll Over Interrupt Flag The ROVRF bit indicates that the RTC has rolled over from 0xFFFF_FFFF to 0x0000_0000. ROVRF is cleared by writing a 1 to ROVRF. 0b - RTC has not rolled over 1b - RTC has rolled over
9-0 —	Reserved

72.5.5 RTC Count (RTCCNT)

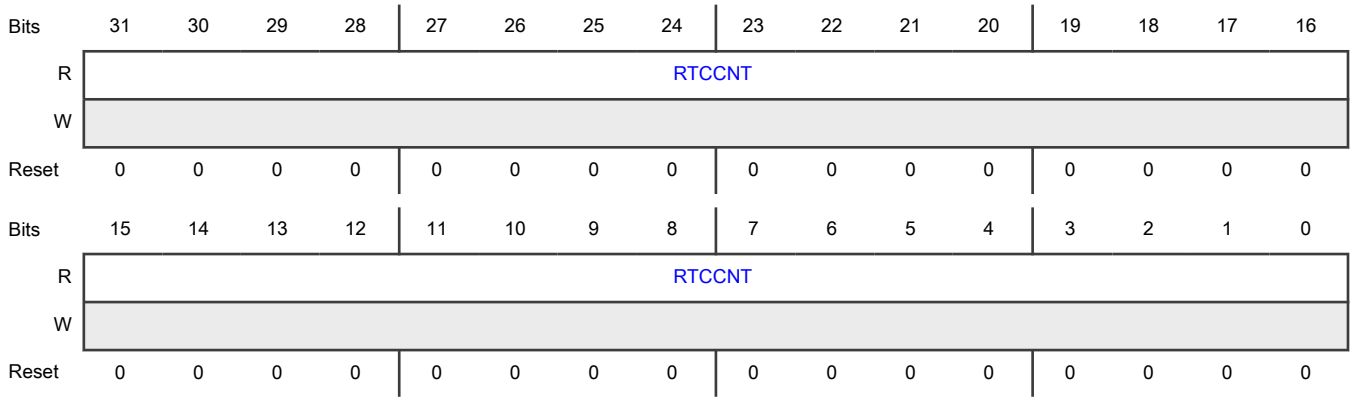
Offset

Register	Offset
RTCCNT	Ch

Function

RTC Counter register

Diagram



Fields

Field	Function
31-0 RTCCNT	RTC Counter Value Because of clock synchronization, the RTCCNT value may represent a previous counter value.

72.5.6 API Compare value register (APIVAL)

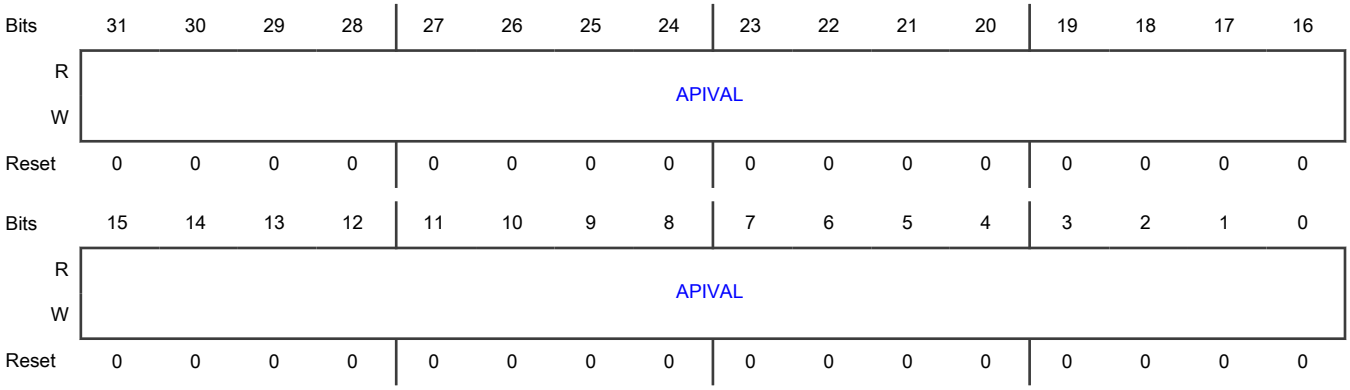
Offset

Register	Offset
APIVAL	10h

Function

The APIVAL offset bits are compared to the RTC counter bits and if a match occurs, an interrupt/wakeup request is asserted.

Diagram



Fields

Field	Function
31-0 APIVAL	API Compare Value APIVAL bits are added to the current count to calculate an offset. The APIVAL offset bits are compared to the RTC counter bits and if a match occurs, an interrupt/wakeup request is asserted. **NOTE** API functionality is active only when APIVAL is non zero. The first API interrupt takes two more cycles because of synchronization of APIVAL to RTC clock. After that, interrupts are periodic in nature and it takes APIVAL+1 cycles. The Minimum supported value of APIVAL is 4. This is because of synchronization.

72.5.7 RTC Compare value register (RTCVAL)

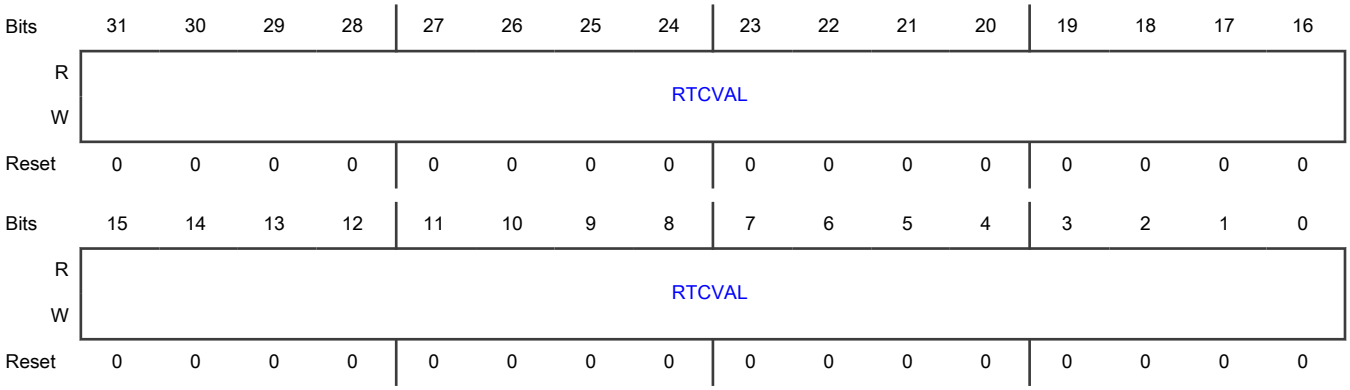
Offset

Register	Offset
RTCVAL	14h

Function

The RTCVAL bits are compared to the RTC counter bits and if a match occurs, RTCF is set. The minimum value of RTCVAL should be 4.

Diagram



Fields

Field	Function
31-0 RTCVAL	RTC Compare Value The RTCVAL bits are compared to the RTC counter bits and if a match occurs, RTCF is set.

72.6 Glossary

API	Autonomous Periodic Interrupt
CMP	Comparator
IRCs	Internal RC Oscillator
OSCs	Oscillator

Chapter 73
Low Power Serial Peripheral Interface (LPSPI)

73.1 Chip-specific LPSPI information

73.1.1 LPSPI instances and configuration

This chip supports 6 instances of LPSPI.

Table 487. LPSPI instances configuration

Instances	TX FIFO Size	RX FIFO Size	Chip Selects
LPSPI0	4x32 bit	4x32 bit	8
LPSPI1	4x32 bit	4x32 bit	6
LPSPI2	4x32 bit	4x32 bit	4
LPSPI3	4x32 bit	4x32 bit	4
LPSPI4	4x32 bit	4x32 bit	4
LPSPI5	4x32 bit	4x32 bit	4

- S32K396 support data rate up to 20 Mbps. Only one LPSPI instance support 20 MHz in loopback mode that is LPSPI0
- All LPSPIs supports a minimum a 10 MHz data rate on standard plus pads and 7.5 MHz on standard pads.
- Low leakage and Wait modes are not supported in this device.

The number of chip selects that each LPSPI instance supports varies. Because of that, in the Configuration Register 1 (CFGR1), the Peripheral Chip Select (PCS) field and the Peripheral Chip Select Polarity (PCSPOL) field also vary. See the next 2 tables.

Table 488. LPSPI instances mapped against Peripheral Chip Select (PCS) field support

PCS supported in	PCS not supported in
LPSPI0_TCR[26-24]	—
LPSPI1_TCR[26-24]	—
LPSPI2_TCR[25–24]	LPSPI2_TCR[26]
LPSPI3_TCR[25–24]	LPSPI3_TCR[26]
LPSPI4_TCR[25–24]	LPSPI4_TCR[26]
LPSPI5_TCR[25–24]	LPSPI5_TCR[26]

Table 489. LPSPI instances mapped against Peripheral Chip Select Polarity (PCSPOL) field support

PCSPOL supported in	PCSPOL not supported in
LPSPI0_CFGR1[15-8]	—
LPSPI1_CFGR1[13–8]	LPSPI1_CFGR1[15–14]
LPSPI2_CFGR1[11–8]	LPSPI2_CFGR1[15–12]
LPSPI3_CFGR1[11–8]	LPSPI3_CFGR1[15–12]

Table continues on the next page...

Table 489. LPSPI instances mapped against Peripheral Chip Select Polarity (PCSPOL) field support (continued)

PCSPOL supported in	PCSPOL not supported in
LPSPI4_CFGR1[11–8]	LPSPI4_CFGR1[15–12]
LPSPI5_CFGR1[11–8]	LPSPI5_CFGR1[15–12]

73.1.2 LPSPI HREQ considerations

It is recommended that the HREQ pin (when PCS[1] is used as HREQ) should get de-asserted before the completion of frame transfer. In case if the HREQ state is still asserted and LPSPI returns to idle state after frame transfer completion, the HREQ state is internally latched and the next data is written to the transmit FIFO without waiting for the next HREQ assertion.

This limitation is present only while using PCS[1] as HREQ and HREQ remains asserted throughout frame transfer. In case of using trigger input as HREQ, there is no issue.

73.2 Overview

LPSPI provides an efficient interface (either as a controller or peripheral) to an SPI bus, which is a synchronous serial communication interface used in embedded systems. It is typically used to perform short distance communications between microcontrollers and peripheral devices, on printed circuit boards. Typical applications include interfacing with secure digital cards and LCD displays.

NOTE

The terminology in this chapter has been updated to align with NXP's inclusive language standards, as shown in the table below.

Table 490. Updated terms

Updated term	Deprecated term
Controller	Master
Peripheral	Slave

73.2.1 Block diagram

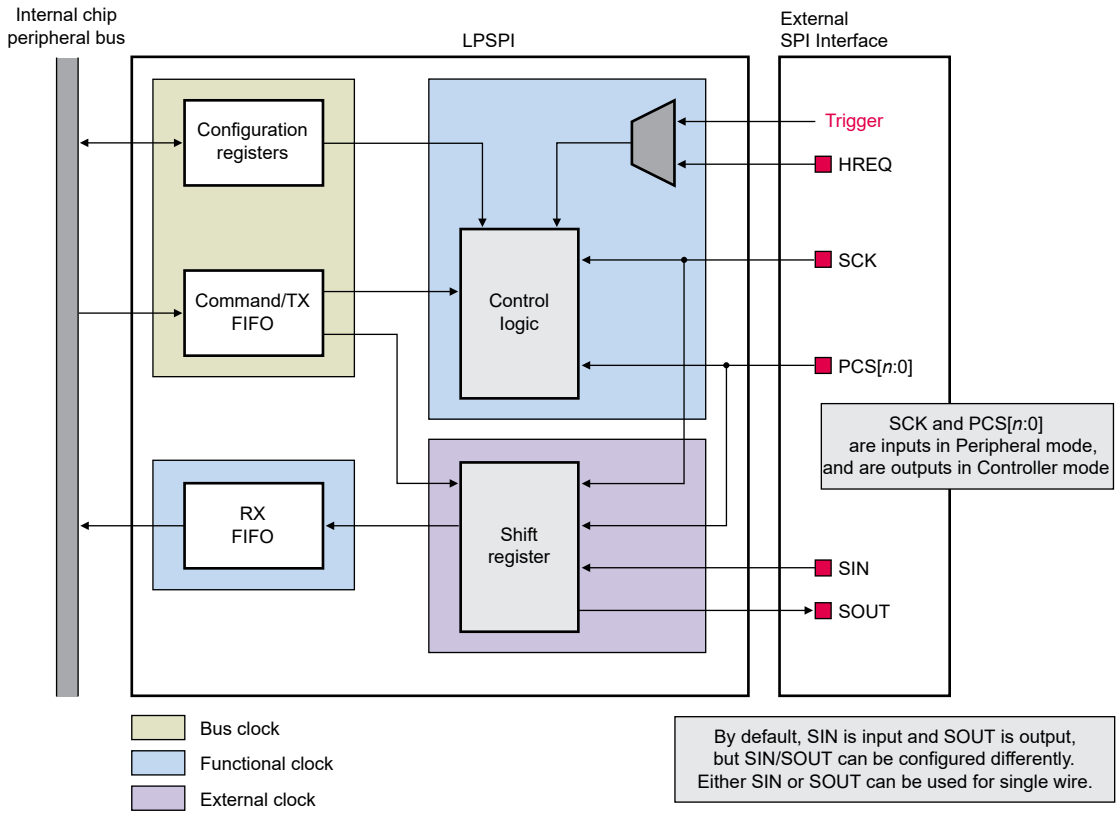


Figure 509. Block diagram

73.2.2 Features

- Minimal CPU overhead, with DMA transmit and receive requests supporting FIFO register accesses
- Support available for 32-bit word size
- Configurable clock polarity and phase
- Support available for 8 peripheral chip selects in Controller mode
- Support available for Peripheral mode
- 4-word transmit and command FIFO
- 4-word receive FIFO
- Flexible timing parameters in Controller mode, including SCK frequency and duty cycle, and delays between PCS and SCK edges
- Continuous transfer option to keep PCS asserted across multiple frames
- Full-duplex transfers that support 1-bit transmit and receive on each clock edge
- Half-duplex transfers that support:
  - 1-bit transmit or receive on each clock edge
  - 2-bit transmit or receive on each clock edge
  - 4-bit transmit or receive on each clock edge
  - 8-bit transmit or receive on each clock edge

- Option to use host request to control the start of an SPI bus transfer

73.3 Functional description

73.3.1 Controller mode

73.3.1.1 Transmit and command FIFO commands

The transmit and command FIFO is a combined FIFO that includes both transmit data words and command words. You store:

- Transmit data words in the transmit and command FIFO, by writing to Transmit Data (TDR).
- Command words in the transmit and command FIFO, by writing to Transmit Command (TCR).

When a command word is at the top of the transmit and command FIFO, the actions that can occur depend on whether LPSPI is busy or between frames (see TCR[CONT] and TCR[CONTC]). See Table 491 for conditions and possible corresponding actions when a command word is at the top of the transmit and command FIFO.

Table 491. Possible actions when a command word is at the top of the transmit and command FIFO

Condition	Action
LPSPI is enabled and idle.	The command word is pulled from the FIFO, and this command word controls all subsequent transfers.
LPSPI is busy and TCR[CONTC] is 0.	The SPI frame completes at the end of the existing word, ignoring TCR[FRAMESZ]. The command word is then pulled from the FIFO and that command word controls all subsequent transfers (or until the next update to the command word). Note that a command word with TCR[CONTC] = 0 always terminates the existing transfer regardless of the previous TCR[CONT] value.
LPSPI is busy; the existing TCR[CONT] value is 1 and the new TCR[CONTC] value is 1.	The command word must be updated at the frame boundary. The command word is pulled from the FIFO during the last SCK pulse of the existing frame (based on the value of FRAMESZ), and the frame continues using the new command value for the rest of the frame (or until the next update to the command word). When TCR[CONTC] = 1, only the lower 24 bits of the command word are updated. If the command word is updated at a word boundary, then the transfer halts (stops) after that word. TCR[CONTC] is ignored when not at a frame boundary, so the frame ends prematurely.

TCR[CONT] = 1 keeps PCS asserted at end of frame, allowing the transfer to continue.

TCR[CONTC] = 1 specifies that this command word must not terminate the existing frame, and the transfer can continue using the new command word.

TCR[CONTC] = 1 is restricted in the sense that the new command must load on a frame boundary, and the only way for a transfer to continue from a frame boundary is when the previous command has TCR[CONT] = 1.

You can read the current state of the existing command word from Transmit Command (TCR). It requires at least three LPSPI functional clock cycles for Transmit Command (TCR) to update after you write to it (assuming an empty FIFO), and LPSPI must be enabled (CR[MEN] = 1).

Writing to Transmit Command (TCR) does not initiate an SPI bus transfer, unless TCR[TXMSK] = 1. When TCR[TXMSK] = 1, a new command word is not loaded until the end of the existing frame (based on the value of TCR[FRAMESZ]); at the end of the transfer, TCR[TXMSK] transitions to 0.

In Controller mode, the LPSPI command word in Transmit Command (TCR) controls SPI attributes based on the selections in register fields. See Table 492 for TCR fields and associated functionality related to data transfer.

Table 492. Command word in Controller mode

Transmit Command (TCR)		Description	Can this field be modified during a data transfer?
Field	Name		
CPOL	Clock polarity	Specifies the polarity of the SCK pin. Any change of CPOL value causes a transition on the SCK pin.	N
CPHA	Clock phase	Specifies the clock phase of the transfer.	N
PRESCALE	Prescaler value	Specifies a prescaler used to divide the LPSPI functional clock, to generate the timing parameters of the SPI bus transfer. Changing PRESCALE in conjunction with PCS enables LPSPI to connect to different peripheral devices at different frequencies.	N
PCS	Peripheral chip select	Specifies which PCS pin asserts for the transfer; the polarity of PCS is static and specified by CFGR1[PCSPOL]. If CFGR1[PCSCFG] = 1, do not select PCS[3:2].	N
LSBF	LSB first	Specifies whether LSB (bit 0) or MSB (bit 31 for a 32-bit word) is transmitted or received first.	Y
BYSW	Byte swap	Enables byte swap on each 32-bit word when transmitting and receiving data. Byte swapping can be useful when interfacing with devices that organize data as big-endian.	Y
CONT	Continuous transfer	Configures LPSPI for a continuous transfer that keeps PCS asserted between frames (as specified by FRAMESZ). You must write a new command word to cause PCS to negate. Also, this field supports changing the command word at frame size boundaries.	Y
CONTC	Continuing command	Indicates that this is a new command word for the existing continuous transfer. When CONTC = 1, the command word must only be written to the transmit and command FIFO on a frame boundary.	Y
RXMSK	Receive data mask	Masks the receive data and does not store the masked receive data in the receive FIFO or perform receive data matching. This option is useful for half-duplex transfers or to specify which fields are compared during receive data matching.	Y
TXMSK	Transmit data mask	Masks the transmit data; masked transmit data is not pulled from the transmit FIFO, and the output data pin is 3-stated (unless otherwise configured by CFGR1[OUTCFG]). This option is useful for half-duplex transfers.	Y
WIDTH	Transfer width	Specifies the number of bits shifted on each SCK pulse: • 1-bit transfers support traditional SPI bus transfers in either half-duplex or full-duplex data formats. • 2-bit and 4-bit half-duplex transfers are useful for interfacing with QuadSPI memory devices, and either TXMSK or RXMSK must also be 1. • 8-bit half-duplex transfers are useful for interfacing with OctelSPI memory devices, and either TXMSK or RXMSK must also be 1.	Y

Table continues on the next page...

Table 492. Command word in Controller mode (continued)

Transmit Command (TCR)		Description	Can this field be modified during a data transfer?
Field	Name		
FRAMESZ	Frame size	Configures the frame size in number of bits equal to (FRAMESZ + 1): • The minimum frame size is 8 bits, or 16 bits for an 8-bit transfer. • If the frame size is larger than 32 bits, then the frame is divided into multiple words of 32 bits; each word is loaded from the transmit FIFO and stored in the receive FIFO separately. • If the size of the frame is not divisible by 32, then the last load of the transmit FIFO and store of the receive FIFO contains the remaining bits. For example, a 72-bit transfer consists of three words: the first and second words are 32 bits, and the third word is 8 bits.	Y

73.3.1.1.1 SPI bus transfers

LPSPI initiates an SPI bus transfer when all these conditions are true:

- Data is written to the transmit FIFO.
- The HREQ pin is asserted (or the HREQ function is disabled).
- LPSPI is enabled.

To perform the SPI bus transfer, LPSPI uses the attributes configured in Transmit Command (TCR) and the timing parameters defined in Clock Configuration (CCR).

The SPI bus transfer ends after the number of bits indicated by the value of FRAMESZ have been transferred (provided CONT = 0), or at the end of a word when a new transmit command word is at the top of the transmit and command FIFO. When LPSPI is disabled, the SPI bus transfers end after the transmit FIFO is empty and LPSPI is idle.

The HREQ input is only checked when PCS is negated.

73.3.1.1.2 Circular FIFO

The transmit and command FIFO supports a circular FIFO feature. This feature enables the LPSPI controller to (periodically) repeat a short data transfer that fits within the transmit and command FIFO, without requiring additional FIFO accesses. When the circular FIFO is enabled (CFGR0[CIRFIFO] = 1), the current state of the FIFO read pointer is saved and the status flags are not updated. After the FIFO is empty and LPSPI is idle, the FIFO read pointer is restored with the saved version, so the contents of the transmit and command FIFO are not permanently pulled from the FIFO when Circular FIFO mode is enabled.

73.3.1.2 Receive FIFO and data match

The receive FIFO stores received data during SPI bus transfers. When TCR[RXMSK] = 1, the received data is discarded instead of being stored in the receive FIFO:

- Received data is written to the receive FIFO when the last bit of the word is sampled.
- If the transmit FIFO is empty during a multiple-word or continuous transfer, then the receive data is written to the receive FIFO before the transfer stalls (assuming CFGR1[NOSTALL] = 0) while waiting for new transmit data or for a command word to be written.

LPSPI provides a receive data match function that can match received data against one of the two words in DMR0 and DMR1, or against a masked data word. You can also configure the received data match function to compare only the first one or two received data words since the start of the frame:

- Received data that is already discarded because of TCR[RXMSK] cannot cause the data match flag to set, and delays the receive data match on the first received data word, until all discarded data is received.
- You can configure the receive data match function to discard all received data until a data match is detected, using CFGR0[RDMO].
- After a receive data match, to allow all subsequent data to be received, write 0 to CFGR0[RDMO], and then write 0 to SR[DMF].

73.3.1.3 Timing parameters

The timing parameters that are used for all SPI bus transfers are relative to the LPSPI functional clock divided by the selection specified in TCR[PRESCALE]. Although you cannot change Clock Configuration (CCR) when LPSPI is busy, to support interfacing with different peripheral devices at different frequencies, you can change the TCR[PRESCALE] selection between SPI bus transfers by using Transmit Command (TCR).

NOTE

The minimum value shown in Table 493 is the minimum counter value, but the values of Clock Configuration (CCR) must also satisfy the data sheet specs based on the LPSPI functional clock frequency and prescaler value.

Table 493. Timing parameters

Clock Configuration (CCR) Clock Configuration 1 (CCR1)		Description	Minimum value	Maximum value
Field	Name			
SCKSET	SCK setup phase	Configures the SCK setup phase to (SCKSET + 1) cycles. The setup phase is the SCK high period when either CPHA = 0 and CPOL = 1, or CPHA = 1 and CPOL = 0. Otherwise, it is the SCK low period. The SCK period is defined as (SCKSET + SCKHLD + 2) and the duty cycle is the difference between SCKSET and SCKHLD.	0 (1 cycle)	255 (256 cycles)
SCKHLD	SCK hold phase	Configures the SCK hold phase to (SCKHLD + 1) cycles. The hold phase is the SCK low period when either CPHA = 0 and CPOL = 1, or CPHA = 1 and CPOL = 0. Otherwise, it is the SCK high period. The SCK period is defined as (SCKSET + SCKHLD + 2) and the duty cycle is the difference between SCKSET and SCKHLD.	0 (1 cycle)	255 (256 cycles)
PCSPCS	PCS-to-PCS delay	Configures the minimum delay between PCS negation and the next PCS assertion to (PCSPCS + PCSPCS + 2) cycles. When the command word is updated between transfers, there is a minimum of (PCSPCS + 1) cycles between the command word update and any change on PCS pins.	0 (2 cycles)	255 (512 cycles)
SCKSCK	SCK-to-SCK delay	Configures the delay during a continuous transfer between the last SCK edge of a frame and the first SCK edge of the continuing frame to (SCKSCK + 1) cycles. This is useful when the external peripheral	0 (1 cycle)	255 (256 cycles)

Table continues on the next page...

Table 493. Timing parameters (continued)

Clock Configuration (CCR) Clock Configuration 1 (CCR1)		Description	Minimum value	Maximum value
Field	Name			
		requires a large delay between different words of an SPI bus transfer.		
PCSSCK	PCS-to-SCK delay	Configures the minimum delay between PCS assertion and the first SCK edge to (PCSSCK + 1) cycles.	0 (1 cycle)	255 (256 cycles)
SCKPCS	SCK-to-PCS delay	Configures the minimum delay between the last SCK edge and the PCS negation to (SCKPCS + 1) cycles.	0 (1 cycle)	255 (256 cycles)

Figure 510 shows the timing settings controlled by:

- TCR[CPHA]
- TCR[CPOL]
- CCR[SCKPCS]
- CCR[PCSSCK]
- CCR1[SCKSET]
- CCR1[SCKHLD]

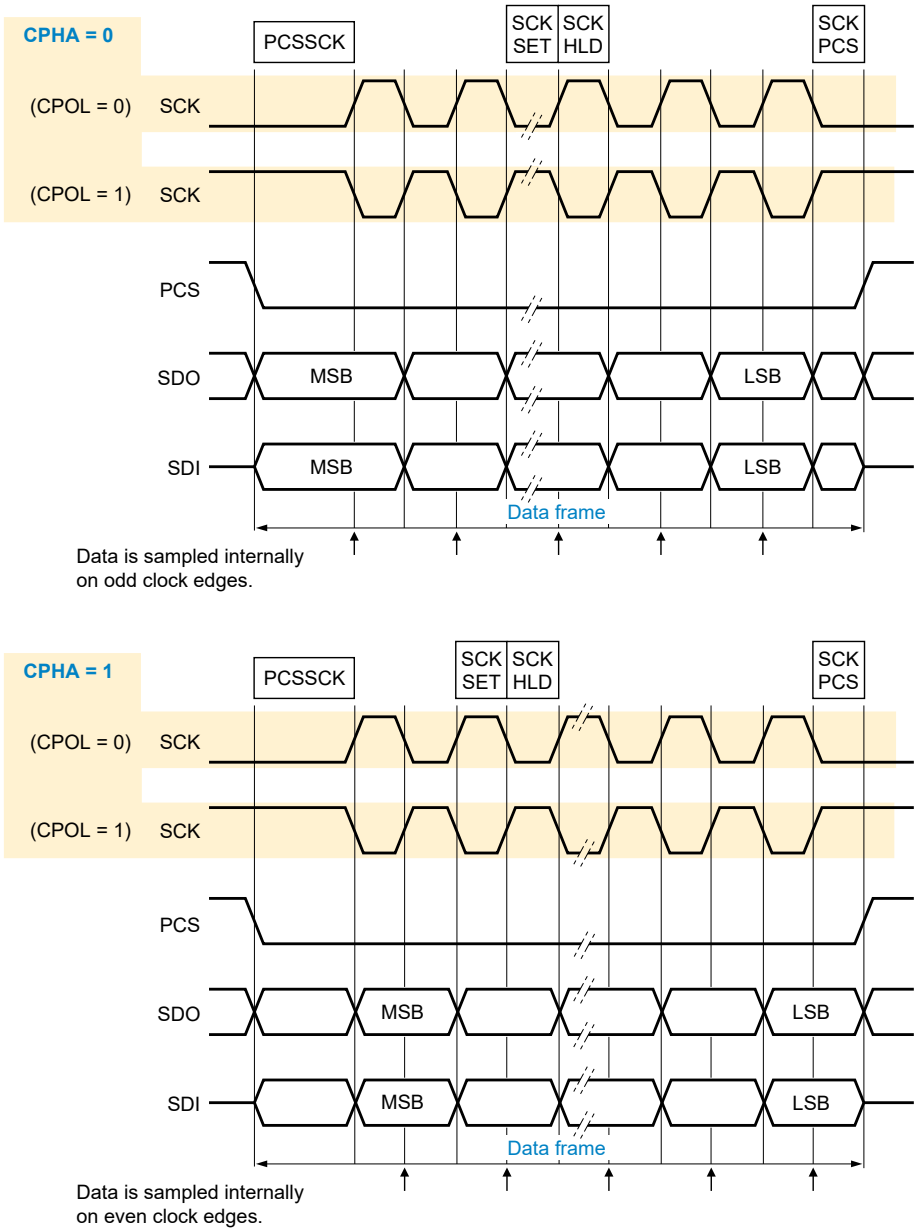


Figure 510. Clock phase (TCR[CPHA]) timing diagram example

To configure for a baud rate of 10 MHz with 50/50 duty cycle and with a functional clock frequency of 100 MHz, use the following settings:

- CCR1[SCKSET] = 0x4 (5 cycles)
- CCR1[SCKHLD] = 0x4 (5 cycles)
- CCR1[PCSPCS] = 0x8 (10 cycles)
- CCR1[SCKSCK] = 0x4 (5 cycles)
- CRR[PCSSCK] = 0x4 (5 cycles)
- CRR[SCKPCS] = 0x4 (5 cycles)
- TCR[PRESCALE] = 0x0 (divide by 1)

73.3.1.4 Pin configuration

Following are the pin configuration settings for half-duplex transfers:

- To swap directions or to support half-duplex transfers on the same pin, you can configure the SIN and SOUT pins using CFGR1[PINCFG].
- To specify whether an output data pin (SOUT, for example) 3-states when PCS is negated, or if the output data pin retains the last value, use CFGR1[OUTCFG].
- When configuring half-duplex transfers, you must configure the output data pins to 3-state when PCS is negated (CFGR1[OUTCFG] = 1).
- When performing half-duplex 2-bit transfers, you can write any value to CFGR1[PCSCFG].
- When performing half-duplex 4-bit transfers, you must write 1h to CFGR1[PCSCFG].

73.3.1.5 Clock loopback

Configure the LPSPI controller to use one of the following clocks to sample the input data:

- The SCK output clock
- A delayed version of the SCK output clock

The delayed version of the SCK is chosen by the SCK pin output delay, plus the SCK pin input delay, and is selected by writing 1 to CFGR1[SAMPLE]. Enabling the loopback version of the SCK pin can improve the setup time of the input data from the peripheral.

See the chip data sheet for the specific input setup time in Controller Loopback mode.

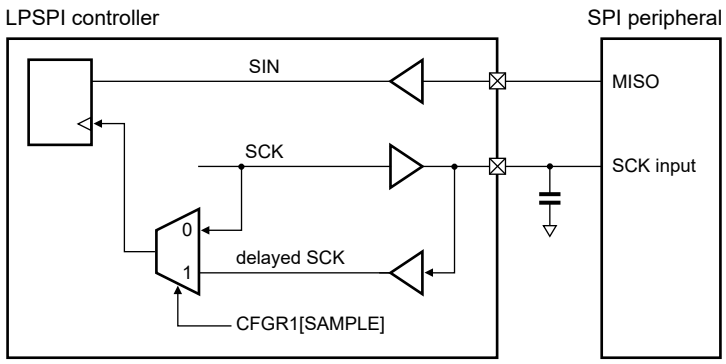


Figure 511. Clock loopback

73.3.2 Peripheral mode

LPSPI Peripheral mode:

- Uses the same shift register and logic that Controller mode uses.
- Does not use Clock Configuration (CCR).
- Requires Transmit Command (TCR) to remain static (unchanged) during SPI bus transfers.

73.3.2.1 Transmit and command FIFO commands

You must initialize Transmit Command (TCR) before enabling LPSPI in Peripheral mode, although this register is not updated until after LPSPI is enabled. After LPSPI is enabled, you must make changes to this register only when LPSPI is idle. In Peripheral mode, the LPSPI command word in this register controls SPI attributes. Before the PCS input asserts, the transmit FIFO must be filled with transmit data, or the transmit error flag sets.

Table 494. Command word in Peripheral mode

Transmit Command (TCR)		Description
Field	Name	
CPOL	Clock polarity	Specifies the polarity of the external SCK input.
CPHA	Clock phase	Specifies the clock phase of transfer.
PRESCALE	Prescaler value	Specifies the LPSPI functional clock prescaler.
PCS	Peripheral chip select	Specifies which PCS is used. The polarity of PCS is static and configured by CFGR1[PCSPOL]. If CFGR1[PCSCFG] is not equal to zero, then do not select the PCS[3:2] pins.
LSBF	LSB first	Specifies whether LSB (bit 0) or MSB (bit 31 for a 32-bit word) is transmitted or received first.
BYSW	Byte swap	Enables byte swap on each 32-bit word when transmitting and receiving data. Byte swapping can be useful when interfacing with devices that organize data as big-endian.
CONT	Continuous transfer	When continuous transfer is selected in Peripheral mode, after the number of bits indicated by FRAMESZ are transferred, LPSPI passes through and transmits the received data until the next PCS negation. Whatever is shifted in on the receive data is shifted out as transmit data considering that there is a 32-bit shift register.
CONTC	Continuing command	When the continuing command is enabled in Peripheral mode, after the number of bits indicated by FRAMESZ are transferred, RXMSK is considered equal to 1 and TXMSK is considered equal to 0 until the next PCS negation. CONTC can be used to change the direction of a transfer after the number of bits indicated by FRAMESZ.
RXMSK	Receive data mask	Masks the receive data; LPSPI does not store masked receive data in the receive FIFO or perform receive data matching. This option is useful for half-duplex transfers or to specify which fields are compared during receive data matching.
TXMSK	Transmit data mask	Masks the transmit data so that the masked transmit data is not pulled from transmit FIFO, and the output data pin is 3-stated (unless otherwise specified in CFGR1[OUTCFG]). This option is useful for half-duplex transfers.
WIDTH	Transfer width	Specifies the number of bits shifted on each SCK pulse: • 1-bit transfers support traditional SPI bus transfers in either half-duplex or full-duplex data formats. • 2-bit and 4-bit half-duplex transfers are useful for interfacing with QuadSPI memory devices, and at least either TCR[TXMSK] or TCR[RXMSK] must be 1. • 8-bit half-duplex transfers are useful for interfacing with OctelSPI memory devices, and at least either TCR[TXMSK] or TCR[RXMSK] must also be 1.
FRAMESZ	Frame size	Specifies the frame size in number of bits equal to (FRAMESZ + 1): • The minimum frame size is 8 bits, or 16 bits for an 8-bit parallel transfer. • If the frame size is larger than 32 bits, then the frame is divided into multiple words of 32 bits; each word is loaded from the transmit FIFO and stored in the receive FIFO separately. • If the size of the frame is not divisible by 32, then the last load of the transmit FIFO and store of the receive FIFO contain the remainder bits. For example, a 72-bit transfer consists of three words: the first and second words are 32 bits, and the third word is 8 bits.

73.3.2.2 Receive FIFO and data match

The receive FIFO stores receive data during SPI bus transfers. When TCR[RXMSK] = 1, the received data is discarded instead of storing the received data in the receive FIFO.

Receive data supports a receive data match function that can match received data against one of the two words in DMR0 and DMR1 or against a masked data word. You can also configure the data match function to compare only the first one or two received data words since the start of the frame.

- Received data that is already discarded because TCR[RXMSK] = 1 cannot cause the data match to set, and delays the match on the first received data word, until all discarded data is received.
- By using CFGR0[RDMO], you can also configure the receiver match function to discard all received data until a data match is detected.
- After a receive data match, to allow all subsequent data to be received, first write 0 to CFGR0[RDMO], then clear SR[DMF].

73.3.2.3 Partial received word

When the PCS pin deasserts and the receive shift register shifts in a partial word, you can configure the receive shift register to either discard the partial word or to store it in the receive FIFO. You must specify this using CFGR1[PARTIAL].

A partial word is defined as less than TCR[FRAMESZ] bits (when TCR[FRAMESZ] is equal or less than 32 bits, or it is the last word in a multi-word frame) or less than 32 bits (when TCR[FRAMESZ] is greater than 32 bits and not the last word in a multi-word frame).

A single-bit frame is not supported. A partial received word of 1 bit is supported, but a partial received frame of 1 bit is not supported.

73.3.2.4 Clocked interface

LPSPI supports interfacing with external controllers that provide only clock and data pins (PCS is not required). This interface requires:

- Writing 1 to TCR[CPHA] (data is changed on the leading edge of SCK and captured on the following edge).
- Configuring the PCS input to be always asserted (CFGR1[PCSPOL*n*] = 1). For example, to configure PCS[0] to be always asserted, write 1 to PCSPOL[0], and do not configure PCS[0] in the pin muxing. The chip-level drives PCS to a certain value (ideally 1); you could use CFGR1[PCSPOL*n*] to invert that value.
- Writing 1 to CFGR1[AUTOPCS] to enable automatic PCS generation. When CFGR1[AUTOPCS] = 1, a minimum of four LPSPI functional clock cycles (divided by the selection specified in TCR[PRESCALE]) is required between the last SCK edge of one word and the first SCK edge of the next word.

73.3.3 Debug mode

Table 495. Debug mode

Chip mode	LPSPI operation
Debug (the core is in Debug or Halted mode)	Can continue operating in Debug mode, if CR[DBGEN] = 1

73.3.4 Clocking

Table 496. LPSPI clocks

Type of clock	Description
Functional	• Asynchronous to the bus clock. • If the LPSPI functional clock remains enabled in low-power modes, then LPSPI can perform SPI bus transfers and low-power wakeups in both Controller and Peripheral modes. • LPSPI divides the functional clock by a prescaler; the resulting frequency must be at least two times faster than the SPI external clock frequency (SCK).
External	• The LPSPI shift register is clocked directly by the SCK clock. • How the SCK clock is generated or supplied depends on the mode (Controller or Peripheral): — In Controller mode, the SCK clock is generated internally. — In Peripheral mode, the SCK clock is supplied externally.
Bus	The bus clock is only used for bus accesses to the LPSPI control and configuration registers. The bus clock frequency must be high enough to support the data bandwidth requirements of the LPSPI registers, including the FIFOs.

See the chip-specific LPSPI information for more.

73.3.5 Reset

Table 497. LPSPI resets

Type of reset	Description
Chip	Resets the LPSPI logic and registers to their default states.
Software	• Resets the LPSPI logic and registers to their default states, except for the Control register. • The LPSPI software reset is controlled using CR[RST].
FIFO	• Resets the transmit and command FIFO and the receive FIFO. • CR[RTF] and CR[RRF] are write-only. • After being reset, FIFO is empty.

73.3.6 Interrupts and DMA requests

The following table lists sources (status flags) that can generate LPSPI interrupts and LPSPI transmit and receive DMA requests.

Table 498. Interrupts and DMA requests

Status (SR)		Description	Can generate		
Status flag	Name		Interrupt?	DMA request?	Low-power wake-up?
TDF	Transmit data flag	Indicates that data can be written to transmit FIFO, as configured by the transmit FIFO watermark, FCR[TXWATER].	Y	TX	Y

Table continues on the next page...

Table 498. Interrupts and DMA requests (continued)

Status (SR)		Description	Can generate		
Status flag	Name		Interrupt?	DMA request?	Low-power wake-up?
RDF	Receive data flag	Indicates that data can be read from the receive FIFO, as configured by the receive FIFO watermark, FCR[RXWATER].	Y	RX	Y
WCF	Word complete flag	Indicates that the word is complete and the last bit of the word has been sampled.	Y	N	Y
FCF	Frame complete flag	Indicates that the frame is complete and PCS is deasserted.	Y	N	Y
TCF	Transfer complete flag	Indicates that transfer is complete, PCS is deasserted, and the transmit and command FIFO is empty.	Y	N	Y
TEF	Transmit error flag	Indicates a transmit and command FIFO underrun. In Controller mode, when CFGR1[NOSTALL] = 0 (transfers stall when transmit FIFO is empty), TEF cannot be set.	Y	N	Y
REF	Receive error flag	Indicates a receive FIFO overflow. In Controller mode, when CFGR1[NOSTALL] = 0 (transfers stall when receive FIFO is full), REF cannot be set.	Y	N	Y
DMF	Data match flag	Indicates that the received data matches the configured data match value.	Y	N	Y
MBF	Module busy flag	Indicates that LPSPI is busy performing an SPI bus transfer.	N	N	N

73.3.6.1 DMA support registers

To support efficient DMA transfers to the transmit and control FIFO, an alias register supports 32-bit write access to the Transmit Command (TCR) and an alias region supports incrementing 32-bit write accesses to the Transmit Data (TDR).

- Transmit Command Burst (TCBR) is a 32-bit alias register for writing to TCR.
- Transmit Data Burst (TDBR0 - TDBR127) is a 512-byte alias region that supports writing to the TDR.

The burst alias locations are contiguous. A DMA transfer can start by writing to the TCBR register to initialize the transfer and then increment into the TDBR region without changing the DMA transfer size. The alias registers can also be used by the DMA to perform burst transfers when accessing the transmit FIFO.

The transmit FIFO prevents writes that overflow the FIFO, but this prevention does not signal an error. Do not perform writes to the TDBR unless there is sufficient room in the transmit FIFO.

Receive Data Burst (RDBR0 - RDBR127) is a 512-byte alias region that supports reading the Receive Data. This can be used by the DMA to perform burst transfers when accessing the receive FIFO.

73.3.7 Peripheral triggers

The connection of the LPSPI peripheral triggers with other peripherals depends on the device that is used.

Table 499. Peripheral triggers

Type of trigger	Description	Additional information
Frame output	The frame output trigger: • Asserts at the end of each frame (when PCS deasserts). • Remains asserted for one cycle of the LPSPI functional clock divided by the configuration defined in TCR[PRESCALE].	LPSPI generates two output triggers that can be connected to other peripherals on the chip.
Word output	The word output trigger: • Asserts at the end of each received word. • Remains asserted for one cycle of the LPSPI functional clock divided by the configuration defined in TCR[PRESCALE].	
Input	To control the start of an LPSPI bus transfer, the LPSPI input trigger can be selected instead of the HREQ input: • The LPSPI input trigger is synchronized, and must assert for at least two cycles of the LPSPI functional clock divided by the configuration defined in TCR[PRESCALE] so that the input trigger can be detected. • When LPSPI is busy, the HREQ input (and therefore the LPSPI input trigger) is ignored. • When LPSPI is busy, both the HREQ and LPSPI input triggers are ignored. They are used to start a new transfer when LPSPI is idle.	

73.4 External signals

Table 500. External signals

Signal	Name	Description	I/O
SCK	Serial clock	• Input in Peripheral mode • Output in Controller mode	I/O
PCS[0]	Peripheral chip select	• Input in Peripheral mode • Output in Controller mode	I/O
PCS[1]/HREQ	Peripheral chip select or host request	Host request pin is selected when CFGR0[HREN] = 1 and CFGR0[HRSEL] = 0: • Input in either Peripheral mode or when used as controller host request • Output in either Controller mode or when used as peripheral host request	I/O
PCS[2]/DATA[2]	Peripheral chip select or data pin 2 during parallel data transfers	When CFGR1[PCSCFG] = 0: • Input in Peripheral mode • Output in Controller mode When CFGR1[PCSCFG] = 1:	I/O

Table continues on the next page...

Table 500. External signals (continued)

Signal	Name	Description	I/O
		• Input in half-duplex parallel data receive transfers • Output in half-duplex parallel data transmit transfers	
PCS[3]/DATA[3]	Peripheral chip select or data pin 3 during parallel data transfers	When CFGR1[PCSCFG] = 0: • Input in Peripheral mode • Output in Controller mode When CFGR1[PCSCFG] = 1: • Input in half-duplex parallel data receive transfers • Output in half-duplex parallel data transmit transfers	I/O
PCS[4]/DATA[4]	Peripheral chip select or data pin 4 during parallel data transfers	When CFGR1[PCSCFG] = 0: • Input in Peripheral mode • Output in Controller mode When CFGR1[PCSCFG] = 11b: • Input in half-duplex parallel data receive transfers • Output in half-duplex parallel data transmit transfers	I/O
PCS[5]/DATA[5]	Peripheral chip select or data pin 5 during parallel data transfers	When CFGR1[PCSCFG] = 0: • Input in Peripheral mode • Output in Controller mode When CFGR1[PCSCFG] = 11b: • Input in half-duplex parallel data receive transfers • Output in half-duplex parallel data transmit transfers	I/O
PCS[6]/DATA[6]	Peripheral chip select or data pin 6 during parallel data transfers	When CFGR1[PCSCFG] = 0: • Input in Peripheral mode • Output in Controller mode When CFGR1[PCSCFG] = 11b: • Input in half-duplex parallel data receive transfers • Output in half-duplex parallel data transmit transfers	I/O

Table continues on the next page...

Table 500. External signals (continued)

Signal	Name	Description	I/O
PCS[7]/DATA[7]	Peripheral chip select or data pin 7 during parallel data transfers	When CFGR1[PCSCFG] = 0: • Input in Peripheral mode • Output in Controller mode When CFGR1[PCSCFG] = 11b: • Input in half-duplex parallel data receive transfers • Output in half-duplex parallel data transmit transfers	I/O
SOUT/DATA[0]	Serial data output	Can be configured as serial data input signal (used as data pin 0 in half-duplex parallel data transfers)	I/O
SIN/DATA[1]	Serial data input	Can be configured as serial data output signal (used as data pin 1 in half-duplex parallel data transfers)	I/O

73.5 Initialization

This module does not require initialization.

73.6 Memory map and registers

NOTE

- Writing to a read-only register or reading a write-only register can cause bus errors.
- LPSPI does not check values programmed in registers for validity, so you must take care to write valid values only.

73.6.1 LPSPI register descriptions

73.6.1.1 LPSPI memory map

LPSPI_0 base address: 4035_8000h

LPSPI_1 base address: 4035_C000h

LPSPI_2 base address: 4036_0000h

LPSPI_3 base address: 4036_4000h

LPSPI_4 base address: 404B_C000h

LPSPI_5 base address: 404C_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VERID)	32	R	0200_0004h
4h	Parameter (PARAM)	32	R	See section

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
10h	Control (CR)	32	RW	0000_0000h
14h	Status (SR)	32	RW	0000_0001h
18h	Interrupt Enable (IER)	32	RW	0000_0000h
1Ch	DMA Enable (DER)	32	RW	0000_0000h
20h	Configuration 0 (CFGR0)	32	RW	0000_0000h
24h	Configuration 1 (CFGR1)	32	RW	0000_0000h
30h	Data Match 0 (DMR0)	32	RW	0000_0000h
34h	Data Match 1 (DMR1)	32	RW	0000_0000h
40h	Clock Configuration (CCR)	32	RW	0000_0000h
44h	Clock Configuration 1 (CCR1)	32	RW	0000_0000h
58h	FIFO Control (FCR)	32	RW	0000_0000h
5Ch	FIFO Status (FSR)	32	R	0000_0000h
60h	Transmit Command (TCR)	32	RW	0000_001Fh
64h	Transmit Data (TDR)	32	W	0000_0000h
70h	Receive Status (RSR)	32	R	0000_0002h
74h	Receive Data (RDR)	32	R	0000_0000h
78h	Receive Data Read Only (RDROR)	32	R	0000_0000h
3FCh	Transmit Command Burst (TCBR)	32	W	0000_0000h
400h - 5FCh	Transmit Data Burst (TDBR0 - TDBR127)	32	W	0000_0000h
600h - 7FCh	Receive Data Burst (RDBR0 - RDBR127)	32	R	0000_0000h

73.6.1.2 Version ID (VERID)

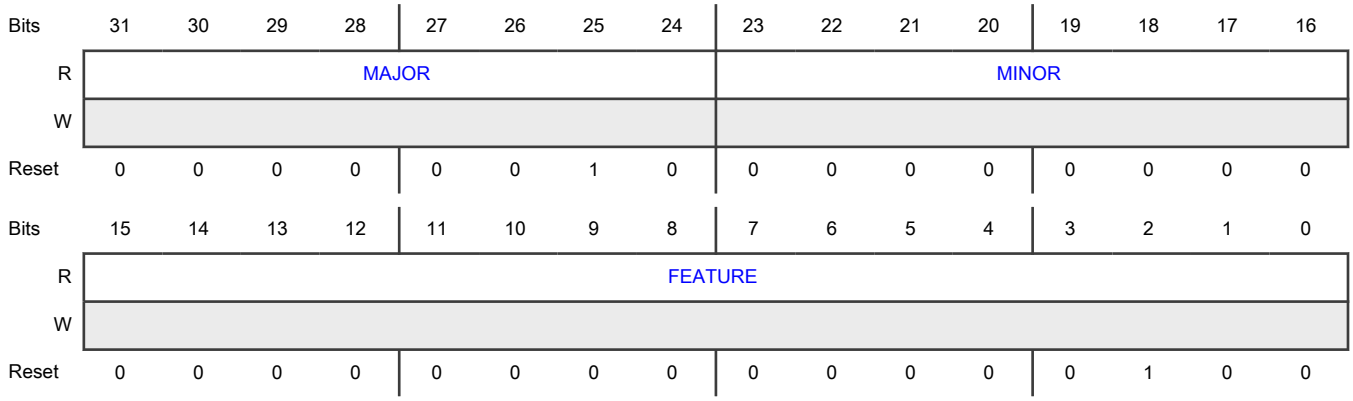
Offset

Register	Offset
VERID	0h

Function

Contains version numbers for the module design and feature set.

Diagram



Fields

Field	Function
31-24 MAJOR	Major Version Number Indicates the major version number of the module specification.
23-16 MINOR	Minor Version Number Indicates the minor version number of the module specification.
15-0 FEATURE	Module Identification Number Indicates the feature set number 0000_0000_0000_0100b - Standard feature set supporting a 32-bit shift register. All other values are reserved.

73.6.1.3 Parameter (PARAM)

Offset

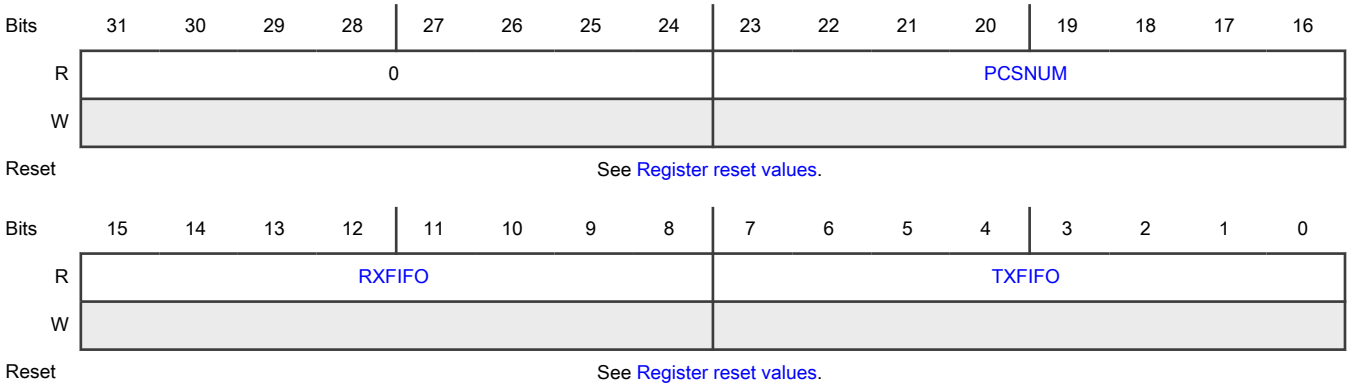
Register	Offset
PARAM	4h

Function

Contains:

- Number of PCS pins.
- Receive FIFO size.
- Transmit FIFO size.

Diagram



Register reset values

Register	Reset value
PARAM	LPSPI_0: 0008_0202h LPSPI_1: 0006_0202h LPSPI_2–LPSPI_5: 0004_0202h

Fields

Field	Function
31-24 —	Reserved
23-16 PCSNUM	PCS Number Indicates the number of PCS pins supported.
15-8 RXFIFO	Receive FIFO Size Indicates the maximum number of words in the receive FIFO. The maximum number of words is 2^{RXFIFO}.
7-0 TXFIFO	Transmit FIFO Size Indicates the maximum number of words in the transmit FIFO. The maximum number of words is 2^{TXFIFO}.

73.6.1.4 Control (CR)

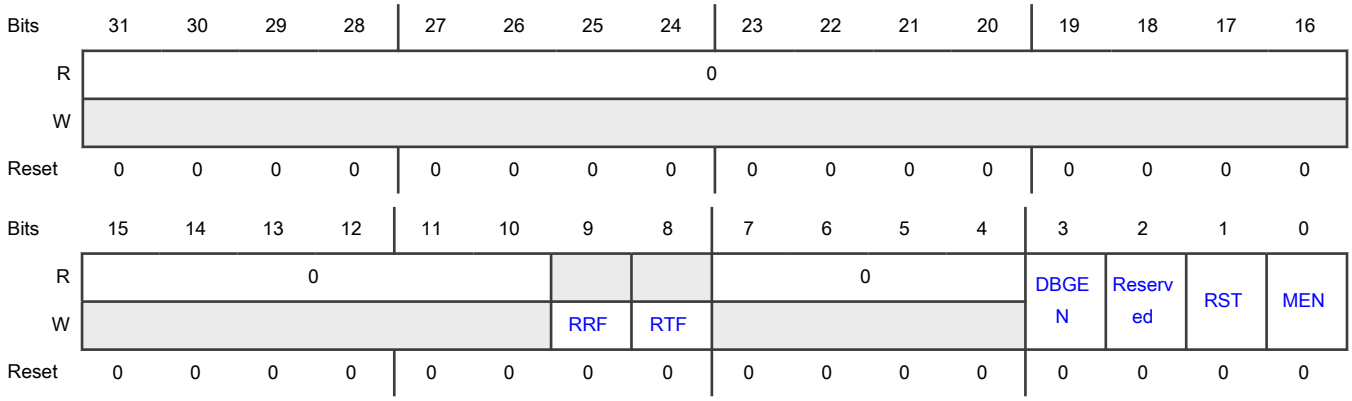
Offset

Register	Offset
CR	10h

Function

Contains fields that control the module operation.

Diagram



Fields

Field	Function
31-10 —	Reserved
9 RRF	Reset Receive FIFO Deletes all entries in the receive FIFO. This field always reads 0. 0b - No effect 1b - Reset
8 RTF	Reset Transmit FIFO Deletes all entries in the transmit FIFO. This field always reads 0. 0b - No effect 1b - Reset
7-4 —	Reserved
3 DBGEN	Debug Enable Enables LPSPI when the CPU is in Debug mode. If this field is 0, LPSPI is disabled when the CPU is halted; the PCS pin is deasserted after the transmit FIFO is empty regardless of the state of Transmit Command (TCR). You must update this field only when LPSPI is disabled (MEN = 0). 0b - Disable 1b - Enable
2 —	Reserved
1	Software Reset

Table continues on the next page...

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Field	Function
RST	Resets all internal logic and registers, except Control (CR). The reset takes effect immediately and remains asserted until you write 0 to it. There is no minimum delay required before clearing the software reset by writing 0. 0b - Not reset 1b - Reset
0 MEN	Module Enable Enables the module. After writing 0, MEN remains set until LPSPI has completed the current transfer and is idle. 0b - Disable 1b - Enable

73.6.1.5 Status (SR)

Offset

Register	Offset
SR	14h

Function
Contains data flow status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0							MBF	0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		DMF	REF	TEF	TCF	FCF	WCF	0						RDF	TDF
W			W1C	W1C	W1C	W1C	W1C	W1C								
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-25	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
24 MBF	Module Busy Flag Indicates, in Controller mode, whether there is data to transmit and LPSPI is able to transmit (for example, the HREQ pin is asserted). The HREQ pin deasserts after the PCS pin deasserts and the LPSPI controller has waited for half the time specified in CCR[DBT] with no new data to transmit. Peripheral mode sets this flag when LPSPI is enabled and PCS is asserted. 0b - LPSPI is idle 1b - LPSPI is busy
23-14 —	Reserved
13 DMF	Data Match Flag Indicates whether the received data matches DMR0[MATCH0] and/or DMR1[MATCH1] (as configured by CFGR1[MATCFG]). **NOTE** This field behaves differently for register reads and writes. When reading 0b - No match 1b - Match When writing 0b - No effect 1b - Clear the flag
12 REF	Receive Error Flag Indicates a receive FIFO overflow error. When this flag is set: 1. End the transfer. 2. Empty the receive FIFO. 3. Clear this flag. 4. Restart the transfer from the beginning. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No overflow 1b - Overflow When writing

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No effect 1b - Clear the flag
11 TEF	Transmit Error Flag Indicates a transmit FIFO underrun error. When this flag is set: 1. End the transfer. 2. Clear this flag. 3. Restart the transfer from the beginning. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No underrun 1b - Underrun When writing 0b - No effect 1b - Clear the flag
10 TCF	Transfer Complete Flag Indicates, in Controller mode, whether all transfers are complete and LPSPI has returned to the Idle state and the transmit FIFO is empty. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not complete 1b - Complete When writing 0b - No effect 1b - Clear the flag
9 FCF	Frame Complete Flag Indicates whether a frame transfer is complete after PCS deasserts. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not complete

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Complete When writing 0b - No effect 1b - Clear the flag
8 WCF	Word Complete Flag Indicates whether the last bit of a received word is sampled. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not complete 1b - Complete When writing 0b - No effect 1b - Clear the flag
7-2 —	Reserved
1 RDF	Receive Data Flag Indicates whether the number of words in the receive FIFO is greater than the value in FCR[RXWATER]. 0b - Receive data not ready 1b - Receive data ready
0 TDF	Transmit Data Flag Indicates whether the number of words in the transmit FIFO is equal to or less than the value in FCR[TXWATER]. 0b - Transmit data not requested 1b - Transmit data requested

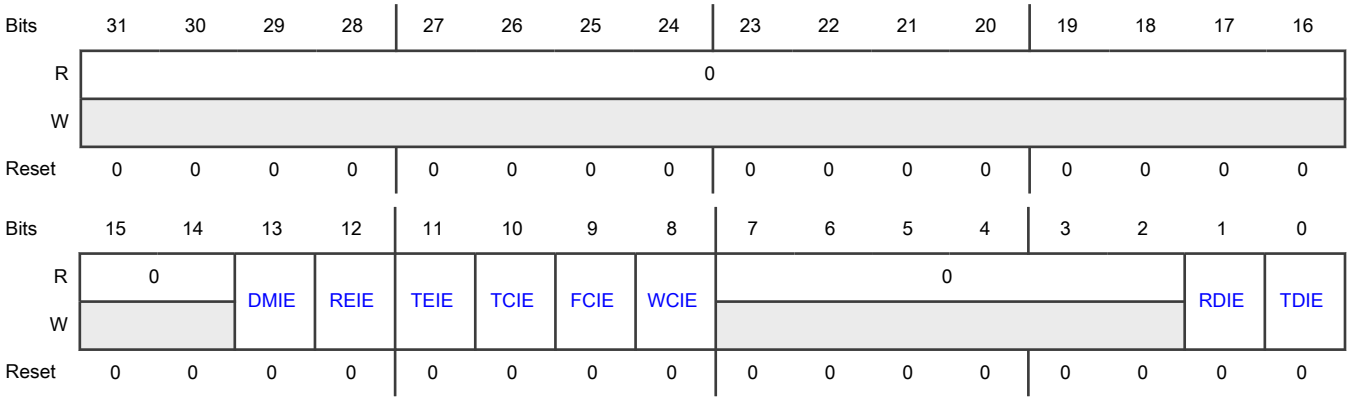
73.6.1.6 Interrupt Enable (IER)

Offset

Register	Offset
IER	18h

Function
Enables interrupts based on data flow and errors.

Diagram



Fields

Field	Function
31-14 —	Reserved
13 DMIE	Data Match Interrupt Enable Enables the data match interrupt. 0b - Disable 1b - Enable
12 REIE	Receive Error Interrupt Enable Enables the receive error interrupt. 0b - Disable 1b - Enable
11 TEIE	Transmit Error Interrupt Enable Enables the transmit error interrupt. 0b - Disable 1b - Enable
10 TCIE	Transfer Complete Interrupt Enable Enables the transfer complete interrupt. 0b - Disable 1b - Enable
9 FCIE	Frame Complete Interrupt Enable Enables the frame complete interrupt. 0b - Disable 1b - Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
8 WCIE	Word Complete Interrupt Enable Enables the word complete interrupt. 0b - Disable 1b - Enable
7-2 —	Reserved
1 RDIE	Receive Data Interrupt Enable Enables the receive data interrupt. 0b - Disable 1b - Enable
0 TDIE	Transmit Data Interrupt Enable Enables the transmit data interrupt. 0b - Disable 1b - Enable

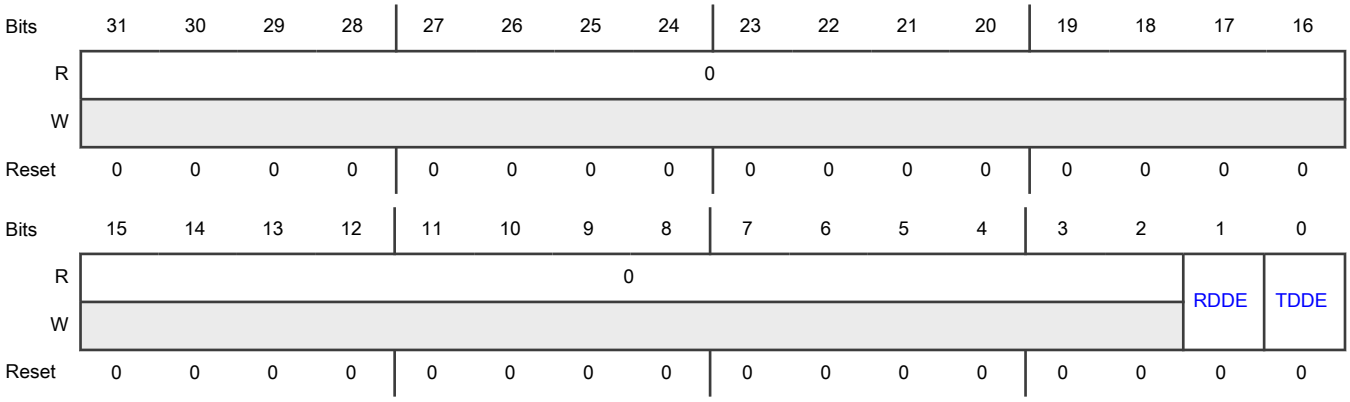
73.6.1.7 DMA Enable (DER)

Offset

Register	Offset
DER	1Ch

Function
Enables the DMA data flow.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 RDDE	Receive Data DMA Enable Enables the receive data DMA. 0b - Disable 1b - Enable
0 TDDE	Transmit Data DMA Enable Enables the transmit data DMA. 0b - Disable 1b - Enable

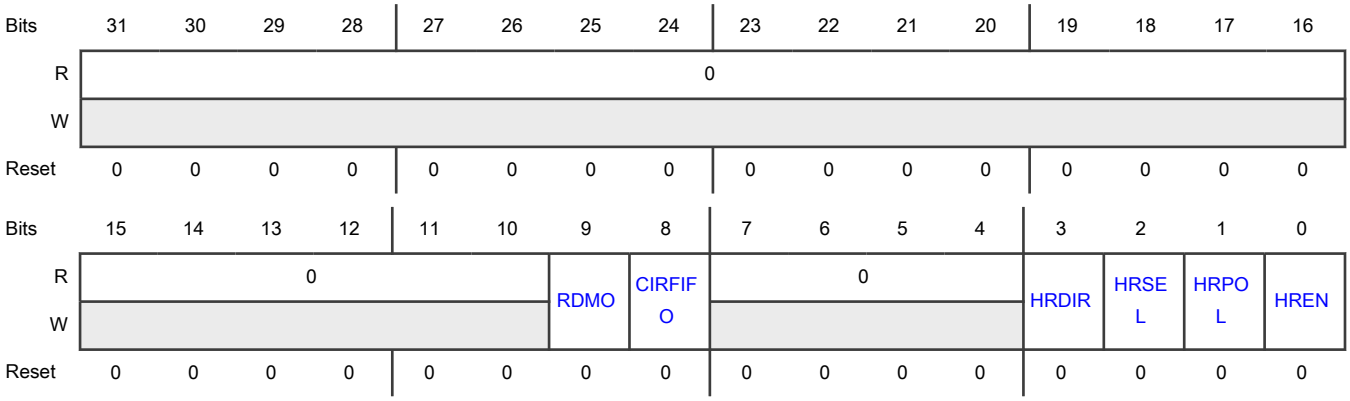
73.6.1.8 Configuration 0 (CFGR0)

Offset

Register	Offset
CFGR0	20h

Function
Includes fields to configure LPSPI.

Diagram



Fields

Field	Function
31-10 —	Reserved
9 RDMO	Receive Data Match Only Enables receive data match. When enabled, all received data that does not cause SR[DMF] to assert is discarded: • Write 1 to this field when LPSPI is idle and SR[DMF] = 0. • After SR[DMF] = 1, this field is ignored. • To ensure that no receive data is lost when disabling RDMO, write 0 to this field before clearing SR[DMF]. See CFGR1[MATCFG] for the received data matching options. When disabled, all received data is stored in the receive FIFO. 0b - Disable 1b - Enable
8 CIRFIFO	Circular FIFO Enable Enables circular FIFO. When enabled, the transmit FIFO read pointer is saved to a temporary register. The transmit FIFO is emptied as in normal operation, but when LPSPI is idle and the transmit FIFO is empty, the read pointer value is restored from the temporary register. This restoring of the read pointer causes the contents of the transmit FIFO to be cycled through repeatedly. **NOTE** The read pointer is restored for as long as this field is 1. Writing additional words to the FIFO when this field is 1 adds them to the end of the FIFO, up to the size of the transmit FIFO. 0b - Disable 1b - Enable
7-4 —	Reserved
3 HRDIR	Host Request Direction Specifies the direction of the HREQ pin. You must configure the HREQ pin only as an output when LPSPI is in Peripheral mode. The HREQ pin direction must be an input for Controller mode. 0b - Input 1b - Output
2 HRSEL	Host Request Select Specifies the source of the host request input. When the host request function is enabled with the HREQ pin, the PCS[1] function is disabled.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - HREQ pin 1b - Input trigger
1 HRPOL	Host Request Polarity Specifies the polarity of the HREQ pin or input trigger. 0b - Active high 1b - Active low
0 HREN	Host Request Enable Enables LPSPI, in Controller mode, to start a new SPI bus transfer only if the host request input is asserted. When LPSPI is busy, the host request input is ignored. In Peripheral mode, causes the HREQ output pin to assert when data is available to be transmitted. 0b - Disable 1b - Enable

73.6.1.9 Configuration 1 (CFGR1)

Offset

Register	Offset
CFGR1	24h

Function

Includes fields to configure LPSPI. You must write to this register only when LPSPI is disabled.

In addition to pin and output configurations, this register contains match configuration details; the following table shows match conditions specified in MATCFG.

Table 501. Match conditions for CFGR1[MATCFG]

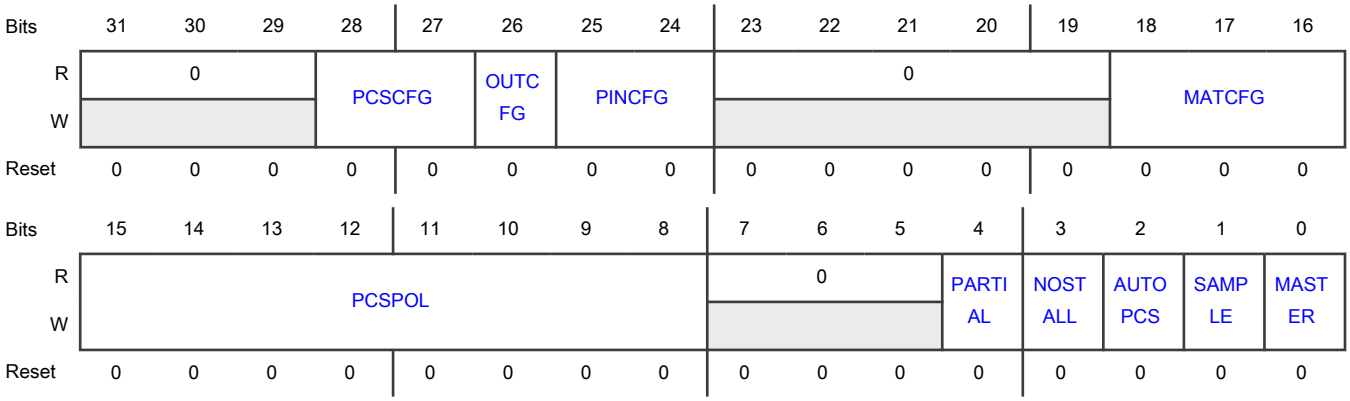
Condition	Description
Match first data word with compare word	Match if first data word equals MATCH0 logically ORed with MATCH1 first_data_word == (MATCH0 || MATCH1)
Match any data word with compare word	Match if any data word equals MATCH0 logically ORed with MATCH1 any_data_word == (MATCH0 || MATCH1)
Sequential match, first data word	Match if first data word equals MATCH0, and second data word equals MATCH1 (first_data_word == MATCH0) && (second_data_word == MATCH1)
Sequential match, any data word	Match if any data word equals MATCH0, and the next data word equals MATCH1

Table continues on the next page...

Table 501. Match conditions for CFGR1[MATCFG] (continued)

Condition	Description
	(any_data_word == MATCH0) && (next_data_word == MATCH1)
Match first data word (masked) with compare word (masked)	Match if first data word logically ANDed with MATCH1 equals MATCH0 logically ANDed with MATCH1 (first_data_word && MATCH1) == (MATCH0 && MATCH1)
Match any data word (masked) with compare word (masked)	Match if any data word logically ANDed with MATCH1 equals MATCH0 logically ANDed with MATCH1 (any_data_word && MATCH1) == (MATCH0 && MATCH1)

Diagram



Fields

Field	Function
31-29 —	Reserved
28-27 PCSCFG	Peripheral Chip Select Configuration Specifies PCS pin configuration. When performing parallel transfers, you must configure this field to enable the desired transfer. **NOTE** This field is not supported in every instance. The following table includes only supported registers.

Instance	Field supported in	Field not supported in
LPSPI_0	CFGR1	—
LPSPI_1	CFGR1[27]	CFGR1[28]
LPSPI_2	CFGR1[27]	CFGR1[28]

Field	Function
	<table><tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr><tr><td>LPSPI_3</td><td>CFGR1[27]</td><td>CFGR1[28]</td></tr><tr><td>LPSPI_4</td><td>CFGR1[27]</td><td>CFGR1[28]</td></tr><tr><td>LPSPI_5</td><td>CFGR1[27]</td><td>CFGR1[28]</td></tr></table> **NOTE** The descriptions of the field settings vary by module instance. <table><tr><th>Instance</th><th>Field value and description</th></tr><tr><td>LPSPI_0</td><td>00b - PCS[7:2] configured for chip select function 01b - PCS[3:2] configured for half-duplex 4-bit transfers (PCS[3:2] = DATA[3:2]) 11b - PCS[7:2] configured for half-duplex 4-bit and 8-bit transfers (PCS[7:2] = DATA[7:2])</td></tr><tr><td>LPSPI_1</td><td>0b - PCS[5:2] configured for chip select function 1b - PCS[3:2] configured for half-duplex 4-bit transfers (PCS[3:2] = DATA[3:2])</td></tr><tr><td>LPSPI_2</td><td>0b - PCS[3:2] configured for chip select function 1b - PCS[3:2] configured for half-duplex 4-bit transfers (PCS[3:2] = DATA[3:2])</td></tr><tr><td>LPSPI_3</td><td>0b - PCS[3:2] configured for chip select function 1b - PCS[3:2] configured for half-duplex 4-bit transfers (PCS[3:2] = DATA[3:2])</td></tr><tr><td>LPSPI_4</td><td>0b - PCS[3:2] configured for chip select function 1b - PCS[3:2] configured for half-duplex 4-bit transfers (PCS[3:2] = DATA[3:2])</td></tr><tr><td>LPSPI_5</td><td>0b - PCS[3:2] configured for chip select function 1b - PCS[3:2] configured for half-duplex 4-bit transfers (PCS[3:2] = DATA[3:2])</td></tr></table>
26 OUTCFG	Output Configuration Specifies whether the output data is 3-stated between accesses (when PCS is deasserted). When performing half-duplex transfers, this field must be 1.

Table continues on the next page...

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Field	Function
	0b - Retain last value 1b - 3-stated
25-24 PINCFG	Pin Configuration Specifies the pins used for input and output data during serial transfers. This field is ignored when performing parallel transfers. 00b - SIN is used for input data; SOUT is used for output data 01b - SIN is used for both input and output data; only half-duplex serial transfers are supported 10b - SOUT is used for both input and output data; only half-duplex serial transfers are supported 11b - SOUT is used for input data; SIN is used for output data
23-19 —	Reserved
18-16 MATCFG	Match Configuration Specifies the condition that causes SR[DMF] to assert. See the match conditions listed in Table 1 for more information. **NOTE** When writing to this field, either the old value or new value must be in the disabled state (0). You cannot transition from a nonzero value to another nonzero value. 000b - Match is disabled 001b - Reserved 010b - Match first data word with compare word 011b - Match any data word with compare word 100b - Sequential match, first data word 101b - Sequential match, any data word 110b - Match first data word (masked) with compare word (masked) 111b - Match any data word (masked) with compare word (masked)
15-8 PCSPOL	Peripheral Chip Select Polarity Specifies the polarity of each PCS pin. Bit *n* in this field (the least-significant bit is bit 0) corresponds to PCS[*n*]. **NOTE** This field is not supported in every instance. The following table includes only supported registers.

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPSPI_0</td><td>CFGR1</td><td>—</td></tr>
<tr><td>LPSPI_1</td><td>CFGR1[13–8]</td><td>CFGR1[15–14]</td></tr>
<tr><td>LPSPI_2</td><td>CFGR1[11–8]</td><td>CFGR1[15–12]</td></tr>
<tr><td>LPSPI_3</td><td>CFGR1[11–8]</td><td>CFGR1[15–12]</td></tr>
<tr><td>LPSPI_4</td><td>CFGR1[11–8]</td><td>CFGR1[15–12]</td></tr>
<tr><td>LPSPI_5</td><td>CFGR1[11–8]</td><td>CFGR1[15–12]</td></tr>
</table>
NOTE
The descriptions of the field settings vary by module instance.
<table>
<tr><th>Instance</th><th>Field value and description</th></tr>
<tr><td>LPSPI_0</td><td>0000_0000b - Active low
0000_0001b - Active high</td></tr>
<tr><td>LPSPI_1</td><td>00_0000b - Active low
00_0001b - Active high</td></tr>
<tr><td>LPSPI_2</td><td>0000b - Active low
0001b - Active high</td></tr>
<tr><td>LPSPI_3</td><td>0000b - Active low
0001b - Active high</td></tr>
<tr><td>LPSPI_4</td><td>0000b - Active low
0001b - Active high</td></tr>
<tr><td>LPSPI_5</td><td>0000b - Active low
0001b - Active high</td></tr>
</table>
</td></tr>
<tr><td>7-5
—</td><td>Reserved</td></tr>
<tr><td>4
PARTIAL</td><td>Partial Enable</td></tr>
</table>

Table continues on the next page...

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Field	Function
	Specifies whether LPSPI, when in Peripheral mode, stores a partial received word in the receive FIFO, or discards it, when PCS deasserts. See Partial received word for more information. 0b - Discard 1b - Store
3 NOSTALL	No Stall Disables a normal operating feature that causes LPSPI, when in Controller mode, to stall transfers when the transmit FIFO is empty or when the receive FIFO is full. This feature prevents transmit FIFO underruns and receive FIFO overruns. Writing 1 to this field disables this functionality. 0b - Disable 1b - Enable
2 AUTOPCS	Automatic PCS Enables automatic PCS generation. For correct operation in Peripheral mode, LPSPI requires the PCS signal to deassert between frames. Writing 1 to this field generates an internal PCS signal at the end of each transfer word when TCR[CPHA] = 1. When this field is 1, SCK must remain idle for at least four LPSPI functional clock cycles, divided by the prescaler (see TCR[PRESCALE]) selected between each word to ensure correct operation. This field is ignored in Controller mode. 0b - Disable 1b - Enable
1 SAMPLE	Sample Point Specifies the SCK clock edge on which LPSPI, when in Controller mode, samples input data. Writing 1 to this field causes LPSPI to sample input data on a delayed loopback SCK clock edge, which improves the setup time when sampling data (see Clock loopback). In this configuration, the input data setup time in Controller mode is equal to the input data setup time in Peripheral mode. In Peripheral mode, this field is ignored. **NOTE** When SAMPLE = 1, both the input and output buffers must be enabled for the SCK pin. Buffers are configured at the chip level. 0b - SCK edge 1b - Delayed SCK edge
0 MASTER	Controller Mode Specifies the LPSPI operating mode, Controller or Peripheral. This field directly controls the direction of the SCK and PCS pins. 0b - Peripheral mode 1b - Controller mode

73.6.1.10 Data Match 0 (DMR0)

Offset

Register	Offset
DMR0	30h

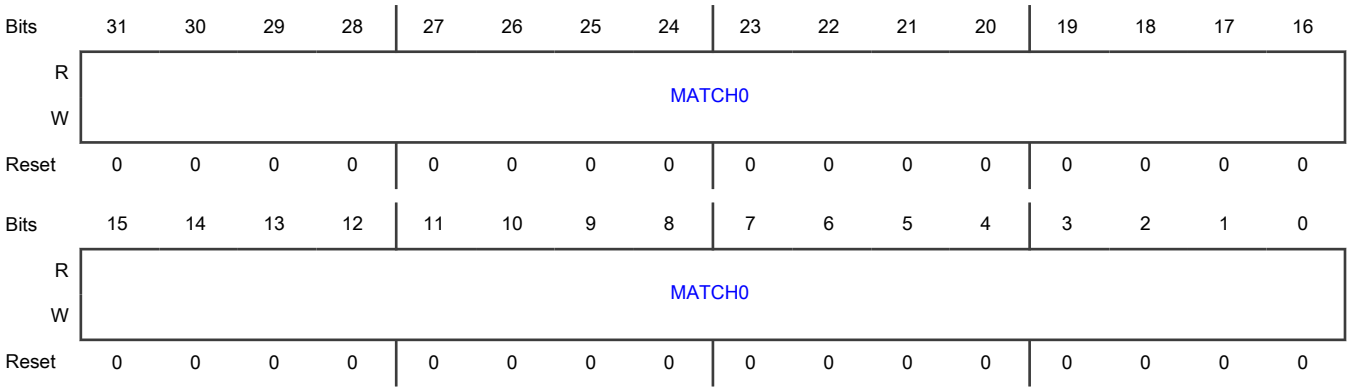
Function

Specifies the match data to be used when data matching is enabled. See CFGR1[MATCFG] for the received data matching options.

NOTE

Do not change the value in this register when CFGR1[MATCFG] > 0.

Diagram



Fields

Field	Function
31-0 MATCH0	Match 0 Value Specifies the MATCH0 value to be compared against received data.

73.6.1.11 Data Match 1 (DMR1)

Offset

Register	Offset
DMR1	34h

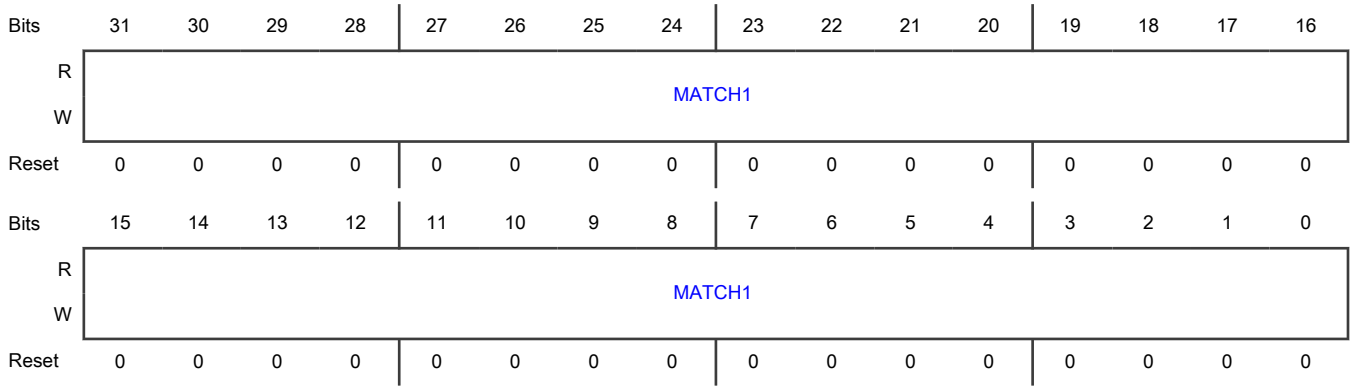
Function

Specifies the match data to be used when data matching is enabled. See CFGR1[MATCFG] for the received data matching options.

NOTE

Do not change the value in this register while CFGR1[MATCFG] > 0.

Diagram



Fields

Field	Function
31-0 MATCH1	Match 1 Value Specifies the MATCH1 value to be compared against received data.

73.6.1.12 Clock Configuration (CCR)

Offset

Register	Offset
CCR	40h

Function

Contains clock configuration fields that are used only in Controller mode; you can only change them when LPSPI is disabled (CR[MEN] = 0).

Warning

Writing a 32-bit value to this register overwrites Clock Configuration 1 (CCR1); DBT and SCKDIV always read 0.

To avoid overwriting CCR1, do one of the following:

- Write to all four fields in Clock Configuration (CCR) simultaneously and only once in a 32-bit data.
- Modify the values of CCR[SCKPCS] and/or CCR[PCSSCK]; write only these two upper bytes in a 16-bit data or one of them in an 8-bit data.
- Modify CCR1[PCSPCS] and CCR1[SCKSCK] only or CCR1[SCKSET] and CCR1[SCKHLD] only, write respectively to CCR[DBT] or CCR[SCKDIV] in 8-bit data.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SCKPCS								PCSSCK							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0							
W	DBT								SCKDIV							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 SCKPCS	SCK-to-PCS Delay Configures SCK-to-PCS delay. In Controller mode, this field helps you configure the delay from the last SCK edge to PCS negation: • The delay is equal to (SCKPCS + 1) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]). • The minimum delay is one cycle. See Figure 510 for more information.
23-16 PCSSCK	PCS-to-SCK Delay Configures PCS-to-SCK delay. In Controller mode, this field helps you configure the delay from PCS assertion to the first SCK edge: • The delay is equal to (PCSSCK + 1) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]). • The minimum delay is one cycle. See Figure 510 for more information.
15-8 DBT	Delay Between Transfers Configures the delay between transfers. Writing to this field updates the contents of CCR1[PCSPCS] and CCR1[SCKSCK].
7-0 SCKDIV	SCK Divider Updates the contents of CCR1[SCKSET] and CCR1[SCKHLD]. Baud rate = function clock ÷ (2^PRESCALE × (SCKSET + SCKHLD + 2))

73.6.1.13 Clock Configuration 1 (CCR1)

Offset

Register	Offset
CCR1	44h

Function

Contains clock configuration fields, which are used only in Controller mode. You can change them only when LPSPI is disabled (CR[MEN] = 0).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SCKSCK								PCSPCS							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SCKHLD								SCKSET							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 SCKSCK	SCK Inter-Frame Delay Configures SCK inter-frame delay in Controller mode: • This field helps you configure the delay from the last SCK pulse of a frame and the first SCK pulse of the following frame, in a continuous transfer. • The delay is equal to (SCKSCK + 1) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]). • The minimum delay is one cycle. **NOTE** For backward compatibility, writing to CCR[DBT] updates this field with the value written.
23-16 PCSPCS	PCS to PCS Delay Configures PCS to PCS delay in Controller mode: • This field helps you configure the delay from the PCS negation to the next PCS assertion. • The delay is equal to (PCSPCS + PCSPCS + 2) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]).

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Field	Function
	• The minimum delay is two cycles. • Half of the delay (PCSPCS + 1) occurs before PCS assertion and the other half of the delay (PCSPCS + 1) occurs after PCS negation. If the command word is updated between two transfers, then the command word is updated halfway between the PCS negation of the last transfer and PCS assertion of the next transfer. • The command word specifies which PCS signal is used, the polarity and phase of the SCK signal, and the selected prescaler. **NOTE** For backward compatibility, writing to CCR[DBT] updates this field with (DBT÷2) rounded up.
15-8 SCKHLD	SCK Hold Configures the hold phase of the SCK pin in Controller mode: • The hold phase is the delay between the SCK edge that samples the receive data and the SCK edge that drives the transmit data. • It is the SCK low period when CPHA = 0 and CPOL = 1, or CPHA = 1 and CPOL = 0. It is the SCK high period when CPHA = 0, CPOL = 0 and CPHA = 1, CPOL = 1. • The SCK hold phase delay is equal to (SCKHLD + 1) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]). • The minimum delay is one cycle. • The SCK period is equal to (SCKSET + SCKHLD + 2) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]). • The SCK duty cycle is based on the difference between SCKSET and SCKHLD. You must configure both these fields to the same value for a 50/50 duty cycle. See Figure 510 for more information. **NOTE** For backward compatibility, writing to CCR[SCKDIV] updates this field with (SCKDIV ÷ 2) rounded down.
7-0 SCKSET	SCK Setup Configures the setup phase of the SCK pin in Controller mode: • The setup phase is the delay between the SCK edge that drives the transmit data and the SCK edge that samples the receive data. • It is the SCK high period when CPHA = 0 and CPOL = 1, or CPHA = 1 and CPOL = 0. It is the SCK low period when CPHA = 0 and CPOL = 0, or CPHA = 1 and CPOL = 1. • The SCK setup phase delay is equal to (SCKSET + 1) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]). • The minimum delay is one cycle.

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Field	Function
	• The SCK period is equal to (SCKSET + SCKHLD + 2) cycles of the LPSPI functional clock divided by the selected prescaler (see TCR[PRESCALE]). • The SCK duty cycle is based on the difference between SCKSET and SCKHLD. You must configure both these fields to the same value for a 50/50 duty cycle. See Figure 510 for more information. **NOTE** For backward compatibility, writing to CCR[SCKDIV] updates this field with (SCKDIV ÷ 2) rounded up.

73.6.1.14 FIFO Control (FCR)

Offset

Register	Offset
FCR	58h

Function

Contains the receive FIFO and transmit FIFO watermark values.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								0				RXWATER			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0				TXWATER			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-18	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
17-16 RXWATER	Receive FIFO Watermark Causes LPSPI to set SR[RDF] when the number of words in the receive FIFO is greater than RXWATER. Writing a value equal to or greater than the FIFO size truncates the written value.
15-8 —	Reserved
7-2 —	Reserved
1-0 TXWATER	Transmit FIFO Watermark Causes LPSPI to set SR[TDF] when the number of words in the transmit FIFO is equal to or less than TXWATER. Writing a value equal to or greater than the FIFO size truncates the written value.

73.6.1.15 FIFO Status (FSR)

Offset

Register	Offset
FSR	5Ch

Function

Contains fields that indicate the number of words currently stored in the receive and transmit FIFOs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								0					RXCOUNT		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								0					TXCOUNT		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-19 —	Reserved
18-16 RXCOUNT	Receive FIFO Count Indicates the number of words currently stored in the receive FIFO.
15-8 —	Reserved
7-3 —	Reserved
2-0 TXCOUNT	Transmit FIFO Count Indicates the number of words currently stored in the transmit FIFO.

73.6.1.16 Transmit Command (TCR)

Offset

Register	Offset
TCR	60h

Function

Pushes the data into the transmit FIFO, in the same order as written.

When you write to either this register or to Transmit Data (TDR), each write pushes data into the transmit FIFO. You must write to this register only using 32-bit writes, which are tagged and cause the command register to update; after that the entry reaches the top of the FIFO and LPSPI is enabled. This allows changes to the command word and the transmit data itself to be interleaved. That is, writes to the two registers can be interleaved (write command word, then data word, then command word, and so on). Changing the command word causes all subsequent SPI bus transfers to be performed using the new command word:

- In Controller mode, writing a new command word does not initiate a new transfer, unless TXMSK is 1. Transfers are initiated by transmit data in the transmit FIFO, or by a new command word (with TXMSK = 1). Hardware writes 0 to TXMSK when PCS deasserts.
- In Controller mode, if the command word is changed before an existing frame has completed, then the existing frame terminates and the command word updates. The command word can be changed during a continuous transfer, if CONTC of the new command word is 1 and the command word is written on a frame size boundary.
- In Peripheral mode, the command word must be changed only when LPSPI is idle and there is no SPI bus transfer.

Avoid resetting the transmit FIFO after writing to this register; wait for the command register to update from the FIFO first.

Avoid register reading problems: Reading this register returns the current state of the register. Reading this register at the same time that it is loaded from the transmit FIFO can return an incorrect register value. It is recommended to:

- Read this register when the transmit FIFO is empty.
- Read this register more than once and then compare the returned values.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CPOL	CPHA	PRESCALE			PCS			LSBF	BYSW	CONT	CONTC	RXMSK	TXMSK	WIDTH	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved				FRAMESZ											
W	0															
Reset	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1

Fields

Field	Function
31 CPOL	Clock Polarity Specifies the value of SCK when it is idle. You can update this field only when PCS is deasserted. See Figure 510 for more information. 0b - Inactive low 1b - Inactive high
30 CPHA	Clock Phase Indicates whether data is captured or changed on the leading edge of SCK and captured or changed on the following edge of SCK. You can update this field only when PCS is deasserted. See Figure 510 for more information. 0b - Captured 1b - Changed
29-27 PRESCALE	Prescaler Value Specifies the division of the LPSPI functional clock. For all SPI bus transfers, this value is applied to Clock Configuration (CCR). You can update this field only when PCS is deasserted. 000b - Divide by 1 001b - Divide by 2 010b - Divide by 4 011b - Divide by 8 100b - Divide by 16 101b - Divide by 32

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>110b - Divide by 64
111b - Divide by 128</td></tr>
<tr><td>26-24
PCS</td><td>Peripheral Chip Select
Configures the peripheral chip select used for the transfer. This field is updated only when PCS is deasserted.
NOTE
This entire field is not fully supported in every LPSPI module instance. See the chip-specific LPSPI information.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPSPI_0</td><td>TCR</td><td>—</td></tr>
<tr><td>LPSPI_1</td><td>TCR</td><td>—</td></tr>
<tr><td>LPSPI_2</td><td>TCR[25–24]</td><td>TCR[26]</td></tr>
<tr><td>LPSPI_3</td><td>TCR[25–24]</td><td>TCR[26]</td></tr>
<tr><td>LPSPI_4</td><td>TCR[25–24]</td><td>TCR[26]</td></tr>
<tr><td>LPSPI_5</td><td>TCR[25–24]</td><td>TCR[26]</td></tr>
</table>
NOTE
The descriptions of the field settings vary by module instance.
<table>
<tr><th>Instance</th><th>Field value and description</th></tr>
<tr><td>LPSPI_0</td><td>000b - Transfer using PCS[0]
001b - Transfer using PCS[1]
010b - Transfer using PCS[2]
011b - Transfer using PCS[3]
100b - Transfer using PCS[4]
101b - Transfer using PCS[5]
110b - Transfer using PCS[6]
111b - Transfer using PCS[7]</td></tr>
</table>
</td></tr>
</table>

Table continued from the previous page...

Field	Function
	<table><tr><th>Instance</th><th>Field value and description</th></tr><tr><td>LPSPI_1</td><td>000b - Transfer using PCS[0] 001b - Transfer using PCS[1] 010b - Transfer using PCS[2] 011b - Transfer using PCS[3] 100b - Transfer using PCS[4] 101b - Transfer using PCS[5] 110b - Transfer using PCS[6] 111b - Transfer using PCS[7]</td></tr><tr><td>LPSPI_2</td><td>00b - Transfer using PCS[0] 01b - Transfer using PCS[1] 10b - Transfer using PCS[2] 11b - Transfer using PCS[3]</td></tr><tr><td>LPSPI_3</td><td>00b - Transfer using PCS[0] 01b - Transfer using PCS[1] 10b - Transfer using PCS[2] 11b - Transfer using PCS[3]</td></tr><tr><td>LPSPI_4</td><td>00b - Transfer using PCS[0] 01b - Transfer using PCS[1] 10b - Transfer using PCS[2] 11b - Transfer using PCS[3]</td></tr><tr><td>LPSPI_5</td><td>00b - Transfer using PCS[0] 01b - Transfer using PCS[1] 10b - Transfer using PCS[2] 11b - Transfer using PCS[3]</td></tr></table>
23 LSBF	LSB First Indicates whether data is transferred with MSB first or LSB first. 0b - MSB first 1b - LSB first
22	Byte Swap

Table continues on the next page...

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Field	Function
BYSW	Swaps the contents of [31:24] with [7:0] and [23:16] with [15:8] for each transmit data word read from the FIFO and for each received data word stored to the FIFO (or compared with match registers). 0b - Disable byte swap 1b - Enable byte swap
21 CONT	Continuous Transfer Enables continuous transfer: • In Controller mode, this field keeps PCS asserted at the end of the frame size until a command word is received that starts a new frame. • In Peripheral mode, when this field is enabled, LPSPI only transmits the first FRAMESZ bits, after which LPSPI transmits received data (assuming a 32-bit shift register) until the next PCS negation. 0b - Disable 1b - Enable
20 CONTC	Continuing Command Enables the command word to be changed within a continuous transfer in Controller mode: • The initial command word must enable continuous transfer (CONT = 1). • The continuing command must have CONTC = 1. • The continuing command word must be loaded on a frame size boundary. For example, if the continuous transfer has a frame size of 64 bits, then a continuing command word must be loaded on a 64-bit boundary. In Peripheral mode, this field modifies the internal RXMSK and TXMSK configuration after the first FRAMESZ bits and until PCS negation: • Receive data is discarded after the first FRAMESZ bits. If CONT is also 1, this does not block the transmission of received data. • Transmit data is not masked after the first FRAMESZ bits. This allows the first FRAMESZ bits to be received and a response transmitted. 0b - Command word for start of new transfer 1b - Command word for continuing transfer
19 RXMSK	Receive Data Mask Masks receive data (receive data is not stored in the receive FIFO). 0b - Normal transfer 1b - Mask receive data
18 TXMSK	Transmit Data Mask Masks transmit data (no data is loaded from the transmit FIFO and the output pin is 3-stated). In Controller mode, TXMSK initiates a new transfer that cannot be aborted by another command word. TXMSK automatically transitions to 0 at the end of the transfer.

Table continues on the next page...

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Field	Function
	0b - Normal transfer 1b - Mask transmit data
17-16 WIDTH	Transfer Width Configures serial (1-bit) or parallel transfers. For half-duplex parallel transfers, either RXMSK or TXMSK must be 1. **NOTE** The descriptions of the field settings vary by module instance.

Instance	Field value and description
LPSPI_0	00b - 1-bit transfer 01b - 2-bit transfer 10b - 4-bit transfer 11b - 8-bit transfer
LPSPI_1	00b - 1-bit transfer 01b - 2-bit transfer 10b - 4-bit transfer 11b - Reserved
LPSPI_2	00b - 1-bit transfer 01b - 2-bit transfer 10b - 4-bit transfer 11b - Reserved
LPSPI_3	00b - 1-bit transfer 01b - 2-bit transfer 10b - 4-bit transfer 11b - Reserved
LPSPI_4	00b - 1-bit transfer 01b - 2-bit transfer 10b - 4-bit transfer 11b - Reserved
LPSPI_5	00b - 1-bit transfer 01b - 2-bit transfer

Table continues on the next page...

Table continued from the previous page...

Field	Function
	<table><tr><th>Instance</th><th>Field value and description</th></tr><tr><td></td><td>10b - 4-bit transfer 11b - Reserved</td></tr></table>
15-12 —	Reserved
11-0 FRAMESZ	Frame Size Configures the frame size in number of bits equal to (FRAMESZ + 1): • The minimum frame size is 8 bits, or 16 bits for an 8-bit transfer. • If the frame size is larger than 32 bits, then the frame is divided into multiple words of 32 bits; each word is loaded from the transmit FIFO and stored in the receive FIFO separately. • If the size of the frame is not divisible by 32, then the last load of the transmit FIFO and store of the receive FIFO contains the remainder bits. For example, a 72-bit transfer consists of three words: the first and second words are 32 bits, and the third word is 8 bits.

73.6.1.17 Transmit Data (TDR)

Offset

Register	Offset
TDR	64h

Function

Pushes the data into the transmit FIFO, in the same order that the data is written. You can write to this register using 32-, 16-, or 8-bit writes.

When you write to this register or to Transmit Command (TCR), each write pushes data into the FIFO with zero pushed in unwritten bytes.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DATA	Transmit Data Indicates transmit data. Both 8-bit and 16-bit writes of transmit data zero-extend the data written and push the data into the transmit FIFO. To zero-extend 8-bit and 16-bit writes (to 32 bits) means that the higher order (most significant) empty parts of the 8-bit and 16-bit writes are filled with zeroes.

73.6.1.18 Receive Status (RSR)

Offset

Register	Offset
RSR	70h

Function

Contains data flow status fields for receive FIFO.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0														RXEMPTY	SOF
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Fields

Field	Function
31-2 —	Reserved
1 RXEMPTY	RX FIFO Empty Indicates whether the receive FIFO is empty. 0b - Not empty 1b - Empty
0 SOF	Start of Frame Indicates whether this is the first data word received after PCS assertion. 0b - Subsequent data word or RX FIFO is empty (RXEMPTY=1). 1b - First data word

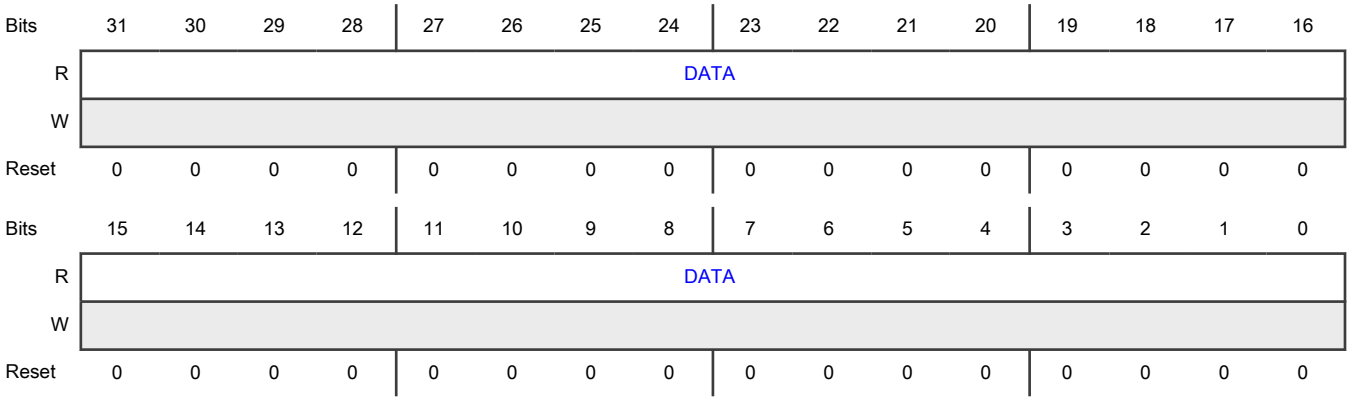
73.6.1.19 Receive Data (RDR)

Offset

Register	Offset
RDR	74h

Function
Pulls the first entry from the receive FIFO.

Diagram



Fields

Field	Function
31-0 DATA	Receive Data

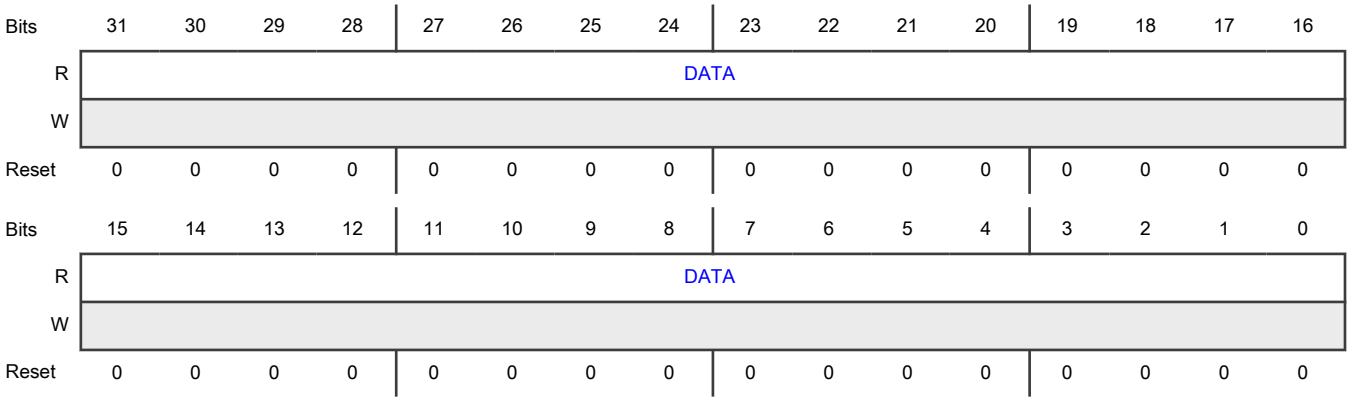
73.6.1.20 Receive Data Read Only (RDROR)

Offset

Register	Offset
RDROR	78h

Function
Returns the first entry in the receive FIFO but does not remove the data from the FIFO.

Diagram



Fields

Field	Function
31-0 DATA	Receive Data

73.6.1.21 Transmit Command Burst (TCBR)

Offset

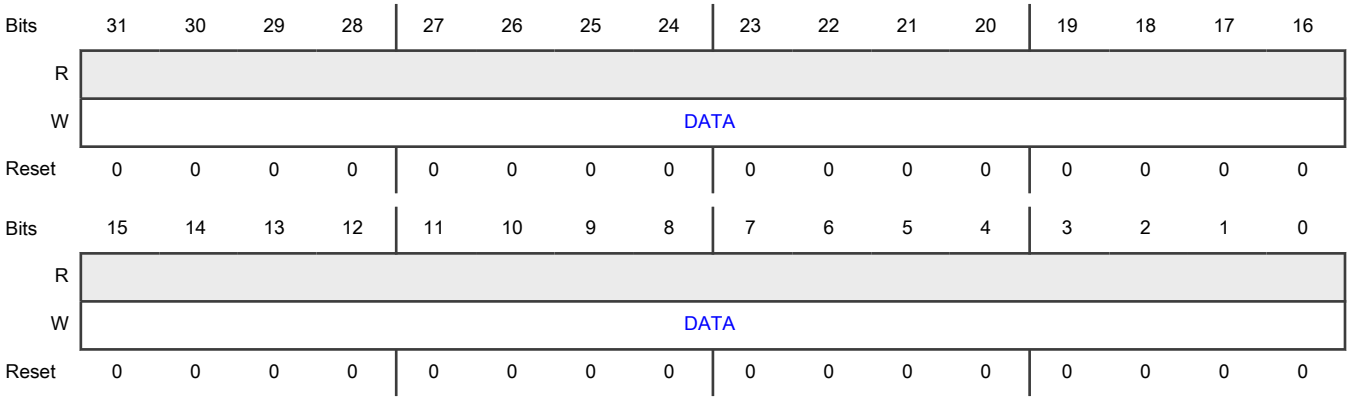
Register	Offset
TCBR	3FCh

Function

Supports burst transfers of command data to the transmit FIFO for use with the DMA controller.

See DMA support registers.

Diagram



Fields

Field	Function
31-0 DATA	Command Data Writes data to Transmit Command (TCR).

73.6.1.22 Transmit Data Burst (TDBR0 - TDBR127)

Offset

For n = 0 to 127:

Register	Offset
TDBRn	400h + (n × 4h)

Function

Supports burst transfers of data to the transmit FIFO for use with the DMA controller. The size of this register is 512 bytes.

See DMA support registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DATA	Data Writes data to Transmit Data (TDR).

73.6.1.23 Receive Data Burst (RDBR0 - RDBR127)

Offset

For n = 0 to 127:

Register	Offset
RDBRn	600h + (n × 4h)

Function

Supports burst transfers of data from the receive FIFO. The size of this register is 512 bytes.

See DMA support registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DATA	Data Reads data from Receive Data (RDR).

73.7 Glossary

PCS	Peripheral chip select
SCK	Serial clock
SDI	Peripheral data in
SDO	Peripheral data out
SS	Peripheral select

Chapter 74
Low Power Inter-Integrated Circuit (LPI2C)

74.1 Chip-specific LPI2C information

74.1.1 LPI2C instances and configuration

This chip has two instances of LPI2C. active="1'd0">[end]

Table 502. LPI2C configuration

Instances	TX FIFO Size	RX FIFO Size	SMBus[1]	Slave Mode Enable
LPI2C_0	4x11 bit	4x8 bit	Yes	Yes
LPI2C_1	4x11 bit	4x8 bit	Yes	Yes

1. System Management Bus

- LPI2C slave mode operation supports up to high speed mode = 3.4MHz (3.4 Mbps data rate; effective data rate reduces according to I2C protocol).
- LPI2C master mode operation supports up to fast Mode = 400KHz (400 kbps data rate; effective data rate reduces according to I2C protocol).
- The LPI2C module includes SMBus (System Management Bus) support and DMA support.
- LPI2C RX FIFO is 8-bit and TX FIFO is 11-bit (8bit data + 3bit command)
- LPI2C supports fast data communication as per I2C standard v3.0.

74.2 Overview

LPI2C supports an efficient interface to an I2C bus as a controller and target:

- Implements logic support for Standard, Fast, Fast+, HS-mode (target only) and Ultra-Fast modes of operation
- Uses little CPU overhead, with DMA offloading of FIFO register accesses

LPI2C also complies with the System Management Bus (SMBus) Specification, version 3. The SMBus is a single-ended simple two-wire bus, which is typically used for low-bandwidth communications.

The Inter-Integrated Circuit (I^2C) serial bus is multi-controller, multi-target, packet-switched, and single-ended, and is often used to attach microcontroller ICs to lower-speed peripheral ICs.

NOTE

Terminology in this chapter has been updated to align with I^2C-bus specification, Rev. 7.0, as shown in Table 503.

Table 503. Updated terms

Updated term	Deprecated term
Controller	Master
Target	Slave

74.2.1 Block diagram

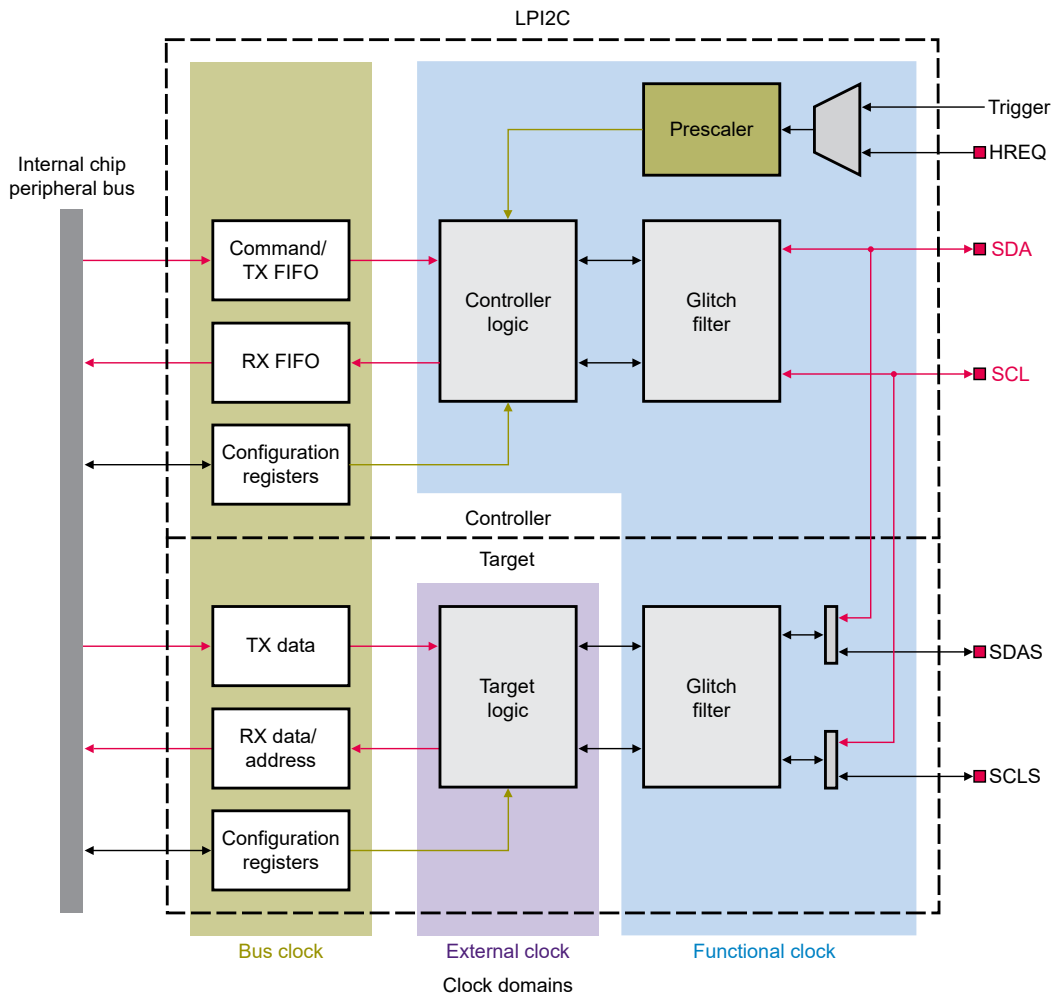


Figure 512. Block diagram

74.2.2 Features

LPI2C supports:

- Standard, Fast, Fast+ and Ultra Fast modes
- HS mode in target mode
- Multicontroller, including synchronization and arbitration, means that any number of controller nodes can be present. Also, controller and target roles can be changed between messages (after a Stop signal is sent).
- Clock stretching. Used on the SCL line, as an I2C flow control mechanism.
- Arbitration for when the system has more than one controller. When used on the SDA line, ensures that there is only one I2C transmitter at a time.
- General call, seven-bit addressing, and ten-bit addressing
- Software reset, Start byte, and device ID (also require software support)

The LPI2C controller supports:

- Command and transmit FIFO of 4 words (8-bit transmit data + 3-bit command)

- Receive FIFO of 4 words (8-bit receive data).
- Command FIFO waiting for an I2C idle bus before initiating a transfer
- Initiation of repeated Start and Stop conditions and one or more controller-receiver transfers by command FIFO
- Stop condition generation from command FIFO, or automatic generation of Stop condition when the transmit FIFO is empty
- Host request input to control the start time of an I2C bus transfer
- Interrupt generation on data match and unwanted data rejection, via flexible receive data match
- Flags and optional interrupt signals at repeated Start condition, Stop condition, loss of arbitration, unexpected NACK, and command word errors
- Configurable bus idle timeout and pin-stuck-low timeout

The LPI2C target supports:

- Separate I2C target registers to minimize software overhead because of controller or target switching
- 7-bit or 10-bit addressing, address range, SMBus alert, and general call address.
- Transmit data register that supports interrupt or DMA requests
- Receive data register that supports interrupt or DMA requests
- Software-controllable ACK or NACK, with optional clock stretching on ACK or NACK field
- Configurable clock stretching, to avoid transmit-FIFO-underrun and receive-FIFO-overrun errors
- Flags and optional interrupt at end of packet, Stop condition, or bit error detection

74.3 Memory map and registers

74.3.1 LPI2C register descriptions

Writing to a read-only register or reading from a write-only register can cause bus errors. This module does not check whether programmed values in the registers are correct; you must ensure that valid programmed values are written to the registers.

74.3.1.1 LPI2C memory map

LPI2C_0 base address: 4035_0000h

LPI2C_1 base address: 4035_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VERID)	32	R	0102_0003h
4h	Parameter (PARAM)	32	R	0000_0202h
10h	Controller Control (MCR)	32	RW	0000_0000h
14h	Controller Status (MSR)	32	RW	0000_0001h
18h	Controller Interrupt Enable (MIER)	32	RW	0000_0000h
1Ch	Controller DMA Enable (MDER)	32	RW	0000_0000h
20h	Controller Configuration 0 (MCFGR0)	32	RW	0000_0000h
24h	Controller Configuration 1 (MCFGR1)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
28h	Controller Configuration 2 (MCFGR2)	32	RW	0000_0000h
2Ch	Controller Configuration 3 (MCFGR3)	32	RW	0000_0000h
40h	Controller Data Match (MDMR)	32	RW	0000_0000h
48h	Controller Clock Configuration 0 (MCCR0)	32	RW	0000_0000h
50h	Controller Clock Configuration 1 (MCCR1)	32	RW	0000_0000h
58h	Controller FIFO Control (MFCR)	32	RW	0000_0000h
5Ch	Controller FIFO Status (MFSR)	32	R	0000_0000h
60h	Controller Transmit Data (MTDR)	32	W	0000_0000h
70h	Controller Receive Data (MRDR)	32	R	0000_4000h
110h	Target Control (SCR)	32	RW	0000_0000h
114h	Target Status (SSR)	32	RW	0000_0000h
118h	Target Interrupt Enable (SIER)	32	RW	0000_0000h
11Ch	Target DMA Enable (SDER)	32	RW	0000_0000h
124h	Target Configuration 1 (SCFGR1)	32	RW	0000_0000h
128h	Target Configuration 2 (SCFGR2)	32	RW	0000_0000h
140h	Target Address Match (SAMR)	32	RW	0000_0000h
150h	Target Address Status (SASR)	32	R	0000_4000h
154h	Target Transmit ACK (STAR)	32	RW	0000_0000h
160h	Target Transmit Data (STDR)	32	W	0000_0000h
170h	Target Receive Data (SRDR)	32	R	0000_4000h

74.3.1.2 Version ID (VERID)

Offset

Register	Offset
VERID	0h

Function

Contains version numbers for the module design and feature set.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MAJOR								MINOR							
W																
Reset	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	FEATURE															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-24 MAJOR	Major Version Number Returns the major version number for the module design specification.
23-16 MINOR	Minor Version Number Returns the minor version number for the module design specification.
15-0 FEATURE	Feature Specification Number Returns the feature set number. 0000_0000_0000_0010b - Controller only, with standard feature set 0000_0000_0000_0011b - Controller and target, with standard feature set

74.3.1.3 Parameter (PARAM)

Offset

Register	Offset
PARAM	4h

Function

Contains parameter values implemented in the module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				MRXFIFO				0				MTXFIFO			
W																
Reset	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0

Fields

Field	Function
31-16 —	Reserved
15-12 —	Reserved
11-8 MRXFIFO	Controller Receive FIFO Size Configures the number of words in the controller receive FIFO to $2^{MRXFIFO}$.
7-4 —	Reserved
3-0 MTXFIFO	Controller Transmit FIFO Size Configures the number of words in the controller transmit FIFO to $2^{MTXFIFO}$.

74.3.1.4 Controller Control (MCR)

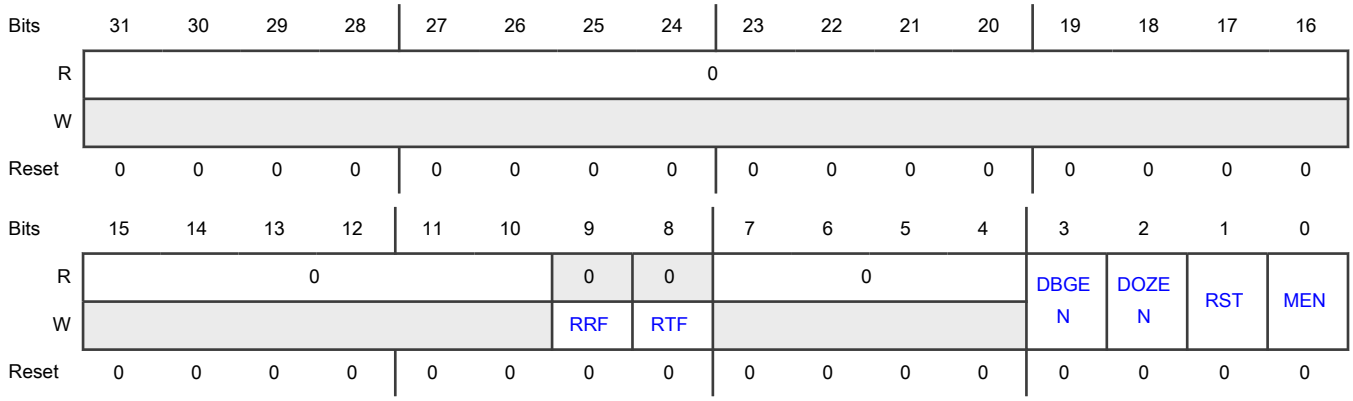
Offset

Register	Offset
MCR	10h

Function

Contains resets, debug enable, and other controller control settings.

Diagram



Fields

Field	Function
31-10 —	Reserved
9 RRF	Reset Receive FIFO Resets the receive FIFO. 0b - No effect 1b - Reset receive FIFO
8 RTF	Reset Transmit FIFO Resets the transmit FIFO. 0b - No effect 1b - Reset transmit FIFO
7-4 —	Reserved
3 DBGEN	Debug Enable Enables the controller in Debug mode. 0b - Disable 1b - Enable
2 DOZEN	Doze Mode Enable Enables the controller in Doze mode. 0b - Enable 1b - Disable
1	Software Reset

Table continues on the next page...

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Field	Function
RST	Resets all internal controller logic and registers except Controller Control (MCR). This field remains 1 (enabled) until you write 0 to it. The reset takes effect immediately and remains asserted until negated by software. There is no minimum delay required before clearing the software reset. 0b - No effect 1b - Reset
0 MEN	Controller Enable Enables the controller logic. 0b - Disable 1b - Enable

74.3.1.5 Controller Status (MSR)

Offset

Register	Offset
MSR	14h

Function

Contains status flags for transmit and receive data, for start and stop conditions, and for bus and controller busy or idle status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0						BBF	MBF	0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	DMF	PLTF	FEF	ALF	NDF	SDF	EPF	0						RDF	TDF
W		W1C	W1C	W1C	W1C	W1C	W1C	W1C								
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-26 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
25 BBF	Bus Busy Flag Specifies whether the I2C bus is busy. 0b - Idle 1b - Busy
24 MBF	Controller Busy Flag Specifies whether the I2C controller is busy. 0b - Idle 1b - Busy
23-16 —	Reserved
15 —	Reserved
14 DMF	Data Match Flag Indicates whether the received data matches MDMR[MATCH0] or MDMR[MATCH1] (as configured by MCFGR1[MATCFG]). Received data discarded due to MTDR[CMD] does not cause this flag to set. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Matching data not received 1b - Matching data received When writing 0b - No effect 1b - Clear the flag
13 PLTF	Pin Low Timeout Flag Indicates whether pin low timeout has occurred. Sets when the SCL or SDA input is low for more than the number of PINLOW cycles defined by MCFGR3[PINLOW], even when the LPI2C controller is idle. You must resolve the pin low condition via software. PLTF cannot be cleared as long as the pin low timeout continues. Before LPI2C can initiate a Start condition, you must clear this flag. See MCFGR1[TIMECFG] for the SCL and/or SDA timeout settings. **NOTE** This field behaves differently for register reads and writes. When reading

Table continues on the next page...

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Field	Function
	0b - Pin low timeout did not occur 1b - Pin low timeout occurred When writing 0b - No effect 1b - Clear the flag
12 FEF	FIFO Error Flag Detects the LPI2C controller's attempt to send or receive data without first generating a (repeated) Start condition. This error can occur when the transmit FIFO underflows when MCFGR1[AUTOSTOP] = 1. When this flag is set, the LPI2C controller sends a Stop condition (if busy). The controller does not initiate a new Start condition until the flag is cleared. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No FIFO error 1b - FIFO error When writing 0b - No effect 1b - Clear the flag
11 ALF	Arbitration Lost Flag Indicates whether arbitration is lost. Either of these conditions sets this flag: • The LPI2C controller transmits a logic 1 and detects a logic 0 on the I2C bus. • The LPI2C controller detects a Start or Stop condition when the LPI2C controller is transmitting data. When ALF is set, the LPI2C controller releases the I2C bus (goes idle), and the LPI2C controller does not initiate a new Start condition until the ALF is cleared. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Controller did not lose arbitration 1b - Controller lost arbitration When writing 0b - No effect 1b - Clear the flag
10	NACK Detect Flag

Table continues on the next page...

Table continued from the previous page...

Field	Function
NDF	Indicates whether an unexpected NACK has been detected. This flag is set when the LPI2C controller detects a NACK it was not expecting when transmitting an address or data. When set, the controller does not initiate a new Start condition until this flag is cleared. If a NACK is expected for a given address (as configured by the command word), this flag is set if a NACK is not generated. When this flag is set, the LPI2C controller automatically transmits a Stop condition if MCFGR1[AUTOSTOP] = 1, or if the transmit FIFO is not empty. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No unexpected NACK detected 1b - Unexpected NACK detected When writing 0b - No effect 1b - Clear the flag
9 SDF	Stop Detect Flag Indicates whether the LPI2C controller has generated a Stop condition. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No Stop condition generated 1b - Stop condition generated When writing 0b - No effect 1b - Clear the flag
8 EPF	End Packet Flag Indicates whether the LPI2C controller has generated a repeated Start condition or a Stop condition. When the controller first generates a Start condition, this flag is not set. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No Stop or repeated Start generated 1b - Stop or repeated Start generated When writing

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No effect 1b - Clear the flag
7-2 —	Reserved
1 RDF	Receive Data Flag Indicates whether the receive data is ready. This flag is set when the number of words in the receive FIFO is greater than MFCR[RXWATER]. 0b - Receive data not ready 1b - Receive data ready
0 TDF	Transmit Data Flag Indicates whether transmit data is requested. This flag is set when the number of words in the transmit FIFO is equal or less than MFCR[TXWATER]. 0b - Transmit data not requested 1b - Transmit data requested

74.3.1.6 Controller Interrupt Enable (MIER)

Offset

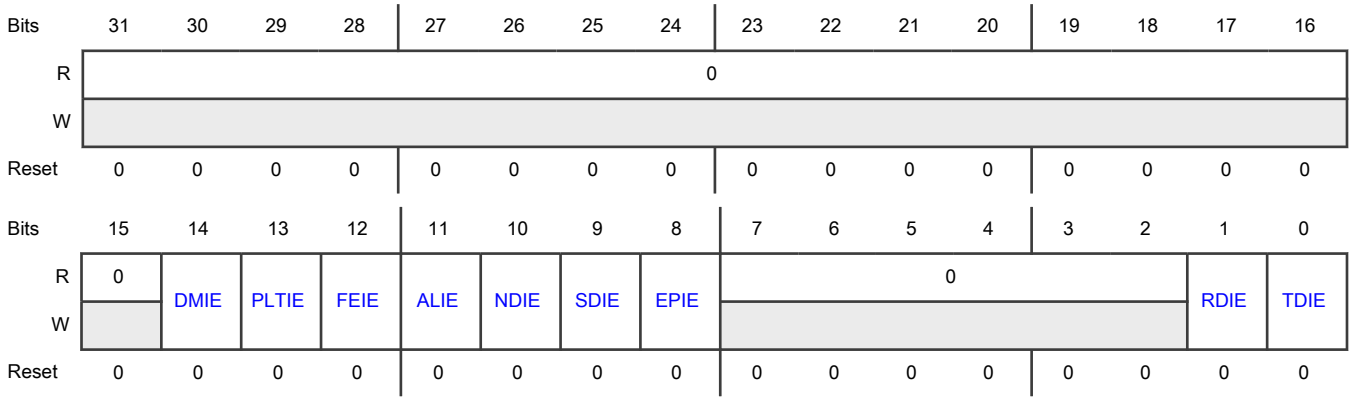
Register	Offset
MIER	18h

Function

Contains enables for:

- Transmit and receive data interrupts
- Start, Stop, and NACK detection interrupts
- DMA interrupts

Diagram



Fields

Field	Function
31-16 —	Reserved
15 —	Reserved
14 DMIE	Data Match Interrupt Enable Enables interrupt for data match. 0b - Disable 1b - Enable
13 PLTIE	Pin Low Timeout Interrupt Enable Enables interrupt for pin-low timeout. 0b - Disable 1b - Enable
12 FEIE	FIFO Error Interrupt Enable Enables interrupt for FIFO error. 0b - Disable 1b - Enable
11 ALIE	Arbitration Lost Interrupt Enable Enables interrupt for arbitration lost. 0b - Disable 1b - Enable
10	NACK Detect Interrupt Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
NDIE	Enables interrupt for NACK detection. 0b - Disable 1b - Enable
9 SDIE	Stop Detect Interrupt Enable Enables interrupt for Stop detection. 0b - Disable 1b - Enable
8 EPIE	End Packet Interrupt Enable Enables interrupt for end packet. 0b - Disable 1b - Enable
7-2 —	Reserved
1 RDIE	Receive Data Interrupt Enable Enables interrupt for receive data. 0b - Disable 1b - Enable
0 TDIE	Transmit Data Interrupt Enable Enables interrupt for transmit data. 0b - Disable 1b - Enable

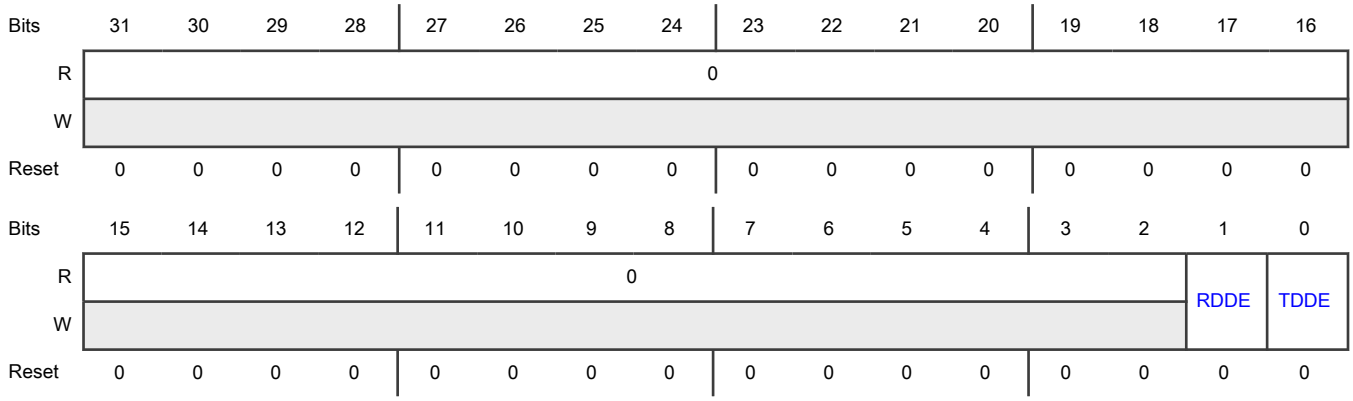
74.3.1.7 Controller DMA Enable (MDER)

Offset

Register	Offset
MDER	1Ch

Function
Contains DMA transmit, request, and receive enables.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 RDDE	Receive Data DMA Enable Enables DMA receive data. 0b - Disable 1b - Enable
0 TDDE	Transmit Data DMA Enable Enables DMA transmit data. 0b - Disable 1b - Enable

74.3.1.8 Controller Configuration 0 (MCFGR0)

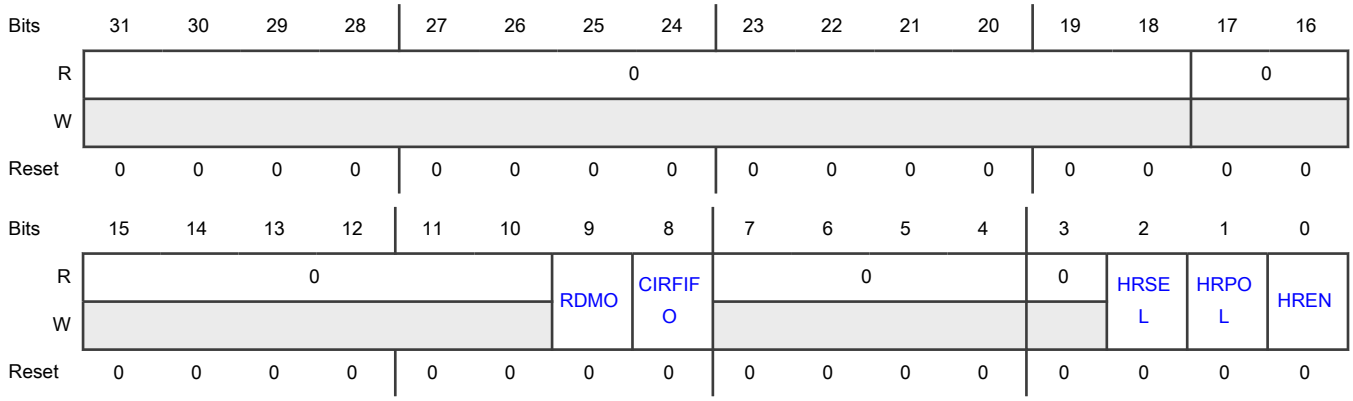
Offset

Register	Offset
MCFGR0	20h

Function

Contains host settings and other receive and transfer settings.

Diagram



Fields

Field	Function
31-18 —	Reserved
17-16 —	Reserved
15-10 —	Reserved
9 RDMO	Receive Data Match Only Determines whether all received data that does not set MSR[DMF] is discarded. After MSR[DMF] is set, the RDMO configuration is ignored. When disabling RDMO, write 0 to this field before writing 0 to MSR[DMF] to ensure that no receive data is lost. 0b - Received data is stored in the receive FIFO 1b - Received data is discarded unless MSR[DMF] is set
8 CIRFIFO	Circular FIFO Enable Enables the transmit FIFO read pointer to be saved to a temporary register. The transmit FIFO empties as normal. After the LPI2C controller is idle and the transmit FIFO is empty, the read pointer value is restored from the temporary register. This setting causes the contents of the transmit FIFO to be cycled through repeatedly. If MCFGR1[AUTOSTOP] is 1, then a Stop condition is sent whenever the transmit FIFO is empty and the read pointer is restored. 0b - Disable 1b - Enable
7-4 —	Reserved
3	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
2 HRSEL	Host Request Select Selects the source of the host request input. When host request is enabled, this field must not change. 0b - Host request input is pin HREQ 1b - Host request input is input trigger
1 HRPOL	Host Request Polarity Configures the polarity of the host request input. When host request is enabled, this field must not change. HRPOL sets the polarity for both the HREQ pin and the input trigger. • When HRPOL=0, the polarity is configured for active low, so host request is asserted if the HREQ pin or input trigger are logic 0. • When HRPOL=1, the polarity is configured for active high, so host request is asserted if the HREQ pin or input trigger are logic 1. 0b - Active low 1b - Active high
0 HREN	Host Request Enable Enables host request. When enabled, the LPI2C controller only initiates a Start condition if the host request input is asserted and the bus is idle. A repeated Start condition is not affected by the host request. 0b - Disable 1b - Enable

74.3.1.9 Controller Configuration 1 (MCFGR1)

Offset

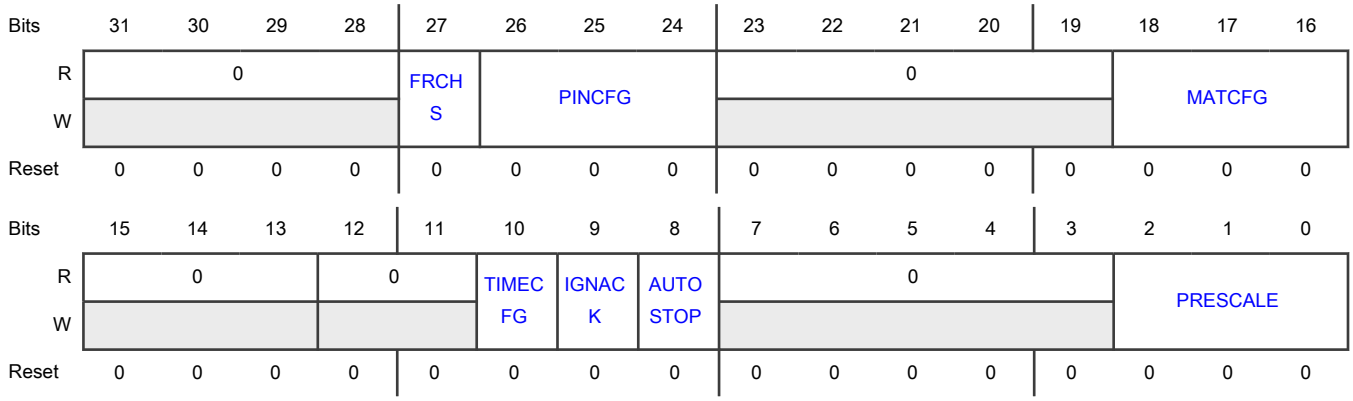
Register	Offset
MCFGR1	24h

Function

Contains controls for pin configuration, clock prescaler, and various other control settings.

Write to this register only when the I2C controller is disabled.

Diagram



Fields

Field	Function
31-28 —	Reserved
27 FRCHS	Force HS Mode Forces the LPI2C pin state into HS mode. Writing 1 to this field does not impact the digital filter configuration or digital timing parameters. **NOTE** This field is not supported in every instance. The following table includes only supported registers. 0b - No effect 1b - LPI2C pin state forced into HS mode
26-24 PINCFG	Pin Configuration Configures the pin mode for LPI2C. 000b - Two-pin open drain mode. SCL/SDA pins: Bidirectional open drain for controller and target. SCLS/SDAS pins: Not used. 001b - Two-pin output only mode (Ultra-Fast mode). SCL/SDA pins: Output-only (Ultra-Fast mode) open drain for controller and target. SCLS/SDAS pins: Not used. 010b - Two-pin push-pull mode. SCL/SDA pins: Bidirectional push-pull for controller and target. SCLS/SDAS pins: Not used. 011b - Four-pin push-pull mode. SCL/SDA pins: Input only for controller and target. SCLS/SDAS pins: Output-only push-pull for controller and target.

Instance	Field supported in	Field not supported in
LPI2C_0	—	MCFGR1
LPI2C_1	MCFGR1	—

Table continues on the next page...

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Field	Function
	100b - Two-pin open-drain mode with separate LPI2C target. SCL/SDA pins: Bidirectional open drain for controller. SCLS/SDAS pins: Bidirectional open drain for target. 101b - Two-pin output only mode (Ultra-Fast mode) with separate LPI2C target. SCL/SDA pins: Output-only (Ultra-Fast mode) open drain for controller. SCLS/SDAS pins: Output-only open drain for target. 110b - Two-pin push-pull mode with separate LPI2C target. SCL/SDA pins: Bidirectional push-pull for controller. SCLS/SDAS pins: Bidirectional push-pull for target. 111b - Four-pin push-pull mode (inverted outputs). SCL/SDA pins: Input only for controller and target. SCLS/SDAS pins: Inverted output-only push-pull for controller and target.
23-19 —	Reserved
18-16 MATCFG	Match Configuration Configures the condition that sets MSR[DMF]. See Controller Data Match (MDMR). 000b - Match is disabled 001b - Reserved 010b - Match is enabled: first data word equals MDMR[MATCH0] OR MDMR[MATCH1] 011b - Match is enabled: any data word equals MDMR[MATCH0] OR MDMR[MATCH1] 100b - Match is enabled: (first data word equals MDMR[MATCH0]) AND (second data word equals MDMR[MATCH1) 101b - Match is enabled: (any data word equals MDMR[MATCH0]) AND (next data word equals MDMR[MATCH1) 110b - Match is enabled: (first data word AND MDMR[MATCH1]) equals (MDMR[MATCH0] AND MDMR[MATCH1]) 111b - Match is enabled: (any data word AND MDMR[MATCH1]) equals (MDMR[MATCH0] AND MDMR[MATCH1])
15-13 —	Reserved
12-11 —	Reserved
10 TIMECFG	Timeout Configuration Configures which signals must be low for longer than the configured timeout to set MSR[PLTF]. When this field is 0, MSR[PLTF] is set when SCL is low for longer than the configured timeout. 0b - SCL 1b - SCL or SDA

Table continues on the next page...

Table continued from the previous page...

Field	Function
9 IGNACK	Ignore NACK Determines whether the LPI2C controller ignores a received NACK and treats it as an ACK. This field must be 1 in Ultra-Fast mode. 0b - No effect 1b - Treat a received NACK as an ACK
8 AUTOSTOP	Automatic Stop Generation Determines whether a Stop condition is generated when the LPI2C controller is busy and the transmit FIFO is empty. A Stop condition can also be generated using a transmit FIFO command. When this field is 1, a Stop condition is automatically generated when the transmit FIFO is empty and the LPI2C controller is busy. 0b - No effect 1b - Stop automatically generated
7-3 —	Reserved
2-0 PRESCALE	Prescaler Configures the clock prescaler used for all LPI2C controller logic except the digital glitch filters. 000b - Divide by 1 001b - Divide by 2 010b - Divide by 4 011b - Divide by 8 100b - Divide by 16 101b - Divide by 32 110b - Divide by 64 111b - Divide by 128

74.3.1.10 Controller Configuration 2 (MCFGR2)

Offset

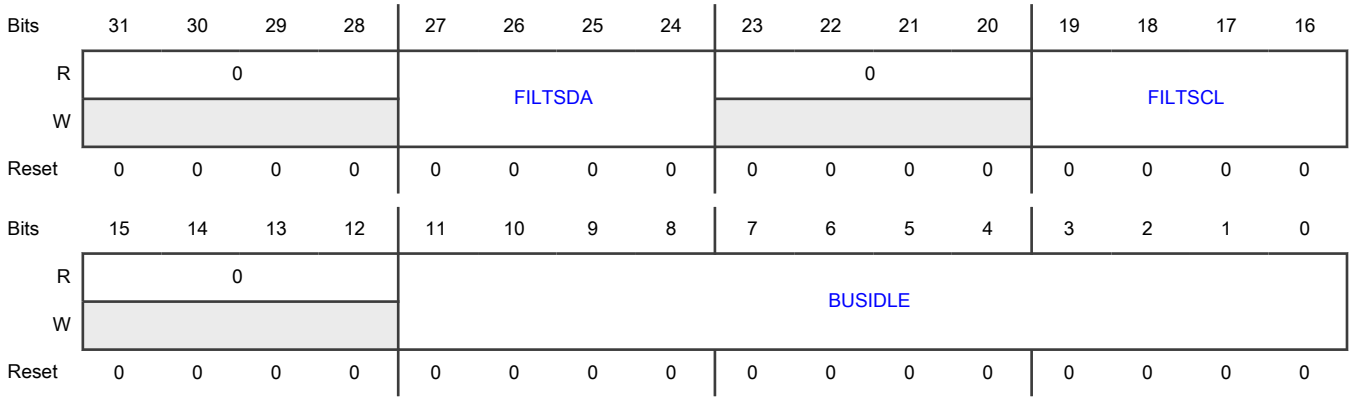
Register	Offset
MCFGR2	28h

Function

Contains the configuration for the bus idle timeout and glitch filters for SDA and SCL.

Write to this register only when the I2C controller is disabled.

Diagram



Fields

Field	Function
31-28 —	Reserved
27-24 FILTSDA	Glitch Filter SDA Configures the I2C controller digital glitch filters for the SDA input. The latency through the glitch filter is equal to the number of cycles defined by this field. The value of this field must be less than the minimum SCL low or high period. Glitches equal to or less than the number of cycles defined by this field are filtered out and ignored. Writing 0 to this field disables the glitch filter. MCFGR1[PRESCALE] does not affect the glitch filter cycle count. It is automatically bypassed in HS mode.
23-20 —	Reserved
19-16 FILTSCL	Glitch Filter SCL Configures the I2C controller digital glitch filters for SCL input. The latency through the glitch filter is equal to the number of cycles defined by this field. The value of this field must be less than the minimum SCL low or high period. Glitches equal to or less than the number of cycles defined by this field are filtered out and ignored. These cycles are based on the functional clock. Writing 0 to this field disables the glitch filter. MCFGR1[PRESCALE] does not affect the glitch filter cycle count. It is automatically bypassed in HS mode.
15-12 —	Reserved
11-0 BUSIDLE	Bus Idle Timeout Configures the bus idle timeout period, in clock cycles.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	If both SCL and SDA are high for longer than the number of cycles defined by this field, the I2C bus is assumed to be idle and the controller can generate a Start condition. Writing 0 to this field disables the bus idle timeout.

74.3.1.11 Controller Configuration 3 (MCFGR3)

Offset

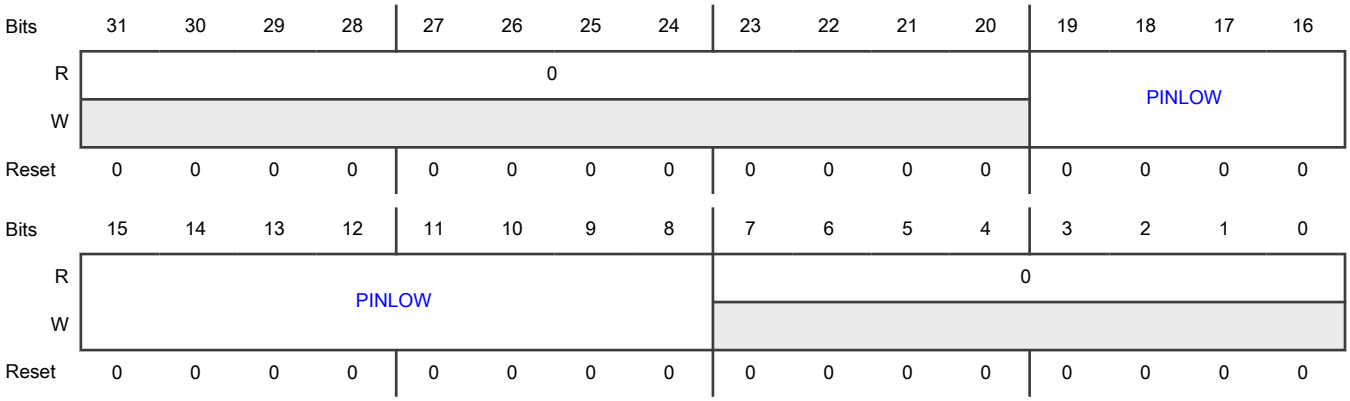
Register	Offset
MCFGR3	2Ch

Function

Configures the threshold value for the pin low timeout flag.

Write to this register only when the I2C controller is disabled.

Diagram



Fields

Field	Function
31-20 —	Reserved
19-8 PINLOW	Pin Low Timeout Configures the threshold value, in clock cycles, that sets MSR[PLTF]. If SCL or SDA (selected by MCFGR1[TIMECFG]) is low for longer than (PINLOW × 256) cycles, MSR[PLTF] is set. When this field is 0, the pin low timeout feature is disabled.

Table continues on the next page...

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Field	Function
7-0 —	Reserved

74.3.1.12 Controller Data Match (MDMR)

Offset

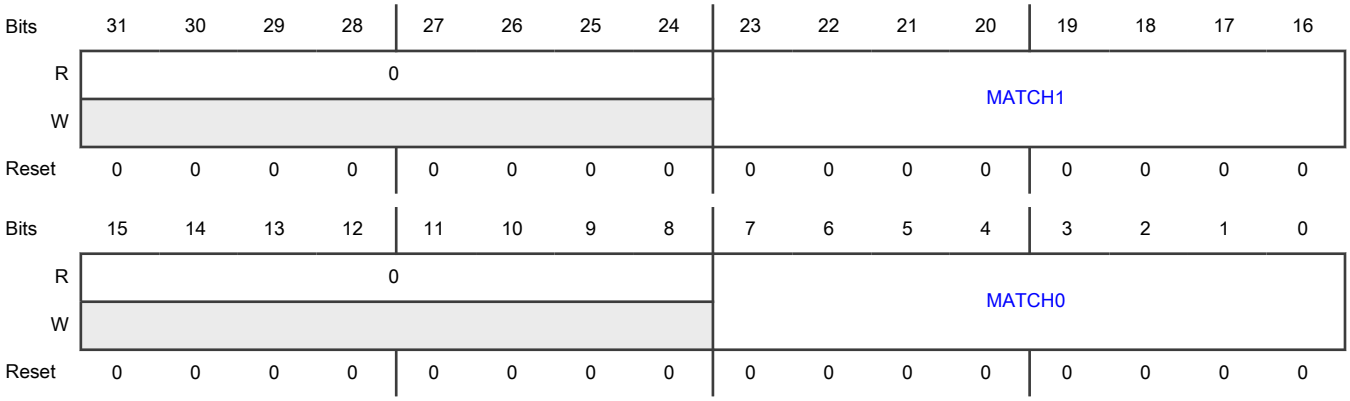
Register	Offset
MDMR	40h

Function

Contains data match values.

Write to this register only when the I2C controller is disabled or idle.

Diagram



Fields

Field	Function
31-24 —	Reserved
23-16 MATCH1	Match 1 Value Specifies match 1 value that is compared to the received data when receive data match is enabled.
15-8 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
7-0 MATCH0	Match 0 Value Specifies match 0 value that is compared to the received data when receive data match is enabled.

74.3.1.13 Controller Clock Configuration 0 (MCCR0)

Offset

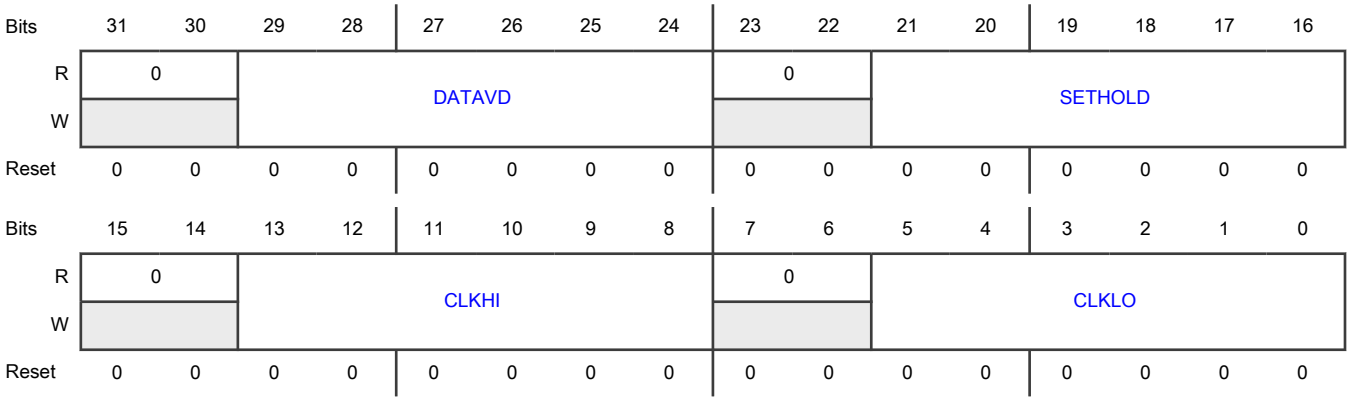
Register	Offset
MCCR0	48h

Function

Configures various clock controls.

You cannot make changes to this register when the I2C controller is enabled and is used for standard, fast, fast-mode plus, and ultra-fast transfers.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-24 DATAVD	Data Valid Delay Specifies the minimum number of cycles (minus one) used as the data hold time for SDA. This value must be less than the minimum SCL low period.
23-22	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
21-16 SETHOLD	Setup Hold Delay Specifies the minimum number of cycles (minus one) used by the controller for these conditions: • Hold time for a Start • Setup and hold time for a repeated Start • Setup time for a Stop The setup time is extended by the time it takes to detect a rising edge on the external SCL pin. Ignoring any additional board delay due to external loading, this time is equal to (2 + FILTSCL) ÷ 2^PRESCALE cycles.
15-14 —	Reserved
13-8 CLKHI	Clock High Period Specifies the minimum number of cycles (minus one) that the controller drives the SCL clock high. The SCL high time is extended by the time needed to detect a rising edge on the external SCL pin. Ignoring any additional board delay due to external loading, this time is equal to (2 + FILTSCL) ÷ 2^PRESCALE cycles.
7-6 —	Reserved
5-0 CLKLO	Clock Low Period Specifies the minimum number of cycles (minus one) that the controller drives the SCL clock low. This value is also used for the minimum bus free time between a Stop and a Start condition. This period is extended by the time needed to detect a rising edge on the external SCL pin. Ignoring any additional board delay due to external loading, this time is equal to (2 + FILTSCL) ÷ 2^PRESCALE cycles.

74.3.1.14 Controller Clock Configuration 1 (MCCR1)

Offset

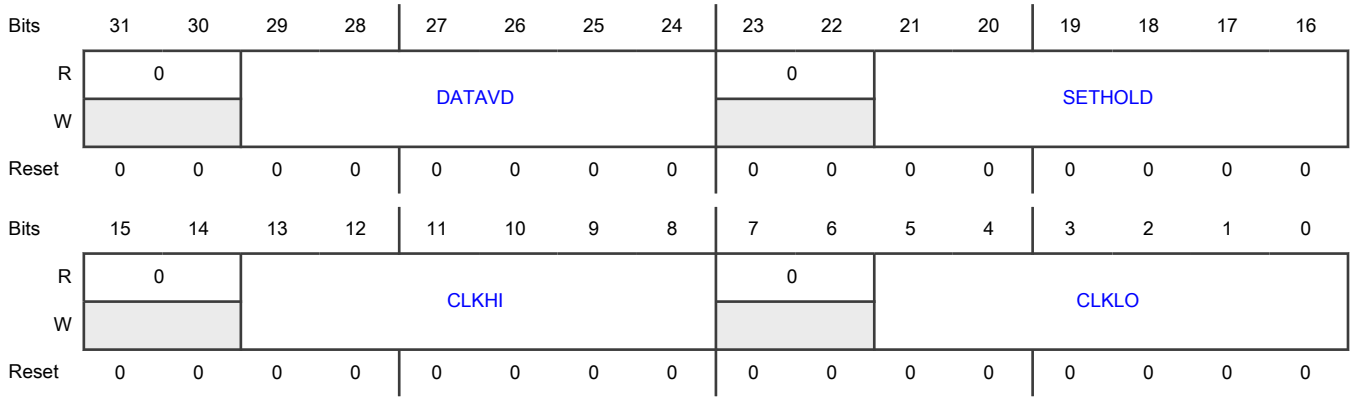
Register	Offset
MCCR1	50h

Function

Configures various clock controls.

You cannot makes changes to this register when the I2C controller is enabled and is used for HS mode transfers. The separate clock configuration for HS mode allows arbitration to take place in Fast mode (with timing configured by Controller Clock Configuration 0 (MCCR0)), before switching to HS mode (with timing configured by MCCR1).

Diagram



Fields

Field	Function
31-30 —	Reserved
29-24 DATAVD	Data Valid Delay Specifies the minimum number of cycles (minus one) used as the data hold time for SDA. This value must be less than the minimum SCL low period.
23-22 —	Reserved
21-16 SETHOLD	Setup Hold Delay Specifies the minimum number of cycles (minus one) used by the controller for these conditions: • Hold time for a Start condition • Setup and hold time for a repeated Start condition • Setup time for a Stop condition The setup time is extended by the time needed to detect a rising edge on the external SCL pin. Ignoring any additional board delay due to external loading, this time is equal to (2 + FILTSCL) ÷ 2^PRESCALE cycles.
15-14 —	Reserved
13-8 CLKHI	Clock High Period Specifies the minimum number of cycles (minus one) that the controller drives the SCL clock high. The SCL high time is extended by the time needed to detect a rising edge on the external SCL pin. Ignoring any additional board delay due to external loading, this time is equal to (2 + FILTSCL) ÷ 2^PRESCALE cycles.
7-6 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
5-0 CLKLO	Clock Low Period Specifies the minimum number of cycles (minus one) that the controller drives the SCL clock low. This value is also used for the minimum bus free time between a Stop and a Start condition. This period is extended by the time needed to detect a rising edge on the external SCL pin. Ignoring any additional board delay due to external loading, this time is equal to (2 + FILTSCL) ÷ 2^PRESCALE cycles.

74.3.1.15 Controller FIFO Control (MFCR)

Offset

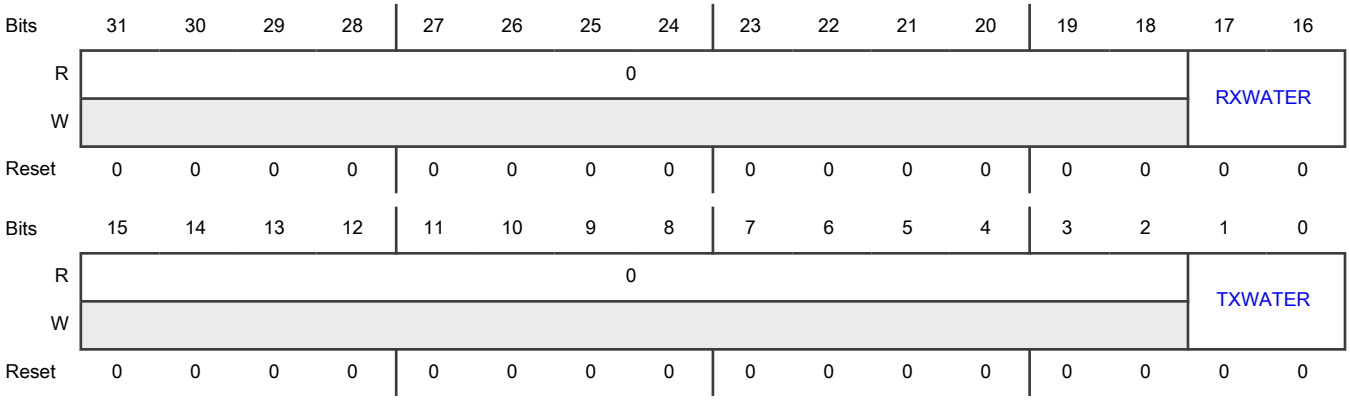
Register	Offset
MFCR	58h

Function

Controls the receive and transmit FIFO watermark values.

This register is used only in Stop mode, when this register is static (not changing).

Diagram



Fields

Field	Function
31-18 —	Reserved
17-16 RXWATER	Receive FIFO Watermark Determines the watermark for setting SSR[RDF]. That flag is set when the number of words in the receive FIFO is greater than the value of this field. Writing a value equal to or greater than the FIFO size truncates the value.

Table continues on the next page...

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Field	Function
15-2 —	Reserved
1-0 TXWATER	Transmit FIFO Watermark Determines the watermark for setting SSR[TDF]. That flag is set when the number of words in the transmit FIFO is equal or less than the value of this field. Writing a value equal to or greater than the FIFO size truncates the value.

74.3.1.16 Controller FIFO Status (MFSR)

Offset

Register	Offset
MFSR	5Ch

Function

Specifies the number of words in the transmit and receive FIFOs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0													RXCOUNT		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0													TXCOUNT		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18-16 RXCOUNT	Receive FIFO Count Specifies the number of words in the receive FIFO.
15-3	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
2-0 TXCOUNT	Transmit FIFO Count Specifies the number of words in the transmit FIFO.

74.3.1.17 Controller Transmit Data (MTDR)

Offset

Register	Offset
MTDR	60h

Function

Configures transmit data:

- An 8-bit write to MTDR[CMD] is ignored and does not increment the FIFO write pointer.
- An 8-bit write to MTDR[DATA] zero-extends the value of MTDR[CMD] and increments the FIFO write pointer.
- A 16-bit or 32-bit write operation writes to both MTDR[CMD] and MTDR[DATA] and increments the FIFO write pointer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	0				CMD				DATA							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-11 —	Reserved
10-8 CMD	Command Data Selects command transmitted by controller.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	000b - Transmit the value in DATA[7:0] 001b - Receive (DATA[7:0] + 1) bytes. DATA[7:0] is used as a byte counter. Receive that many bytes and check each for a data match (if configured) before storing the received data in the receive FIFO. 010b - Generate Stop condition on I2C bus 011b - Receive and discard (DATA[7:0] + 1) bytes. DATA[7:0] is used as a byte counter. Receive that many bytes but do not check for a data match or store those bytes in the receive FIFO. 100b - Generate (repeated) Start on the I2C bus and transmit the address in DATA[7:0] 101b - Generate (repeated) Start on the I2C bus and transmit the address in DATA[7:0] (this transfer expects a NACK to be returned) 110b - Generate (repeated) Start on the I2C bus and transmit the address in DATA[7:0] using HS mode 111b - Generate (repeated) Start on the I2C bus and transmit the address in DATA[7:0] using HS mode (this transfer expects a NACK to be returned)
7-0 DATA	Transmit Data Contains data used by the commands listed in MTDR[CMD]. Performing an 8-bit write to this field zero-extends the value of MTDR[CMD].

74.3.1.18 Controller Receive Data (MRDR)

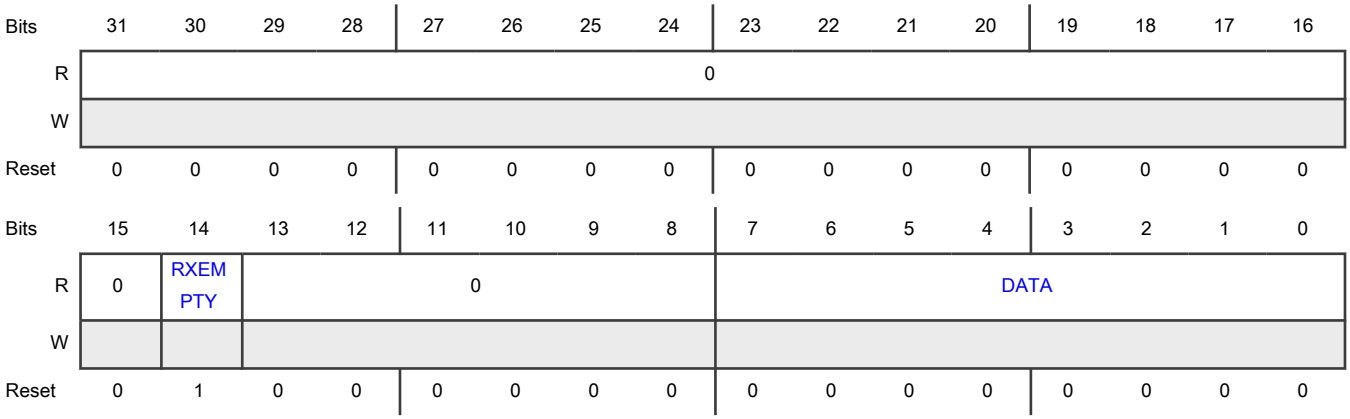
Offset

Register	Offset
MRDR	70h

Function

Contains the status of the receive FIFO and the data received by the I2C controller that has not been discarded.

Diagram



Fields

Field	Function
31-15 —	Reserved
14 RXEMPTY	Receive Empty Indicates whether the controller receive data FIFO is empty. 0b - Not empty 1b - Empty
13-8 —	Reserved
7-0 DATA	Receive Data Contains data received by the I2C controller that has not been discarded. Received data can be discarded due to the command in MTDR[CMD], or the controller can be configured to discard nonmatching data.

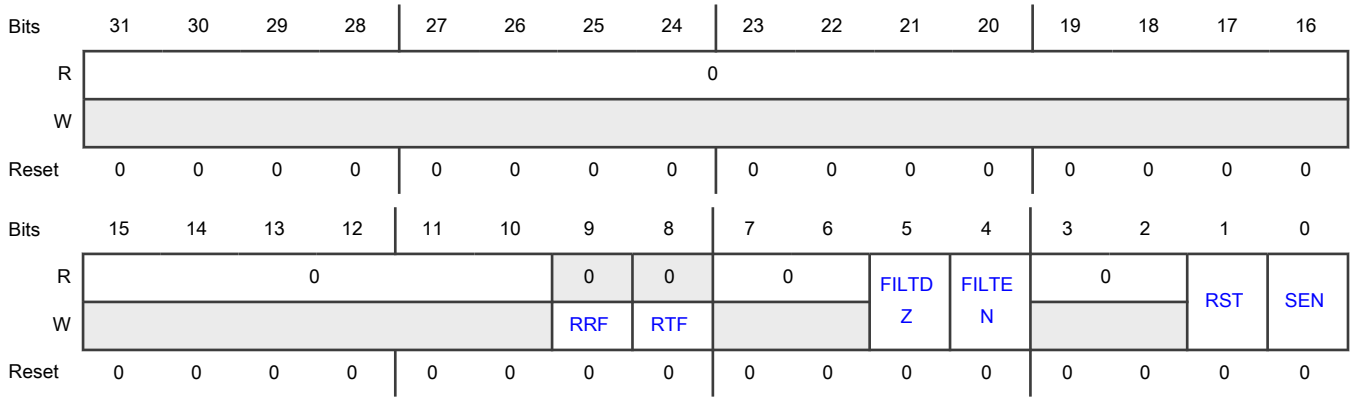
74.3.1.19 Target Control (SCR)

Offset

Register	Offset
SCR	110h

Function
Contains resets and other target control settings.

Diagram



Fields

Field	Function
31-10 —	Reserved
9 RRF	Reset Receive FIFO Empties the receive FIFO in Target Receive Data (SRDR). 0b - No effect 1b - SRDR is now empty
8 RTF	Reset Transmit FIFO Empties the transmit FIFO in Target Transmit Data (STDR). 0b - No effect 1b - STDR is now empty
7-6 —	Reserved
5 FILTDZ	Filter Doze Enable Enables filter in Doze mode. Update this field only when the I2C target is disabled. 0b - Enable 1b - Disable
4 FILTEN	Filter Enable Enables digital filter and output delay counter for target mode. Update this field only when the I2C target is disabled. 0b - Disable 1b - Enable
3-2 —	Reserved
1 RST	Software Reset Resets target mode logic. The reset takes effect immediately. The value of this field remains 1 until you write 0 to it. There is no minimum delay required before clearing the software reset. 0b - Not reset 1b - Reset
0 SEN	Target Enable Enables I2C Target mode. 0b - Disable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Enable

74.3.1.20 Target Status (SSR)

Offset

Register	Offset
SSR	114h

Function

Contains status flags for transmit and receive data, for error conditions, and for bus and target busy or idle status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0						BBF	SBF	0							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SARF	GCF	AM1F	AM0F	FEF	BEF	SDF	RSF	0				TAF	AVF	RDF	TDF
W					W1C	W1C	W1C	W1C								
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25 BBF	Bus Busy Flag Indicates whether an I2C bus is idle or busy. 0b - Idle 1b - Busy
24 SBF	Target Busy Flag Indicates whether an I2C target is idle or busy. 0b - Idle

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Busy
23-16 —	Reserved
15 SARF	SMBus Alert Response Flag Indicates whether an SMBus alert response has been detected. You can clear this flag by reading Target Address Status (SASR). This flag cannot generate an asynchronous wakeup. 0b - Disabled or not detected 1b - Enabled and detected
14 GCF	General Call Flag Indicates whether a target has detected the general call address. You can clear this flag by reading Target Address Status (SASR). This flag cannot generate an asynchronous wakeup. 0b - General call address disabled or not detected 1b - General call address detected
13 AM1F	Address Match 1 Flag Indicates whether the received address matches the value in ADDR1, or it falls within the ADDR0 to ADDR1 range as configured by SCFGR1[ADDRCFG]. This flag is cleared by reading Target Address Status (SASR). This flag cannot generate an asynchronous wakeup. 0b - Matching address not received 1b - Matching address received
12 AM0F	Address Match 0 Flag Indicates whether the received address matches the ADDR0 field, as configured by SCFGR1[ADDRCFG]. This flag is cleared by reading Target Address Status (SASR). This flag cannot generate an asynchronous wakeup. 0b - ADDR0 matching address not received 1b - ADDR0 matching address received
11 FEF	FIFO Error Flag Indicates whether there is a FIFO error. This flag can only be set when clock stretching is disabled. **NOTE** This field behaves differently for register reads and writes.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When reading 0b - No FIFO error 1b - FIFO error When writing 0b - No effect 1b - Clear the flag
10 BEF	Bit Error Flag Indicates whether the LPI2C target has transmitted a logic 1 and detects a logic 0 on the I2C bus. The target ignores the rest of the transfer until the next (repeated) Start condition. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No bit error occurred 1b - Bit error occurred When writing 0b - No effect 1b - Clear the flag
9 SDF	Stop Detect Flag Indicates whether the LPI2C target detects a Stop condition, and if the LPI2C target matched the last address byte. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No Stop detected 1b - Stop detected When writing 0b - No effect 1b - Clear the flag
8 RSF	Repeated Start Flag Indicates whether the LPI2C target detects a repeated Start condition and if the LPI2C target matched the last address byte. This flag is not set when the target first detects a Start condition. **NOTE** This field behaves differently for register reads and writes.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When reading 0b - No repeated Start detected 1b - Repeated Start detected When writing 0b - No effect 1b - Clear the flag
7-4 —	Reserved
3 TAF	Transmit ACK Flag Indicates whether a transmit ACK or NACK is required. You can clear this flag by writing to Target Transmit ACK (STAR). 0b - Not required 1b - Required
2 AVF	Address Valid Flag Indicates whether the contents of Target Address Status (SASR) are valid. You can clear this flag by reading SASR. When SCFGR1[RXCFG] = 1, this flag is also cleared by reading Target Receive Data (SRDR). 0b - Not valid 1b - Valid
1 RDF	Receive Data Flag Indicates whether receive data is ready. You can clear this flag by reading Target Receive Data (SRDR). When SCFGR1[RXCFG] = 1, this flag is not cleared when reading Target Receive Data (SRDR) if SSR[AVF] = 1. 0b - Not ready 1b - Ready
0 TDF	Transmit Data Flag Indicates whether transmit data has been requested. This flag is cleared by writing to Target Transmit Data (STDR). When SCFGR1[TXCFG] = 0, if a NACK, repeated Start, or Stop condition is detected, this flag is also cleared. 0b - Transmit data not requested 1b - Transmit data is requested

74.3.1.21 Target Interrupt Enable (SIER)

Offset

Register	Offset
SIER	118h

Function

Contains transmit and receive data interrupt enables, start and stop detect interrupt enables, and other target interrupt enables.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SARIE	GCIE	AM1IE	AM0IE	FEIE	BEIE	SDIE	RSIE	0				TAIE	AVIE	RDIE	TDIE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15 SARIE	SMBus Alert Response Interrupt Enable Enables interrupt for SMBus alert response. 0b - Disable 1b - Enable
14 GCIE	General Call Interrupt Enable Enables interrupt for general call. 0b - Disabled 1b - Enabled
13 AM1IE	Address Match 1 Interrupt Enable Enables interrupt for address match 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
12 AM0IE	Address Match 0 Interrupt Enable Enables interrupt for address match 0. 0b - Disable 1b - Enable
11 FEIE	FIFO Error Interrupt Enable Enables interrupt for FIFO error. 0b - Disable 1b - Enable
10 BEIE	Bit Error Interrupt Enable Enables interrupt for bit error. 0b - Disable 1b - Enable
9 SDIE	Stop Detect Interrupt Enable Enables interrupt for Stop detection. 0b - Disable 1b - Enable
8 RSIE	Repeated Start Interrupt Enable Enables interrupt for repeated start. 0b - Disable 1b - Enable
7-4 —	Reserved
3 TAIE	Transmit ACK Interrupt Enable Enables interrupt for transmit ACK. 0b - Disable 1b - Enable
2 AVIE	Address Valid Interrupt Enable Enables interrupt for valid address.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
1 RDIE	Receive Data Interrupt Enable Enables interrupt for receive data. 0b - Disable 1b - Enable
0 TDIE	Transmit Data Interrupt Enable Enables interrupt for transmit data. 0b - Disable 1b - Enable

74.3.1.22 Target DMA Enable (SDER)

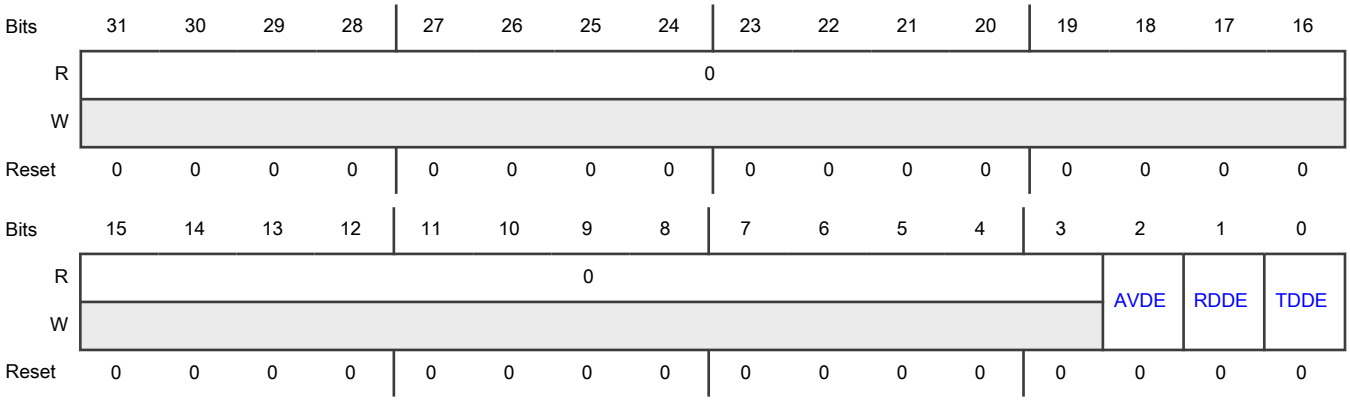
Offset

Register	Offset
SDER	11Ch

Function

Contains the transmit, request, and receive enables for DMA.

Diagram



Fields

Field	Function
31-3 —	Reserved
2 AVDE	Address Valid DMA Enable Enables address valid DMA request. The address valid DMA request is shared with the receive data DMA request. If both are enabled, write 1 to SCFGR1[RXCFG] to allow the DMA to read the address from Target Receive Data (SRDR). 0b - Disable 1b - Enable
1 RDDE	Receive Data DMA Enable Enables receive data for DMA. 0b - Disable DMA request 1b - Enable DMA request
0 TDDE	Transmit Data DMA Enable Enables transmit data for DMA. 0b - Disable 1b - Enable

74.3.1.23 Target Configuration 1 (SCFGR1)

Offset

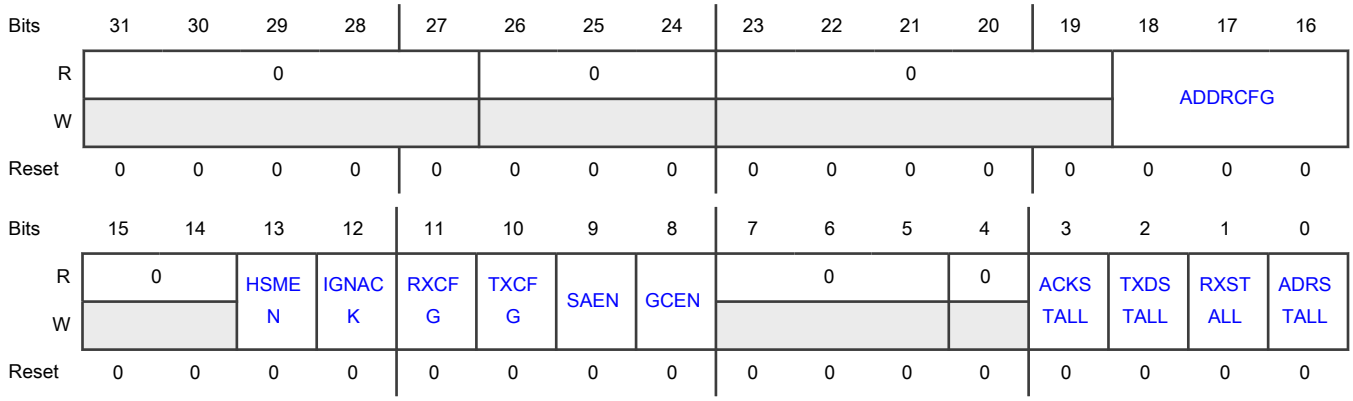
Register	Offset
SCFGR1	124h

Function

Configures various aspects of the target.

Write to this register only when the I2C target is disabled.

Diagram



Fields

Field	Function
31-27 —	Reserved
26-24 —	Reserved
23-19 —	Reserved
18-16 ADDRCFG	Address Configuration Configures the condition that causes an address to match. 000b - Address match 0 (7-bit) 001b - Address match 0 (10-bit) 010b - Address match 0 (7-bit) or address match 1 (7-bit) 011b - Address match 0 (10-bit) or address match 1 (10-bit) 100b - Address match 0 (7-bit) or address match 1 (10-bit) 101b - Address match 0 (10-bit) or address match 1 (7-bit) 110b - From address match 0 (7-bit) to address match 1 (7-bit) 111b - From address match 0 (10-bit) to address match 1 (10-bit)
15-14 —	Reserved
13 HSMEN	HS Mode Enable Enables detection of the HS mode controller code of target address 0000_1XX, but does not cause an address match on this code. When this field is 1 and any HS mode controller code is detected, SCR[FILTEN] and SCFGR1[ACKSTALL] are ignored until the next Stop condition is detected.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
12 IGNACK	Ignore NACK Determines whether the target ends transfer when a NACK condition is detected. When this field is 1, the LPI2C target continues transfers after a NACK is detected. This field is required to be 1 in Ultra-Fast mode. 0b - End transfer on NACK 1b - Do not end transfer on NACK
11 RXCFG	Receive Data Configuration Configures which data is returned and which flags are cleared when reading Target Receive Data (SRDR). When this field is 0, reading SRDR returns received data and clears MSR[RDF]. When this field is 1, reading SRDR: • Returns the value of Target Address Status (SASR) and clears SSR[AVF] when SSR[AVF] is set. • Returns received data and clears MSR[RDF] when SSR[AVF] is not set. 0b - Return received data, clear MSR[RDF] 1b - Return SASR and clear SSR[AVF] when SSR[AVF] is set, return received data and clear MSR[RDF] when SSR[AFV] is not set
10 TXCFG	Transmit Flag Configuration Determines which conditions set MSR[TDF]. This field always becomes 1 before a NACK is detected at the end of a target-transmit transfer. This change can cause an extra word to be written to the transmit data FIFO. When this field is 0, Target Transmit Data (STDR) is automatically emptied when a target-transmit transfer is detected. MSR[TDF] is set when a target-transmit transfer is detected, and MSR[TDF] is cleared at the end of the target-transmit transfer. When this field is 1, MSR[TDF] is set when STDR is empty, and MSR[TDF] is cleared when STDR is full. This setting allows STDR to be filled before a target-transmit transfer is detected. However, it can cause STDR to be written before a NACK is detected on the last byte of a target-transmit transfer. 0b - MSR[TDF] is set only during a target-transmit transfer when STDR is empty 1b - MSR[TDF] is set whenever STDR is empty
9 SAEN	SMBus Alert Enable Enables a match on an SMBus alert. 0b - Disable 1b - Enable
8	General Call Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
GCEN	Enables a general call address. 0b - Disable 1b - Enable
7-5 —	Reserved
4 —	Reserved
3 ACKSTALL	ACK SCL Stall Enables SCL clock stretching during target-transmit address bytes and target-receiver address and data bytes, so you can write to Target Transmit ACK (STAR) before the ACK or NACK is transmitted. Clock stretching occurs when transmitting the ninth bit, and is therefore not compatible with HS mode. If this field is 1: • You do not need to write 1 to SCFGR1[RXSTALL] or SCFGR1[ADRSTALL]. • When there is an address match on the first byte of a 10-bit address, SSR[AVF] is set, allowing you to read the received address before writing to Target Transmit ACK (STAR). 0b - Disable 1b - Enable
2 TXDSTALL	Transmit Data SCL Stall Enables SCL clock stretching when SSR[TDF] = 1 during a target-transmit transfer. Clock stretching occurs following the ninth bit, and is therefore compatible with HS mode. 0b - Disable 1b - Enable
1 RXSTALL	RX SCL Stall Enables SCL clock stretching when SSR[RDF] = 1 during a target-receive transfer. Clock stretching occurs following the ninth bit, and is therefore compatible with HS mode. 0b - Disable 1b - Enable
0 ADRSTALL	Address SCL Stall Enables SCL clock stretching when SSR[AVF] = 1. Clock stretching only occurs following the ninth bit, and is therefore compatible with HS mode. 0b - Disable 1b - Enable

74.3.1.24 Target Configuration 2 (SCFGR2)

Offset

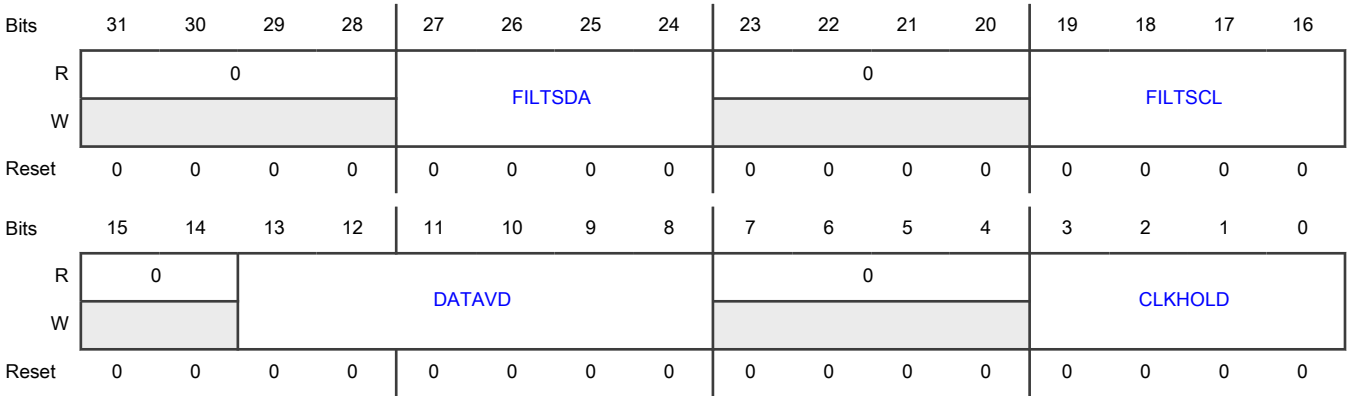
Register	Offset
SCFGR2	128h

Function

Configures data valid delay, clock hold time, and glitch filters for SDA and SCL.

Write to this register only when the I2C target is disabled.

Diagram



Fields

Field	Function
31-28 —	Reserved
27-24 FILTSDA	Glitch Filter SDA Configures the I2C target digital glitch filters for SDA input. Writing 0 to this field disables the glitch filter. Glitches equal to or less than the number of cycles defined by this field are filtered out and ignored. The latency through the glitch filter is equal to the number of cycles defined by this field + 3. The latency must be configured to be less than the minimum SCL low or high period. MCFGR1[PRESCALE] does not affect the glitch filter cycle count, and the glitch filter cycle count is disabled in HS mode.
23-20 —	Reserved
19-16	Glitch Filter SCL

Table continues on the next page...

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Field	Function
FILTSCL	Configures the I2C target digital glitch filters for SCL input. Writing 0 to this field disables the glitch filter. Glitches equal to or less than the number of cycles defined by this field are filtered out and ignored. The latency through the glitch filter is equal to the number of cycles defined by this field + 3. The latency must be configured to be less than the minimum SCL low or high period. MCFGR1[PRESCALE] does not affect the glitch filter cycle count, and the glitch filter cycle count is disabled in HS mode.
15-14 —	Reserved
13-8 DATAVD	Data Valid Delay Configures the SDA data valid delay time for the I2C target, which is equal to FILTSCL + DATAVD + 3 cycles. The data valid delay must be configured to be less than the minimum SCL low period. MCFGR1[PRESCALE] does not affect the I2C target data valid delay time, and the I2C target data valid delay time is disabled in HS mode.
7-4 —	Reserved
3-0 CLKHOLD	Clock Hold Time Configures the minimum clock hold time for the I2C target, when clock stretching is enabled. The minimum hold time is equal to the number of cycles defined by this field + 3. MCFGR1[PRESCALE] does not affect the I2C target clock hold time, and the I2C target clock hold time is disabled in HS mode.

74.3.1.25 Target Address Match (SAMR)

Offset

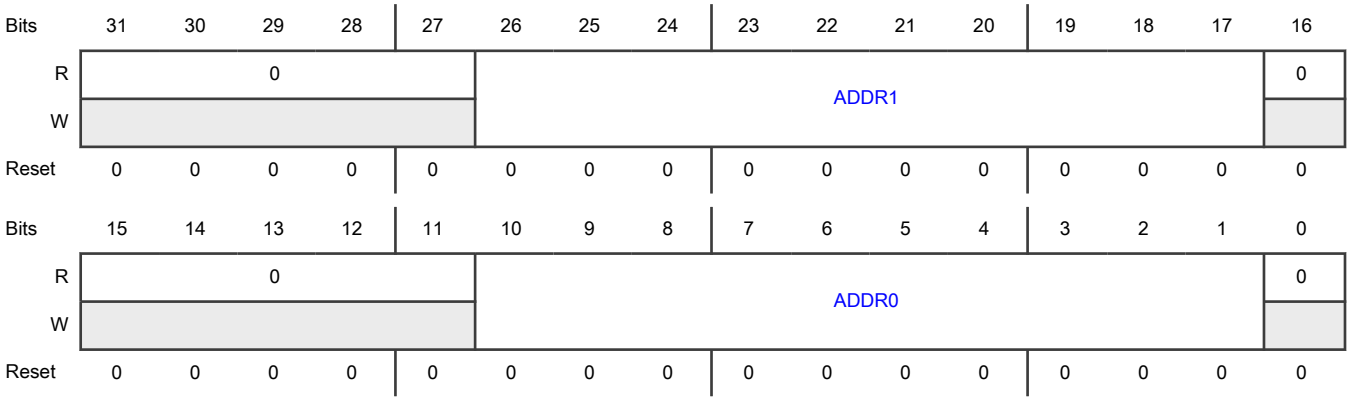
Register	Offset
SAMR	140h

Function

Contains address values for received target match comparison.

Write to this register only when the I2C target is disabled.

Diagram



Fields

Field	Function
31-27 —	Reserved
26-17 ADDR1	Address 1 Value Contains the value of address 1, which is compared to the received address to detect the target address. In 10-bit mode, the first address byte is compared to {11110, ADDR1[26:25]} and the second address byte is compared to ADDR1[24:17]. In 7-bit mode, the address is compared to ADDR1[23:17].
16-11 —	Reserved
10-1 ADDR0	Address 0 Value Contains the value of address 0, which is compared to the received address to detect the target address. In 10-bit mode, the first address byte is compared to {11110, ADDR0[10:9]} and the second address byte is compared to ADDR0[8:1]. In 7-bit mode, the address is compared to ADDR0[7:1].
0 —	Reserved

74.3.1.26 Target Address Status (SASR)

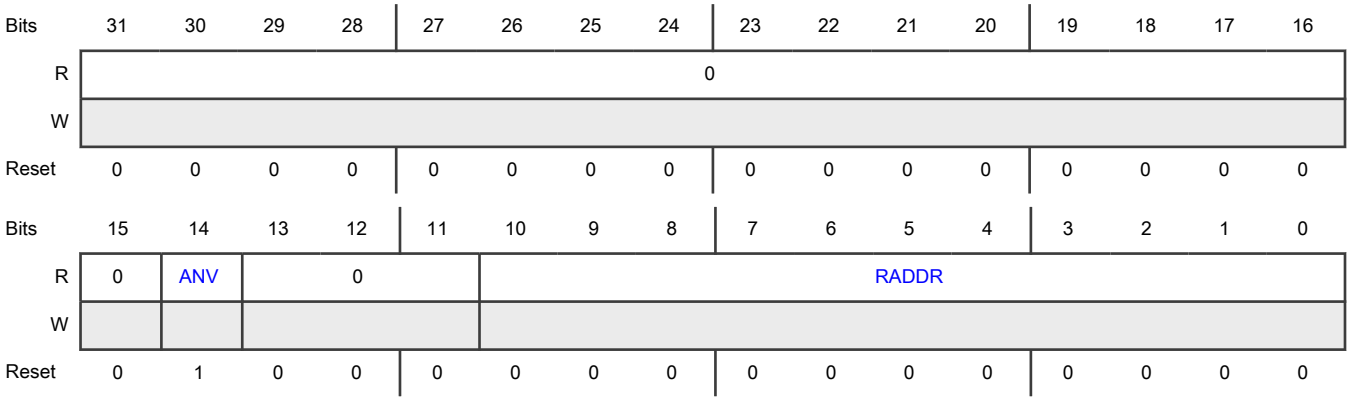
Offset

Register	Offset
SASR	150h

Function

Contains the received address and its validity.

Diagram



Fields

Field	Function
31-15 —	Reserved
14 ANV	Address Not Valid Indicates whether SASR[RADDR] is valid. 0b - Valid 1b - Not valid
13-11 —	Reserved
10-0 RADDR	Received Address Contains the received address. Updates whenever SSR[AM0F] or SSR[AM1F] is set. Reading Target Address Status (SASR) clears SSR[AM0F] and SSR[AM1F]. In 7-bit mode, the address byte is stored in RADDR[7:0]. In 10-bit mode, the first address byte is {11110, RADDR[10:9], RADDR[0]} and the second address byte is RADDR[8:1]. The Read-or-Write bit is therefore always stored in RADDR[0]. When SCFGR1[ACKSTALL] = 1, if the first address byte matches in 10-bit mode, the first address byte is stored in RADDR[7:0] so you can read this field before writing the Transmit ACK. If the second address byte matches, this field is then updated with the full 10-bit address.

74.3.1.27 Target Transmit ACK (STAR)

Offset

Register	Offset
STAR	154h

Function

Configures choice of ACK or NACK on each received word.

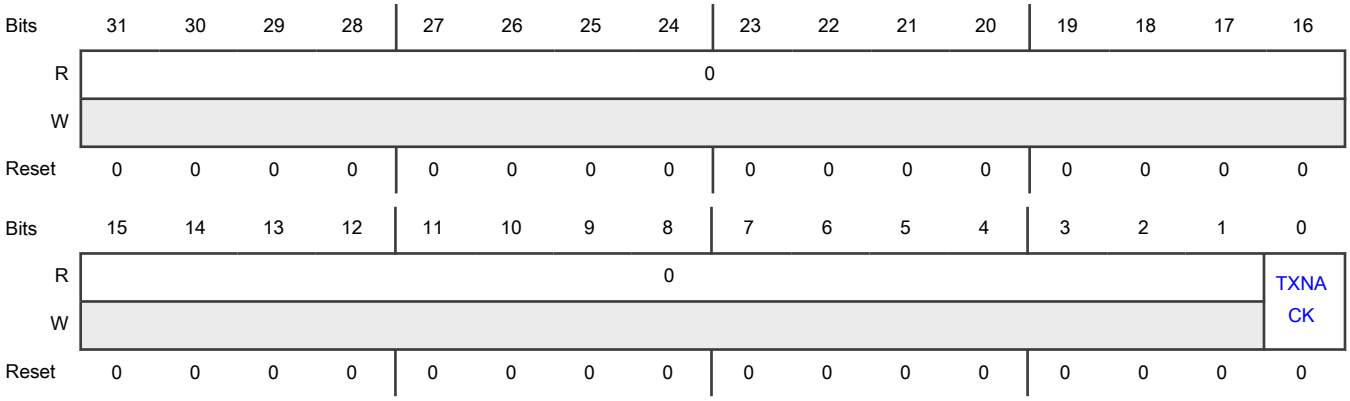
You can write to this register only when SCFGR1[ACKSTALL] = 1.

SCFGR1[ACKSTALL] enables clock stretching during the ACK-or-NACK bit slot. During this time, you can write to this register.

The logic ensures that the clock stretching continues for at least one bus clock cycle after this register is updated.

This clock stretching time can be extended via SCFGR2[CLKHOLD].

Diagram



Fields

Field	Function
31-1 —	Reserved
0 TXNACK	Transmit NACK Selects whether transmit ACK (logic 0) or NACK (logic 1) is returned on the bus by the I2C target after receiving each word. • When SCFGR1[ACKSTALL] = 1, a transmit NACK signal must be written once for each matching address byte and each received word. SCFGR1[ACKSTALL] must be 1, because that setting stalls the data transfer until software reads the received word (and determines whether to respond with an ACK or NACK). • To configure the default (ACK or NACK), you can write to this field when LPI2C target is disabled or idle. 0b - Transmit ACK 1b - Transmit NACK

74.3.1.28 Target Transmit Data (STDR)

Offset

Register	Offset
STDR	160h

Function

Contains the I2C target data to transmit.

Clock stretching (enabled or disabled) affects when the transmit data is transferred. SCFGR1[TXDSTALL] enables clock stretching during the first data bit of a target-transmit transfer.

If clock stretching is enabled (SCFGR1[TXDSTALL] = 1), the transmit data transfer is stalled until this register is updated. Clock stretching is extended by at least 1 bus clock cycle after this register is updated. Clock stretching can be delayed further by using SCFGR2[CLKHOLD].

If clock stretching is disabled (SCFGR1[TXDSTALL] = 0), the transmit data must be written before the start of the target-transmit transfer, otherwise SSR[FEF] is set.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	0								DATA							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0 DATA	Transmit Data Contains the I2C target data to transmit. Writing data to this register stores I2C target transmit data in this register.

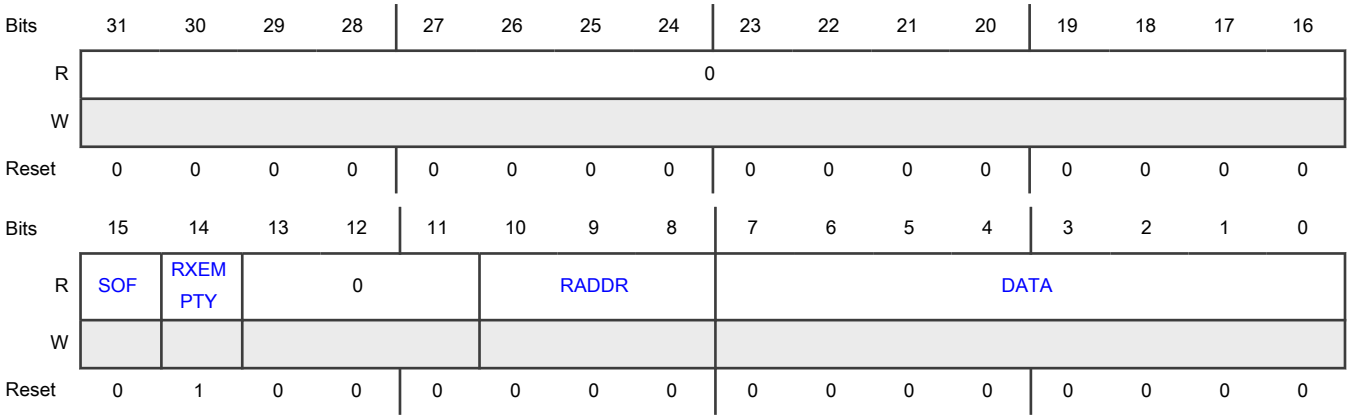
74.3.1.29 Target Receive Data (SRDR)

Offset

Register	Offset
SRDR	170h

Function
Contains status of target receive data transfer.

Diagram



Fields

Field	Function
31-16 —	Reserved
15 SOF	Start of Frame Indicates whether this data word is the first data word since a (repeated) Start or Stop condition. 0b - Not first 1b - First
14 RXEMPTY	Receive Empty Indicates whether this register is empty. 0b - Not empty 1b - Empty
13-11 —	Reserved
10-8	Received Address

Table continues on the next page...

Table continued from the previous page...

Field	Function
RADDR	Contains the address received by the IC2 target. When both SCFGR1[RXCFG] and SSR[AVF] are 1, bits [10:8] of SASR[RADDR] are returned. Otherwise, this field returns zero.
7-0 DATA	Received Data Contains the data received by the I2C target. When both SCFGR1[RXCFG] and SSR[AVF] are 1, bits [7:0] of SASR[RADDR] are returned.

74.4 Functional description

74.4.1 Controller mode

The LPI2C controller logic operates independently from the target logic to perform all controller-mode transfers on the I2C bus.

74.4.1.1 Transmit and Command FIFO commands

The transmit FIFO stores command data to initiate various I2C operations. The following operations can be initiated through commands in the transmit FIFO:

- Start or repeated Start condition with address byte, expecting ACK or NACK.
- Transmit data. This operation is the default for zero-extended-byte writes to the transmit FIFO.
- Receive 1-256 bytes of data. You can configure this operation to discard received data and not to store it in the receive FIFO.
- Stop condition. You can configure this operation to send a Stop condition when the transmit FIFO is empty.

Multiple transmit and receive commands can be inserted between the Start and Stop conditions. To comply with the I2C specification, transmit and receive commands must not be interleaved. The receive data command and the receive data and discard commands can be interleaved. This interleaving ensures that only the desired received data is stored in the receive FIFO (or compared with the data match logic).

The LPI2C controller automatically transmits a NACK on the last byte of a receive data command. It transmits the NACK unless the next command in the FIFO is also a receive data command. If the transmit FIFO is empty when a receive data command completes, a NACK is also automatically transmitted.

The LPI2C controller supports 10-bit addressing via a (repeated) Start condition, followed by a transmit data byte containing the second address byte, followed by any number of data bytes with the controller transmit data.

A Start or repeated Start condition expecting a NACK (for example, HS mode controller code) must be followed by a Stop or (repeated) Start condition.

74.4.1.2 Controller operations

When LPI2C is enabled, it monitors the I2C bus to detect when the I2C is idle (MSR[BBF]). If either SCL or SDA are low, the I2C bus is no longer considered idle. The bus becomes idle if a Stop condition is detected or if a bus idle timeout is detected (as configured by MCFGR2[BUSIDLE]). After the bus is idle, if the transmit FIFO is not empty and the host request is asserted or disabled, the LPI2C controller initiates a transfer on the bus. This transfer involves the following steps:

1. Wait the bus idle time equal to (MCCR0[CLKLO] + 1) multiplied by the prescaler (MCFGR1[PRESCALE]).
2. Transmit a Start condition and address byte using the timing configuration in Controller Clock Configuration 0 (MCCR0). If an HS mode transfer is configured, the timing configuration from Controller Clock Configuration 1 (MCCR1) is used instead.
3. Perform controller transmit or controller receive transfers, as configured by the transmit FIFO.

4. Transmit NACK on the last byte of a controller receive transfer. This action is performed unless the next command in the transmit FIFO is also a receive data command and the transmit FIFO is not empty.
5. Transmit a repeated Start or Stop condition as configured by the transmit FIFO or MCFGR1[AUTOSTOP]. A repeated Start can change which timing configuration register is used.

When the LPI2C controller is disabled, LPI2C continues emptying the transmit FIFO until a Stop condition is transmitted. (The controller could be disabled due to MCR[MEN] being 0, or automatically due to mode entry.) However, LPI2C no longer stalls the I2C bus by waiting for the transmit or receive FIFO. After the transmit FIFO is empty, LPI2C generates a Stop condition automatically.

The LPI2C controller can stall the I2C bus under certain conditions. This stalling results in SCL pulled low continuously on the first bit of a byte, until these conditions change:

- The LPI2C controller is enabled and busy, the transmit FIFO is empty, and MCFGR1[AUTOSTOP] is 0. The LPI2C controller continues to stall the bus until the transmit FIFO is loaded with more data.
- The LPI2C controller is enabled and receiving data, receive data is not being discarded (due to command or receive data match), and the receive FIFO is full. The LPI2C controller continues to stall the I2C bus until the receive FIFO is emptied.

74.4.1.3 Receive FIFO and data matching

The receive FIFO stores receive data during controller-receiver transfers. You can configure the LPI2C controller to discard received data instead of storing it in the receive FIFO. This option is configured via the command word in the transmit FIFO.

Received data supports a receive data match function that can match received data against one of two bytes, or against a masked data byte. You can configure the data match function to compare only the first one or two data words received since the last (repeated) Start condition. Received data that is already discarded due to the command word cannot cause a data match. It delays the match on the first data word received until after the discarded data is received.

You can configure the receiver match function to discard all received data until a data match is detected, using MCFGR0[RDMO]. Following a data match, write 0 to MCFGR0[RDMO] before writing 0 to MSR[DMF] to allow all subsequent data to be received.

74.4.1.4 Timing parameters

The LPI2C controller can configure the following timing parameters. Parameters are configured separately for HS mode (Controller Clock Configuration 1 (MCCR1)) and other modes (Controller Clock Configuration 0 (MCCR0)). This separation allows the HS mode controller code to be sent using regular timing parameters. Then it allows a switch to HS mode timing (following a repeated Start) until the next STOP condition.

Configure the LPI2C controller timing parameters, measured in LPI2C functional clock cycles, as shown in Table 504. You must configure these parameters to meet the I2C timing specification for the required mode.

Table 504. Timing parameters

I2C specification timing parameter	I2C specification timing symbol	LPI2C timing parameter (in LPI2C functional clock cycles)
SCL clock period	tSCL	(CLKHI + CLKLO + 2 + SCL_LATENCY) × (2 ^ PRESCALE)
Hold time (repeated) Start condition	tHD:STA	(SETHOLD +1) × (2 ^ PRESCALE)
Low period of the SCL clock	tLOW	(CLKLO + 1) × (2 ^ PRESCALE)
High period of the SCL clock	tHIGH	(CLKHI + 1 + SCL_LATENCY) × (2 ^ PRESCALE)
Setup time for a repeated Start condition or Stop condition	tSU:STA, tSU:STO	(SETHOLD + 1 + SCL_LATENCY) × (2 ^ PRESCALE)

Table continues on the next page...

Table 504. Timing parameters (continued)

I2C specification timing parameter	I2C specification timing symbol	LPI2C timing parameter (in LPI2C functional clock cycles)
Data hold time	tHD:DAT	(DATAVD + 1) × (2 ^ PRESCALE)
Data setup time	tSU:DAT	(SDA_LATENCY + 1) × (2 ^ PRESCALE)
Bus free time between a Stop and Start condition	tBUF	(CLKLO + 1 + SDA_LATENCY) × (2 ^ PRESCALE)
Data valid time, data valid acknowledge time	tVD:DAT, tVD:ACK	(DATAVD + 1) × (2 ^ PRESCALE)

Table 505 defines the latency parameters. These parameters assume that the risetime is less than one LPI2C functional clock cycle. The risetime depends on a number of factors, including the I/O propagation delay, the I2C bus loading, and the external pullup resistor sizing. A larger risetime increases the number of cycles that the signal takes to propagate through the synchronizer (and glitch filter), which increases the latency.

Table 505. Synchronization latency

Timing parameter	Timing definition
SCL_LATENCY	ROUNDDOWN ((2 + FILTSCL + SCL_RISETIME) ÷ (2 ^ PRESCALE))
SDA_LATENCY	ROUNDDOWN ((2 + FILTSDA + SDA_RISETIME) ÷ (2 ^ PRESCALE))

The following timing restrictions must be enforced to avoid unexpected Start or Stop conditions on the I2C bus. These restrictions also avoid unexpected Start or Stop conditions detected by the LPI2C controller. The timing restrictions can be summarized as "SDA cannot change when SCL is high outside a transmitted (repeated) Start or Stop condition."

Table 506. LPI2C timing parameter restrictions

Timing parameter	Minimum	Maximum	Comment
CLKLO	03h	—	CLKLO x (2 ^ PRESCALE) > SCL_LATENCY
CLKHI	01h	—	Configure CLKHI to meet the duty cycle requirements in the I2C specification
SETHOLD	02h	—	SETHOLD × (2 ^ PRESCALE) > SDA_LATENCY
DATAVD	01h	CLKLO – SDA_LATENCY – 1	Configure DATAVD to meet the data hold requirement in the I2C specification
FILTSCL	00h	[CLKLO × (2 ^ PRESCALE)] – 3	FILTSCL and FILTSDA are the only parameters not multiplied by (2 ^ PRESCALE)
FILTSDA	FILTSCL	[CLKLO × (2 ^ PRESCALE)] – 3	Configuring FILTSDA greater than FILTSCL can delay the SDA input to compensate for board level skew
BUSIDLE	(CLKLO + SETHOLD + 2) × 2	—	Must also be greater than (CLKHI + 1)

See the UM10204, *I2C-bus specification and user manual*.

See Application information for example LPI2C timing configurations.

74.4.1.5 Error conditions

The LPI2C controller monitors errors while it is active. The following conditions generate an error flag and block a new Start condition from being sent, until the flag is cleared by software:

- A Start or Stop condition is detected and is not generated by the LPI2C controller (MSR[ALF] becomes 1).
- Transmitting data on SDA and different values are received (MSR[ALF] becomes 1).
- NACK is detected when transmitting data, and MCFGR1[IGNACK] is 0 (MSR[NDF] becomes 1).
- NACK is detected and is expecting ACK for the address byte, and MCFGR1[IGNACK] is 0 (MSR[NDF] becomes 1).
- ACK is detected and is expecting NACK for the address byte, and MCFGR1[IGNACK] is 0 (MSR[NDF] becomes 1).
- Transmit FIFO is requesting to transmit or receive data without a Start condition (MSR[FEF] becomes 1).
- SCL (or SDA if MCFGR1[TIMECFG] is 1) is low for (MCFGR2[TIMELOW] × 256) prescaler cycles without a pin transition (MSR[PLTF] becomes 1).

You must respond to MSR[PLTF] to terminate the existing command. You can terminate the command cleanly by writing 0 to MCR[MEN], or you can terminate it abruptly by writing 1 to MCR[RST].

You can use MCFGR2[BUSIDLE] to force the I2C bus to be considered idle when SCL and SDA remain high for (BUSIDLE + 1) prescaler cycles. The bus is considered idle when the LPI2C controller is first enabled. When BUSIDLE is configured greater than zero, then SCL or SDA must be high for (BUSIDLE + 1) prescaler cycles before the I2C bus is considered idle.

74.4.1.6 Pin configuration

Configuration	Description
Open-drain support	The LPI2C controller defaults to open-drain configuration of the SDA and SCL pins. Support for true open drain depends on the specific device, and requires the pins where LPI2C pins are muxed to support true open drain.
HS mode support	Support for HS mode depends on the specific device. This mode requires the SCL pin to support the current source pullup required in the I2C specification.
Ultra-Fast mode support	The LPI2C controller supports the output-only push-pull function required for I2C Ultra-Fast mode using the SDA and SCL pins. Support for Ultra-Fast mode also requires MCFGR1[IGNACK] to be 1.
Push-pull two-wire support	A push-pull two-wire configuration is available to the LPI2C controller. If LPI2C is the only controller and all I2C pins on the bus are at the same voltage, this configuration may support a partial HS mode. A partial HS mode, not a full HS mode, because this configuration actively drives high rather than enabling a current service pull-up. This configuration sets the SCL pin as push-pull for every clock except the first clock pulse, to allow HS-mode-compatible targets to perform clock stretching. In this mode, the SDA pin is tristated for controller-receive data bits and controller-transmit ACK/NACK bits, and is configured as push-pull at other times. To avoid the risk of contention when SDA is push-pull, configure the pin for open-drain operation, as part of the device-specific configuration.
Push-pull four-wire support	The push-pull four-wire configuration separates the SCL input data and output data into separate pins. It also separates the SDA input data and output data into separate pins. The SCL/SDA pins are used for input data; the SCLS/SDAS pins are used for output data, with configurable polarity. This configuration simplifies external connections when connecting the LPI2C to the I2C bus through external level shifters or discrete components. When using this four-wire configuration, the LPI2C controller logic and LPI2C target logic cannot connect to separate I2C buses.

74.4.2 Target mode

To perform all target mode transfers on the I2C bus, the LPI2C target logic operates independently from the LPI2C controller logic.

74.4.2.1 Address matching

You can configure the LPI2C target:

- To match one of two addresses, using either 7-bit or 10-bit addressing modes for each address.
- To match a range of addresses in either 7-bit or 10-bit addressing modes.
- To match the general call address and generate appropriate flags.
- To match the SMBus alert address and generate appropriate flags.
- To detect the HS mode controller code address, and to disable the digital filters and output valid delay time until the next Stop condition is detected.

After a valid address is matched, the LPI2C target automatically performs target-transmit or target-receive transfers until:

- A NACK is detected (unless SCFGR1[IGNACK] becomes 1).
- A bit error is detected (the LPI2C target is driving SDA, but a different value is sampled).
- A (repeated) Start or Stop condition is detected.

74.4.2.2 Transmit and receive data

Target Transmit Data (STDR) and Target Receive Data (SRDR) are double-buffered and only update during a target-transmit and target-receive transfer, respectively.

You can configure the target address that was received to be read from SRDR (for example, when using DMA to transfer data) or from Target Address Status (SASR).

You can configure STDR to request data only after a target-transmit transfer is detected. You can also configure it to request new data whenever STDR is empty.

Write to STDR only when SSR[TDF] is set.

Read SRDR only when SSR[RDF] is set, or when SSR[AVF] is set and SCFGR1[RXCFG] = 1.

Read SASR only when SSR[AVF] is set.

74.4.2.3 Clock stretching

The LPI2C target supports many configurable options for clock stretching. You can configure these conditions to perform clock stretching:

- SSR[AVF] is set during the ninth clock pulse of the address byte.
- SSR[TDF] is set during the ninth clock pulse of a target-transmit transfer.
- SSR[RDF] is set during the ninth clock pulse of a target-receive transfer.
- SSR[TAF] is set during the eighth clock pulse of an address byte or a target-receive transfer. In HS mode, this option is disabled.
- Clock stretching can be extended for a number of cycles equal to the value of SCFGR2[CLKHOLD] cycles. This stretching allows additional setup time to sample the SDA pin externally. In HS mode, this option is disabled.

When clock stretching is enabled, clock stretching extends for one peripheral bus clock cycle after SDA updates, unless extended by the SCFGR2[CLKHOLD] configuration.

74.4.2.4 Timing parameters

The LPI2C target can configure the following timing parameters:

- SDA data valid time from SCL negation to SDA update
- SCL hold time when clock stretching is enabled to increase setup time when sampling SDA externally

- SCL glitch filter time
- SDA glitch filter time

These parameters are disabled when SCR[FILTEN] is 0, when SCR[FILTDZ] is 1 in Doze mode, and when LPI2C target detects HS mode. When disabled, the LPI2C target is clocked directly from the I2C bus. In this case, the target may not satisfy all timing requirements of the I2C specification (such as SDA minimum hold time in Standard/Fast mode).

The LPI2C target places the following restrictions on the timing parameters:

- You must configure SCFGR2[FILTSDA] to be greater than or equal to SCFGR2[FILTSCL] (unless compensating for board level skew between SDA and SCL).
- You must configure SCFGR2[DATAVD] to be less than the minimum SCL low period.

74.4.2.5 Error conditions

The LPI2C target can flag the following error conditions:

- SSR[BEF] is set when the LPI2C target is driving SDA but it samples a different value than what is expected.
- SSR[FEF] is set due to a transmit data underrun or a receive data overrun. To eliminate the possibility of underrun and overrun, enable clock stretching.
- SSR[FEF] is also set due to an address overrun, but only when SCFGR1[RXCFG] is 1. To eliminate the possibility of overrun, enable clock stretching.

The LPI2C target does not implement a timeout due to SCL or SDA being stuck low. If this detection is required, use the LPI2C controller logic so you can reset the LPI2C target when this condition is detected.

74.4.3 Low-power modes

LPI2C remains functional during low-power modes, if MCR[DOZEN] = 0 and LPI2C uses an external or internal clock source that remains enabled. LPI2C can generate an interrupt or DMA request to cause a wake-up from low-power modes.

You can configure LPI2C to be disabled in low-power modes when MCR[DOZEN] = 1. In this case, LPI2C waits for the current transfer to complete any pending operation.

NOTE

See the chip-specific information for low-power modes available on your chip.

74.4.4 Debug mode

Table 507. Debug mode

Mode	LPI2C operation
Debug	If MCR[DBGEN] = 1, can continue operating in Debug mode.

74.4.5 Peripheral triggers

The connection of the LPI2C peripheral triggers to other peripherals depends upon the specific device being used.

Table 508. LPI2C triggers

Trigger	Description
Controller output trigger	Generates an output trigger that can be connected to other peripherals on the device. The controller output trigger asserts on either a repeated Start or a Stop condition. The trigger remains asserted for one cycle of the LPI2C functional clock divided by MCFGR1[PRESCALE].

Table continues on the next page...

Table 508. LPI2C triggers (continued)

Trigger	Description
Target output trigger	Generates an output trigger that can be connected to other peripherals on the device. The target output trigger asserts on either a repeated Start or a Stop condition that occurs after a target address match. The target output trigger remains asserted until the next target SCL pin negation.
Input trigger	To control the start of a LPI2C bus transfer, the LPI2C input trigger can be selected instead of the HREQ input. The input trigger is synchronized. To be detected, the input trigger must assert for at least two cycles of the LPI2C functional clock divided by the value of MCFGR1[PRESCALE]. When LPI2C is busy, the HREQ input (and therefore the input trigger) is ignored.

74.4.6 Clocking

Table 509. LPI2C clocks

Clock	Description
LPI2C functional clock	The LPI2C functional clock is asynchronous to the bus clock. It can remain enabled in low-power modes to support I2C bus transfers by the LPI2C controller. The functional clock is also used by the LPI2C target to support digital filter and data hold time configurations. The LPI2C controller divides the functional clock by a prescaler (MCFGR1[PRESCALE]) and the resulting frequency must be at least eight times faster than the I2C bus bandwidth.
External clock	The LPI2C target logic is clocked directly from the external pins. These pins are SCL and SDA, or SCLS and SDAS if the controller and target are implemented on separate pins). This clocking allows the LPI2C target to remain operational, even when the LPI2C functional clock is disabled. **NOTE** If the LPI2C functional clock is disabled, the LPI2C target digital filter must be disabled. This condition can affect compliance with some timing parameters of the I2C specification, such as data hold time.
Bus clock	The bus clock is only used for bus accesses to the control and configuration registers. The bus clock frequency must be sufficient to support the data bandwidth requirements of the LPI2C controller and target registers.

For chip-specific clocking information, see the Clocking chapter.

74.4.7 Reset

Table 510. LPI2C resets

Reset	Description
Chip reset	The logic and registers for the LPI2C controller and target are reset to their default states after a chip reset.
Software reset	The LPI2C controller implements a software reset field in its control register. MCR[RST] resets all controller logic and registers to their default states, except for Controller Control (MCR) itself. The LPI2C target implements a software reset field in its control register. SCR[RST] resets all target logic and registers to their default states, except for Target Control (SCR) itself.

Table continues on the next page...

Table 510. LPI2C resets (continued)

Reset	Description
FIFO reset	The LPI2C controller implements write-only control fields that reset the transmit FIFO (MCR[RTF]) and receive FIFO (MCR[RRF]). After a FIFO is reset, that FIFO is empty. The LPI2C target implements write-only control fields that reset the transmit data register (SCR[RTF]) and receive data register (SCR[RRF]). After a data register is reset, that data register is empty.

74.4.8 Interrupts and DMA requests

Depending on the configuration, interrupts and DMA requests can be combined:

- LPI2C controller and target interrupts
- LPI2C controller and target transmit DMA requests
- LPI2C controller and target receive DMA requests

74.4.8.1 Controller mode

Table 511 lists the Controller mode sources that can generate LPI2C controller interrupts and LPI2C controller transmit and receive DMA requests.

Table 511. Controller interrupts and DMA requests

Status flag	Description	Can generate		
		Interrupt?	DMA request?	Low-power wake-up?
Transmit Data Flag (MSR[TDF])	Data can be written to transmit FIFO, as configured by MFCR[TXWATER].	Y	TX	Y
Receive Data Flag (MSR[RDF])	Data can be read from the receive FIFO, as configured by MFCR[RXWATER].	Y	RX	Y
End Packet Flag (MSR[EPF])	Controller has transmitted a repeated Start or Stop condition.	Y	N	Y
Stop Detect Flag (MSR[SDF])	Controller has transmitted a Stop condition .	Y	N	Y
NACK Detect Flag (MSR[NDF])	During an address byte, the controller expects an ACK but detects a NACK. During an address byte, the controller expects a NACK but detects an ACK. During a controller-transmitter data byte, the controller detects a NACK.	Y	N	Y
Arbitration Lost Flag (MSR[ALF])	The controller lost arbitration due to a Start or Stop condition detected at the wrong time, or the controller was transmitting data but received data different from the data that was transmitted.	Y	N	Y

Table continues on the next page...

Table 511. Controller interrupts and DMA requests (continued)

Status flag	Description	Can generate		
		Interrupt?	DMA request?	Low-power wake-up?
FIFO Error Flag (MSR[FEF])	The controller expects a Start condition in the command FIFO, but the next entry in the command FIFO is not a Start condition.	Y	N	Y
Pin Low Timeout Flag (MSR[PLTF])	Pin low timeout is enabled and SCL (or SDA, if configured) is low for longer than the configured timeout.	Y	N	Y
Data Match Flag (MSR[DMF])	The received data matches the configured data match, but the received data is not discarded due to a command FIFO entry.	Y	N	Y
Controller Busy Flag (MSR[MBF])	LPI2C controller is busy transmitting or receiving data.	N	N	N
Bus Busy Flag (MSR[BBF])	LPI2C controller is enabled and activity is detected on the I2C bus, but no Stop condition is detected and no bus idle timeout (if enabled) occurred.	N	N	N

74.4.8.2 Target mode

Table 512 lists the target mode sources that can generate LPI2C target interrupts and LPI2C target transmit and receive DMA requests.

Table 512. Target interrupts and DMA requests

Status flag	Description	Can generate		
		Interrupt?	DMA request?	Low-power wake-up?
Transmit Data Flag (SSR[TDF])	Data can be written to Target Transmit Data (STDR).	Y	TX	Y
Receive Data Flag (SSR[RDF])	Data can be read from Target Receive Data (SRDR).	Y	RX	Y
Address Valid Flag (SSR[AVF])	Address can be read from Target Address Status (SASR).	Y	RX	Y
Transmit ACK Flag (SSR[TAF])	ACK or NACK can be written to Target Transmit ACK (STAR).	Y	N	Y
Repeated Start Flag (SSR[RSF])	Target has detected an address match followed by a repeated Start condition.	Y	N	Y
Stop Detect Flag (SSR[SDF])	Target has detected an address match followed by a Stop condition.	Y	N	Y
Bit Error Flag (SSR[BEF])	Target was transmitting data, but received data is different from what was transmitted.	Y	N	Y

Table continues on the next page...

Table 512. Target interrupts and DMA requests (continued)

Status flag	Description	Can generate		
		Interrupt?	DMA request?	Low-power wake-up?
FIFO Error Flag (SSR[FEF])	This flag is set by: • Transmit data underrun • Receive data overrun • Address status overrun when SCFGR1[RXCFG] = 1 This flag can only be set when clock stretching is disabled.	Y	N	Y
Address Match 0 Flag (SSR[AM0F])	Target detected an address match SAMR[ADDR0].	Y	N	N
Address Match 1 Flag (SSR[AM1F])	Target detected an address match with SAMR[ADDR1] or using an address range.	Y	N	N
General Call Flag (SSR[GCF])	Target detected an address match with the general call address.	Y	N	N
SMBus Alert Response Flag (SSR[SARF])	Target detected an address match with the SMBus alert address.	Y	N	N
Target Busy Flag (SSR[SBF])	LPI2C target is busy receiving an address byte or is transmitting or receiving data.	N	N	N
Bus Busy Flag (SSR[BBF])	LPI2C target is enabled and a Start condition is detected on I2C bus, but no Stop condition detected.	N	N	N

74.5 External signals

Table 513. External signals

Signal	Name	Two-wire scheme	Four-wire scheme	Direction
SCL	LPI2C clock line	SCL	In Four-Wire mode, this pin is the SCL input pin.	Input or output
SDA	LPI2C data line	SDA	In Four-Wire mode, this pin is the SDA input pin.	Input or output
SCLS	Secondary I2C clock line	Not used	In Four-Wire mode, this pin is the SCLS output pin. If LPI2C controller/target are configured to use separate pins, then this pin is the LPI2C target SCL pin.	Input or output
SDAS	Secondary I2C data line	Not used	In Four-Wire mode, this pin is the SDAS output pin. If LPI2C controller/target are configured to use separate pins, then this pin is the LPI2C target SDA pin.	Input or output

Table continues on the next page...

Table 513. External signals (continued)

Signal	Name	Two-wire scheme	Four-wire scheme	Direction
HREQ	Host request	If host request is asserted and the I2C bus is idle, then it initiates an LPI2C controller transfer. HREQ is an additional pin separate from the two-wire or four-wire scheme.		Input

Figure 513 shows the two-signal connection.

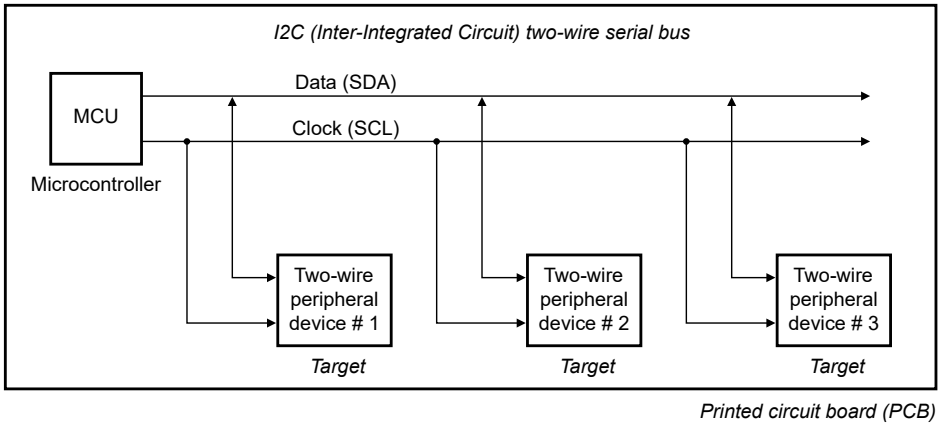


Figure 513. I²C two-wire serial bus

Figure 514 shows a possible four-signal connection.

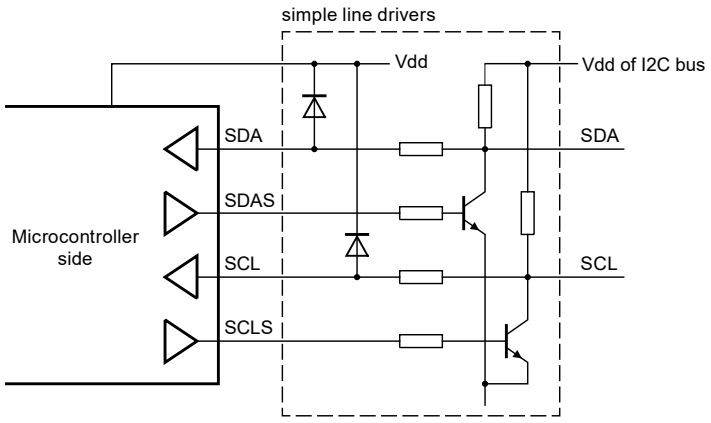


Figure 514. I²C four-wire serial bus

74.6 Initialization

To initialize the LPI2C controller:

1. Configure Controller Configuration 0 (MCFGR0)–Controller Configuration 3 (MCFGR3) as required by the application.
2. Configure Controller Clock Configuration 0 (MCCR0) and Controller Clock Configuration 1 (MCCR1) to satisfy the timing requirements of the I2C mode supported by the application.
3. Enable controller interrupts and DMA requests as required by the application.

4. Enable the LPI2C controller by writing 1 to MCR[MEN].

To initialize the LPI2C target:

1. Configure Target Address Match (SAMR) with the I2C address of the target location on the I2C bus.
2. Configure Target Configuration 1 (SCFGR1) as required by the application.
3. Configure Target Configuration 2 (SCFGR2) to satisfy the timing requirements of the I2C mode supported by the application.
4. Enable target interrupts and DMA requests as required by the application.
5. Enable the LPI2C target by writing 1 to SCR[SEN].

74.7 Application information

Configure the I2C timing parameters to meet the requirements of the I2C specification. This configuration depends on the supported mode and LPI2C functional clock frequency. When switching between two modes using different clock configuration registers (for example, Fast mode and HS mode), MCFGR1[PRESCALE] must remain constant between the modes.

Table 514. Example timing configurations

I2C mode	Clock frequency	Baud rate	PRESCALE	FILTSCL / FILTSDA	SETHOLD	CLKLO	CLKHI	DATAVD
Standard	8 MHz	100 kbit/s	0h	0h/0h	24h	28h	24h	02h
Standard	48 MHz	100 kbit/s	2h	1h/1h	37h	3Fh	37h	03h
Standard	60 MHz	100 kbit/s	2h	1h/1h	45h	50h	44h	04h
Fast	8 MHz	400 kbit/s	0h	0h/0h	04h	0Bh	05h	02h
Fast+	8 MHz	1 Mbit/s	0h	0h/0h	02h	03h	01h	01h
Fast	48 MHz	400 kbit/s	0h	1h/1h	1Dh	3Eh	35h	0Fh
Fast	48 MHz	400 kbit/s	2h	1h/1h	07h	11h	0Bh	03h
Fast+	48 MHz	1 Mbit/s	2h	1h/1h	03h	06h	04h	04h
HS	48 MHz	3.2 Mbit/s	0h	0h/0h	07h	08h	03h	01h
Fast	60 MHz	400 kbit/s	1h	2h/2h	11h	28h	1Fh	08h
Fast+	60 MHz	1 Mbit/s	1h	2h/2h	07h	0Fh	0Bh	01h
HS	60 MHz	3.33 Mbit/s	1h	0h/0h	04h	04h	02h	01h

74.8 Glossary

HREQ	Host request
SCL	Serial clock line
SCLS	Secondary serial clock line
SDA	Serial data line
SDAS	Secondary serial data line

Chapter 75
Flexible I/O (FlexIO)

75.1 Chip-specific FlexIO information

75.1.1 FlexIO instances and configuration

The device contains one instance of FlexIO.

FlexIO is a highly configurable module providing a wide range of functionality including:

- Emulation of a variety of serial communication protocols like UART, I2C, SPI. It can work either as master or slave.
- Flexible 16-bit timers with support for a variety of trigger, reset, enable and disable conditions.

Table 515. FlexIO configuration

No. of pins	No. of timers	No. of shift registers	No. of bits in counter
32	8	8	16

Table 516. Data rate limitation

FlexIO operation	Data rate limitation
Master Tx	FlexIO_clk/4
Slave Tx	FlexIO_clk/10
Master Rx	FlexIO_clk/8
Slave Rx	FlexIO_clk/6

NOTE

FlexIO supports 32 bit accesses only.

75.2 Overview

FLEXIO is a highly configurable module that provides:

- Emulation of various serial or parallel communication protocols.
- Flexible 16-bit timers with support for various trigger, reset, enable, and disable conditions.
- Programmable logic blocks that allow the implementation of digital logic functions on-chip and configurable interaction of internal and external modules.
- Programmable state machine for offloading basic system control functions from the CPU.

75.2.1 Block diagram

The following diagram provides a high-level overview of the FLEXIO timer and shifter configuration.

FLEXIO uses shifters, timers, and external triggers to shift data into or out of FLEXIO. As shown in the block diagram, timers control the timing of this data shift. You can configure the timers to use generic timer functions, external triggers, or various other conditions to determine the control.

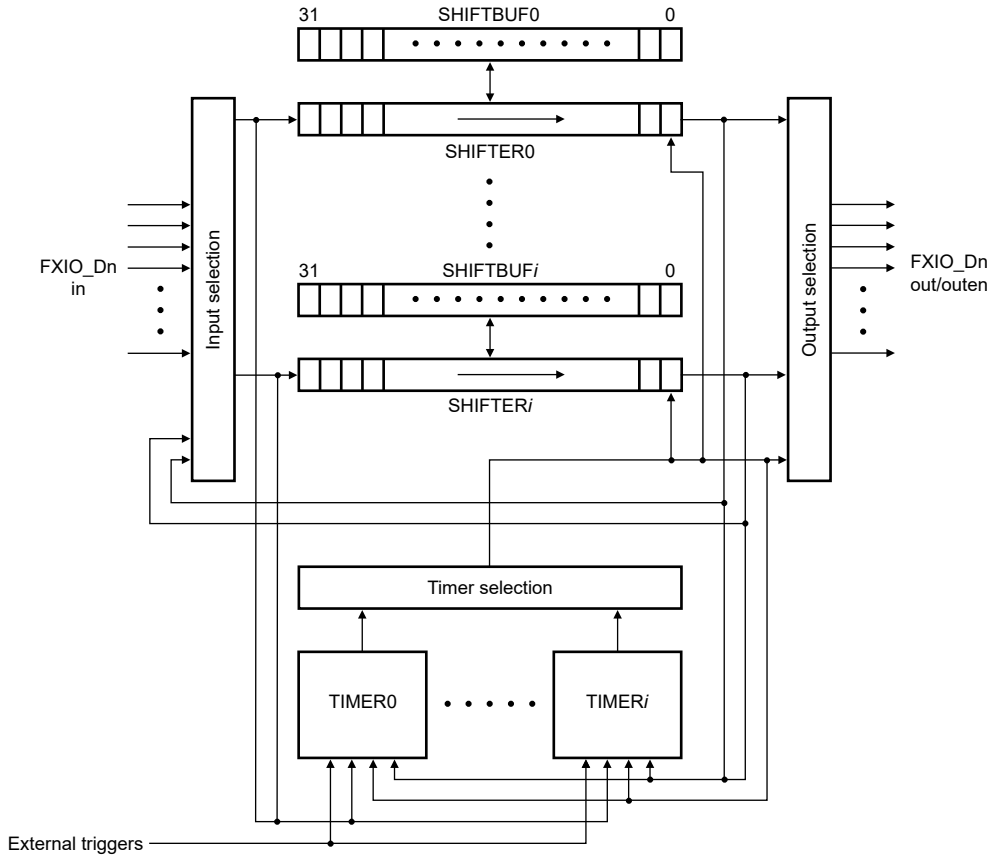


Figure 515. Block diagram

75.2.2 Features

- Array of 32-bit shift registers with transmit, receive, data match, logic, and state modes:
  - Double-buffered shifter operation for continuous data transfer
  - Shifter concatenation to support large transfer sizes
  - Automatic start and stop bit generation
  - 1, 2, 4, 8, 16, or 32 multi-bit shift widths for parallel interface support
  - Interrupt, DMA, or polled transmit and receive operation
- Highly flexible 16-bit timers with support for various internal or external triggers, reset, enable, and disable conditions:
  - Programmable baud rates independent of bus clock frequency
  - Programmable logic mode for integrating external digital logic functions on-chip, or combining pin, shifter, or timer functions to generate complex outputs
  - Programmable state machine for offloading basic system control functions from CPU, with support for up to eight states, eight outputs, and three selectable inputs per state
- Integrated general-purpose I/O registers and pin rising or falling edge interrupts to simplify software support
- Support for a wide range of protocols, including but not limited to:
  - UART
  - I2C

— SPI

— I2S

— Camera IF

— Motorola 68K or Intel 8080 bus

— PWM or waveform generation

— Input-capture (pulse-edge interval measurement), such as SENT

75.3 Functional description

75.3.1 Shifter operation

Shifters are responsible for buffering and shifting data into or out of FLEXIO. The timer assigned to the shifter controls the timing of shift, load, and store events via SHIFTCTL*n*[TIMSEL]. Shifters are designed to support either DMA, interrupt, or polled operations. The following figure provides a detailed view of the shifter microarchitecture.

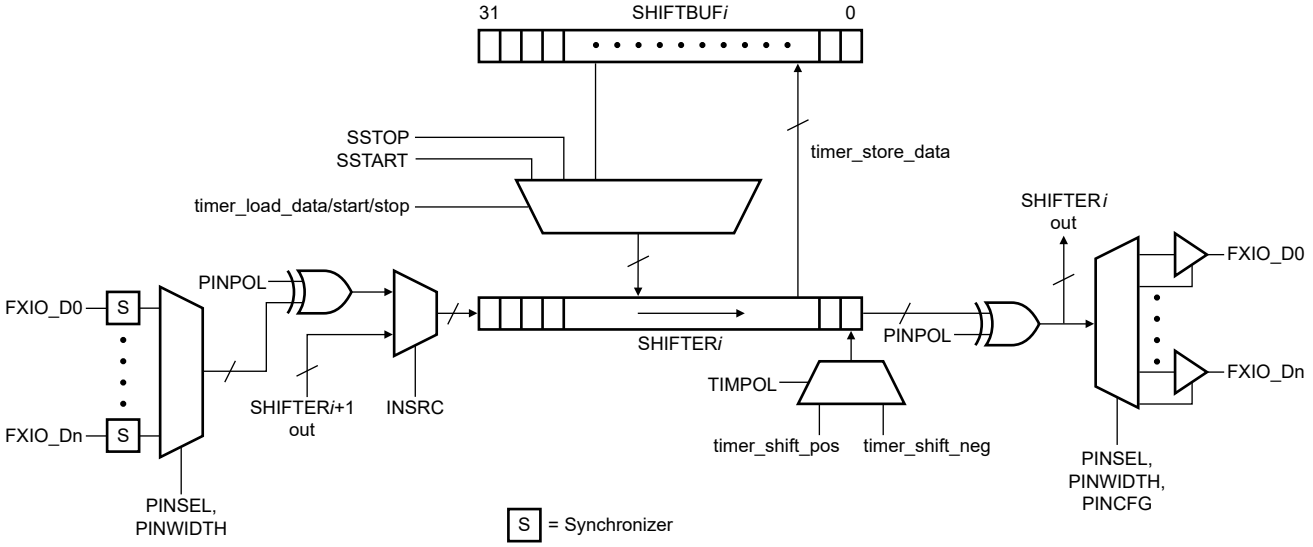


Figure 516. Shifter microarchitecture

75.3.1.1 Transmit mode

In Transmit mode (SHIFTCTL*n*[SMOD] = 010b), the shifter loads data from Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) and shifts data out when the assigned timer signals a load event. An optional start and stop bit can be automatically loaded before or after SHIFTBUF register data by configuring either SHIFTCFG[SSTART] and TIMCFG[TSTART], or SHIFTCFG[SSTOP] and TIMCFG[TSTOP] in the shifter and timer.

NOTE

If a stop bit is enabled, the shifter immediately loads a stop bit when it is initially configured for Transmit mode.

The shifter status flag (SHIFTSTAT[SSF]) and any enabled interrupts or DMA requests are set when data has either been loaded from the SHIFTBUF register into the shifter or when the shifter is initially configured for Transmit mode. To clear the flag, write 1 or write new data to SHIFTBUF. In Transmit mode, write any value to the SHIFTBUF register to clear the corresponding shifter status flag, which is cleared regardless of what is writing to the register (DMA or interrupt), or the state of the DMA or interrupt enables. See the functional description of SHIFTSTAT[SSF] for information on how the flag is set and cleared for each mode.

The shifter error flag (SHIFTERR[SEF]) and any enabled interrupts are set when an attempt to load data from an empty SHIFTBUF register occurs (buffer underrun). Clear the flag by writing 1.

75.3.1.2 Receive mode

When the assigned timer signals a store event in Receive mode (SHIFTCTL*n*[SMOD] = 001b), the shifter shifts and stores data in Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). You can check for a start and stop bit before or after the shifter data is sampled by configuring either SHIFTCFG[SSTART] and TIMCFG[TSTART], or SHIFTCFG[SSTOP] and TIMCFG[TSTOP] in the shifter and timer.

The shifter status flag (SHIFTSTAT[SSF]) and any enabled interrupts or DMA requests are set when data is stored in the SHIFTBUF register from the shifter. To clear the flag, write 1 to or read the data from SHIFTBUF. Any read of the SHIFTBUF register clears the corresponding shifter status flag when the shifter is in Receive mode. The flag is cleared regardless of what is reading the register (DMA or interrupt) or the state of the DMA or interrupt enables. See the functional description of SHIFTSTAT[SSF] for information on how the flag is set or cleared for each mode.

The shifter error flag (SHIFTERR[SEF]) and any enabled interrupts are set either when an attempt to store data into a full SHIFTBUF register occurs (buffer overrun) or when a mismatch occurs on a start or stop bit check. Write 1 to clear the flag.

75.3.1.3 Match Store mode

In Match Store mode (SHIFTCTL*n*[SMOD] = 100b), the shifter shifts data in, checks for a match result, and stores matched data in Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) when the assigned timer signals a store event. By configuring either SHIFTCFG[SSTART], TIMCFG[TSTART], and SHIFTCFG[SSTOP], or TIMCFG[TSTOP] in the shifter and timer, you can check for a start and stop bit before or after the shifter data is sampled. You can compare up to 16 bits of data using SHIFTBUF[31:16] to configure the data to be matched and SHIFTBUF[15:0] to mask the match result.

The shifter status flag (SHIFTSTAT[SSF]) and any enabled interrupts or DMA requests are set when a match occurs and the matched data is stored in the SHIFTBUF register from the shifter. To clear the flag, read the matched data from the SHIFTBUF register or write 1 to the flag. Any read of the SHIFTBUF register clears the corresponding shifter status flag when the shifter is configured in Match Store mode. The flag is cleared regardless of what is reading the register (DMA or interrupt) or the state of the DMA or interrupt enables. See the functional description for SHIFTSTAT[SSF] to know how the flag is set or cleared for each mode.

The shifter error flag (SHIFTERR[SEF]) and any enabled interrupts are set when an attempt to store matched data into a full SHIFTBUF register occurs (buffer overrun), or when a mismatch occurs on a start or stop bit check. Write 1 to clear the flag.

75.3.1.4 Match Continuous mode

In Match Continuous mode (SHIFTCTL*n*[SMOD] = 101b), the shifter shifts data in and continuously checks for a match result whenever a shift event is signaled by the assigned timer. You can compare up to 16 bits of data using SHIFTBUF[31:16] to configure the data to be matched and SHIFTBUF[15:0] to mask the match result.

The shifter status flag (SHIFTSTAT[SSF]) and any enabled interrupts or DMA requests are set when a match occurs. The flag clears automatically as soon as no match exists between the shifter data and Shifter Buffer (SHIFTBUF0 - SHIFTBUF7).

You cannot clear the flag by reading the SHIFTBUF register.

The shifter error flag (SHIFTERR[SEF]) and any enabled interrupts are set when a match occurs. To clear the flag, write 1 or perform a read from the SHIFTBUF register.

75.3.1.5 State mode

State mode enables you to implement any state machine with up to eight states, eight outputs, and three selectable inputs per state. This feature allows basic control functions to be offloaded from the CPU.

In State mode (SHIFTCTL*n*[SMOD] = 110b), when the shifter is selected by the current state pointer (SHIFTSTATE[STATE]), use the SHIFTBUF register to drive the output and compute the next state values. The following figure provides a detailed view of the shifter microarchitecture when configured for State mode.

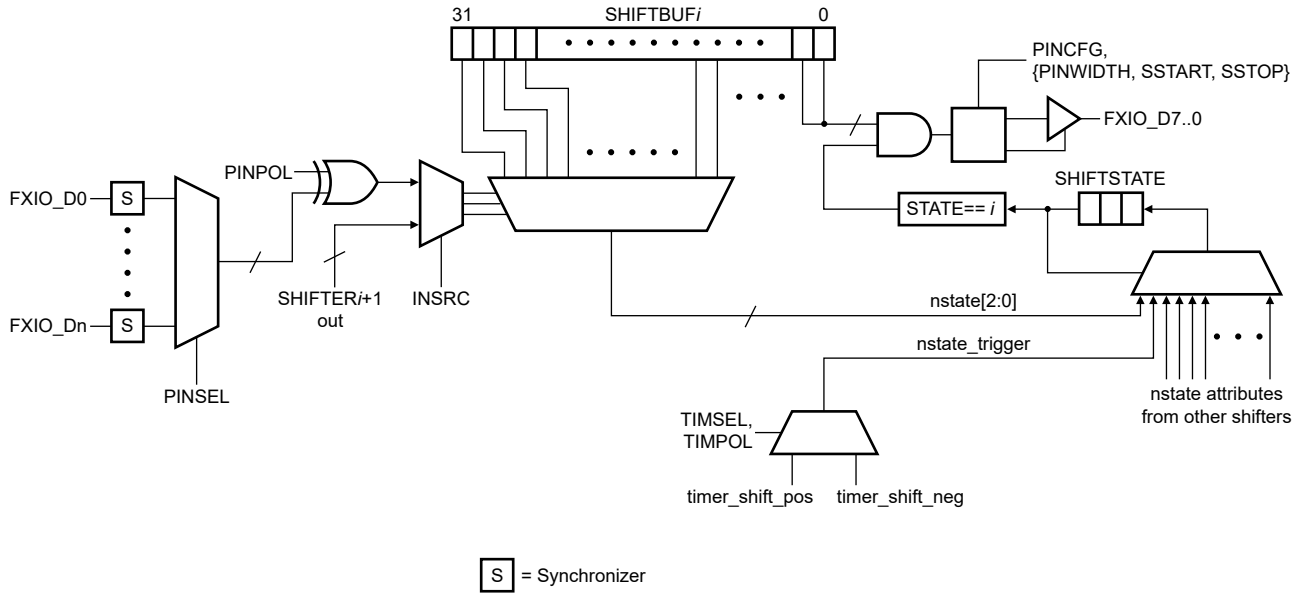


Figure 517. State microarchitecture

When the current state pointer selects a specific shifter (shifter *n*), output pins FXIO_D[7:0] are driven by SHIFTBUF*n*[31:24]; the configuration is defined by SHIFTCTL*n*[PINCFG]. Write 1 to Shifter Configuration (SHIFTCFG0 - SHIFTCFG7) {PWIDTH[3:0],SSTOP[1:0],SSTART[1:0]} to disable the output drive on pins FXIO_D[7:0] for state machine applications that require less than eight output pins.

Use the three input pins selected by SHIFTCTL*n*[PINSEL] and SHIFTBUF*n*[23:0] to compute the next state value.

NOTE

Each state can use a different set of three input pins.

The following table shows how the next state value is computed when the current state pointer is pointing to shifter *n*.

Table 517. Next state computation for SHIFTSTATE[STATE] = *n*

FXIO_D[PINSEL + 2]	FXIO_D[PINSEL + 1]	FXIO_D[PINSEL]	Next state value
0	0	0	SHIFTBUF*n*[2:0]
0	0	1	SHIFTBUF*n*[5:3]
0	1	0	SHIFTBUF*n*[8:6]
0	1	1	SHIFTBUF*n*[11:9]
...	...	...	...
1	1	1	SHIFTBUF*n*[23:21]

NOTE

You can configure other shifters and timers to drive the input pins of a given state, allowing you to create complex combinations of shifters and timers as needed. For example, the output of a shifter configured for Logic mode can be used to drive a state machine input.

The next state transition is triggered using the timer output selected by SHIFTCTL*n*[TIMSEL], with polarity controlled by SHIFTCTL*n*[TIMPOL].

NOTE

Each state can use a different timer to trigger each next state transition, allowing various internal or external trigger sources and clocking configurations to be used. See Timer section for more information.

The current state pointer defaults to shifter 0 at reset; however, you can write to select a different shifter for the initial state. If the current state pointer selects a shifter that is not configured for State mode, then outputs are not driven and the next state transition is never triggered.

The shifter status flag (SHIFTSTAT[SSF]) and any enabled interrupts or DMA requests are set when the shifter is selected by the current state pointer. The flag is cleared when the current state pointer is updated to a different shifter.

75.3.1.6 Logic mode

Logic mode enables you to implement a small amount of programmable digital logic within a FLEXIO shifter.

In Logic mode (SHIFTCTL*n*[SMOD] = 111b), use Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) to implement a 5-input, 32-bit programmable logic lookup table. The following figure provides a detailed view of shifter microarchitecture when configured for Logic mode.

Use the SHIFTBUF register to configure the lookup table for the four pin inputs. You can also use SHIFTER*n* to configure a feedback or delayed pin source as the fifth input to the lookup table.

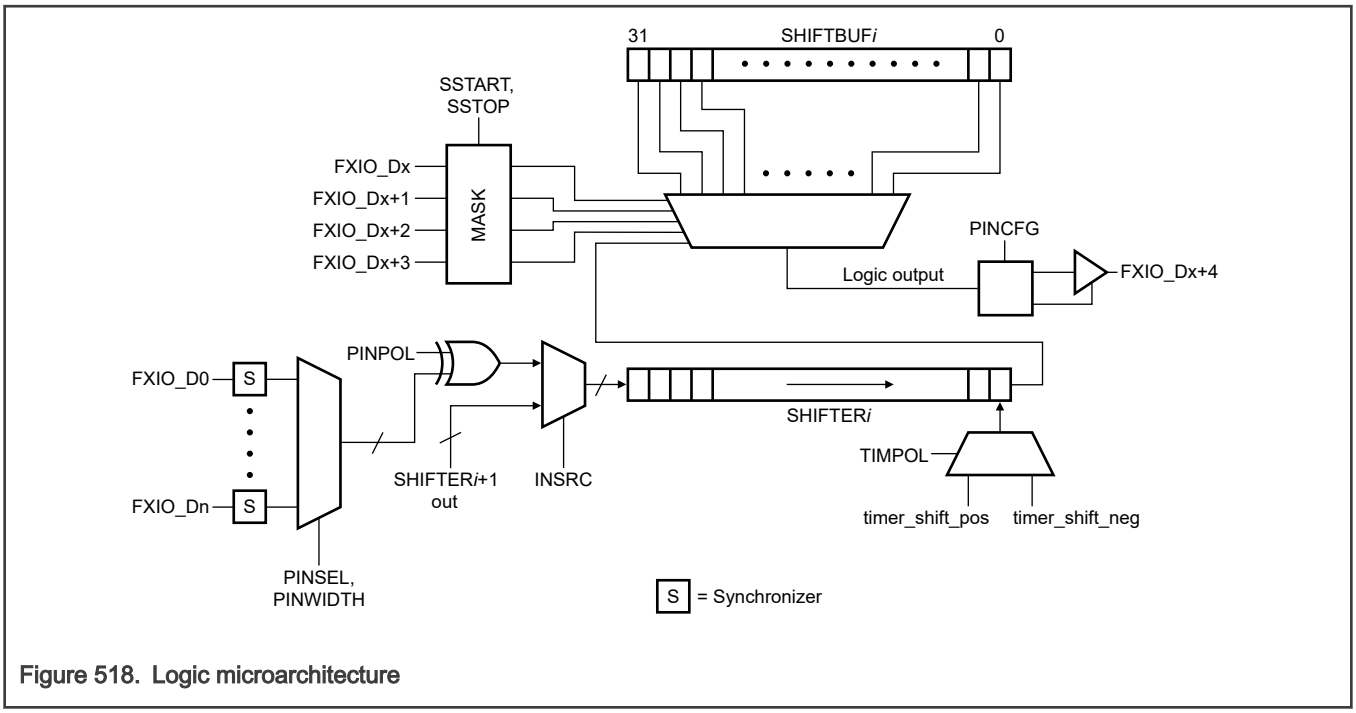


Figure 518. Logic microarchitecture

The lookup table is driven using four pin inputs (maskable using SHIFTCFG[SSTOP] and SHIFTCFG[SSTART]), plus one input from the internal shifter. It can be configured to drive an output pin using SHIFTCTL[PINCFG]. Pin inputs and outputs are fixed for each logic lookup table and are not selectable. The following table lists the logic output value selected by the lookup table for shifter *n*.

Table 518. Logic lookup table for shifter *n*

SHIFTER*n*[0]	FXIO_D[*x* + 3][1]	FXIO_D[*x* + 2]	FXIO_D[*x* + 1]	FXIO_D[*x*]	Logic output to FXIO_D[*x* + 4]
0	0	0	0	0	SHIFTBUF*n*[0]
0	0	0	0	1	SHIFTBUF*n*[1]

Table continues on the next page...

Table 518. Logic lookup table for shifter *n* (continued)

SHIFTER*n*[0]	FXIO_D[*x* + 3][1]	FXIO_D[*x* + 2]	FXIO_D[*x* + 1]	FXIO_D[*x*]	Logic output to FXIO_D[*x* + 4]
0	0	0	1	0	SHIFTBUF*n*[2]
0	0	0	1	1	SHIFTBUF*n*[3]
...	...	...	...	...	...
1	1	1	1	1	SHIFTBUF*n*[31]

1. for shifters *n* = 0...3, *x* = *n*

   for shifter *n* = 4...7, *x* = *n* + 4

To minimize output glitches, use SHIFTCFG*n*[SSTOP] and SHIFTCFG*n*[SSTART] to mask unused input pins. When these fields are 1, {SSTOP[1:0] and SSTART[1:0]} mask FXIO_D[*x* + 3]...FXIO_D[*x*] inputs respectively so that any transitions on these pins do not cause the logic output to glitch.

NOTE

You can configure other shifters and timers to drive the input pins of a given lookup table, allowing you to concatenate lookup tables or create complex combinations of shifters and timers as needed.

SHIFTCFG[PWIDTH] controls the number of delay stages introduced by the internal shifter input (SHIFTER*n*[0]). For example, when configured for a 1-bit shift (SHIFTCFG[PWIDTH] = 0), the internal shifter introduces a 32-shift clock delay before passing its input (selected by SHIFTCTL[PINSEL]) to the lookup table. When configured for a 32-bit shift (SHIFTCFG[PWIDTH] = 16...31), the internal shifter introduces a 1-shift clock delay to its input.

The shifter status flag (SHIFTSTAT[SSF]) and any enabled interrupts or DMA requests are set whenever the output pin allocated to the logic lookup table has a value of 1 after being synchronized with the FLEXIO clock. The flag clears when the output pin has a value of 0. This also allows SHIFTSTAT[SSF] to be used as a trigger to a timer if needed.

The shifter error flag (SHIFTERR[SEF]) and any enabled interrupts are set when the output pin allocated to the logic lookup table is asserted. Clear the flag by writing 1 to it.

The Logic mode input pins, including pins driven by other shifters and timers, are synchronized with the FLEXIO functional clock before they are input to the programmable logic lookup table.

75.3.2 Timer operation

The FLEXIO 16-bit timers control the loading, shifting, and storing of the shift registers. The counters load the contents of the compare register and decrement down to zero on the FLEXIO clock. The counters can perform generic timer functions such as generating a clock, select output, or a PWM waveform. You can configure these timers to perform any of the following functions:

- Enable in response to a trigger, pin, or shifter condition.
- Decrement always or only on a trigger or pin edge.
- Reset in response to a trigger or pin condition.
- Disable on a trigger or pin condition or on a timer compare.

Timers can optionally include a start condition and a stop condition.

Although each timer operates independently, you can configure a timer to enable or disable at the same time as the previous timer (for example, timer 1 can enable or disable at the same time as timer 0) and a timer output can be used to trigger any other timer. The trigger used by each timer is configured independently as a timer output, shifter status flag, pin input, or an external trigger input. The trigger configuration is separate from pin configuration; you can perform it to configure input, output data, or output enable. See the chip-specific FLEXIO information for information on external trigger connections.

You must configure Timer Configuration (TIMCFG0 - TIMCFG7) before writing 1 to TIMCTL*n*[TIMOD].

75.3.2.1 Timer 8-bit Baud Counter mode

In 8-bit Baud Counter mode, the 16-bit counter is divided into two 8-bit counters. The lower 8 bits are used to configure the baud rate of the shift clock and the upper 8 bits are used to configure the number of shift clock edges in the transfer. When the lower 8 bits decrement to zero, the timer output is toggled and the lower 8 bits reload from the compare register. The upper 8 bits decrement when the lower 8 bits become zero and decrement.

NOTE

A timer reset event in 8-bit Baud Counter mode only resets the lower 8-bit counter. The upper 8-bit counter is not affected and can decrement if the timer reset is configured to update the state of the timer output, which toggles as a result of the timer reset event.

A timer compare event occurs when the upper 8 bits equal zero and decrement. The timer status flag is set on a timer compare event.

75.3.2.2 Timer 8-bit High PWM mode

In 8-bit High PWM mode, the 16-bit counter is divided into two 8-bit counters. The lower 8 bits are used to configure the timer output high period and the upper 8 bits are used to configure the timer output low period. The lower 8 bits decrement when the output is high. When the lower 8 bits become zero and decrement, the timer output is cleared and the lower 8 bits are reloaded from the compare register. The upper 8 bits decrement when the output is low. When the upper 8 bits become zero and decrement, the timer output is set and the upper 8 bits are reloaded from the compare register.

A timer compare event occurs when the upper 8 bits become zero and decrement. The timer status flag is set on a timer compare event.

75.3.2.3 Timer 16-bit Counter mode

In 16-bit Counter mode, you can use the 16-bit counter to configure either the baud rate of the shift clock (for example, TIMDEC[1:0] ≠ 10 or 11) or the number of shift clock edges in the transfer (for example, TIMDEC[1:0] = 10 or 11). When the 16-bit counter equals zero and decrements, the timer output toggles and the counter reloads from the compare register.

A timer compare event occurs when the 16-bit counter equals zero and decrements. The timer status flag is set on a timer compare event.

75.3.2.4 Timer 16-bit Counter Disable mode

In 16-bit Counter Disable mode, the 16-bit counter can be used to configure either the baud rate of the shift clock (for example, TIMDEC[1:0] ≠ 10 or 11) or the number of shift clock edges in the transfer (for example, TIMDEC[1:0] = 10 or 11). When the 16-bit counter equals zero and decrements, the timer output toggles and the counter reloads from the compare register.

A timer compare event occurs when the 16-bit counter equals zero and decrements. The timer status flag is set on a timer disable event.

75.3.2.5 Timer 8-bit Word Counter mode

In 8-bit Word Counter mode, the 16-bit counter is divided into two 8-bit counters. The lower 8 bits are used to configure the number of shift clock edges in each word and the upper 8 bits are used to configure the number of words in the transfer. When the lower 8 bits decrement to zero, the timer output is toggled and the lower 8 bits reload from the compare register. The upper 8 bits only decrement when the lower 8 bits become zero and decrement.

A timer compare event occurs when the lower 8 bits become zero and decrement. The timer status flag is set when the upper 8 bits become zero and decrement.

75.3.2.6 Timer 8-bit Low PWM mode

In 8-bit Low PWM mode, the 16-bit counter is divided into two 8-bit counters. The lower 8 bits are used to configure the timer output low period and the upper 8 bits are used to configure the timer output high period. The lower 8 bits decrement when the output is low. When the lower 8 bits become zero and decrement, the timer output is set and the lower 8 bits are reloaded from the compare

register. The upper 8 bits decrement when the output is high. When the upper 8 bits become zero and decrement, the timer output is cleared and the upper 8 bits are reloaded from the compare register.

A timer compare event occurs when the upper 8 bits become zero and decrement. The timer status flag is set on a timer compare event.

75.3.2.7 Timer enable and start functions

The following events occur when you configure TIMCTL*n*[TIMOD] for the desired mode and the condition configured by the timer enable (TIMCFG*n*[TIMENA]) is detected. When TIMCTL*n*[ONETIM] is 1, the timer status flag must be clear to generate a timer enable event; otherwise, the timer enable event is blocked. You can use this to enforce software intervention after each timer iteration:

- The timer counter loads the current value of the compare register and starts decrementing, as configured by TIMCFG*n*[TIMDEC].
- The timer output may update to its initial state depending on the configuration of TIMCFG*n*[TIMOUT]. Shifters that are controlled by this timer do not see this as a rising edge on the timer shift clock.
- Transmit shifters controlled by this timer either output their start bit value or load the shift register from the shift buffer and output the first bit, as configured by SHIFTCFG*n*[SSTART].

If the timer start bit is enabled, the timer counter reloads with the compare register on the first rising edge of the shift clock after the timer starts decrementing. If there is no falling edge on the shift clock before the first rising edge (for example, when TIMCFG*n*[TIMOUT] = 1), a shifter that is configured to shift on the falling edge and load on the first shift does not load correctly.

75.3.2.8 Timer decrement and reset functions

The timer generates the timer output and timer shift clock depending on the fields, TIMCTL*n*[TIMOD] and TIMCFG*n*[TIMDEC]. The shifter clock is either equal to the timer output (when TIMCFG*n*[TIMDEC] ≠ 10 or 11) or equal to the decrement clock (when TIMCFG*n*[TIMDEC] = 10 or 11). If you configure TIMCFG*n*[TIMDEC] to decrement from a pin or trigger, the timer decrements on both rising and falling edges.

If a timer is configured to decrement on the FLEXIO functional clock divided by 16 or 256 (when TIMCFG*n*[TIMDEC] = 100 or 101), then a common prescaler that is shared by all timers is used to generate the two divide ratios. This prescaler is reset when all timers are either idle or configured not to use the prescaler (TIMCFG*n*[TIMDEC] ≠ 100 or 101).

If you configure the timer to reset as determined by TIMCFG*n*[TIMRST], then the timer counter loads the current value of the compare register again. You can configure the timer output and timer shift clock to update on timer reset, as configured by TIMCFG*n*[TIMOUT]. If the time output toggles as a result of the timer reset, this can result in a timer shift clock edge. In 8-bit Baud Counter mode, this also decrements the upper 8 bits of the counter.

In general, when the timer counter decrements to zero, a timer compare event is triggered. The timer compare event causes:

- The timer counter to load the contents of the timer compare register.
- The timer output to toggle.
- Any configured transmit shift registers to load.
- Any configured receive shift registers to store.

Depending on the timer mode, the timer status flag may also be set.

75.3.2.9 Timer disable and stop functions

When the timer is configured to add a stop bit on each compare, the following additional events occur:

- Transmit shifters controlled by this timer output their stop bit value (if configured by SHIFTCFG*n*[SSTOP]).
- Receive shifters controlled by this timer store the contents of the shift register in their shift buffer, as configured by SHIFTCFG*n*[SSTOP].

- The timer counter reloads the current value of the compare register on the first rising edge of the shifter clock after the compare.

If you configure the timer to insert a stop bit on each compare, you must configure the transmit shifters to load on the first shift.

When the condition configured by timer disable (TIMCFG*n*[TIMDIS]) is detected, the following events occur:

- Timer counter reloads the current value of the compare register and starts decrementing as configured by TIMCFG*n*[TIMDEC].
- Timer output clears. Shifters that are controlled by this timer do not see this as a falling edge on the timer shift clock, but can generate a shift event if the timer shift clock otherwise generates one.
- Transmit shifters controlled by this timer output their stop bit value (if configured by SHIFTCFG*n*[SSTOP]).
- Receive shifters controlled by this timer store the contents of the shift register in their shift buffer, as configured by SHIFTCFG*n*[SSTOP].

If the timer stop bit is enabled, the timer counter continues decrementing until the next rising edge of the shift clock is detected, at which point it finishes decrementing. Although the timer output is forced low during the stop bit, the timer shift clock can toggle during the stop bit. The timer output does not generate shift events during the stop bit.

A timer enable condition can be detected in the same cycle as a timer disable condition (if timer stop bit is disabled), or on the first rising edge of the shift clock after the disable condition (if stop bit is enabled). When TIMCTL*n*[ONETIM] is 1, the timer status flag must be clear before the next timer enable condition is detected. When the timer is in the stop state condition, receive shift registers with stop bit enabled store the contents of the shift register into the shift buffer and verify the state of the input data on the configured shift edge. If there is no configured edge between the timer disable and the next rising edge of the shift clock, then the final store and verify do not occur.

75.3.3 Pin operation

The pin configuration for each timer and shifter can be set to use any FLEXIO pin with either polarity. You can configure each timer and shifter as an input, output data, output enable, or bidirectional output. A pin configured for output enable can be used as an open drain (with inverted polarity because the output enable assertion causes logic zero to be output on the pin) or to control the enable on the bidirectional output. You can configure any timer or shifter to control the output enable for a pin where the bidirectional output data is driven by another timer or shifter.

75.3.3.1 Parallel interface

You can configure shifters to use multiple FLEXIO pins simultaneously by using SHIFTCFG*n*[PWIDTH], which is used to configure the following settings of a shifter:

1. Number of bits shifted per shift clock.
2. Number of pins driven by the shifter per shift clock (only on shifters supporting parallel transmit—that is, SHIFTER0 and SHIFTER4.)
3. Number of pins sampled by the shifter per shift clock (only on shifters supporting parallel receive—that is, SHIFTER3 and SHIFTER7.)

When configured for parallel shift, either 4, 8, 16, or 32 bits can be shifted on every shift clock. If an adjacent shifter is selected as the input source (SHIFTCFG*n*[INSRC] = 1), the least significant 4, 8, 16, or 32 bits from the adjacent shifter are sampled on each shift clock.

For shifters supporting parallel receive (SHIFTER3, SHIFTER7), you can configure the shifter to sample multiple pins (INSRC = 0), with PWIDTH and PINSEL selecting the pins as FXIO_D[PINSEL+PWIDTH]:FXIO_D[PINSEL].

NOTE

If PWIDTH is less than the number of bits being shifted on each shift clock, then the most significant bits are masked with 0. For example, if PINSEL = 7 and PWIDTH = 6, then SHIFTER[31:24] samples {0,0,FXIO_D[12:7]} on each shift clock.

For shifters supporting parallel transmit (SHIFTER0, SHIFTER4), you can configure the shifter to drive multiple pins using SHIFTCTL*n*[PINCFG], with PWIDTH and PINSEL selecting the pins as follows: FXIO_D[PINSEL+PWIDTH]:FXIO_D[PINSEL].

NOTE

If PWIDTH is less than the number of bits being shifted on each shift clock, then the most significant pins are not driven. For example, if PINSEL = 7 and PWIDTH = 6, then SHIFTER[5:0] drives only FXIO_D[12:7] on each shift clock.

75.3.3.2 Pin synchronization

When you configure a pin as an input (this includes a timer trigger configured as a pin input), the input signal is first synchronized with the FLEXIO clock before a timer or shifter could use the signal. This introduces a small latency of 0.5–1.5 FLEXIO clock cycles when using an external pin input to generate an output or control a shifter. This sets the maximum setup time at 1.5 FLEXIO clock cycles.

If an input is used by more than one timer or shifter, then the synchronization occurs once to ensure any edge is seen on the same cycle by all timers and shifters using that input.

NOTE

FLEXIO pins are also connected internally. Configuring a FLEXIO shifter or timer to output data on an unused pin makes an internal connection that allows other shifters and timers to use this pin as an input. This allows a shifter output to trigger a timer or a timer output to be shifted into a shifter. This path is also synchronized with the FLEXIO clock and therefore incurs a one-cycle latency.

When using a pin input as a timer trigger, timer clock, or shifter data input, the following synchronization delays occur:

- 0.5–1.5 FLEXIO clock cycles for an external pin
- One FLEXIO clock cycle for an internally driven pin

See Application information for timing considerations such as output valid time and input setup time for specific applications (SPI controller, SPI target, I2C controller, I2S controller, and I2S target).

75.3.3.3 Pin override

You can change the state of any FLEXIO pin at any time. Pin Output Enable (PINOUTE) configures any pin as an output and drives that pin with the value in Pin Output Data (PINOUTD).

Alias registers for PINOUTE and data registers also exist. Writing a logic 1 to an alias register updates the corresponding register fields in both PINOUTE and PINOUTD as follows:

- Pin Output Disable (PINOUTDIS) clears Pin Output Enable (PINOUTE) and Pin Output Data (PINOUTD).
- Pin Output Clear (PINOUTCLR) sets Pin Output Enable (PINOUTE) and clears Pin Output Data (PINOUTD).
- Pin Output Set (PINOUTSET) sets Pin Output Enable (PINOUTE) and Pin Output Data (PINOUTD).
- Pin Output Toggle (PINOUTTOG) sets Pin Output Enable (PINOUTE) and toggles Pin Output Data (PINOUTD).

75.3.3.4 Pin interrupt

You can read the state of any FLEXIO pin at any time and also configure any pin to set a status flag when either a rising or falling edge is detected on that pin. Additionally, you can configure the pin status flag to generate an interrupt.

75.3.4 Low-power modes

FLEXIO remains functional during low-power modes, if the FLEXIO functional clock remains enabled.

75.3.5 Debug mode

FLEXIO remains functional in Debug mode, provided the value of CTRL[DBGE] is 1.

75.3.6 Clocking

Table 519. FLEXIO clocks

Clock	Description
Functional clock	Is asynchronous to the bus clock and can remain enabled in low-power modes. You must enable the FLEXIO functional clock before accessing any of the FLEXIO registers. Provided the FLEXIO functional clock is at least equal to the bus clock, you can configure CTRL[FASTACC] to support fast register accesses.
Bus clock	Is used only for bus accesses to the control and configuration registers.

75.3.7 Reset

Table 520. FLEXIO reset types

Reset	Description
Chip reset	Resets the FLEXIO logic and registers to their default states on chip reset.
Software reset	Resets, using CTRL[SWRST], all logic and registers to their default states, except for the Control register.

75.3.8 Interrupts and DMA requests

The following table shows the status flags that generate the FLEXIO interrupt and DMA requests.

Table 521. FLEXIO interrupts and DMA requests

Flag	Description	Interrupt	DMA request	Low-power wake-up
SHIFTSTAT[SSF]	Shifter status flag	Y	Y	Y
SHIFTERR[SEF]	Shifter error flag	Y	N	Y
TIMSTAT[TSF]	Timer status flag	Y	Y	Y
PINSTAT[PSF]	Pin status flag	Y	N	Y
TRGSTAT[ETSF]	External trigger status flag	Y	N	Y

75.3.9 Peripheral triggers

The connection between FLEXIO peripheral triggers and other peripherals is device-specific.

75.3.9.1 Output triggers

Each FLEXIO timer generates an output trigger equal to the timer output. The output trigger is not affected by the timer pin polarity configuration.

75.3.9.2 Input trigger

FLEXIO supports multiple external trigger inputs that can be used to trigger one or more FLEXIO timers. If a rising edge is detected on an external trigger when FLEXIO is enabled, then the external trigger status flag is set. The external triggers are synchronized to the FLEXIO functional clock and must assert for at least two cycles of the FLEXIO functional clock to be sampled correctly.

75.4 External signals

Table 522. External signals

Signal	Description	Direction
FXIO_D*n* (*n* = 0...31)	Bidirectional FLEXIO shifter and timer pin	Input or output

75.5 Initialization

Perform the following procedure to initialize FLEXIO registers:

1. Enable FLEXIO by writing 1 to CTRL[FLEXEN].
2. Configure shift registers for the given application. It is recommended to write to Shifter Configuration (SHIFTCFG0 - SHIFTCFG7) before writing to the corresponding register, Shifter Control (SHIFTCTL0 - SHIFTCTL7).
3. Configure timer registers for the given application. It is recommended to write to Timer Compare (TIMCMP0 - TIMCMP7) and Timer Configuration (TIMCFG0 - TIMCFG7) before writing to the corresponding register, Timer Control (TIMCTL0 - TIMCTL7).
4. Enable interrupts and/or DMA requests, as appropriate, for the given application.
5. Write transmit data to initiate a transfer (depending on the given application).

75.6 Application information

This section provides examples for a variety of FLEXIO module applications. See FLEXIO register descriptions for more information.

75.6.1 UART transmit

UART transmit can be supported using one timer, one shifter, and one pin (two pins, if supporting CTS). The start and stop bit insertion is handled automatically, and multiple transfers are supported using the DMA controller. The timer status flag is used to indicate when the stop bit of each word is transmitted.

Break and idle characters require software intervention. Before transmitting a break or idle character, you must modify SHIFTCFG*n*[SSTART] and SHIFTCFG*n*[SSTOP] to transmit the required state, and the data to transmit must equal FFh or 00h. Supporting a second stop bit requires the stop bit to be inserted into the data stream using software (and increasing the number of bits to transmit). When performing byte writes to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) (or Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) for transmitting MSB first), the rest of the register remains unaltered. This allows an address mark bit or additional stop bit to remain undisturbed.

NOTE

FLEXIO does not support automatic insertion of parity bits.

Table 523. UART transmit configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0032h	Configure start bit of 0 and stop bit of 1.
SHIFTCTL*n*	0003_0002h	Configure transmit using timer 0 on the positive edge of clock with output data on pin 0. You can configure the PINPOL field to invert output data, or support open-drain by writing 1h to the PINPOL and PINCFG fields.

Table continues on the next page...

Table 523. UART transmit configuration (continued)

Register	Value	Configuration
TIMCMP*n*	0000_0F01h	Configure 8-bit transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] as (number of bits × 2) - 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG*n*	0000_2222h	Configure start bit, stop bit, enable on trigger asserted and disable on compare. You can support CTS by configuring the TIMENA field as 3h.
TIMCTL*n*	01C0_0001h	Configure the dual 8-bit counter using the shifter 0 status flag as an inverted internal trigger source. To support CTS, configure the PINSEL (for pin 1) and PINPOL fields as 1h.
SHIFTBUF*n*	Data to transmit	Transmit data can be written to SHIFTBUF[7:0] to initiate an 8-bit transfer. Use the shifter status flag to indicate when data can be written using an interrupt or a DMA request. Write to SHIFTBUFBBS[7:0] instead to support MSB first transfer.

The following table shows an alternative configuration that supports slower baud rates. This configuration requires two timers.

Table 524. UART transmit configuration for slow baud rate

Register	Value	Configuration
SHIFTCFG*n*	0000_0032h	Configure start bit of 0 and stop bit of 1.
SHIFTCTL*n*	0003_0002h	Configure transmit using timer 0 on the positive edge of clock with output data on pin 0. Invert output data by writing 1 to the PINPOL field. Support open-drain by configuring the PINPOL and PINCFG fields as 1h.
TIMCMP*n*	0000_000Fh	Configure for 8-bit transfer, and configure TIMCMP[15:0] as (number of bits × 2) - 1.
TIMCFG*n*	0030_2622h	Configure start bit, stop bit, enable on trigger rising edge, decrement on trigger and disable on compare.
TIMCTL*n*	0740_0003h	Configure the 16-bit counter using the timer 1 output as an internal trigger source.
TIMCMP(*n* + 1)	0000_0001h	Configure baud rate of divide by 4 of the FLEXIO clock, and configure

Table continues on the next page...

Table 524. UART transmit configuration for slow baud rate (continued)

Register	Value	Configuration
		TIMCMP[15:0] as (baud rate divider ÷ 2) - 1.
TIMCFG(*n* + 1)	0000_1200h	Configure enable on trigger asserted and disable on timer 0 disable. You can configure the TIMEN field as 3h to support CTS.
TIMCTL(*n* + 1)	01C0_0003h	Configure the 16-bit counter using the shifter 0 status flag as an inverted internal trigger source. You can support CTS by configuring the PINSEL (for pin 1) and PINPOL fields as 1h.
SHIFTBUF*n*	Data to transmit	Transmit data can be written to SHIFTBUF[7:0] to initiate an 8-bit transfer. Use the shifter status flag to indicate when data can be written using an interrupt or a DMA request. Write to SHIFTBUFBBS[7:0] instead to support MSB first transfer.

75.6.2 UART receive

UART receive can be supported using one timer, one shifter, and one pin (two timers and two pins, if supporting RTS). The start and stop bit verification is handled automatically and multiple transfers are supported using the DMA controller. The timer status flag is used to indicate when the stop bit of each word is received.

FLEXIO does not support triple voting of the received data, which is sampled only once in the middle of each bit. You can use a timer to implement a glitch filter on the incoming data and a different timer to detect an idle line of programmable length. Break characters cause the error flag to set, and the shifter buffer register returns 00h.

NOTE

FLEXIO does not support automatic verification of parity bits.

Table 525. UART receiver configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0032h	Configure start bit of 0 and stop bit of 1.
SHIFTCTL*n*	0080_0001h	Configure receive using timer 0 on the negative edge of clock with input data on pin 0. You can invert input data by writing 1 to the PINPOL field.
TIMCMP*n*	0000_0F01h	Configure 8-bit transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] as (number of bits × 2) - 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG*n*	0204_2422h	Configure start bit, stop bit, enable on pin positive edge and disable on

Table continues on the next page...

Table 525. UART receiver configuration (continued)

Register	Value	Configuration
		compare. Enable resynchronization to received data with TIMOUT = 2h and TIMRST = 4h.
TIMCTL*n*	0000_0081h	Configure the dual 8-bit counter using the inverted pin 0 input.
SHIFTBUF*n*	Data to receive	You can read received data from SHIFTBUFBYS[7:0]. Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from SHIFTBUFBIS[7:0] instead to support MSB first transfer.

The UART receiver with RTS configuration uses a second timer to generate the RTS output. RTS asserts when the start bit is detected and negates when the data is read from the shifter buffer register. If no start bit is detected when the RTS is asserted, the received data is ignored.

Table 526. UART receiver with RTS configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0032h	Configure start bit of 0 and stop bit of 1.
SHIFTCTL*n*	0080_0001h	Configure receive using timer 0 on the negative edge of clock with input data on pin 0. Invert input data by writing 1 to the PINPOL field.
TIMCMP*n*	0000_0F01h	Configure 8-bit transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] as (number of bits × 2) - 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG*n*	0204_2522h	Configure start bit, stop bit, enable on pin positive edge with trigger asserted and disable on compare. Enable resynchronization to received data with TIMOUT = 2h and TIMRST = 4h.
TIMCTL*n*	02C0_0081h	Configure dual 8-bit counter using the inverted pin 0 input. Trigger is internal using the inverted pin 1 input.
TIMCMP(*n* + 1)	0000_FFFFh	Never compare.
TIMCFG(*n* + 1)	0030_6100h	Enable on timer *n* enable and disable on the trigger falling edge. Decrement on trigger to ensure no compare.
TIMCTL(*n* + 1)	0143_0003h	Configure 16-bit counter and output on pin 1. Trigger is internal using the shifter 0 flag.

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Table 526. UART receiver with RTS configuration (continued)

Register	Value	Configuration
SHIFTBUF*n*	Data to receive	You can read received data using SHIFTBUFBYS[7:0]. Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from SHIFTBUFBIS[7:0] instead to support MSB first transfer.

75.6.3 SPI controller

SPI Controller mode can be supported using two timers, two shifters, and four pins. Using the DMA controller, either CPHA = 0 or CPHA = 1 and transfers can be supported. For CPHA = 1, the chip select can remain asserted for multiple transfers and the timer status flag can be used to indicate the end of the transfer.

The stop bit is used to guarantee a minimum of one clock cycle between the target chip select negating and before the next transfer. To initiate each transfer, either the core or DMA writes to the transmit buffer.

NOTE

Because of synchronization delays, the setup time for the serial input data is 1.5 FLEXIO clock cycles. This means the maximum baud rate is divide by 4 of the FLEXIO clock frequency.

Table 527. SPI controller (CPHA = 0) configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0000h	Start and stop bit disabled.
SHIFTCTL*n*	0083_0002h	Configure transmit using timer 0 on the negative edge of clock with output data on pin 0.
SHIFTCFG(*n* + 1)	0000_0000h	Start and stop bit disabled.
SHIFTCTL(*n* + 1)	0000_0101h	Configure receive using timer 0 on the positive edge of clock with input data on pin 1.
TIMCMP*n*	0000_3F01h	Configure 32-bit transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] as (number of bits × 2) - 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG*n*	0100_2222h	Configure start bit, stop bit, enable on trigger high and disable on compare; initial clock state is logic 0.
TIMCTL*n*	01C3_0201h	Configure dual 8-bit counter using the pin 2 output (shift clock), with shifter 0 flag as the inverted trigger. Write 1 to the PINPOL field to invert the output shift clock.
TIMCMP(*n* + 1)	0000_FFFFh	Never compare.

Table continues on the next page...

Table 527. SPI controller (CPHA = 0) configuration (continued)

Register	Value	Configuration
TIMCFG(*n* + 1)	0000_1100h	Enable when timer 0 is enabled and disable when timer 0 is disabled.
TIMCTL(*n* + 1)	0003_0383h	Configure 16-bit counter (never compare) using the inverted pin 3 output as target select.
SHIFTBUF*n*	Data to transmit	You can write transmit data to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). Use the shifter status flag to indicate when data can be written using interrupt or DMA request. Write to Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.
SHIFTBUF(*n* + 1)	Data to receive	Received data can be read from Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.

Table 528. SPI controller (CPHA = 1) configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0021h	Start bit loads data on first shift.
SHIFTCTL*n*	0003_0002h	Configure transmit using timer 0 on the positive edge of clock with output data on pin 0.
SHIFTCFG(*n* + 1)	0000_0000h	Start and stop bit disabled.
SHIFTCTL(*n* + 1)	0080_0101h	Configure receive using timer 0 on the negative edge of clock with input data on pin 1.
TIMCMP*n*	0000_3F01h	Configure 32-bit transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] as (number of bits x 2) - 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG*n*	0100_2222h	Configure start bit, stop bit, enable on trigger high and disable on compare; initial clock state is logic 0.
TIMCTL*n*	01C3_0201h	Configure dual 8-bit counter using pin 2 output (shift clock), with the shifter 0 flag as the inverted trigger. Write 1 to the

Table continues on the next page...

Table 528. SPI controller (CPHA = 1) configuration (continued)

Register	Value	Configuration
		PINPOL field to invert the output shift clock, and set the TIMDIS field as 3 to keep target select asserted for as long as there is data in the transmit buffer.
TIMCMP(*n* + 1)	0000_FFFFh	Never compare.
TIMCFG(*n* + 1)	0000_1100h	Enable when timer 0 is enabled and disable when timer 0 is disabled.
TIMCTL(*n* + 1)	0003_0383h	Configure 16-bit counter (never compare) using inverted pin 3 output (as target select).
SHIFTBUF*n*	Data to transmit	Transmit data can be written to SHIFTBUF. Use the shifter status flag to indicate when data can be written using interrupt or DMA request. Write to Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.
SHIFTBUF(*n* + 1)	Data to receive	Received data can be read from Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.

75.6.4 SPI target

SPI Target mode can be supported using one timer, two shifters, and four pins. Either CPHA = 0 or CPHA = 1 can be supported and transfers can be supported using the DMA controller. For CPHA = 1, the select can remain asserted for multiple transfers and the timer status flag can be used to indicate the end of the transfer.

You must write the transmit data to the transmit buffer register before the external target select asserts; otherwise, the shifter error flag is set.

NOTE

Because of synchronization delays, the output valid time for the serial output data is 2.5 FLEXIO clock cycles. This means the maximum baud rate is divide by 6 of the FLEXIO clock frequency.

Table 529. SPI target (CPHA = 0) configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0000h	Start and stop bit disabled.
SHIFTCTL*n*	0083_0002h	Configure transmit using timer 0 on the falling edge of shift clock with output data on pin 0.

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Table 529. SPI target (CPHA = 0) configuration (continued)

Register	Value	Configuration
SHIFTCFG(*n* + 1)	0000_0000h	Start and stop bit disabled.
SHIFTCTL(*n* + 1)	0000_0101h	Configure receive using timer 0 on the rising edge of shift clock with input data on pin 1.
TIMCMP*n*	0000_003Fh	Configure 32-bit transfer. Set TIMCMP[15:0] as (number of bits × 2) - 1.
TIMCFG*n*	0120_0600h	Configure enable on trigger rising edge. Initial clock state is logic 0 and decrements on pin input.
TIMCTL*n*	06C0_0203h	Configure 16-bit counter using pin 2 input (shift clock), with pin 3 input (target select) as the inverted trigger.
SHIFTBUF*n*	Data to transmit	Transmit data can be written to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). Use the shifter status flag to indicate when data can be written using interrupt or DMA request. Write to Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.
SHIFTBUF(*n* + 1)	Data to receive	Received data can be read from Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.

Table 530. SPI target (CPHA = 1) configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0001h	Shifter configured to load on first shift and stop bit disabled.
SHIFTCTL*n*	0003_0002h	Configure transmit using timer 0 on rising edge of shift clock with output data on pin 0.
SHIFTCFG(*n* + 1)	0000_0000h	Start and stop bit disabled.
SHIFTCTL(*n* + 1)	0080_0101h	Configure receive using timer 0 on falling edge of shift clock with input data on pin 1.

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Table 530. SPI target (CPHA = 1) configuration (continued)

Register	Value	Configuration
TIMCMP*n*	0000_003Fh	Configure 32-bit transfer. Set TIMCMP[15:0] as (number of bits × 2) - 1).
TIMCFG*n*	0120_6602h	Configure start bit, enable on trigger rising edge, disable on trigger falling edge. Initial clock state is logic 0 and decrements on pin input.
TIMCTL*n*	06C0_0203h	Configure 16-bit counter using pin 2 input (shift clock), with pin 3 input (target select) as the inverted trigger.
SHIFTBUF*n*	Data to transmit	Transmit data can be written to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). Use the shifter status flag to indicate when data can be written using interrupt or DMA request. Write to Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.
SHIFTBUF(*n* + 1)	Data to receive	Received data can be read from Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7) instead to support MSB first transfer.

75.6.5 I2C controller

I2C Controller mode can be supported using two timers, two shifters, and two pins. One timer is used to generate the SCL output and another one is used to control the shifters. The two shifters that are used to transmit and receive for every word, when receiving the transmitter, must transmit FFh to 3-state the output. FLEXIO inserts a stop bit after every word to generate and verify the ACK or NACK. FLEXIO waits for the first write to the transmit data buffer before enabling SCL generation. Data transfers can be supported using the DMA controller and the shifter error flag sets on transmit underrun or receive overflow.

The first timer generates the bit clock for the entire packet (start to repeated start or stop condition), so you must program the compare register with the total number of clock edges in the packet (minus one). The timer supports clock stretching using the reset counter when pin is equal to output. However, this increases both the clock high and clock low periods by at least one FLEXIO clock cycle each. The second timer uses the SCL input pin to control the transmit and receive shift registers. This enforces an SDA data hold time by an extra two FLEXIO clock cycles.

Both the transmit and receive shifters must be serviced for each word in the transfer. The transmit shifter must transmit FFh when receiving, and the receive shifter returns the data present on the SDA pin. The transmit shifter loads one additional word on the last falling edge of the SCL pin. When generating a stop condition or a repeated start condition, this word must be 00h and FFh, respectively. During the last word of a controller-receiver transfer, you must set the transmit SHIFTCFG*n*[SSTOP] field to generate a NACK.

The receive shift register asserts an error interrupt if a NACK is detected, but you are responsible for generating the stop or repeated start condition. If a NACK is detected during controller-transmit, the interrupt routine must immediately write 00h (when generating a stop condition) or FFh (when generating a repeated start condition) to the transmit shifter register. You must wait for

the next rising edge on SCL before disabling both timers. The transmit shifter must be disabled after the setup delay for a repeated start or stop condition.

NOTE

Because of synchronization delays, the data valid time for the transmit output is two FLEXIO clock cycles. This means the maximum baud rate is divide by 6 of the FLEXIO clock frequency.

To guarantee SDA hold time, the I2C controller data valid is delayed by two cycles because the clock output is passed through a synchronizer before clocking the transmit or receive shifter. Because the SCL output is synchronous with FLEXIO clock, the synchronization delay is one cycle, and then an additional cycle is involved to generate the output.

Table 531. I2C controller configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0032h	Start bit enabled (logic 0) and stop bit enabled (logic 1).
SHIFTCTL*n*	0101_0082h	Configure transmit using timer 1 on the rising edge of clock with inverted output enable (open-drain output) on pin 0.
SHIFTCFG(*n* + 1)	0000_0020h	Start bit disabled and stop bit enabled (logic 0) for ACK or NACK detection.
SHIFTCTL(*n* + 1)	0180_0001h	Configure receive using timer 1 on the falling edge of clock with input data on pin 0.
TIMCMP*n*	0000_2501h	Configure 2 word transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] as (number of words × 18) + 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG*n*	0102_2222h	Configure start bit, stop bit, enable on trigger high, disable on compare, reset if output equals pin. Initial clock state is logic 0 and is not affected by reset.
TIMCTL*n*	01C1_0101h	Configure dual 8-bit counter using pin 1 output enable (SCL open-drain), with the shifter 0 flag as the inverted trigger.
TIMCMP(*n* + 1)	0000_000Fh	Configure 8-bit transfer. Set TIMCMP[15:0] as (number of bits x 2) - 1.
TIMCFG(*n* + 1)	0020_1112h	Enable when timer 0 is enabled; disable when timer 0 is disabled. Enable start bit and stop bit at the end of each word and decrement on pin input.
TIMCTL(*n* + 1)	01C0_0183h	Configure 16-bit counter using inverted pin 1 input (SCL).
SHIFTBUF*n*	Data to transmit	Transmit data can be written to SHIFTBUFBBS[7:0]. Use the shifter

Table continues on the next page...

Table 531. I2C controller configuration (continued)

Register	Value	Configuration
		status flag to indicate when data can be written using interrupt or DMA request.
SHIFTBUF(*n* + 1)	Data to receive	Received data can be read from SHIFTBUFBIS[7:0]. Use the shifter status flag to indicate when data can be read using interrupt or DMA request.

75.6.6 I2S controller

I2S Controller mode can be supported using two timers, two shifters, and four pins. One timer is used to generate the bit clock and control the shifters and another timer is used to generate the frame sync. FLEXIO waits for the first write to the transmit data buffer before enabling bit clock and frame sync generation. Data transfers are supported using the DMA controller and the shifter error flag sets on transmit underrun or receive overflow.

The bit clock frequency is an even integer divide of the FLEXIO clock frequency. The initial frame sync assertion occurs at the same time as the first bit clock edge. The timer uses the start bit to ensure that the frame sync is generated one clock cycle before the first output data.

NOTE

Because of synchronization delays, the setup time for the receiver input is 1.5 FLEXIO clock cycles. This means that the maximum baud rate is divide by 4 of the FLEXIO clock frequency.

Table 532. I2S controller configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0001h	Load transmit data on first shift and stop bit disabled.
SHIFTCTL*n*	0003_0002h	Configure transmit using timer 0 on the rising edge of clock with output data on pin 0.
SHIFTCFG(*n* + 1)	0000_0000h	Start and stop bit disabled.
SHIFTCTL(*n* + 1)	0080_0101h	Configure receive using timer 0 on the falling edge of clock with input data on pin 1.
TIMCMP*n*	0000_3F01h	Configure 32-bit transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] as (number of bits × 2) - 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG*n*	0000_0202h	Configure start bit, enable on trigger high and never disable. Initial clock state is logic 1.
TIMCTL*n*	01C3_0281h	Configure dual 8-bit counter using inverted pin 2 output (bit clock), with shifter 0 flag as the inverted trigger.

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Table 532. I2S controller configuration (continued)

Register	Value	Configuration
		Write 0 to the PINPOL field to invert the polarity of the output shift clock.
TIMCMP(*n* + 1)	0000_007Fh	Configure 32-bit transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:0] as (number of bits × baud rate divider) ÷ 1.
TIMCFG(*n* + 1)	0000_0100h	Enable when timer 0 is enabled and never disable.
TIMCTL(*n* + 1)	0003_0383h	Configure 16-bit counter using inverted pin 3 output (as frame sync). Write 0 to the PINPOL field to invert the polarity of the output frame sync.
SHIFTBUF*n*	Data to transmit	Transmit data can be written to Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7). Use the shifter status flag to indicate when data can be written using interrupt or DMA request. Write to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) instead to support LSB first transfer.
SHIFTBUF(*n* + 1)	Data to receive	Received data can be read from Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7). Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) instead to support LSB first transfer.

75.6.7 I2S target

I2S Target mode can be supported using three timers, two shifters, and four pins. For single transmit and single receive, other combinations of transmit and receive are possible.

The transmit data must be written to the transmit buffer register before the external frame sync asserts, otherwise the shifter error flag is set.

NOTE

Because of synchronization delays, the output valid time for the serial output data is 2.5 FLEXIO clock cycles. This means the maximum baud rate is divide by 6 of the FLEXIO clock frequency.

The output valid time of I2S target is maximum 2.5 cycles because there is a maximum 1.5 cycle delay on the clock synchronization, plus one cycle to output the data.

Timer 2 detects the falling edge of frame sync (start of new frame) and asserts output until the rising edge of bit clock (when the frame sync is normally sampled). Timer 0 detects the rising edge of bit clock with timer 2 output asserted and asserts output for length of frame. Timer 1 detects the falling edge of bit clock with timer 0 output asserted and controls shift registers for 32-bit transfers.

Table 533. I2S target configuration

Register	Value	Configuration
SHIFTCFG*n*	0000_0000h	Start and stop bit disabled.
SHIFTCTL*n*	0103_0002h	Configure transmit using timer 1 on the rising edge of shift clock with output data on pin 0.
SHIFTCFG(*n* + 1)	0000_0000h	Start and stop bit disabled.
SHIFTCTL(*n* + 1)	0180_0101h	Configure receive using timer 1 on the falling edge of shift clock with input data on pin 1.
TIMCMP*n*	0000_007Fh	Configure two 32-bit transfers per frame. Set TIMCMP[15:0] as (number of bits × 4) - 1.
TIMCFG*n*	0020_2500h	Configure enable on pin rising edge (inverted bit clock) with trigger high (timer 2) and disable on compare. Initial clock state is logic 1 and decrements on pin input (bit clock).
TIMCTL*n*	0B40_0203h	Configure 16-bit counter using pin 2 input (bit clock), with timer 2 output as the trigger.
TIMCMP(*n* + 1)	0000_003Fh	Configure 32-bit transfers. Set TIMCMP[15:0] as (number of bits × 2) - 1.
TIMCFG(*n* + 1)	0020_2500h	Configure enable on pin (bit clock) rising edge with trigger (timer 0) high and disable on compare. Initial clock state is logic 1 and decrement on pin input (bit clock).
TIMCTL(*n* + 1)	0340_0283h	Configure 16-bit counter using inverted pin 2 input (bit clock), with timer 0 output as the trigger.
TIMCMP(*n* + 2)	0000_0000h	Compare on zero (first edge).
TIMCFG(*n* + 2)	0020_6400h	Configure enable on inverted pin (frame sync) rising edge and disable on trigger falling edge (bit clock). Initial clock state is logic 1 and decrement on inverted pin input (frame sync).
TIMCTL(*n* + 2)	04C0_0383h	Configure 16-bit counter using inverted pin 3 input (frame sync), with pin 2 inverted input (bit clock) as the trigger.
SHIFTBUF*n*	Data to transmit	Transmit data can be written to Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7). Use the shifter status flag to indicate when data can be written

Table continues on the next page...

Table 533. I2S target configuration (continued)

Register	Value	Configuration
		using interrupt or DMA request. Write to the SHIFTBUF register instead to support LSB first transfer.
SHIFTBUF(*n* + 1)	Data to receive	Received data can be read from Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7). Use the shifter status flag to indicate when data can be read using interrupt or DMA request. Read from the SHIFTBUF register instead to support LSB first transfer.

75.6.8 SENT receiver

The SENT receiver can be supported by using one timer and one pin. The timer is configured as Input-Capture mode, and captures the counter value at the falling edge of the pin input. After the counter value is captured, the counter is automatically restarted from counter value 0. Therefore, the captured value always indicates the period between the previous falling edge and current falling edge. You can configure the CPU interrupt or DMA trigger at each capture of the counter. The CPU software performs the entire SENT frame decoding with the latest tick width adjustment.

Table 534. SENT receiver configuration

Register	Value	Configuration
TIMCMP*n*	—	Stores counter value at the falling edge of the pin.
TIMCFG*n*	0000_6000h	Timer is always enabled. It is disabled on trigger falling edge, decrement counter on FLEXIO clock.
TIMCTL*n*	0040_0007h	Single 16-bit input capture mode. The PINSEL field selects the timer pin input and output. Timer pin output disabled, internal trigger selected, select pin 0 as trigger.

75.6.9 Camera interface

Camera interface can be supported using one timer, one or more shifters, and multiple pins. Multiple transfers can be supported using the DMA controller.

The example configuration shown in the following table describes the FLEXIO configuration for interfacing with an 8-bit CMOS sensor with PCLK, VSYNC, HREF, and D[7:0] outputs. The example uses a 128-bit buffer to capture 16 pixels of image data before an interrupt or DMA transfer. You can use a bigger or smaller buffer depending on system DMA performance and FLEXIO resource usage by other applications.

NOTE

You can use additional timers to track the number of pixels per row and number of rows per frame, or HREF or VSYNC can be assigned as GPIO interrupts for software tracking.

Table 535. Camera interface configuration for 8-bit CMOS sensor

Register	Value	Configuration
SHIFTCFG*n*...*n*+2[1]	0007_0100h	Configure 8-bit parallel shift in from adjacent shifter.
SHIFTCFG*n*+3	0007_0000h	Configure 8-bit parallel shift in from pins FXIO_D[7:0] (D[7:0]).
SHIFTCTL*n*...*n*+3	0080_0001h	Configure receive using timer 0 on the negative edge of clock.
TIMCMP*n*	0000_001Fh	Configure 16 pixel (8 bits/pixel × 16 pixels = 128 bits) transfer. Set TIMCMP[15:0] as (number of pixels × 2) - 1.
TIMCFG*n*	0120_6600h	Configure enable on trigger (HREF) rising edge and disable on trigger falling edge. Initial shift clock state is logic 0 and decrement on PCLK input.
TIMCTL*n*	12C0_0803h	Configure 16-bit counter using FXIO_D[8] input (PCLK), with FXIO_D[9] input (HREF) as the inverted trigger.
SHIFTBUF*n*...*n*+3	Data to receive	Received data can be read from SHIFTBUF*n*...*n*+3. Use the shifter status flag to indicate when data can be read using interrupt or DMA request.

1. *n* = 0 or 4

75.6.10 Motorola 68K and Intel 8080 bus interface

Motorola 68K and Intel 8080 bus are two parallel interfaces commonly used by smart and asynchronous LCD controllers. With GPIO, FLEXIO can drive these interfaces using one timer and one shifter. Additional shifters can be used to support large transfers via the DMA controller.

The following table provides an example of how to drive a 16-bit 68K or 8080 bus. For an 8080 bus, two GPIOs are used to drive the nCS and RS pins. For a 68K bus, an additional GPIO is required to drive the RDWR pin.

Table 536. Motorola 68K and Intel 8080 write configuration

Register	Value	Configuration
SHIFTCFG0...0	000F_0100h	Configure 16-bit parallel shift in from adjacent shifter.
SHIFTCTL0	0003_0002h	Configure transmit using timer 0 on the positive edge of clock with data output to FXIO_D[15:0].
SHIFTCTL1...0	0000_0002h	Configure transmit using timer 0 on the positive edge of clock.
TIMCMP0	0000_0101h (1 beat)	Configure 1 or 16-beat transfer with baud rate of divide by 4 of the FLEXIO

Table continues on the next page...

Table 536. Motorola 68K and Intel 8080 write configuration (continued)

Register	Value	Configuration
	0000_1F01h (16 beats)	clock. Set TIMCMP[15:8] as (number of beats × 2) - 1, and set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG0	0000_2200h	Configure enable on trigger high and disable on compare. Timer output high on enable.
TIMCTL0	01C3_1001h (Motorola 68K, 1 beat) 1DC3_1001h (Motorola 68K, 16 beats) 01C3_1081h (Intel 8080, 1 beat) 1DC3_1081h (Intel 8080, 16 beats)	Configure dual 8-bit counter using FXIO_D[16] output (EN pin for 68K, nWR pin for 8080), with shifter 0 (1-beat) or shifter 0 (16 beats) flag as the inverted trigger.
SHIFTBUF0...0	Data to transmit	Transmit data can be written to SHIFTBUF0 (1 beat) or SHIFTBUF0...0(16-beats) to initiate a transfer; use the shifter status flag to indicate when data can be written using interrupt or DMA request.

Table 537. Motorola 68K and Intel 8080 read configuration

Register	Value	Configuration
SHIFTCFG0...3	000F_0100h	Configure 16-bit parallel shift in from the adjacent shifter.
SHIFTCFG0	000F_0000h	Configure 16-bit parallel shift in from pin.
SHIFTCTL0...0	0080_0001h	Configure receive using timer 0 on the negative edge of clock with data input from FXIO_D[15:0].
TIMCMP0	0000_0101h (1 beat) 0000_1F01h (16 beats)	Configure 1 or 16-beat transfer with baud rate of divide by 4 of the FLEXIO clock. Set TIMCMP[15:8] = (number of beats × 2) - 1, and set TIMCMP[7:0] = (baud rate divider ÷ 2) - 1.
TIMCFG0	0000_2220h	Configure stop_bit. Enable on trigger high and disable on compare. Timer output high on enable.
TIMCTL0	1DC3_1001h (Motorola 68K, 1 beat) 01C3_1001h (Motorola 68K, 16 beats) 1DC3_1181h (Intel 8080, 1 beat) 01C3_1181h (Intel 8080, 16 beats)	Configure dual 8-bit counter using either FXIO_D[16] output (EN pin for 68K) or FXIO_D[17] output (nRD pin for 8080), with shifter 0 flag (1-beat) or shifter 0 flag (16 beats) as the inverted trigger.
SHIFTBUF0...0	Data received	Received data can be read from SHIFTBUF0 (1 beat) or SHIFTBUF0...0

Table continues on the next page...

Table 537. Motorola 68K and Intel 8080 read configuration (continued)

Register	Value	Configuration
		(16 beats). Use the shifter status flag to indicate when data can be read using interrupt or DMA request.

In general, any operation to a 68K or 8080 bus target begins with a register write cycle followed by one or more data read or write cycles. To accomplish this, perform the following procedure:

1. Configure FLEXIO with 1-beat write configuration.
2. Configure GPIO to assert the nCS and RS pins (and deassert the RDWR pin for 68K).
3. Write register index data to SHIFTBUF0[15:0].
4. Configure GPIO to deassert the RS pin (and assert the RDWR pin for 68K data read).
5. Configure FLEXIO with the desired read or write configuration (1 or 16 beats).
6. Use the shifter status flag to trigger interrupt or DMA driven data transfers to and from Shifter Buffer (SHIFTBUF0 - SHIFTBUF7).
7. Configure GPIO to deassert the nCS pin.

75.6.11 Low-power state machine

Table 538 shows an example of a hypothetical state machine to illustrate the flexibility allowed in Shifter State mode.

In this example, FLEXIO waits for the FXIO_D[2] pin to assert and then drives a complementary square wave output at a frequency of FLEXIO_CLK/131072 on the FXIO_D[1:0] pins while the comparator output is asserted. This assumes that the comparator is connected to external trigger 15. See the chip-specific FLEXIO information for actual FLEXIO trigger mappings. Figure 519 shows the states and transitions implemented by this example.

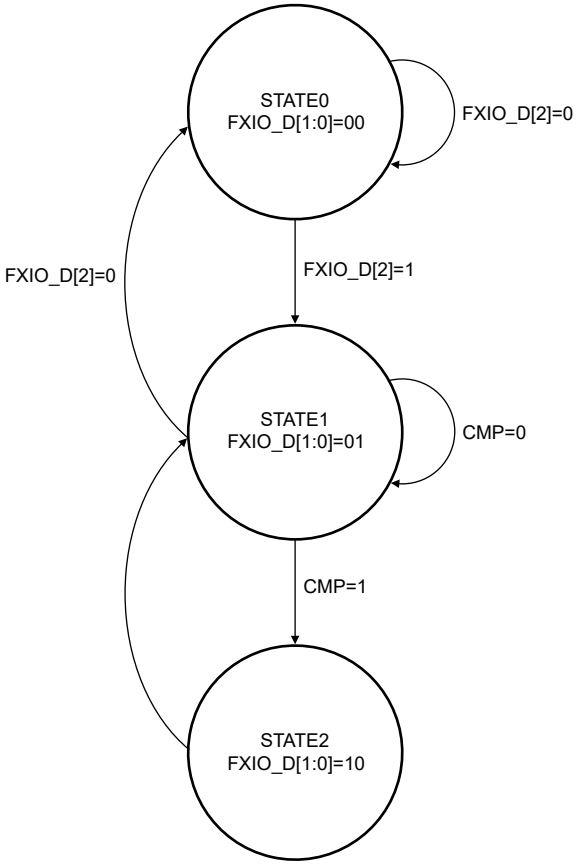

Figure 519. State diagram

Table 538. State machine configuration

Register	Value	Configuration
SHIFTCFG0...2	0000_0003h	Enable FXIO_D[1:0] as outputs.
SHIFTCTL0	0080_0206h	Configure for State mode using FXIO_D[4:2] as inputs to select next state and timer 0 output low to trigger next state.
SHIFTBUF0	0020_8208h	State0: Drive FXIO_D[1:0] = 00; transition to state0 if FXIO_D[2] = 0, state1 if FXIO_D[2] = 1.
SHIFTCTL1	0000_0206h	Configure for State mode using FXIO_D[4:2] as inputs to select next state and timer 0 output high to trigger next state.
SHIFTBUF1	0140_8408h	State1: Drive FXIO_D[1:0]=01; transition to state0 if FXIO_D[2]=0, state1 if CMP = 0, state2 if CMP = 1 (FXIO_D[3]=1).

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Table 538. State machine configuration (continued)

Register	Value	Configuration
SHIFTCTL2	0080_0206h	Configure for State mode using FXIO_D[4:2] as inputs to select next state and timer 0 output low to trigger next state.
SHIFTBUF2	0224_9249h	State2: Drive FXIO_D[1:0] = 10, transition to state1 with timer 0 output low.
TIMCMP0	0000_FFFFh	Configure baud rate of divide by 131072 of the FLEXIO clock. Set TIMCMP[7:0] as (baud rate divider ÷ 2) - 1.
TIMCFG0	0000_0000h	Configure timer always enabled.
TIMCTL0	0000_0003h	Configure single 16-bit counter.
TIMCFG1	0010_7600h	Configure timer enabled on trigger rising edge, disabled on trigger falling edge, decrement on trigger edge.
TIMCTL1	0F03_0303h	Configure timer output enabled on FXIO_D[3], external trigger 15 (comparator output) selected.

75.6.12 Keypad interface

The keypad interface can support a 3 × 4 keypad matrix using three timers and three shifters, although a larger matrix can be supported using additional shifters. The configuration is designed for four columns configured as active low open-drain pins and three rows configured as input pins with pull-up resistors enabled.

One shifter is configured in Logic mode to assert its output when any of the row inputs are low, indicating a key is pressed. Use a timer to filter the shifter output to ensure that the key is pressed for a minimum amount of time before performing the column scan.

A different shifter is configured for parallel transmit. Use this shifter to scan each column when a keypress is detected. When not scanning, the shifter output is configured to assert all active low open-drain column outputs to detect any keypress. Use a dedicated timer to control the transmit shifter.

The last shifter is configured for parallel receive. Use this shifter to capture the result of the column scanning so that you can decode which key (or keys) was pressed. This configuration captures the state of both row and column pins for each scan, although the row state can also be deduced by the shift order. Use a dedicated timer to control the receive shifter, which shifts at half the frequency of the transmit shifter.

When the result of the key scan is available in the receive shifter register, FLEXIO continues to monitor the row inputs and can trigger multiple scans from a single keypress. To support debouncing, you can decide how many consecutive scans must be considered as a single keypress.

NOTE

Because the pins used in Logic mode are fixed per shifter and the shifters that support parallel shifts are limited, this configuration is restricted to what pins and shifters it can use. Increasing the matrix beyond four-row inputs requires multiple shifters in Logic mode. Increasing beyond four-column outputs requires concatenating transmit shifters to create a larger shift register.

Table 539. Keypad interface configuration

Register	Value	Configuration
SHIFTCFG0	0003_0032h	Start bit enabled (logic 0) and stop bit enabled (logic 1), configured for 4-bit shift.
SHIFTCTL0	0101_0402h	Configure transmit using timer 1 on the rising edge of clock generating open-drain output on pins[7:4] (column outputs).
SHIFTBUF0	0804_0201h	Static data containing the column scan pattern; each column is scanned one-hot with dead time in between.
SHIFTCFG1	0000_0020h	In Logic mode, mask input 3.
SHIFTCTL1	0000_0007h	Configure Logic mode.
SHIFTBUF1	07FF_07FFh	Static data configuring Logic mode LUT. Output asserts if pins [3:1] are logic 0.
SHIFTCFG3	0007_0000h	Configured for 8-bit shift.
SHIFTCTL3	0280_0001h	Configure receive using timer 2 on falling edge of clock with input data on pins [7:0] (both rows and columns; pin 0 is don't care).
TIMCMP0	0000_00ffh	Configure prescanning glitch filter to 256 FLEXIO clock cycles. For different filter cycles, configure TIMCMP[15:0] as (filter cycles) - 1.
TIMCFG0	0103_6600h	Configure enable on trigger rising edge and disable on trigger falling edge. Initial clock state is logic 0 and is not affected by reset.
TIMCTL0	0540_0003h	Configure 16-bit counter using the shifter 1 flag (logic state) as trigger.
TIMCMP1	0000_0F3Fh	Configure eight shifts (twice for each column) at column scan rate of divide by 128. For a different scan frequency, define TIMCMP[7:0] as (scan divider ÷ 2) - 1.
TIMCFG1	0020_2622h	Enable on trigger rising edge, disable on compare. Start and stop bits are enabled.
TIMCTL1	0340_0001h	Configure dual 8-bit counter using timer 0 output as the trigger.
TIMCMP2	0000_0801h	Configure four shifts at half the frequency of the timer 1 trigger.

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Table 539. Keypad interface configuration (continued)

Register	Value	Configuration
TIMCFG2	0110_2100h	Enable on timer 1 enable, disable on compare, decrement on trigger input with output initially negated, and not affected by reset.
TIMCTL2	0740_0001h	Configure dual 8-bit counter using timer 1 output as the trigger.
SHIFTBUF3	Keypad scan result	Keypad scan result can be read from SHIFTBUF3. Each byte is the result of one scan with both row and column pin state from the scan (pin 0 is not used). Use the shifter status flag to indicate when data can be written using interrupt or DMA request.

75.7 Memory map and registers

75.7.1 FLEXIO register descriptions

NOTE

Invalid register accesses, which include reading a write-only register, writing to a read-only register, or accessing an invalid address, result in a bus error.

75.7.1.1 FLEXIO memory map

FlexIO base address: 4032_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VERID)	32	R	0201_0003h
4h	Parameter (PARAM)	32	R	0420_0808h
8h	FLEXIO Control (CTRL)	32	RW	0000_0000h
Ch	Pin State (PIN)	32	R	0000_0000h
10h	Shifter Status (SHIFTSTAT)	32	RW	0000_0000h
14h	Shifter Error (SHIFTERR)	32	RW	0000_0000h
18h	Timer Status Flag (TIMSTAT)	32	RW	0000_0000h
20h	Shifter Status Interrupt Enable (SHIFTSIEN)	32	RW	0000_0000h
24h	Shifter Error Interrupt Enable (SHIFTEIEN)	32	RW	0000_0000h
28h	Timer Interrupt Enable (TIMIEN)	32	RW	0000_0000h
30h	Shifter Status DMA Enable (SHIFTSDEN)	32	RW	0000_0000h
38h	Timer Status DMA Enable (TIMERSDEN)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
40h	Shifter State (SHIFTSTATE)	32	RW	0000_0000h
48h	Trigger Status (TRGSTAT)	32	RW	0000_0000h
4Ch	External Trigger Interrupt Enable (TRIGIEN)	32	RW	0000_0000h
50h	Pin Status (PINSTAT)	32	RW	0000_0000h
54h	Pin Interrupt Enable (PINIEN)	32	RW	0000_0000h
58h	Pin Rising Edge Enable (PINREN)	32	RW	0000_0000h
5Ch	Pin Falling Edge Enable (PINFEN)	32	RW	0000_0000h
60h	Pin Output Data (PINOUTD)	32	RW	0000_0000h
64h	Pin Output Enable (PINOUTE)	32	RW	0000_0000h
68h	Pin Output Disable (PINOUTDIS)	32	W	0000_0000h
6Ch	Pin Output Clear (PINOUTCLR)	32	W	0000_0000h
70h	Pin Output Set (PINOUTSET)	32	W	0000_0000h
74h	Pin Output Toggle (PINOUTTOG)	32	W	0000_0000h
80h - 9Ch	Shifter Control (SHIFTCTL0 - SHIFTCTL7)	32	RW	0000_0000h
100h - 11Ch	Shifter Configuration (SHIFTCFG0 - SHIFTCFG7)	32	RW	0000_0000h
200h - 21Ch	Shifter Buffer (SHIFTBUF0 - SHIFTBUF7)	32	RW	0000_0000h
280h - 29Ch	Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7)	32	RW	0000_0000h
300h - 31Ch	Shifter Buffer Byte Swapped (SHIFTBUFBYS0 - SHIFTBUFBYS7)	32	RW	0000_0000h
380h - 39Ch	Shifter Buffer Bit Byte Swapped (SHIFTBUFBBS0 - SHIFTBUFBBS7)	32	RW	0000_0000h
400h - 41Ch	Timer Control (TIMCTL0 - TIMCTL7)	32	RW	0000_0000h
480h - 49Ch	Timer Configuration (TIMCFG0 - TIMCFG7)	32	RW	0000_0000h
500h - 51Ch	Timer Compare (TIMCMP0 - TIMCMP7)	32	RW	0000_0000h
680h - 69Ch	Shifter Buffer Nibble Byte Swapped (SHIFTBUFNBS0 - SHIFTBUFNBS7)	32	RW	0000_0000h
700h - 71Ch	Shifter Buffer Halfword Swapped (SHIFTBUFHWS0 - SHIFTBUFHWS7)	32	RW	0000_0000h
780h - 79Ch	Shifter Buffer Nibble Swapped (SHIFTBUFNIS0 - SHIFTBUFNIS7)	32	RW	0000_0000h
800h - 81Ch	Shifter Buffer Odd Even Swapped (SHIFTBUFOES0 - SHIFTBUFOES7)	32	RW	0000_0000h
880h - 89Ch	Shifter Buffer Even Odd Swapped (SHIFTBUFEOS0 - SHIFTBUFEOS7)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
900h - 91Ch	Shifter Buffer Halfword Byte Swapped (SHIFTBUFHBS0 - SHIFTBUFHBS7)	32	RW	0000_0000h

75.7.1.2 Version ID (VERID)

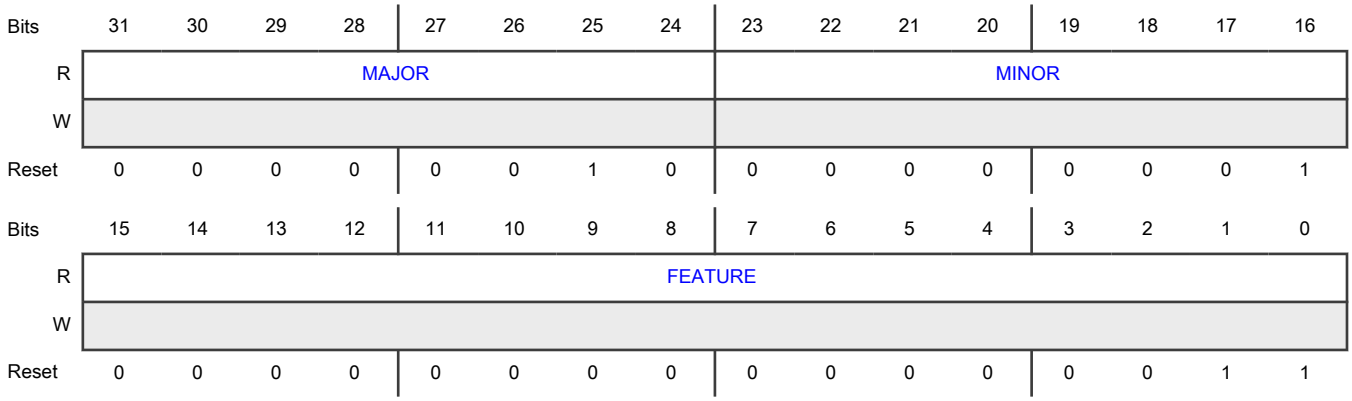
Offset

Register	Offset
VERID	0h

Function

Indicates the version of FLEXIO.

Diagram



Fields

Field	Function
31-24 MAJOR	Major Version Number Indicates the major version number of the module specification.
23-16 MINOR	Minor Version Number Indicates the minor version number of the module specification.
15-0 FEATURE	Feature Specification Number Indicates the feature set number. 0000_0000_0000_0000b - Standard features implemented

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Field	Function
	0000_0000_0000_0001b - State, logic, and parallel modes supported 0000_0000_0000_0010b - Pin control registers supported 0000_0000_0000_0011b - State, logic, and parallel modes, plus pin control registers supported

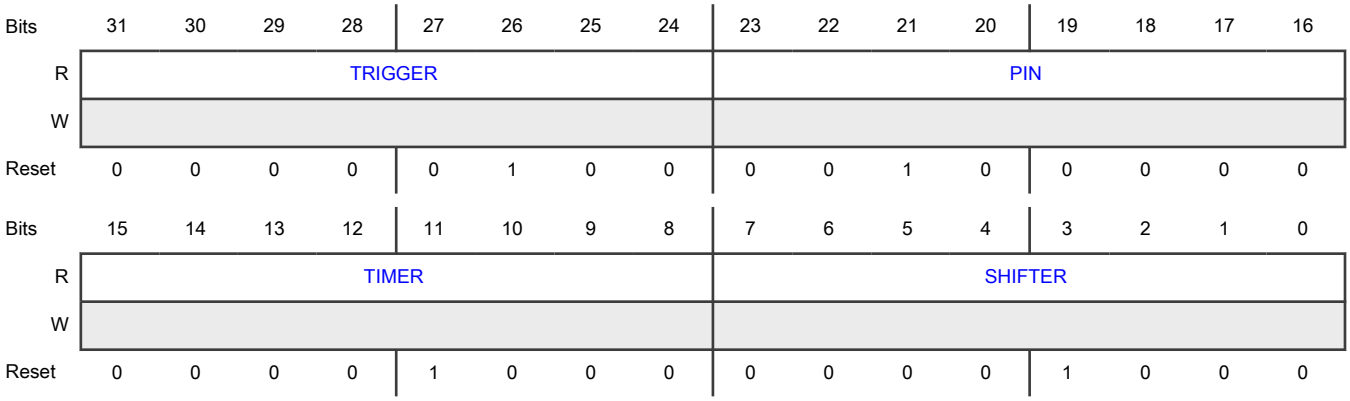
75.7.1.3 Parameter (PARAM)

Offset

Register	Offset
PARAM	4h

Function
Contains the number of shifters, timers, pins, and triggers.

Diagram



Fields

Field	Function
31-24 TRIGGER	Trigger Number Indicates the number of external triggers implemented.
23-16 PIN	Pin Number Indicates the number of pins implemented.
15-8 TIMER	Timer Number Indicates the number of timers implemented.
7-0 SHIFTER	Shifter Number Indicates the number of shifters implemented.

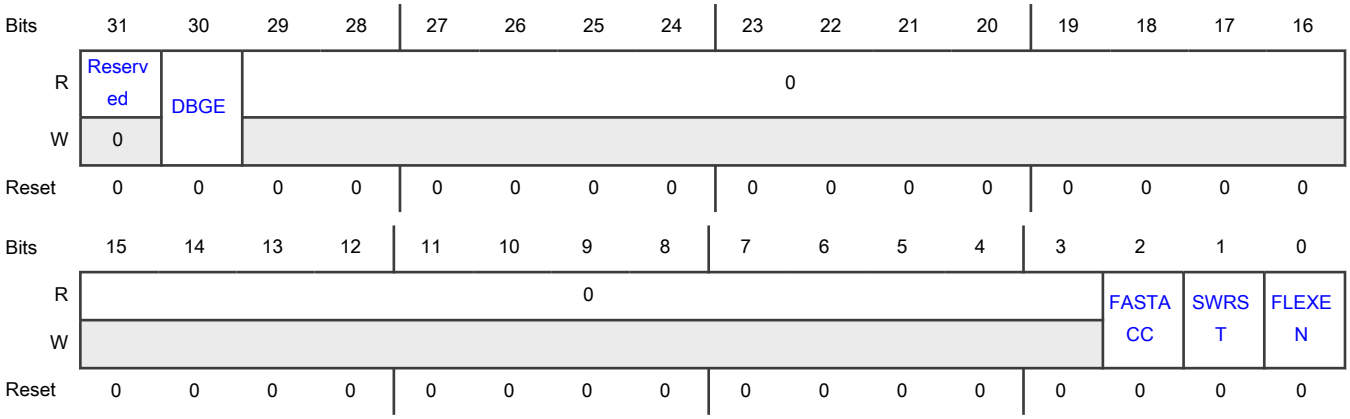
75.7.1.4 FLEXIO Control (CTRL)

Offset

Register	Offset
CTRL	8h

Function
Controls various aspects of the FLEXIO operation.

Diagram



Fields

Field	Function
31 —	Any write value to this bit must be zero.
30 DBGE	Debug Enable Enables the FLEXIO operation in Debug mode. 0b - Disable 1b - Enable
29-3 —	Reserved
2 FASTACC	Fast Access Configures fast or normal register accesses to FLEXIO registers, but requires the FLEXIO functional clock to be at least equal to the frequency of the bus clock. 0b - Normal 1b - Fast

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Field	Function
1 SWRST	Software Reset Specifies whether software reset is enabled. The software reset does not affect this register but it affects all other logic in FLEXIO. All other register accesses are ignored until this field is cleared. The field remains 1 until software clears it and the reset has cleared in the FLEXIO clock domain. If you write 1 to this field, all FLEXIO registers except the Control register are reset. 0b - Disabled 1b - Enabled
0 FLEXEN	FLEXIO Enable Enables FLEXIO. 0b - Disable 1b - Enable

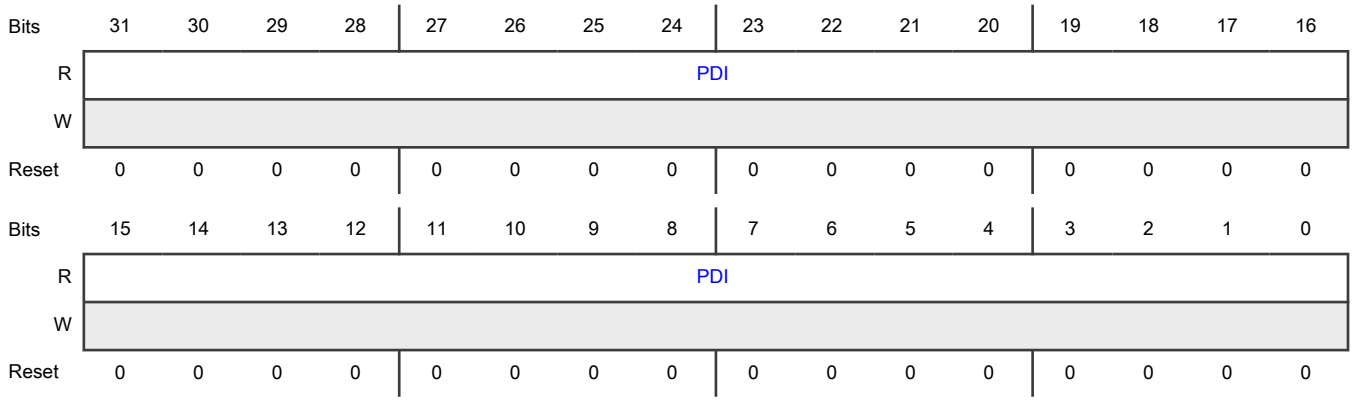
75.7.1.5 Pin State (PIN)

Offset

Register	Offset
PIN	Ch

Function
Indicates the status of the pin data input.

Diagram



Fields

Field	Function
31-0 PDI	Pin Data Input Indicates the input data on each of the FLEXIO pins.

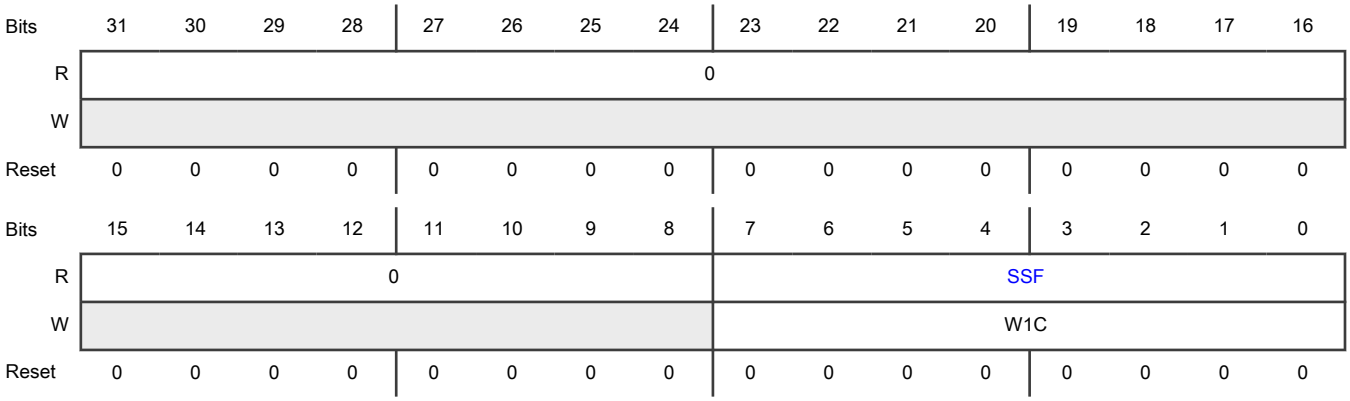
75.7.1.6 Shifter Status (SHIFTSTAT)

Offset

Register	Offset
SHIFTSTAT	10h

Function
Contains shifter status flags.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 SSF	Shifter Status Flag Indicates the shifter status. This flag is updated in one of the following cases: • If SHIFTCTL*n*[SMOD] = 001b (Receive mode), the status flag is set when SHIFTBUF is loaded with data from the shifter (SHIFTBUF is full). The status flag is cleared when you read Shifter Buffer (SHIFTBUF0 - SHIFTBUF7).

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Field	Function
	• If SHIFTCTL*n*[SMOD] = 010b (Transmit mode), the status flag is set when SHIFTBUF data is transferred to the shifter (SHIFTBUF is empty) or when SHIFTCTL*n*[SMOD] is initially configured as 010b (Transmit mode). The status flag is cleared when you write to the SHIFTBUF register. • If SHIFTCTL*n*[SMOD] = 100b (Match Store mode), the status flag is set when a match occurs between SHIFTBUF and the shifter. The status flag is cleared when you read the SHIFTBUF register. • If SHIFTCTL*n*[SMOD] = 101b (Match Continuous mode), the status flag returns the current match result between SHIFTBUF and the shifter. You cannot clear the status flag by reading the SHIFTBUF register. • If SHIFTCTL*n*[SMOD] = 110b (State mode), the status flag for a shifter sets when it is selected by the current state pointer. • If SHIFTCTL*n*[SMOD] = 111b (Logic mode), the status flag returns the current value of the programmable logic block output. You can clear this status flag by writing a logic one to the flag for all modes except Match Continuous mode, State mode, and Logic mode. **NOTE** This field behaves differently for register reads and writes. When reading 0000_0000b - Clear 0000_0001b - Set When writing 0000_0000b - No effect 0000_0001b - Clear the flag

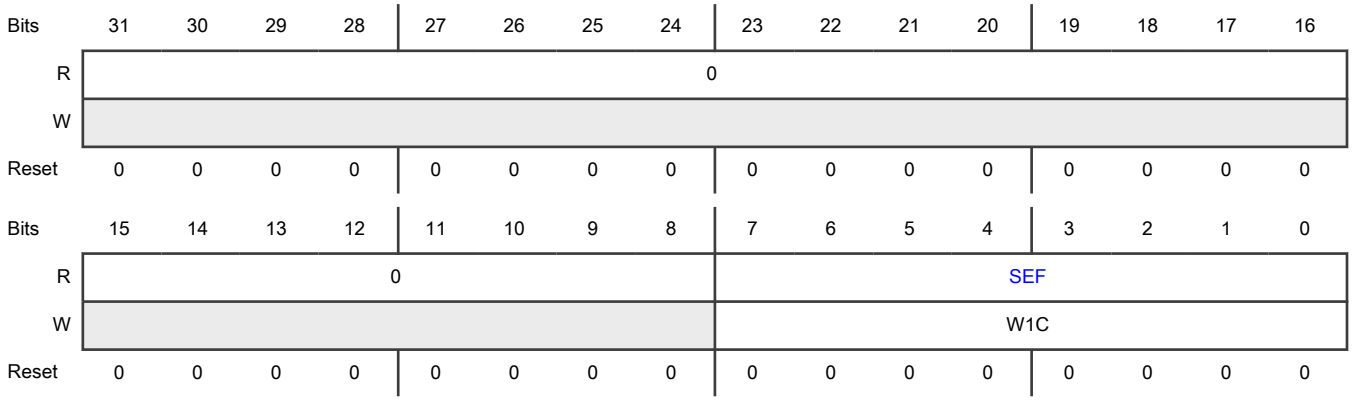
75.7.1.7 Shifter Error (SHIFTERR)

Offset

Register	Offset
SHIFTERR	14h

Function
Reports shifter errors.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 SEF	Shifter Error Flag Indicates shifter error flag status. This flag is set when one of the following events occurs: • If SHIFTCTL*n*[SMOD] = 001b (Receive mode), it indicates that either the shifter is ready to store new data into SHIFTBUF before the previous data is read from SHIFTBUF (SHIFTBUF overrun), or the received start or stop bit does not match the expected value. • If SHIFTCTL*n*[SMOD] = 010b (Transmit mode), it indicates that the shifter is ready to load new data from SHIFTBUF before new data is written into SHIFTBUF (SHIFTBUF underrun). • If SHIFTCTL*n*[SMOD] = 100b (Match Store mode), it indicates the occurrence of a match event before the previous match data is read from SHIFTBUF (SHIFTBUF overrun). • If SHIFTCTL*n*[SMOD] = 101b (Match Continuous mode), the error flag is set when a match occurs between SHIFTBUF and the shifter. • If SHIFTCTL*n*[SMOD] = 111b (Logic mode), the error flag is set when the output of the programmable logic block is asserted. For SHIFTCTL*n*[SMOD] = 101b (Match Continuous mode), the flag can also be cleared when you read Shifter Buffer (SHIFTBUF0 - SHIFTBUF7). **NOTE** This field behaves differently for register reads and writes. When reading 0000_0000b - Clear 0000_0001b - Set When writing 0000_0000b - No effect 0000_0001b - Clear the flag

75.7.1.8 Timer Status Flag (TIMSTAT)

Offset

Register	Offset
TIMSTAT	18h

Function
Reports timer status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								TSF							
W									W1C							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0 TSF	Timer Status Flag Indicates timer status. This flag is set depending on Timer mode: • In 8-bit baud counter mode, this flag is set when the upper 8-bit counter equals zero and decrements. • In 8-bit high PWM mode, this flag is set when the upper 8-bit counter equals zero and decrements. • In 16-bit counter mode, this flag is set when the 16-bit counter equals zero and decrements. • In 16-bit counter disable mode, TSF is set when a timer disable event is detected. • In 8-bit word counter mode, TSF is set when the upper 8-bit counter equals zero and decrements. • In 8-bit low PWM mode, TSF is set when the upper 8-bit counter equals zero and decrements. • In 16-bit input capture mode, TSF is set when a timer disable event is detected and the flag is clear. In this mode, you must read Timer Control (TIMCTL0 - TIMCTL7) only when TSF is set. **NOTE** This field behaves differently for register reads and writes.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When reading 0000_0000b - Clear 0000_0001b - Set When writing 0000_0000b - No effect 0000_0001b - Clear the flag

75.7.1.9 Shifter Status Interrupt Enable (SHIFTSIEN)

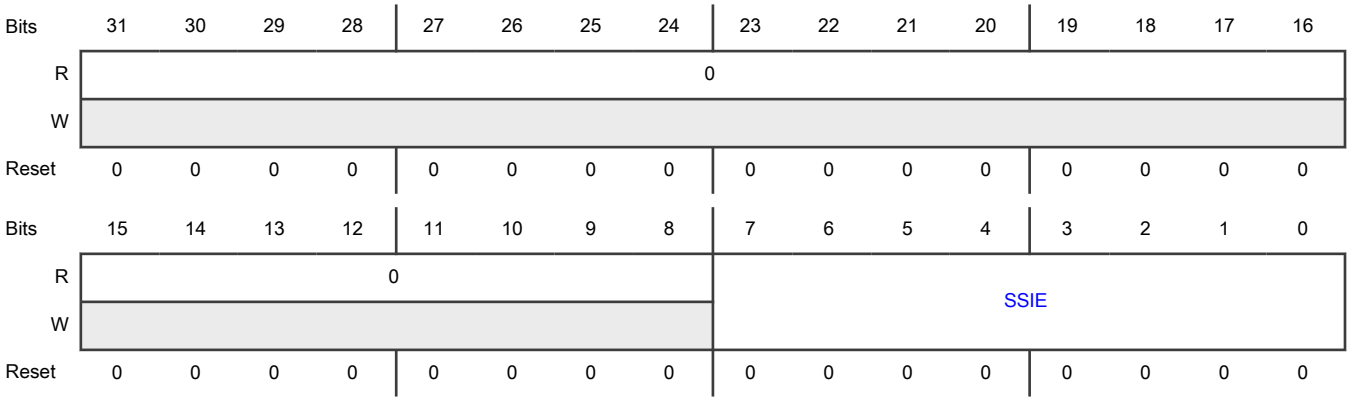
Offset

Register	Offset
SHIFTSIEN	20h

Function

Enables shifter status interrupts.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 SSIE	Shifter Status Interrupt Enable Enables interrupt generation when the corresponding SHIFTSTAT[SSF] flag is set. If you write 0 to this field, SHIFTSTAT[SSF] is disabled; and if you write 1 to this field, SHIFTSTAT[SSF] is enabled.

Table continues on the next page...

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Field	Function
	0b - Disable 1b - Enable

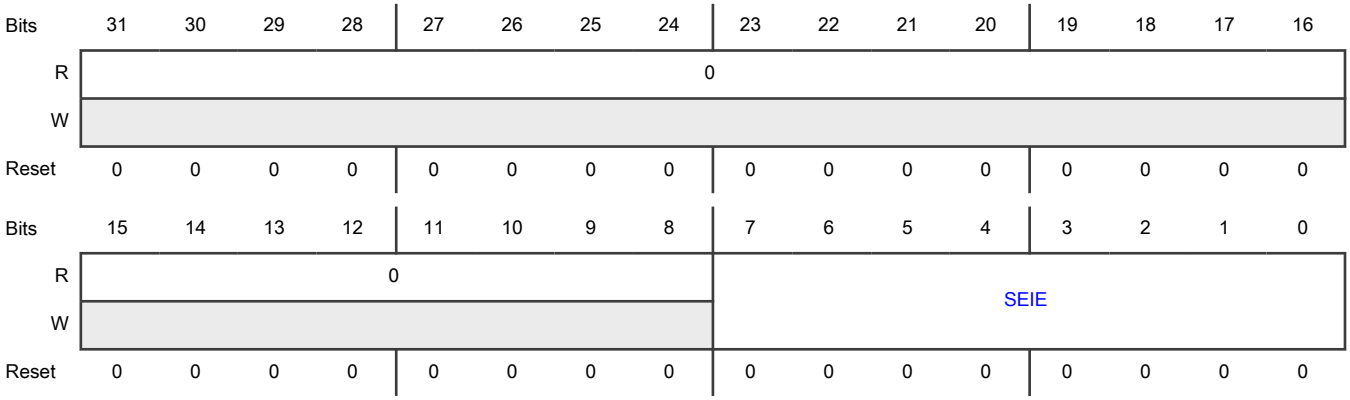
75.7.1.10 Shifter Error Interrupt Enable (SHIFTEIEN)

Offset

Register	Offset
SHIFTEIEN	24h

Function
Enables shifter error interrupts.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 SEIE	Shifter Error Interrupt Enable Enables interrupt generation when the corresponding SHIFTERR[SEF] flag is set. If you write 0 to this field, SHIFTERR[SEF] is disabled; and if you write 1 to this field, SHIFTERR[SEF] is enabled. 0b - Disable 1b - Enable

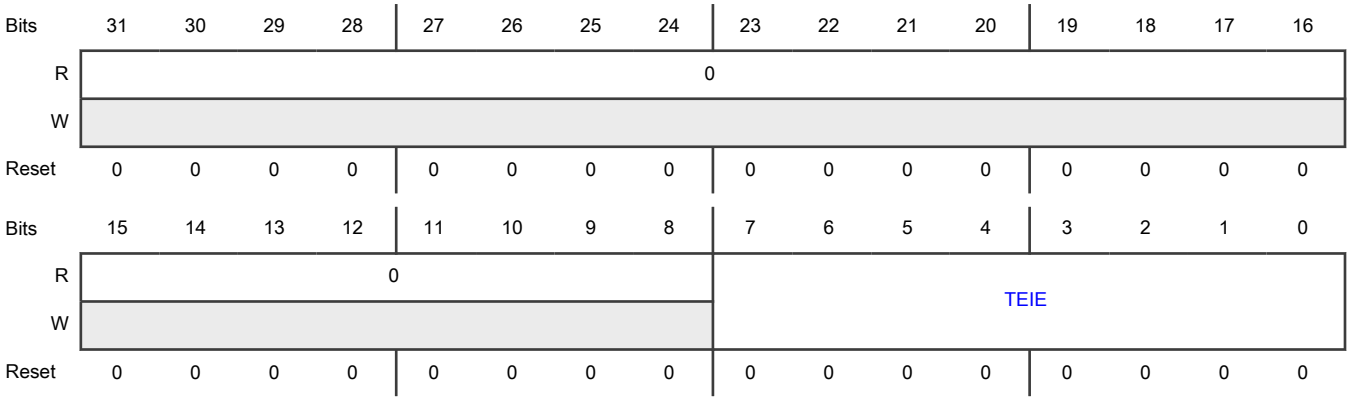
75.7.1.11 Timer Interrupt Enable (TIMIEN)

Offset

Register	Offset
TIMIEN	28h

Function
Enables timer status interrupts.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 TEIE	Timer Status Interrupt Enable Enables interrupt generation when the corresponding TIMSTAT[TSF] flag is set. If you write 0 to this field, TIMSTAT[TSF] is disabled; and if you write 1 to this field, TIMSTAT[TSF] is enabled. 0b - Disable 1b - Enable

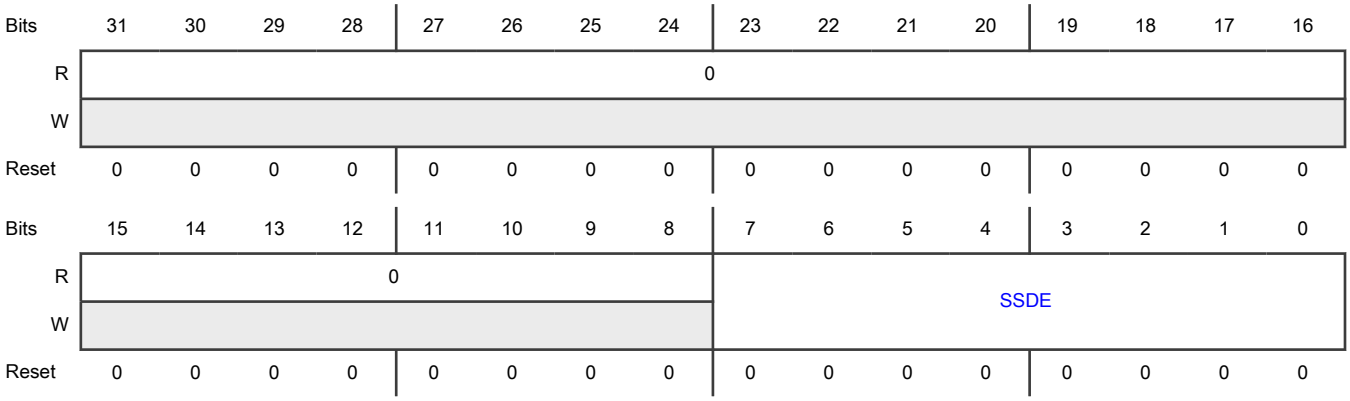
75.7.1.12 Shifter Status DMA Enable (SHIFTSDEN)

Offset

Register	Offset
SHIFTSDEN	30h

Function
Enables shifter DMA requests.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 SSDE	Shifter Status DMA Enable Enables DMA request generation when the corresponding SHIFTSTAT[SSF] flag is set. If you write 0 to this field, SHIFTSTAT[SSF] is disabled; and if you write 1 to this field, SHIFTSTAT[SSF] is enabled. 0b - Disable 1b - Enable

75.7.1.13 Timer Status DMA Enable (TIMERSDEN)

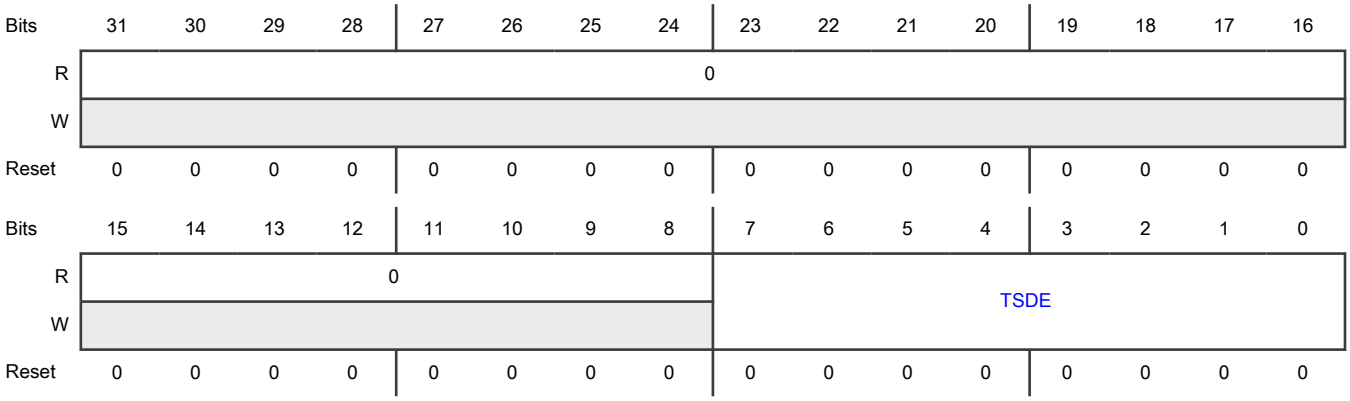
Offset

Register	Offset
TIMERSDEN	38h

Function

Enables DMA requests when the timer status flag is set.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 TSDE	Timer Status DMA Enable Enables DMA request generation when the corresponding TIMSTAT[TSF] flag is set. When the timer status DMA request is enabled, reading or writing to a timer compare register clears the corresponding timer status register. The DMA must therefore read or write to the timer compare register as part of the DMA transfer; otherwise, the DMA request remains asserted. 0b - Disable 1b - Enable

75.7.1.14 Shifter State (SHIFTSTATE)

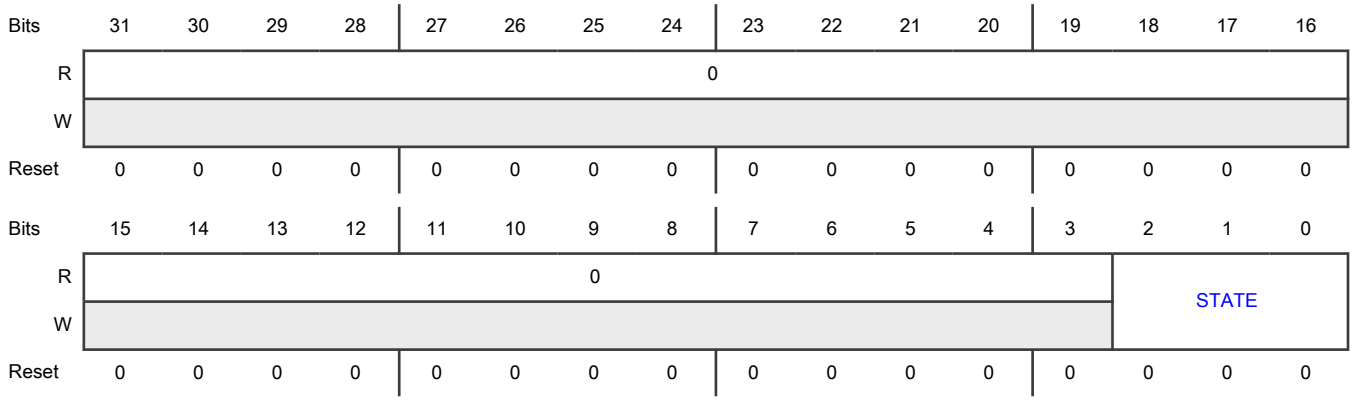
Offset

Register	Offset
SHIFTSTATE	40h

Function

Contains a pointer to track the current shifter.

Diagram



Fields

Field	Function
31-3 —	Reserved
2-0 STATE	Current State Pointer Maintains a pointer to track the current shifter (configured for State mode) enabled to drive outputs and compute the next state. Reading this register when the state pointer is updating can result in the return of an incorrect state. The value that you write to this field overrides the current state.

75.7.1.15 Trigger Status (TRGSTAT)

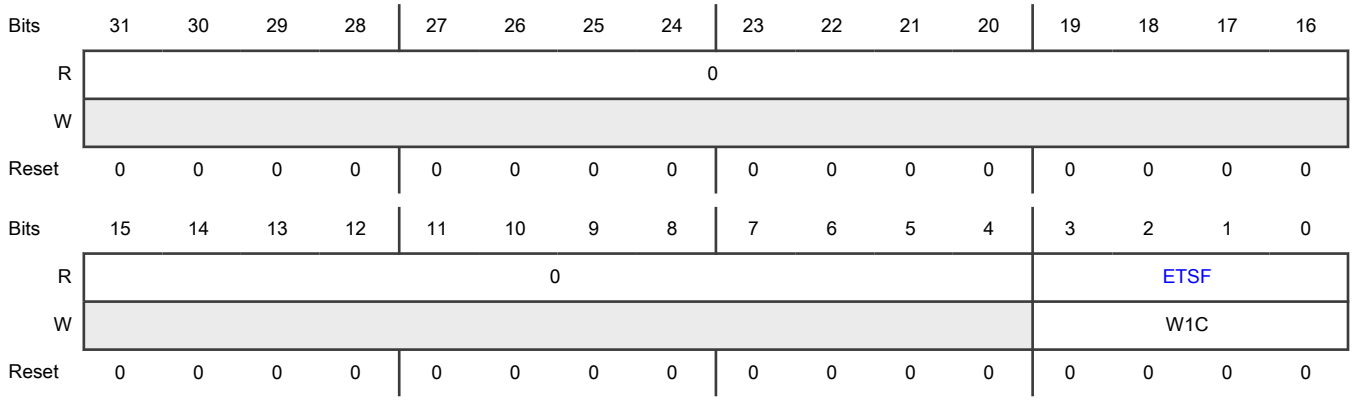
Offset

Register	Offset
TRGSTAT	48h

Function

Contains external trigger status flags.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 ETSF	External Trigger Status Flag Specifies whether the external trigger status flag is set when a rising edge is detected on the corresponding external trigger input. **NOTE** This field behaves differently for register reads and writes. When reading 0000b - Clear 0001b - Set When writing 0000b - No effect 0001b - Clear the flag

75.7.1.16 External Trigger Interrupt Enable (TRIGIEN)

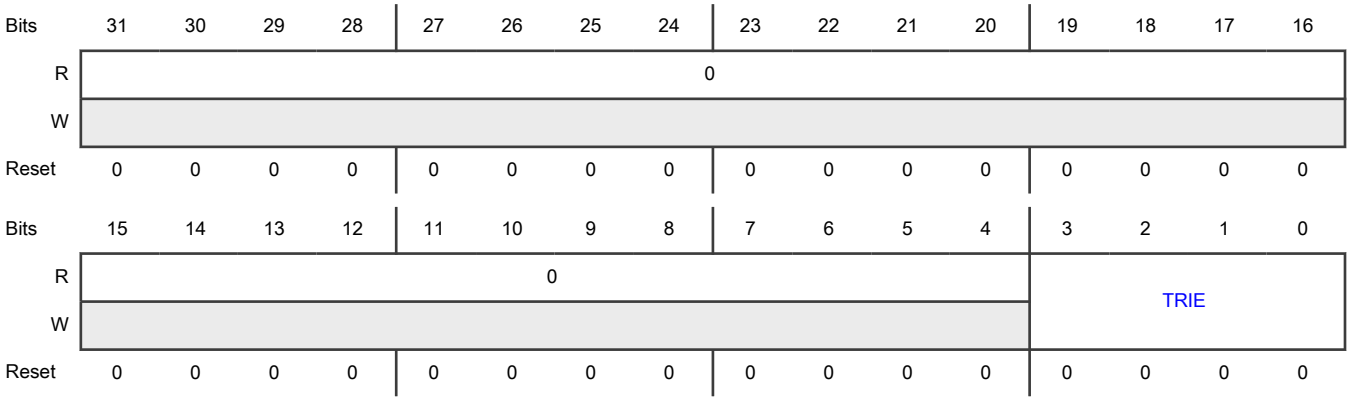
Offset

Register	Offset
TRIGIEN	4Ch

Function

Enables external trigger interrupts.

Diagram



Fields

Field	Function
31-4 —	Reserved
3-0 TRIE	External Trigger Interrupt Enable Enables interrupt generation when the corresponding TRGSTAT[ETSF] flag is set. If you write 0 to this field, TRGSTAT[ETSF] is disabled, and if you write 1 to this field, TRGSTAT[ETSF] is enabled. 0b - Disable 1b - Enable

75.7.1.17 Pin Status (PINSTAT)

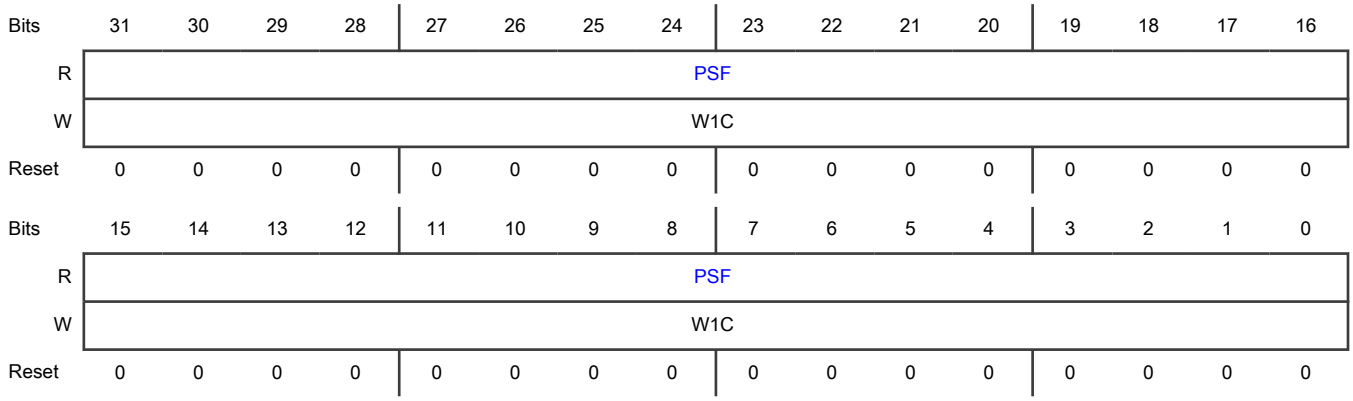
Offset

Register	Offset
PINSTAT	50h

Function

Contains pin status flags.

Diagram



Fields

Field	Function
31-0 PSF	Pin Status Flag Indicates whether the pin status flag is set when a rising edge or falling edge (if configured) is detected on the corresponding pin, as configured by the pin. **NOTE** This field behaves differently for register reads and writes. When reading 0000_0000_0000_0000_0000_0000_0000_0000b - Clear 0000_0000_0000_0000_0000_0000_0000_0001b - Set When writing 0000_0000_0000_0000_0000_0000_0000_0000b - No effect 0000_0000_0000_0000_0000_0000_0000_0001b - Clear the flag

75.7.1.18 Pin Interrupt Enable (PINIEN)

Offset

Register	Offset
PINIEN	54h

Function

Enables pin status interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PSIE															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PSIE															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PSIE	Pin Status Interrupt Enable Enables interrupt generation when the corresponding PINSTAT[PSF] flag is set. If you write 0 to this field, PINSTAT[PSF] is disabled, and if you write 1 to this field, PINSTAT[PSF] is enabled. 0b - Disable 1b - Enable

75.7.1.19 Pin Rising Edge Enable (PINREN)

Offset

Register	Offset
PINREN	58h

Function
Enables the pin status flag on a rising edge.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PRE															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PRE															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PRE	Pin Rising Edge Specifies whether the pin status flag is set whenever a rising edge is detected on the pin. 0b - Not set 1b - Set

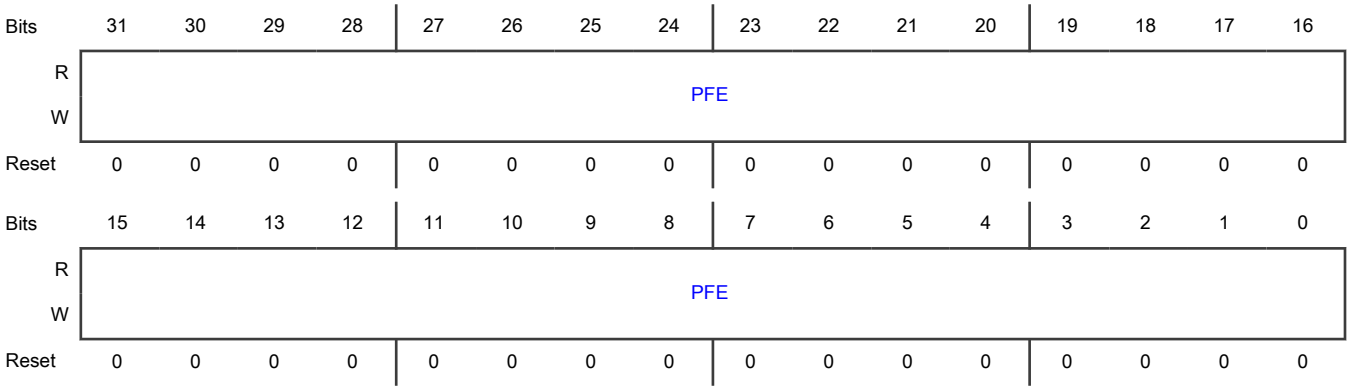
75.7.1.20 Pin Falling Edge Enable (PINFEN)

Offset

Register	Offset
PINFEN	5Ch

Function
Enables the pin status flag on a falling edge.

Diagram



Fields

Field	Function
31-0 PFE	Pin Falling Edge Specifies whether the pin status flag is set whenever a falling edge is detected on the pin. 0b - Not set 1b - Set

75.7.1.21 Pin Output Data (PINOUTD)

Offset

Register	Offset
PINOUTD	60h

Function
Contains data output when direct pin output is enabled.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	OUTD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	OUTD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 OUTD	Output Data Configures the value driven on the corresponding pin when direct pin output is enabled. 0b - Logic zero 1b - Logic one

75.7.1.22 Pin Output Enable (PINOUTE)

Offset

Register	Offset
PINOUTE	64h

Function
Enables pin output.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	OUTE															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	OUTE															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 OUTE	Output Enable Enables direct output on the corresponding pin. If this field is 0, the pin is controlled by timer/shifter configuration, and if this field is 1, pin is an output and driven with the value of Pin Output Data (PINOUTD). 0b - Controlled by timer/shifter configuration 1b - Output; driven with value of PINOUTD

75.7.1.23 Pin Output Disable (PINOUTDIS)

Offset

Register	Offset
PINOUTDIS	68h

Function
Disables pin output.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W	OUTDIS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W	OUTDIS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 OUTDIS	Output Disable Configures the corresponding pins to disable direct output. If this field is 1, the corresponding fields in Pin Output Data (PINOUTD) and Pin Output Enable (PINOUTE) become 0. 0b - No effect 1b - Corresponding fields become 0

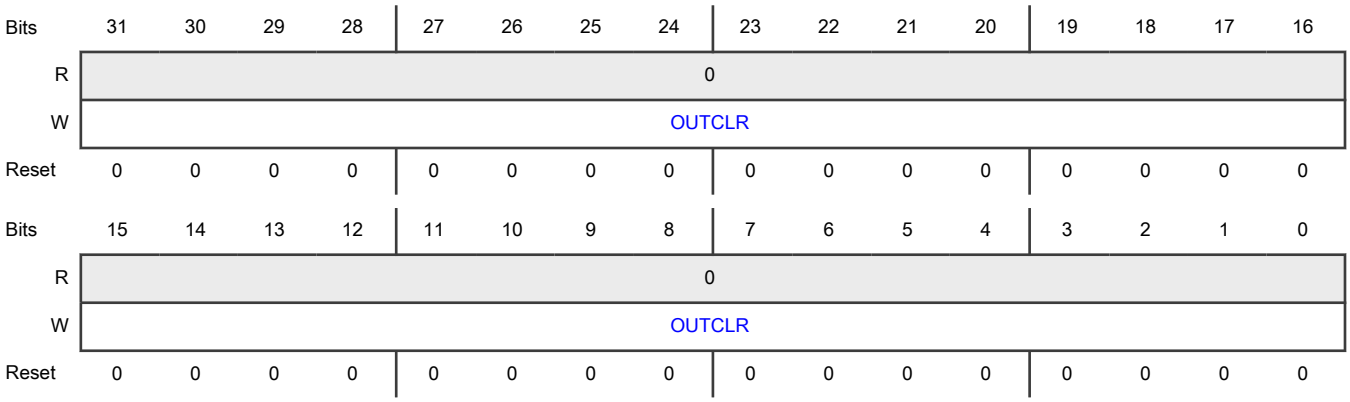
75.7.1.24 Pin Output Clear (PINOUTCLR)

Offset

Register	Offset
PINOUTCLR	6Ch

Function
Clears pin output.

Diagram



Fields

Field	Function
31-0 OUTCLR	Output Clear Configures the corresponding pins to output zero. If this field is 1, the corresponding field in Pin Output Data (PINOUTD) becomes 0 and the one in Pin Output Enable (PINOUTE) becomes 1. 0b - No effect 1b - Corresponding field in PINOUTD becomes 0; corresponding field in PINOUTE becomes 1

75.7.1.25 Pin Output Set (PINOUTSET)

Offset

Register	Offset
PINOUTSET	70h

Function
Sets pin output.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W	OUTSET															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W	OUTSET															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 OUTSET	Output Set Configures the corresponding pins to output logic one. If this field is 1, the corresponding fields in Pin Output Data (PINOUTD) and Pin Output Enable (PINOUTE) become 1. 0b - No effect 1b - Corresponding fields become 1

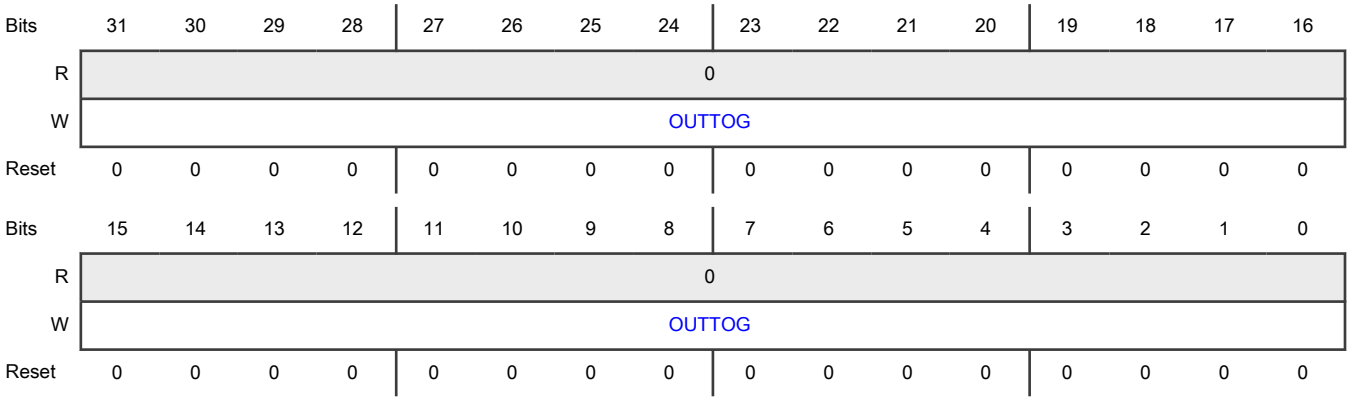
75.7.1.26 Pin Output Toggle (PINOUTTOG)

Offset

Register	Offset
PINOUTTOG	74h

Function
Toggles pin output.

Diagram



Fields

Field	Function
31-0 OUTTOG	Output Toggle Configures the corresponding pins to toggle. If this field is 1, the corresponding field in Pin Output Data (PINOUTD) is inverted and the one in Pin Output Enable (PINOUTE) becomes 1. 0b - No effect 1b - Corresponding field in PINOUTD is inverted; corresponding field in PINOUTE becomes 1

75.7.1.27 Shifter Control (SHIFTCTL0 - SHIFTCTL7)

Offset

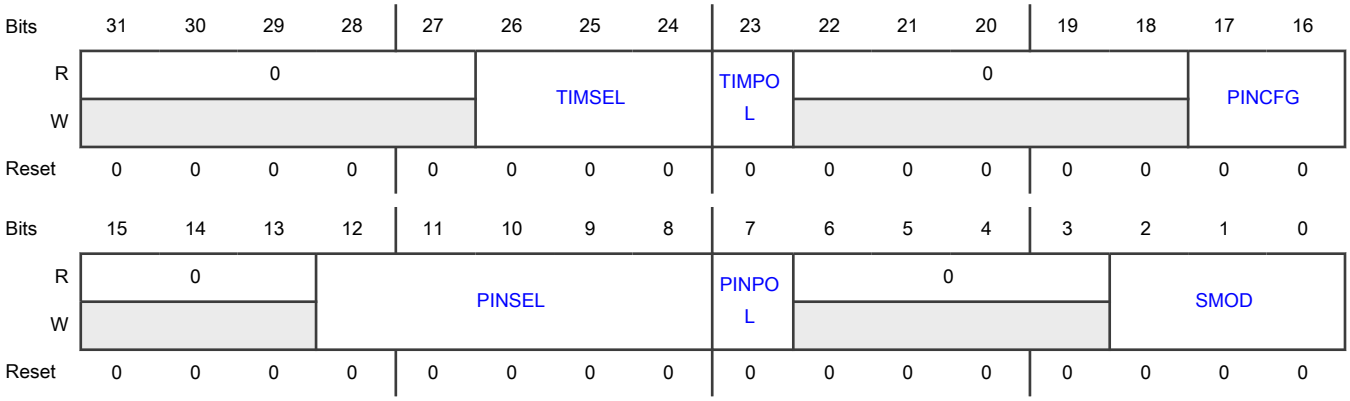
For n = 0 to 7:

Register	Offset
SHIFTCTLn	80h + (n × 4h)

Function

Provides shifter controls.

Diagram



Fields

Field	Function
31-27 —	Reserved
26-24 TIMSEL	Timer Select Selects which timer is used for controlling the logic or shift register and generating the shift clock. TIMSEL = i selects TIMERi.
23 TIMPOL	Timer Polarity Determines whether the shift occurs on the positive edge or negative edge of the shift clock. 0b - Positive edge 1b - Negative edge
22-18 —	Reserved
17-16 PINCFG	Shifter Pin Configuration Specifies shifter pin configuration. For pins configured as an output (PINCFG = 11b), this field takes effect when you write to the register. **NOTE** When initially configuring PINCFG as 11b, FLEXIO may briefly drive the pin low. To avoid this, you can configure PINCFG as 10b along with the rest of the Control register and then perform a subsequent write to set PINCFG as 11b. Likewise, when changing the value of PINCFG from 11b to 00b, you must perform an initial write to set PINCFG as 10b and then perform a subsequent write to update the rest of the Control register with the value of PINCFG as 00b. 00b - Shifter pin output disabled 01b - Shifter pin open-drain or bidirectional output enable 10b - Shifter pin bidirectional output data 11b - Shifter pin output
15-13 —	Reserved
12-8 PINSEL	Shifter Pin Select Selects the pin that is used by the shifter input or output. PINSEL = i selects the FXIO_Di pin. For pins configured as an output (PINCFG = 11b), this field takes effect when you write to the register.
7 PINPOL	Shifter Pin Polarity Specifies the shifter pin polarity. For pins configured as an output (PINCFG = 11b), this field takes effect when you write to this register.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Active high 1b - Active low
6-3 —	Reserved
2-0 SMOD	Shifter Mode Configures the mode of the shifter. 000b - Disable 001b - Receive mode; capture the current shifter content into SHIFTBUF on expiration of the timer 010b - Transmit mode; load SHIFTBUF contents into the shifter on expiration of the timer 011b - Reserved 100b - Match Store mode; shifter data is compared to SHIFTBUF content on expiration of the timer 101b - Match Continuous mode; shifter data is continuously compared to SHIFTBUF contents 110b - State mode; SHIFTBUF contents store programmable state attributes 111b - Logic mode; SHIFTBUF contents implement programmable logic lookup table

75.7.1.28 Shifter Configuration (SHIFTCFG0 - SHIFTCFG7)

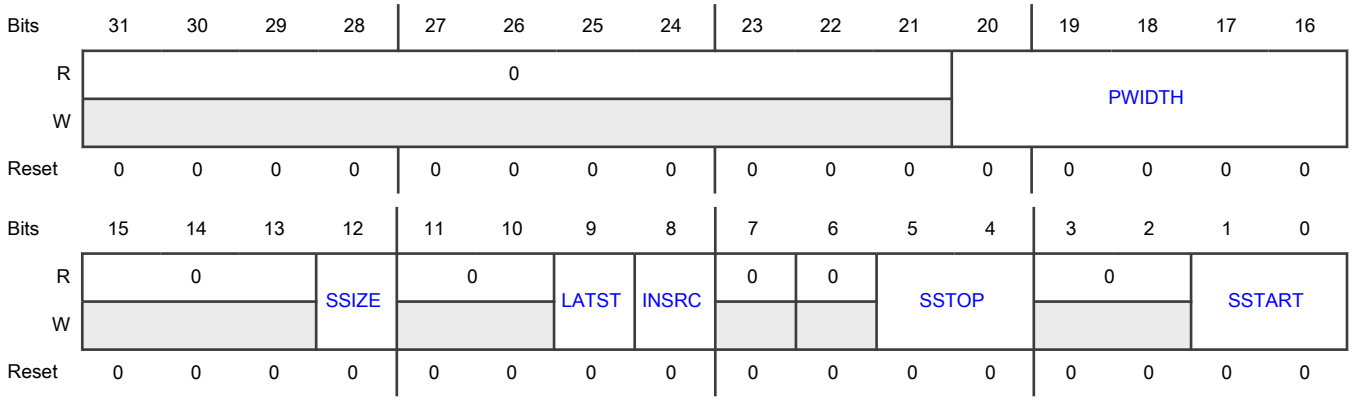
Offset

For n = 0 to 7:

Register	Offset
SHIFTCFGn	100h + (n × 4h)

Function
Provides fields for shifter configuration.

Diagram



Fields

Field	Function
31-21 —	Reserved
20-16 PWIDTH	Parallel Width Configures the number of bits to be shifted on each shift clock for all shifters: • 1-bit shift for PWIDTH = 0 • 2-bit shift for PWIDTH = 1 • 4-bit shift for PWIDTH = 2...3 • 8-bit shift for PWIDTH = 4...7 • 16-bit shift for PWIDTH = 8...15 • 32-bit shift for PWIDTH = 16...31 For shifters that support parallel transmit (SHIFTER0, SHIFTER4, ...) or parallel receive (SHIFTER3, SHIFTER7, ...), this field, together with PINSEL, also selects the pins to be driven or sampled on each shift clock: FXIO_D[PINSEL+PWIDTH]:FXIO_D[PINSEL]. Shifters that do not support parallel transmit or parallel receive only support parallel shift when SHIFTCFG*n*[INSRC] = 1. If SHIFTCTL*n*[SMOD] = 110b (State mode), use this field to disable state outputs (see State mode).
15-13 —	Reserved
12 SSIZE	Shifter Size Configures the size of the Shift registers. A 24-bit Shift register shifts data only into bits [23:0] and does not update bits [31:24] during shift operations. When the Shift register is configured for a 24-bit shift, configuring PWIDTH as 8..15 performs a 12-bit shift and PWIDTH as 16..31 performs a 24-bit shift.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - 32-bit 1b - 24-bit
11-10 —	Reserved
9 LATST	Late Store Configures what happens when a receive or match Shift register is configured to both shift and store on the same cycle. 0b - Store the pre-shift register state 1b - Store the post-shift register state
8 INSRC	Input Source Selects the input source for the shifter. Configuring this field as 1 is not supported for the last shifter. 0b - Pin 1b - Shifter n+1 output
7 —	Reserved
6 —	Reserved
5-4 SSTOP	Shifter Stop Allows automatic stop bit insertion, if the selected timer has also enabled a stop bit, when SHIFTCTL*n*[SMOD] is 10b (Transmit mode). If SHIFTCTL*n*[SMOD] is 1b or 100b (Receive mode or Match Store mode), this field allows automatic stop bit checking if the selected timer has also enabled a stop bit. If SHIFTCTL*n*[SMOD] is 110b (State mode), this field disables state outputs (see State mode). If SHIFTCTL*n*[SMOD] is 111b (Logic mode), this field masks logic pin inputs (see Logic mode). 00b - Stop bit disabled for Transmitter, Receiver, and Match Store modes 01b - Stop bit disabled for Transmitter, Receiver, and Match Store modes; when timer is in stop condition, Receiver and Match Store modes store receive data on the configured shift edge 10b - Transmitter mode outputs stop bit value 0 in Match Store mode; if stop bit is not 0, Receiver and Match Store modes set error flag (when timer is in stop condition, these modes also store receive data on the configured shift edge) 11b - Transmitter mode outputs stop bit value 1 in Match Store mode; if stop bit is not 1, Receiver and Match Store modes set error flag (when timer is in stop condition, these modes also store receive data on the configured shift edge)
3-2	Reserved

Table continues on the next page...

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Field	Function
—	
1-0 SSTART	Shifter Start Allows automatic start bit insertion, if the selected timer has also enabled a start bit, when SHIFTCTL*n*[SMOD] is 10b (Transmit mode). If SHIFTCTL*n*[SMOD] = 1b (Receive mode) or 100b (Match Store mode), this field allows automatic start bit checking if the selected timer has also enabled a start bit. If SHIFTCTL*n*[SMOD] is 110b (State mode), this field disables state outputs (see State mode). If SHIFTCTL*n*[SMOD] = 111b (Logic mode), this field masks logic pin inputs (see Logic mode). 00b - Start bit disabled for Transmitter, Receiver, and Match Store modes; Transmitter mode loads data on enable 01b - Start bit disabled for Transmitter, Receiver, and Match Store modes; Transmitter mode loads data on first shift 10b - Transmitter mode outputs start bit value 0 before loading data on first shift; if start bit is not 0, Receiver and Match Store modes set error flag 11b - Transmitter mode outputs start bit value 1 before loading data on first shift; if start bit is not 1, Receiver and Match Store modes set error flag

75.7.1.29 Shifter Buffer (SHIFTBUF0 - SHIFTBUF7)

Offset

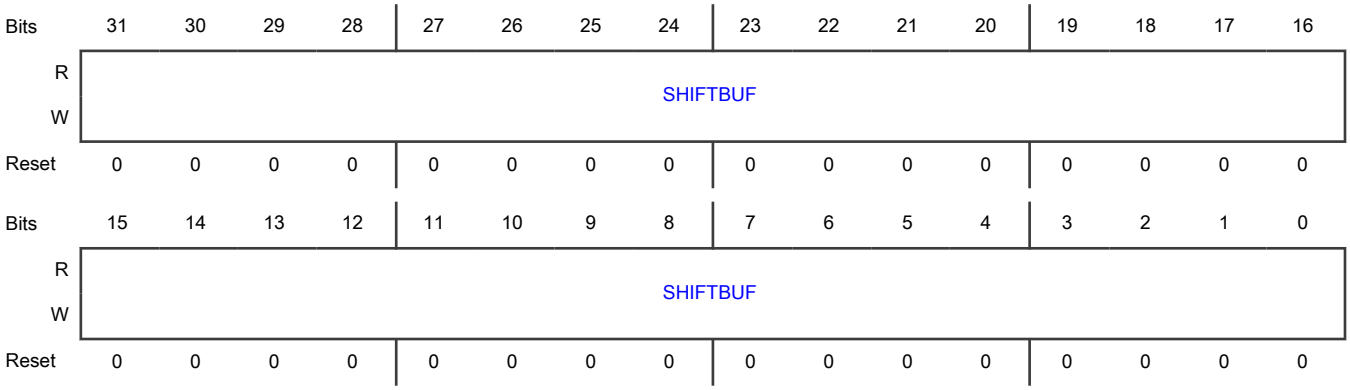
For n = 0 to 7:

Register	Offset
SHIFTBUFn	200h + (n × 4h)

Function

Contains shift buffer data.

Diagram



Fields

Field	Function
31-0 SHIFTBUF	Shift Buffer Contains the data to be matched with the shifter contents and is used for various other functions, depending on the setting of SHIFTCTL*n*[SMOD]: • If SHIFTCTL0[SMOD] is 1b (Receive mode), shifter data is transferred into SHIFTBUF at the expiration of the timer. You must read this register only when the corresponding SHIFTSTAT[SSF] flag is set, indicating that new shifter data is available. • If SHIFTCTL0[SMOD] is 10b (Transmit mode), SHIFTBUF data is transferred into the shifter before the timer begins. • If SHIFTCTL0[SMOD] is 100b (Match Store mode), SHIFTBUF[31:16] contains the data to be matched with the shifter contents and SHIFTBUF[15:0] can be used to mask the match result (1 = mask, 0 = no mask). The match is checked when the timer expires. Shifter data [31:16] is written to SHIFTBUF[31:16] whenever a match event occurs. You must read this register only when the corresponding shifter status flag is set, indicating that new shifter data is available. • If SHIFTCTL0[SMOD] is 101b (Match Continuous mode), SHIFTBUF[31:16] contains the data to be matched with the shifter contents, and SHIFTBUF[15:0] can be used to mask the match result (1 = mask, 0 = no mask). • If SHIFTCTL0[SMOD] is 111b (Logic mode), SHIFTBUF[31:0] implements a 5-input, 32-bit programmable logic lookup table (see Logic mode). • If SHIFTCTL0[SMOD] is 110b (State mode), use SHIFTBUF[31:24] to drive the output value when this shifter is selected by the current state pointer and use SHIFTBUF[23:0] to configure the value of the next state transition (see State mode).

75.7.1.30 Shifter Buffer Bit Swapped (SHIFTBUFBIS0 - SHIFTBUFBIS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFBISn	280h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, but it is bit-swapped.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFBIS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFBIS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFBIS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register are bit-swapped. Reads return SHIFTBUF[0:31].

75.7.1.31 Shifter Buffer Byte Swapped (SHIFTBUFBYS0 - SHIFTBUFBYS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFBYSn	300h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, but it is byte-swapped.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFBYS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFBYS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFBYS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register are byte-swapped. Reads return {SHIFTBUF[7:0], SHIFTBUF[15:8], SHIFTBUF[23:16], SHIFTBUF[31:24]}.

75.7.1.32 Shifter Buffer Bit Byte Swapped (SHIFTBUFBBS0 - SHIFTBUFBBS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFBBSn	380h + (n × 4h)

Function

Contains the register data for Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but it is bit-swapped within each byte.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFBBS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFBBS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFBBS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), except that reads or writes to this register are bit-swapped within each byte. Reads return {SHIFTBUF[24:31], SHIFTBUF[16:23], SHIFTBUF[8:15], SHIFTBUF[0:7]}.

75.7.1.33 Timer Control (TIMCTL0 - TIMCTL7)

Offset

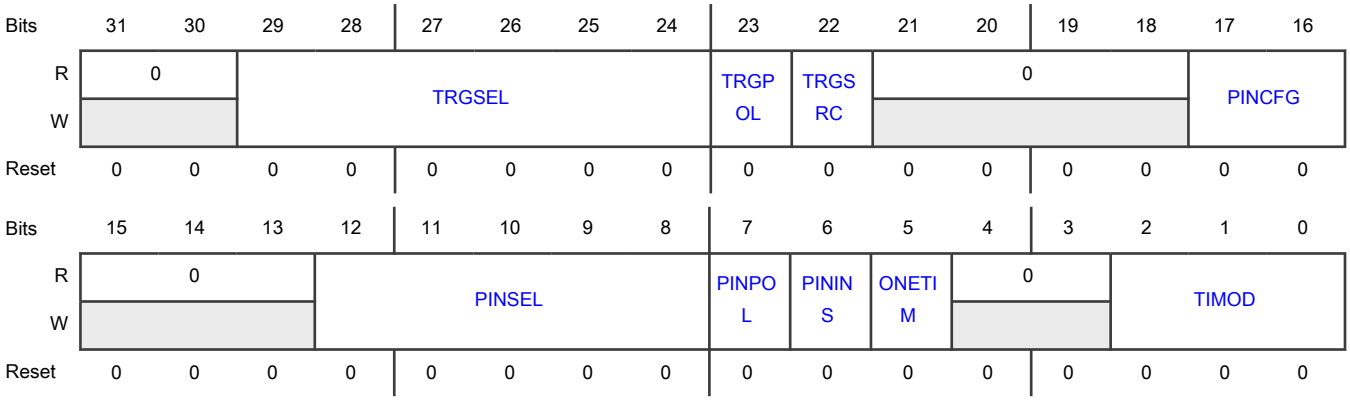
For n = 0 to 7:

Register	Offset
TIMCTLn	400h + (n × 4h)

Function

Controls various settings for timer *n*.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-24 TRGSEL	Trigger Select Selects the trigger. The valid values for TRGSEL depend on the configuration of Parameter (PARAM): • If TRGSRC = 1, the valid values for *n* depend on the settings of PARAM[PIN], PARAM[TIMER], and PARAM[SHIFTER]. • If TRGSRC = 0, the valid values for *n* depend on PARAM[TRIGGER]. See the chip-specific FLEXIO information for external trigger selection. **NOTE** For a pin, *n* = 0 to 31, for a shifter, *n* = 0 to 7, and for a timer, *n* = 0 to 7. If TRGSRC = 0, configure the trigger selection as *n* = external trigger *n* input. If TRGSRC = 1, you can configure the internal trigger to select an input pin as 2×*n* = pin *n* input. If TRGSRC = 1, you can configure the internal trigger to select a shifter or timer signal as: • 4×*n* + 1 = shifter *n* status flag • 4×*n* + 3 = timer *n* trigger output Following are the values for expanded internal trigger selection (TRGSRC = 1):

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Field	Function
	• 0000 = Pin 0 • 0001 = Shifter 0 flag • 0010 = Pin 1 • 0011 = Timer 0 trigger • 0100 = Pin 2 • 0101 = Shifter 1 flag • 0110 = Pin 3 • 0111 = Timer 1 trigger • ... • This continues up to pin 31, shifter 7, and timer 7.
23 TRGPOL	Trigger Polarity Specifies whether the trigger is active high or active low. 0b - Active high 1b - Active low
22 TRGSRC	Trigger Source Specifies whether the selected trigger source is external or internal. 0b - External 1b - Internal
21-18 —	Reserved
17-16 PINCFG	Timer Pin Configuration Configures the direction of the timer pin. For pins configured as an output (PINCFG = 11b), this field takes effect when you write to the register. **NOTE** When you initially configure PINCFG as 11b, FLEXIO may briefly drive the pin low. To avoid this, configure PINCFG as 10b along with the rest of the Control register and then perform a subsequent write to set the value of PINCFG as 11b. Likewise, when changing the value of PINCFG from 11b to 00b, you must perform an initial write to set PINCFG as 10b, and then perform a subsequent write to update the rest of the Control register with PINCFG as 00b. 00b - Timer pin output disabled 01b - Timer pin open-drain or bidirectional output enable 10b - Timer pin bidirectional output data 11b - Timer pin output

Table continues on the next page...

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Field	Function
15-13 —	Reserved
12-8 PINSEL	Timer Pin Select Selects the pin that is used by the timer input or output. PINSEL = i selects the FXIO_Di pin. For pins configured as an output (PINCFG = 11b), this field takes effect when you write to the register.
7 PINPOL	Timer Pin Polarity Specifies the timer pin polarity. For pins configured as an output (PINCFG = 11b), this field takes effect when you write to the register. 0b - Active high 1b - Active low
6 PININS	Timer Pin Input Select Specifies what selects the timer pin input. If this field is 1, the timer input pin is different from the timer output pin. PINSEL must select an even-numbered pin when this field is 1, which means that the output pin is even-numbered and input pin is odd-numbered. 0b - PINSEL selects timer pin input and output 1b - PINSEL + 1 selects the timer pin input; timer pin output remains selected by PINSEL
5 ONETIM	Timer One Time Operation Configures the timer to perform a single enable or disable iteration. Clear the timer status flag for the timer to be enabled again. 0b - Generate the timer enable event as normal 1b - Block the timer enable event unless the timer status flag is clear
4-3 —	Reserved
2-0 TIMOD	Timer Mode Specifies the timer mode: • In 8-bit baud counter mode, the lower 8 bits of the counter and compare register are used to configure the baud rate of the timer shift clock. The upper 8 bits are used to configure the shifter bit count. • In 8-bit PWM high mode, the lower 8 bits of the counter and compare register are used to configure the high period of the timer shift clock. The upper 8 bits are used to configure the low period of the timer shift clock. The shifter bit count is configured using another timer or external signal. • In 16-bit counter mode, the full 16 bits of the counter and compare register are used to configure either the baud rate of the shift clock or the shifter bit count. • In 16-bit counter disable mode, the full 16 bits of the counter and compare register are used to configure either the baud rate of the shift clock or the shifter bit count.

Table continues on the next page...

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Field	Function
	• In 8-bit word counter mode, the lower 8 bits of the counter and compare register are used to configure the shifter bit count. The upper 8 bits are used to configure the shifter word count. • In 8-bit PWM low mode, the lower 8 bits of the counter and compare register are used to configure the low period of the timer shift clock. The upper 8 bits are used to configure the high period of the timer shift clock. Use another timer or external signal to configure the shifter bit count. • In 16-bit input capture mode, the inverted value of the 16-bit counter is latched into the compare register when a timer counter disable condition is detected (as configured by TIMCFG*n*[TIMDIS]). This also sets the timer status flag. The timer counter is immediately restarted from FFFFh. 000b - Timer disabled 001b - Dual 8-bit counters baud mode 010b - Dual 8-bit counters PWM high mode 011b - Single 16-bit counter mode 100b - Single 16-bit counter disable mode 101b - Dual 8-bit counters word mode 110b - Dual 8-bit counters PWM low mode 111b - Single 16-bit input capture mode

75.7.1.34 Timer Configuration (TIMCFG0 - TIMCFG7)

Offset

For n = 0 to 7:

Register	Offset
TIMCFGn	480h + (n × 4h)

Function

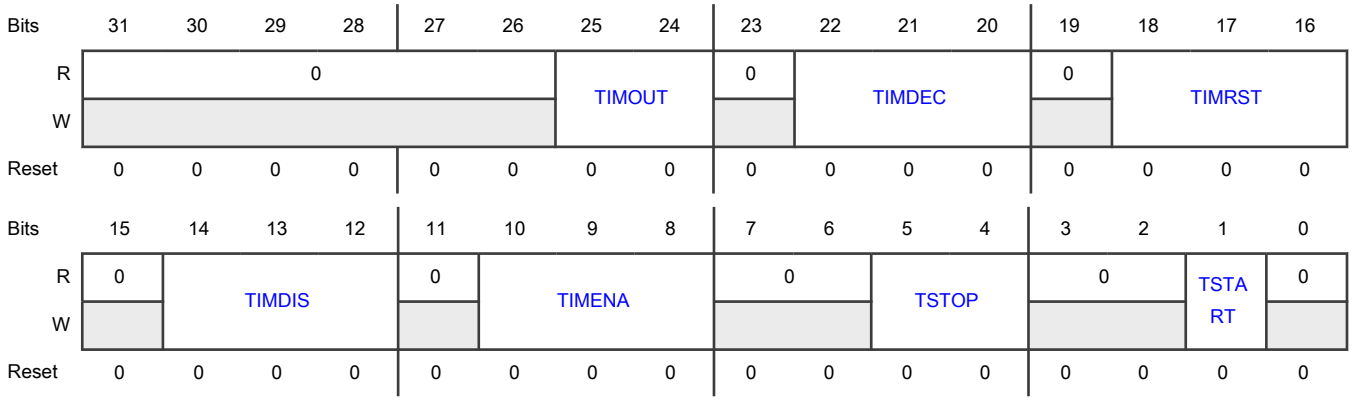
Controls various aspects of timer configuration.

The options to enable or disable the timer using the timer *n* - 1 enable or disable are reserved when *n* is evenly divisible by 4 (timer 0, for example).

NOTE

The pin and trigger level and edges specified in this register refer to the signal state after being modified by the settings of TIMCTL*n*[PINPOL] and TIMCTL*n*[TRGPOL]. For example, "trigger low" means that a trigger is actually at logic level 1 if TIMCTL*n*[TRGPOL] is 1 (active low).

Diagram



Fields

Field	Function
31-26 —	Reserved
25-24 TIMOUT	Timer Output Configures the initial state of the timer output and whether it is affected by the timer reset. 00b - Logic one when enabled; not affected by timer reset 01b - Logic zero when enabled; not affected by timer reset 10b - Logic one when enabled and on timer reset 11b - Logic zero when enabled and on timer reset
23 —	Reserved
22-20 TIMDEC	Timer Decrement Configures the source of the timer decrement and that of the shift clock. 000b - Decrement counter on FLEXIO clock; shift clock equals timer output 001b - Decrement counter on trigger input (both edges); shift clock equals timer output 010b - Decrement counter on pin input (both edges); shift clock equals pin input 011b - Decrement counter on trigger input (both edges); shift clock equals trigger input 100b - Decrement counter on FLEXIO clock divided by 16; shift clock equals timer output 101b - Decrement counter on FLEXIO clock divided by 256; shift clock equals timer output 110b - Decrement counter on pin input (rising edge); shift clock equals pin input 111b - Decrement counter on trigger input (rising edge); shift clock equals trigger input
19 —	Reserved

Table continues on the next page...

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Field	Function
18-16 TIMRST	Timer Reset Configures the condition that causes the timer counter (and optionally the timer output) to be reset. In 8-bit counter mode, the timer reset only resets the lower 8 bits that configure the baud rate. In all other modes, the timer reset resets full 16 bits of the counter. 000b - Never reset timer 001b - Timer reset on timer output high. 010b - Timer reset on timer pin equal to timer output 011b - Timer reset on timer trigger equal to timer output 100b - Timer reset on timer pin rising edge 101b - Reserved 110b - Timer reset on trigger rising edge 111b - Timer reset on trigger rising or falling edge
15 —	Reserved
14-12 TIMDIS	Timer Disable Configures the condition that causes the timer to be disabled and stop decrementing. 000b - Timer never disabled 001b - Timer disabled on timer n-1 disable 010b - Timer disabled on timer compare (upper 8 bits match and decrement) 011b - Timer disabled on timer compare (upper 8 bits match and decrement) and trigger low 100b - Timer disabled on pin rising or falling edge 101b - Timer disabled on pin rising or falling edge provided trigger is high 110b - Timer disabled on trigger falling edge 111b - Reserved
11 —	Reserved
10-8 TIMENA	Timer Enable Configures the condition that causes the timer to be enabled and start decrementing. 000b - Timer always enabled 001b - Timer enabled on timer n-1 enable 010b - Timer enabled on trigger high 011b - Timer enabled on trigger high and pin high

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Field	Function
	100b - Timer enabled on pin rising edge 101b - Timer enabled on pin rising edge and trigger high 110b - Timer enabled on trigger rising edge 111b - Timer enabled on trigger rising or falling edge
7-6 —	Reserved
5-4 TSTOP	Timer Stop Specifies whether the stop bit is enabled. The stop bit can be added on a timer compare (between each word) or on a timer disable. When stop bit is enabled, configured shifters output the contents of the stop bit when the timer is disabled. When stop bit is enabled on timer disable, the timer remains disabled until the next rising edge of the shift clock. If configured for both timer compare and timer disable, only one stop bit is inserted on timer disable. 00b - Disabled 01b - Enabled on timer compare 10b - Enabled on timer disable 11b - Enabled on timer compare and timer disable
3-2 —	Reserved
1 TSTART	Timer Start Specifies whether the start bit is enabled. If it is enabled, configured shifters output the contents of the start bit when the timer is enabled. The timer counter reloads from the compare register on the first rising edge of the shift clock. 0b - Disabled 1b - Enabled
0 —	Reserved

75.7.1.35 Timer Compare (TIMCMP0 - TIMCMP7)

Offset

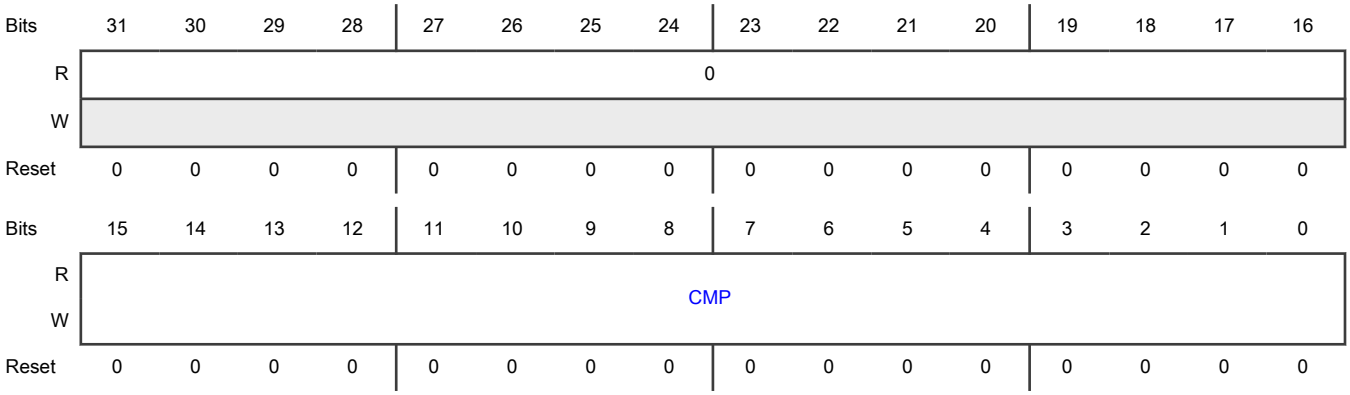
For n = 0 to 7:

Register	Offset
TIMCMPn	500h + (n × 4h)

Function

Contains the timer compare value.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 CMP	Timer Compare Value Loads into the timer counter when the timer is first enabled, when the timer is reset, and when the timer decrements down to zero. In 8-bit baud counter mode, the lower 8 bits configure the baud rate divider as (CMP[7:0] + 1) × 2. The upper 8 bits configure the number of bits in each word as (CMP[15:8] + 1) ÷ 2. In 8-bit PWM high mode, the lower 8 bits configure the high period of the output to (CMP[7:0] + 1) and the upper 8 bits configure the low period of the output to (CMP[15:8] + 1). In 16-bit counter mode, the compare value can be used to generate the baud rate divider (if shift clock source is timer output) as (CMP[15:0] + 1) × 2. When the shift clock source is a pin or trigger input, the compare register is used to set the number of bits in each word as (CMP[15:0] + 1) ÷ 2. In 16-bit counter disable mode, the compare value can be used to generate the baud rate divider (if shift clock source is timer output) as (CMP[15:0] + 1) × 2. When the shift clock source is a pin or trigger input, the compare register is used to set the number of bits in each word as (CMP[15:0] + 1) ÷ 2. In 8-bit word counter mode, the lower 8 bits configure the number of bits in each word as (CMP[7:0] + 1) ÷ 2. The upper 8 bits configure the number of words to transfer equal to (CMP[15:8] + 1) ÷ 2. In 8-bit PWM low mode, the lower 8 bits configure the low period of the output to (CMP[7:0] + 1) and the upper 8 bits configure the high period of the output to (CMP[15:8] + 1). In 16-bit input capture mode, the compare register is updated with the inverse of the timer counter value whenever the timer status flag is set. You must read this register only when the timer status flag is set.

75.7.1.36 Shifter Buffer Nibble Byte Swapped (SHIFTBUFNBS0 - SHIFTBUFNBS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFNBSn	680h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, but it is nibble-swapped within each byte.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFNBS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFNBS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFNBS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register are nibble-swapped within each byte. Reads return {SHIFTBUF[27:24], SHIFTBUF[31:28], SHIFTBUF[19:16], SHIFTBUF[23:20], SHIFTBUF[11:8], SHIFTBUF[15:12], SHIFTBUF[3:0], SHIFTBUF[7:4]}.

75.7.1.37 Shifter Buffer Halfword Swapped (SHIFTBUFHWS0 - SHIFTBUFHWS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFHWSn	700h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, but it is halfword-swapped.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFHWS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFHWS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFHWS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register are halfword-swapped. Reads return {SHIFTBUF[15:0], SHIFTBUF[31:16]}.

75.7.1.38 Shifter Buffer Nibble Swapped (SHIFTBUFNIS0 - SHIFTBUFNIS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFNISn	780h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, but it is nibble-swapped.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFNIS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFNIS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFNIS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register are nibble-swapped. Reads return {SHIFTBUF[3:0], SHIFTBUF[7:4], SHIFTBUF[11:8], SHIFTBUF[15:12], SHIFTBUF[19:16], SHIFTBUF[23:20], SHIFTBUF[27:24], SHIFTBUF[31:28]}.

75.7.1.39 Shifter Buffer Odd Even Swapped (SHIFTBUFOES0 - SHIFTBUFOES7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFOESn	800h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, but it has odd and even bits partitioned separately.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFOES															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFOES															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFOES	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register have the odd and even bits partitioned separately. Only 32-bit accesses are supported for this register. Reads return {SHIFTBUF[31], SHIFTBUF[29], SHIFTBUF[27],SHIFTBUF[25],SHIFTBUF[23],SHIFTBUF[21],SHIFTBUF[19],SHIFTBUF[17],SHIFTBUF[15],SHIFTBUF[13],SHIFTBUF[11],SHIFTBUF[9], SHIFTBUF[7], SHIFTBUF[5], SHIFTBUF[3], SHIFTBUF[1], SHIFTBUF[30], SHIFTBUF[28], SHIFTBUF[26], SHIFTBUF[24], SHIFTBUF[22], SHIFTBUF[20], SHIFTBUF[18], SHIFTBUF[16], SHIFTBUF[14], SHIFTBUF[12], SHIFTBUF[10], SHIFTBUF[8], SHIFTBUF[6], SHIFTBUF[4], SHIFTBUF[2], SHIFTBUF[0]}.

75.7.1.40 Shifter Buffer Even Odd Swapped (SHIFTBUFEOS0 - SHIFTBUFEOS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFEOSn	880h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, with even and odd bits partitioned separately.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFEOS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFEOS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFEOS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register have the even and odd bits partitioned separately. Only 32-bit accesses are supported for this register. Reads return {SHIFTBUF[30], SHIFTBUF[28], SHIFTBUF[26], SHIFTBUF[24], SHIFTBUF[22], SHIFTBUF[20], SHIFTBUF[18], SHIFTBUF[16], SHIFTBUF[14], SHIFTBUF[12], SHIFTBUF[10], SHIFTBUF[8], SHIFTBUF[6], SHIFTBUF[4], SHIFTBUF[2], SHIFTBUF[0], SHIFTBUF[31], SHIFTBUF[29], SHIFTBUF[27],SHIFTBUF[25],SHIFTBUF[23],SHIFTBUF[21],SHIFTBUF[19],SHIFTBUF[17],SHIFTBUF[15],SHIFTBUF[13],SHIFTBUF[11],SHIFTBUF[9], SHIFTBUF[7], SHIFTBUF[5], SHIFTBUF[3], SHIFTBUF[1]}.

75.7.1.41 Shifter Buffer Halfword Byte Swapped (SHIFTBUFHBS0 - SHIFTBUFHBS7)

Offset

For n = 0 to 7:

Register	Offset
SHIFTBUFHBSn	900h + (n × 4h)

Function

Contains Shifter Buffer (SHIFTBUF0 - SHIFTBUF7) content, but it is halfword byte-swapped.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SHIFTBUFHBS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SHIFTBUFHBS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SHIFTBUFHBS	Shift Buffer Acts as an alias to Shifter Buffer (SHIFTBUF0 - SHIFTBUF7), but reads or writes to this register are halfword byte-swapped. Reads return {SHIFTBUF[23:16], SHIFTBUF[31:24], SHIFTBUF[7:0], SHIFTBUF[15:8]}.

75.8 Glossary

Baud rate	Number of bits that LPUART transmits or receives per second
Break character	Break character is generated when the transmitter is holding the data line at the space level for at least 1 character time
Idle character	Idle character is generated when the transmitter is holding the data line at logic 1 for at least 1 character time
PWM	Pulse width modulation

Chapter 76
CAN (FlexCAN)

76.1 Chip-specific FlexCAN information

76.1.1 FlexCAN instances and configuration

This chip contains up to 6 instances of FlexCAN:

- FlexCAN_0
- FlexCAN_1
- FlexCAN_2
- FlexCAN_3
- FlexCAN_4
- FlexCAN_5

NOTE

Message buffer, Enhanced RX FIFO, and Legacy RXFIFO structure of Flexcan is big endian whereas Cortex-M7 cores support little endian format. So, to align with the IP, there is an extra software overhead for endianness correction.

Table 540. FlexCAN modules instantiation

Feature	FlexCAN0	FlexCAN1	FlexCAN2	FlexCAN3	FlexCAN4	FlexCAN5
Flexible Data Rate (CAN FD) protocol specification and CAN protocol.	Yes	Yes	Yes	Yes	Yes	Yes
Number of message buffers.	96	96	96	64	64	64
Rx FIFO Filtering	Yes	Yes	Yes	Yes	Yes	Yes
ECC	Yes	Yes	Yes	Yes	Yes	Yes
PNET	No	No	No	No	No	No
External Tick Time	Yes, Supported by PIT_RTI_2 Trigger[0]					
DMA	Yes	Yes	Yes	Yes	Yes	Yes
Enhanced RX FIFO Feature	Yes	Yes	Yes	No	No	No

NOTE

See attached interrupt map file for the vector numbers for the CAN instances and their corresponding interrupt sources.

76.1.2 FlexCAN error injection

Error injection address mapping

Use the following table to convert from the memory map address to the location in the physical FlexCAN RAM (where pairs of values are provided, the first is the address for MCR[FDEN] negated, the second is for MCR[FDEN] asserted):

RAM contents	Memory map	Injection address	
—	—	FlexCAN0/1/2	FlexCAN3/4/5
FlexCAN Registers	—	Not mapped	Not mapped
MBs	0080h	0000h	0000h
RXIMRs	0880h	600h	400h
RXIFR_0	0A80h	780h	500h
RXIFR_1	0A84h	784h	504h
RXIFR_2	0A88h	788h	508h
RXIFR_3	0A8Ch	78Ch	50Ch
RXIFR_4	0A90h	790h	510h
RXIFR_5	0A94h	794h	514h
Reserved	0A98h	—	—
RXMGMASK	0AA0h	7A0h	520h
RXFGMASK	0AA4h	7A4h	524h
RX14MASK	0AA8h	7A8h	528h
RX15MASK	0AACh	7ACh	52Ch
Tx_SMB	0AB0h/0F28h	7B0h	530h
Rx_SMB0	0AC0h/0F70h	7C0h/7F8h	540h/578h
Rx_SMB1	0AD0h/0FB8h	7D0h/840h	550h/5C0h
Rx_SMB0_TIME_STAMP	0C20h	888h	608h
Rx_SMB1_TIME_STAMP	0C24h	88Ch	60Ch
HR_TIME_STAMP	0C30h	890h	610h
Enhanced RX FIFO	2000h	A10h	—
ERFFEL	3000h	1050h	—

FlexCAN memory initialization

All FlexCAN memory must be initialized before starting its operation in order to have the parity bits in memory properly updated. CTRL2[WRMFRZ] grants write access to all memory positions that require initialization.

These locations are as listed in this table:

from 080h–ADFh and from C20h–31FFh.

Instance	Offset address ranges to be initialized
FlexCAN0/1/2	080h–ADFh; C20h–31FFh
FlexCAN3/4/5	080h–ADFh; C20h–FFFh

76.1.3 Reset value of MDIS bit

The CAN_MCR[MDIS] bit is set to 1 when the module is reset. Therefore, FlexCAN module is disabled following a reset. For details of CAN_MCR[MDIS] register refer to "CAN register description" section.

76.1.4 CAN Timestamp Implementation

FlexCAN uses Ethernet Media Access Controller (EMAC) and System Timer Module (STM_0) counters as time source. For details see 'FlexCAN timestamp implementation' section in Clocking chapter.

76.1.4.1 Considerations while using FlexCAN timestamp in S32K396

While using FlexCAN timestamp feature, the message buffers should be unlocked within each 20 CAN bits. A failure to do so while using FlexCAN timestamp feature along with FlexCAN RX FIFO or enhanced RX FIFO might result in timestamp information being missed.

76.1.5 CAN clock setup

For clock setup, see Clocking chapter.

76.2 Overview

FlexCAN is a communication controller implementing the CAN protocol according to the ISO 11898-1:2015 standard and CAN 2.0 Part B protocol specifications.

The CAN protocol was primarily designed to be used as a vehicle serial data bus, meeting the specific real-time processing and reliable operation requirements in the electromagnetic interference (EMI) environment of a vehicle. FlexCAN is a full implementation of the CAN protocol specification, the CAN with flexible data rate (CAN FD) protocol, and the CAN version 2.0 Part B protocol. It supports both standard and extended message frames and long payloads.

NOTE

Legacy Receive (RX) FIFO cannot be used in Flexible Data (FD) mode.

NOTE

In CAN FD mode, use the Enhanced Receive FIFO feature instead of the Legacy Receive FIFO.

76.2.1 Block diagram

Figure 520 shows the main submodules implemented in FlexCAN.

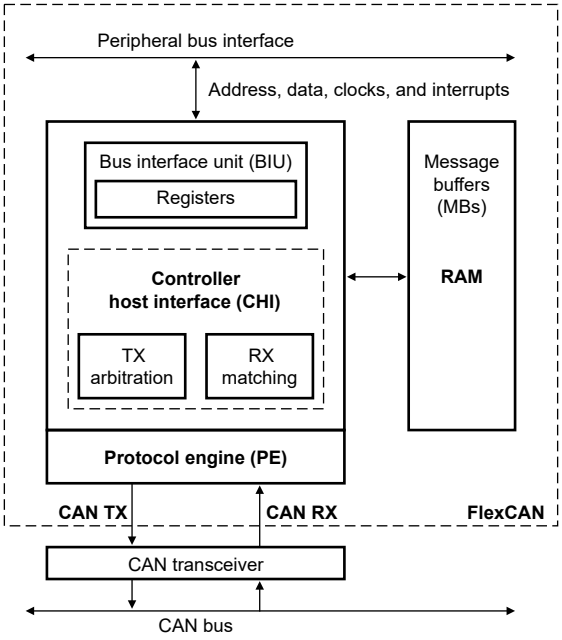


Figure 520. Block diagram

The Protocol Engine (PE) submodule manages the serial communication on the CAN bus:

- RAM access for receiving and transmitting message frames
- Receive message validation
- Error handling.
- CAN FD message detection

The Controller Host Interface (CHI) submodule manages:

- Message buffer (MB) selection for reception and transmission
- Arbitration and ID matching algorithms for both CAN FD and non-CAN FD message formats

The Bus Interface Unit (BIU) submodule controls access to and from the internal interface bus to establish connection to the CPU and to other blocks. The BIU manages access to:

- Clocks
- Address and data buses
- Interrupt outputs
- DMA
- Test signals

76.2.2 Features

- Full implementation of *CAN with Flexible data rate (CAN FD) protocol specification* and *CAN Specification Version 2.0, Part B*
  - Standard data frames
  - Extended data frames
  - Data length of 0–64 bytes
  - Programmable bit rate (see chip-specific FlexCAN information for specific maximum rate configuration)

  - Content-related addressing
- Compliance with ISO 11898-1:2015 standard
- Flexible message buffers that can be configured to store a payload of 0, 8, 16, 32, or 64 bytes
  - Increasing the payload size decreases the number of supported message buffers (see FlexCAN memory partition for CAN FD).
  - Message buffers are configurable as receive or transmit, supporting standard and extended messages.
- Individual Receive Mask registers for each message buffer
- Full-featured Legacy RX FIFO with storage capacity for six frames and automatic internal pointer handling with DMA support
- Full-featured Enhanced RX FIFO with storage capacity of 20 CAN FD frames and automatic internal pointer handling with DMA support
- Transmission abort capability
- Optional general purpose RAM space, using RAM not used by reception or transmission structures
- Listen-Only mode
- Programmable loopback mode supporting self-test operation
- Programmable transmission priority scheme: lowest ID, lowest buffer number, or highest priority
- Timestamp based on 32-bit free-running timer, with optional external time tick
- Global network time, synchronized by specific message
- Maskable interrupts
- Independence from transmission medium (external transceiver is assumed)
- Short latency time due to arbitration scheme for high-priority messages
- Low-power mode
- Transceiver delay compensation when transmitting CAN FD messages at faster data rates
- Management of remote request frames, automatically or by software
- Restriction only to write CAN bit time settings and configuration bits in Freeze mode
- Transmit message buffer status (lowest-priority buffer or empty buffer)
- Identifier Acceptance Filter Hit Indicator (IDHIT) register for received frames
- ESR1[SYNCH] to indicate module is synchronous with CAN bus
- CRC status for transmitted message
- Legacy RX FIFO Global Mask register
- Selectable priority between message buffers and receive FIFO during matching process
- Powerful Legacy RX FIFO ID filtering, capable of matching incoming IDs against either 128 extended IDs, 256 standard IDs, or 512 partial (8-bit) IDs, with 32 individual masking capability
- Powerful Enhanced RX FIFO ID filtering, capable of matching incoming IDs against either 64 extended or 128 standard ID filter elements with three filtering schemes: mask plus filter, range, and two filters without mask.
- Complete backward compatibility with previous FlexCAN version
- Detection and correction of errors in memory read accesses.
  - Each byte of FlexCAN memory is associated to five parity bits.
  - The error correction mechanism ensures that errors in one bit of this 13-bit word can be corrected (correctable errors).

— Errors in two bits can be detected but not corrected (noncorrectable errors).

76.3 Functional description

FlexCAN is a CAN protocol engine with a flexible message buffer system for transmitting and receiving CAN frames. The system is a set of message buffers (MBs) that stores configuration and control data, timestamp, message ID, and data (see Message buffer structure). The memory corresponding to the first 38 message buffers can be configured to support a Legacy FIFO reception scheme with a powerful ID filtering mechanism. This scheme can check incoming frames against a table of IDs (up to 128 extended IDs or 256 standard IDs or 512 8-bit ID slices), with an individual mask register for up to 32 ID filter table elements.

For classical CAN frames, FlexCAN supports simultaneous reception through Legacy FIFO and message buffer. For CAN FD frames, FlexCAN supports reception through message buffer and enhanced receive FIFO.

For message buffer reception, a matching algorithm makes it possible to store received frames only into MBs that have the same ID programmed in the ID field. A masking scheme makes it possible to match the ID programmed on the message buffer with a range of IDs on received CAN frames. For transmission, an arbitration algorithm decides the prioritization of message buffers to be transmitted based on the message ID (optionally augmented by three local priority bits) or the message buffer ordering.

A message buffer is active at a given time if it can participate in both the matching and arbitration processes. A receive message buffer with a 0b code is inactive (see Table 577). A transmit message buffer with a 1000b or 1001b code is also inactive (see Table 578).

FlexCAN can receive and transmit messages in CAN FD format. The message buffers are sized to store the quantity of data bytes selected by FDCTRL[MBDSRn]. The quantity of FD message buffers available for a given quantity of data bytes is described in the CAN FD Control (FDCTRL) register. See also FlexCAN memory partition for CAN FD.

76.3.1 Modes of operation

FlexCAN has these functional modes:

Table 541. Functional modes

Mode	Description
Normal (User or Supervisor)	In Normal mode, FlexCAN receives and transmits message frames, manages errors normally, and enables all CAN Protocol functions. User and Supervisor modes differ in the access to some restricted control registers.
Freeze	Freeze mode is enabled when MCR[FRZ] = 1. If enabled, FlexCAN enters Freeze mode when MCR[HALT] is 1 or when is requested at chip level and FlexCAN writes 1 to MCR[FRZACK]. In this mode, no transmission or reception of frames is done, and synchronicity to the CAN bus is lost. See Freeze mode.
Loopback	FlexCAN enters this mode when CTRL1[LPB] becomes 1. In this mode, FlexCAN performs an internal loopback that can be used for self-test. The bit stream output of the transmitter is internally fed back to the receiver input. The receiving CAN input pin is ignored and the transmitting CAN output goes to the recessive state (logic 1). FlexCAN behaves as it normally does when transmitting and treats its own transmitted message as a message received from a remote node. To ensure proper reception of its own message, FlexCAN ignores the bit sent during the ACK slot in the CAN frame acknowledge field. Both transmit and receive interrupts are generated.
Listen-Only	FlexCAN enters this mode when CTRL1[LOM] becomes 1. In this mode, transmission is disabled, all error counters are frozen, and the module operates in a CAN Error Passive mode. Only messages acknowledged by another CAN station are received. If FlexCAN detects an unacknowledged message, it flags a BIT0 error (without changing the REC), as if it was trying to acknowledge the message.
CAN FD Active	In this mode, FlexCAN can transmit and receive all messages formatted according to the CAN FD Standard (2.0) and 2.0B Protocol in an interleaved fashion. The CPU can put FlexCAN into CAN FD Active mode by configuring MCR[FDEN] in Freeze mode.

Some features available in classical CAN are unavailable in CAN FD mode.

Table 542. Differences between classical CAN and CAN FD

Feature	Classical CAN	CAN FD
Legacy RX FIFO DMA	Yes	No
Legacy RX FIFO	Yes	No
Enhanced RX FIFO DMA	Yes	Yes
Enhanced RX FIFO	Yes	Yes

FlexCAN can operate in these low-power modes:

Table 543. Low-power modes

Mode	Description
Module Disable	FlexCAN enters this mode when the CPU writes 1 to MCR[MDIS] and FlexCAN writes 1 to MCR[LPMACK]. After FlexCAN is disabled, it issues a request to disable the clocks to the CAN Protocol Engine and Controller Host Interface submodules. Writing 0 to MCR[MDIS] exits this mode. See Module Disable mode.

76.3.1.1 Modes of operation details

FlexCAN has functional modes and low-power modes. See Modes of operation for an introductory description of all the modes of operation. The following subsections contain functional details about Freeze mode and low-power modes.

CAUTION

FlexCAN does not support "Permanent Dominant" failure on the CAN bus line. If a Low-Power request or Freeze mode request occurs during a "Permanent Dominant" condition, the corresponding acknowledgment field can never be 1.

76.3.1.1.1 Freeze mode

This mode is requested either by the CPU writing 1 to MCR[HALT] or when the chip is put into Debug mode. MCR[FRZ] must be 1 and the module must not be in a low-power mode.

When MECR[NCEFAFRZ] becomes 1 and a noncorrectable error is detected in a memory read access performed by FlexCAN internal processes (see Error response), FlexCAN also requests Freeze mode. This request occurs via both MCR[HALT] and MCR[FRZ] automatically becoming 1.

To obtain acknowledgment, FlexCAN writes 1 to MCR[FRZACK]. The CPU must only consider FlexCAN to be in Freeze mode when both request and acknowledgment conditions are satisfied.

When Freeze mode is requested, FlexCAN:

1. Waits to be in either Intermission, Error Passive, Bus Off, or Idle state.
2. Waits for all internal activities like arbitration, matching, move-in, and move-out to finish. A pending move-in does not prevent entering Freeze mode.
3. Ignores the receive input pin and drives the transmit pin as recessive.
4. Stops the prescaler, halting all CAN protocol activities.
5. Grants write access to the Error Counters register, which is read-only in other modes.
6. Writes 1 to MCR[NOTRDY] and MCR[FRZACK].

After requesting Freeze mode, you must wait for MCR[FRZACK] to become 1 before executing any other action, otherwise FlexCAN may operate unpredictably. In Freeze mode, all memory-mapped registers are accessible.

Freeze mode is exited in one of these conditions:

- CPU writes 0 to MCR[FRZ].
- The chip is removed from Debug mode or the MCR[HALT] becomes 0.

MCR[FRZACK] becomes 0 after the protocol engine recognizes the negation of the freeze request. After leaving Freeze mode, FlexCAN tries to resynchronize to the CAN bus by waiting for 11 consecutive recessive bits.

76.3.1.1.2 Module Disable mode

This low-power mode is normally used to disable a complete FlexCAN block temporarily, with no power consumption. The CPU requests this mode by writing 1 to MCR[MDIS], and FlexCAN acknowledges the request by writing 1 to MCR[LPMACK]. The CPU must only consider FlexCAN to be in Disable mode when both the request and acknowledgment conditions are satisfied.

If FlexCAN is disabled during Freeze mode, the module requests to disable the clocks to the PE and CHI submodules, writes 1 to MCR[LPMACK] and writes 0 to MCR[FRZACK].

If the module is disabled during transmission or reception, FlexCAN:

1. Waits to be in either Idle or Bus Off state, or waits for the third bit of Intermission and then checks that it is recessive.
2. Waits for all internal activities like arbitration, matching, move-in, and move-out to finish. FlexCAN does not take a pending move-in into account.
3. Ignores its receive input pin and drives its transmit pin as recessive.
4. Shuts down the clocks to the PE and CHI submodules.
5. Writes 1 to MCR[NOTRDY] and MCR[LPMACK].

In this mode, the Bus Interface Unit continues to operate, enabling the CPU to access memory-mapped registers, except for:

- The Receive Message Buffers Global Mask registers
- The Receive Buffer 14 Mask register
- The Receive Buffer 15 Mask register
- The Legacy Receive FIFO Global Mask register

When in Disable mode, these items may not be accessed:

- The Legacy Receive FIFO Information register
- The message buffers
- The Receive Individual Mask registers
- The reserved words within RAM

To exit this mode, the CPU writes 0 to MCR[MDIS], causing FlexCAN to request to resume the clocks and write 0 to MCR[LPMACK]. This write occurs after the CAN protocol engine recognizes the negation of disable mode requested by the CPU.

76.3.2 Transmission process

NOTE

Instances of MB_CS in this topic refer to items in message buffers. See Message buffer structure for details.

To transmit a CAN frame, the CPU must prepare a message buffer for transmission by executing the following procedure:

1. Check whether the respective interrupt flag is set, and clear it if necessary.
2. If the message buffer is active (transmission pending), request an abort of the transmission. Write the ABORT code (1001b) to the CODE field of the Control and Status word.
3. Poll the IFLAG register until the corresponding IFLAG flag is set, or wait for the interrupt request (if enabled by the respective IMASK field).

4. Read the CODE field to identify whether the transmission was aborted or transmitted (see Transmission abort mechanism).
5. Clear the corresponding interrupt flag.
6. Write the ID register (containing the local priority if enabled via MCR[LPRIOEN]).
7. Write payload data bytes.
8. Configure the Control and Status word as needed.
    a. Set ID type via MB_CS[IDE].
    b. Set Remote Transmission Request (if needed) via MB_CS[RTR].
    c. If MCR[FDEN] = 1, configure MB_CS[EDL] and MB_CS[BRS]. For details about the relationship between the written value and transmitted value of MB_CS[ESI], see Table 554.[38]
    d. Configure Data Length Code in bytes via MB_CS[DLC]. See Table 581 for detailed information.
    e. To transmit the CAN frame, activate the message buffer by writing Ch to MB_CS[CODE].

NOTE

To maximize software performance, configure all the fields in the MB_CS word in a single 32-bit write operation. If the fields are configured in separate writes, MB_CS[CODE] must be the last write in the Control and Status word.

When the MB is activated, it participates in the arbitration process and its contents are eventually transmitted according to its priority. When the DLC value stored in the MB selected for transmission exceeds the MB payload size, FlexCAN completes the expected DLC by adding a constant CCh pattern.

After a successful transmission:

1. The value of the free-running timer is written into the timestamp field.
2. The CODE field in the Control and Status word is updated.
3. Both Cyclic Redundancy Check (CRCR) and CAN FD CRC (FDCRC) are updated.
4. A status flag is set in the Interrupt Flag register.
5. If allowed by the corresponding Interrupt Mask Register field, an interrupt is generated.

After transmission, the new CODE field depends on the code used to activate the message buffer (see Table 577 and Table 578 in Message buffer structure).

When the Abort feature is enabled (MCR[AEN] is 1), after the Interrupt flag is set for an MB configured as transmit buffer, the message buffer is blocked. The CPU cannot update the message buffer until the Interrupt Flag is cleared by the CPU. The CPU must clear the corresponding IFLAG flag before preparing this MB for a new transmission or reception.

NOTE

For backward compatibility (MCR[AEN] is 0), write the INACTIVE code (1000b) to the CODE field to deactivate the MB. In this case, the pending frame may be transmitted without notification (see Message buffer inactivation).

76.3.3 Arbitration process

The arbitration process scans the message buffers, searching for the transmission MB that holds the message to be sent at the next opportunity. This MB is called the arbitration winner. The scan starts from the lowest number MB and continues to the higher ones.

The arbitration process is triggered when at least one of the following occur:

- CRC field of the CAN frame arrives. The starting point depends on the value of CTRL2[TASD].

[38] There is no need to write the ESI field; it is automatically transmitted as dominant by error active nodes and as recessive by error passive nodes. If FlexCAN is operating as a network gateway, however, the CPU writes MB_CS[ESI] according to the error status of the node that sent the message.

- Error Delimiter field of a CAN frame is in progress.
- Overload Delimiter field of a CAN frame is in progress.
- The winner of the arbitration is deactivated, and the CAN bus has not reached the first bit of the Intermission field.
- CPU writes to the Control and Status word of a winner MB, and the CAN bus has not reached the first bit of the Intermission field.
- CHI is in the Idle state and the CPU writes to the Control and Status word of any message buffer.
- FlexCAN exits Bus Off state.
- FlexCAN leaves Freeze mode or a low-power mode.

If the arbitration process does not evaluate all message buffers before the CAN bus reaches the first bit of the Intermission field, the temporary arbitration winner is invalidated. FlexCAN will not compete for the CAN bus at the next opportunity.

The arbitration process selects the winner among the active transmission message buffers at the end of the scan according to the values of CTRL1[LBUF] and MCR[LPRIOEN].

See Arbitration process (continued) for more information about this process.

76.3.3.1 Lowest-number message buffer first

If CTRL1[LBUF] is 1, the first (lowest number) active transmission message buffer found is the arbitration winner. MCR[LPRIOEN] has no effect when CTRL1[LBUF] is 1.

76.3.3.2 Highest-priority message buffer first

If CTRL1[LBUF] is 0, the arbitration process searches for the active transmission message buffer with the highest priority. The frame of this message buffer has a higher probability of winning the arbitration on the CAN bus when multiple external nodes compete for the bus simultaneously.

The sequence of bits considered for this arbitration is called the arbitration value of the message buffer. The transmission message buffer with the lowest arbitration value among all transmission message buffers has the highest priority.

If two or more message buffers have equivalent arbitration values, the message buffer with the lowest number is the arbitration winner.

The composition of the arbitration value depends on MCR[LPRIOEN].

76.3.3.2.1 Local priority disabled

If MCR[LPRIOEN] = 0, the arbitration value is built using the exact sequence of bits that would be transmitted in a CAN frame where local priority is disabled.

Table 544. Composition of the arbitration value when local priority is disabled

Format	Message buffer arbitration value (32 bits)				
Standard (IDE = 0)	Standard ID (11 bits)	RTR (1 bit)	IDE (1 bit)	— (18 bits)	— (1 bit)
Extended (IDE = 1)	Extended ID[28:18] (11 bits)	SRR (1 bit)	IDE (1 bit)	Extended ID[17:0] (18 bits)	RTR (1 bit)

76.3.3.2.2 Local priority enabled

To enable local priority, MCR[LPRIOEN] must be 1. In this case, the message buffer PRIO field (see Message buffer structure) is included at the very left of the arbitration value.

Table 545. Composition of the arbitration value when local priority is enabled

Format	Message buffer arbitration value (35 bits)					
Standard (IDE = 0)	PRIO (3 bits)	Standard ID (11 bits)	RTR (1 bit)	IDE (1 bit)	— (18 bits)	— (1 bit)
Extended (IDE = 1)	PRIO (3 bits)	Extended ID[28:18] (11 bits)	SRR (1 bit)	IDE (1 bit)	Extended ID[17:0] (18 bits)	RTR (1 bit)

Because the PRIO field is the most significant part of the arbitration value, message buffers with low PRIO values have higher priority than message buffers with high PRIO values. This priority is maintained regardless of the rest of their arbitration values.

The PRIO field is not part of the frame on the CAN bus. Its purpose is only to affect the internal arbitration process.

76.3.3.3 Arbitration process (continued)

After the arbitration winner is found (see Arbitration process), its content is copied to a hidden auxiliary message buffer called a transmit serial message buffer (TX SMB). The TX SMB has the same structure as a normal message buffer, but is not user-accessible. This copy operation is called move-out. After it is done, write access to the Control and Status word of the corresponding MB is blocked (if MCR[AEN] = 1). Write access is restored in one of the following events:

- The CPU clears the corresponding IFLAG flag after the message buffer is transmitted.
- FlexCAN enters Freeze mode or Bus Off state.
- FlexCAN loses the bus arbitration, or there is an error during the transmission.

At the first opportunity window on the CAN bus, the message on the TX SMB is transmitted according to the CAN protocol rules.

The arbitration process can be triggered under the following conditions:

- During RX and TX frames from CAN CRC field to end of frame. The value of CTRL2[TASD] may be changed to optimize the arbitration start point.
- During CAN Bus Off state from TX_ERR_CNT = 124 to 128. The value of CTRL2[TASD] may be changed to optimize the arbitration start point.
- During Control and Status write by CPU in Bus Idle. The first Control and Status write starts the arbitration process, and a second Control and Status write during this same arbitration restarts the process. If other Control and Status writes are performed, the transmission arbitration process is pending. If there is no arbitration winner after the arbitration process has finished, then the TX arbitration machine begins a new arbitration process. If there is a pending arbitration and Bus Idle state starts, then an arbitration process is triggered. In this case, the first and second Control and Status writes in Bus Idle do not restart the arbitration process. If there is not enough time to finish arbitration in the Wait For Bus Idle state and the next state is Idle, the scan is not interrupted. That scan is completed during Bus Idle state. During this arbitration, a Control and Status write does not cause an arbitration restart.
- Deactivation of an arbitration winner during a valid arbitration window.
- Upon exiting Freeze mode (first bit of the Wait For Bus Idle state). If a resynchronization occurs during Wait For Bus Idle, the arbitration process is restarted.

The arbitration process stops when:

- All message buffers are scanned.
- A transmission message buffer is found (if lowest buffer feature is enabled).
- An arbitration winner deactivates or aborts during any arbitration process.
- There is not enough time to finish the transmission arbitration process (for instance, when a deactivation is performed near the end of frame). In this case, the arbitration process is pending.
- An error or overload flag occurs in the bus.

- A low-power or Freeze mode request occurs in Idle state.

Arbitration is considered pending when:

- It is not possible to finish arbitration process in time.
- A Control and Status write occurs during arbitration, when that write is performed in an MB whose number is lower than the transmission arbitration pointer.
- Any Control and Status write occurs when there is no transmission arbitration process in progress.
- RX Match has updated an RX code to TX code.
- FlexCAN enters the Bus Off state.

If a Control and Status write is performed in the arbitration winner, a new process is restarted immediately.

If a Control and Status write is performed in an MB whose number is higher than the transmission arbitration pointer, the ongoing arbitration process scans this MB as normal.

76.3.4 Receive process

To be able to receive CAN frames into a message buffer, the CPU must prepare it for reception by executing the following steps:

1. If the message buffer is active (either TX or RX), deactivate it (see Message buffer inactivation), preferably with a safe deactivation (see Transmission abort mechanism).
2. Write the ID word into the message buffer.
3. To activate the message buffer, write the EMPTY code (0100b) to the CODE field of the Control and Status word. No setup is required for EDL, BRS, and ESI fields. The respective fields in the received message overwrite these fields.

After the MB is activated, it can receive frames that match the programmed filter. At the end of a successful reception, the move-in process updates the message buffer (see Move-in) as follows:

1. The received data field (up to eight bytes for Classical CAN message format and up to 64 bytes for CAN FD message format) is stored.
2. The received Identifier field is stored.
3. The value of the free-running timer when the second bit of the Identifier field of the frame is written into the Timestamp field of the MB.
4. The received SRR, IDE, RTR, EDL, BRS, ESI, and DLC fields are stored.
5. The CODE field in the Control and Status word is updated (see Table 577 and Table 578 in Section Message buffer structure).
6. If allowed by the corresponding Interrupt Mask field, a status flag is set in the Interrupt Flag register and an interrupt is generated.

The recommended way for the CPU to service (read) the frame received in a message buffer is:

1. Read the Control and Status word of that message buffer.
2. Verify that the BUSY bit is 0, indicating that the message buffer is locked. If it is not 0, repeat step 1 until it becomes 0. See Message buffer lock mechanism.
3. Read the contents of the message buffer. After the message buffer is locked, FlexCAN move-in processes do not modify its contents. See Move-in.
4. Acknowledge the proper flag in the IFLAG registers.
5. Unlock the message buffer by reading the free-running timer.

To verify frame reception, the CPU should poll the status flag bit for that specific message buffer in one of the IFLAG registers, not the CODE field of that message buffer. Polling the CODE field does not work in this case. After a frame is received and the CPU services the message buffer (by reading the Control and Status word and unlocking the message buffer), the CODE field does not return to EMPTY. It remains FULL, as explained in Table 577. If the CPU tries to work around this behavior by writing to

the Control and Status word to force an EMPTY code after reading the message buffer without a prior safe deactivation, a newly received frame matching the filter of that message buffer may be lost.

CAUTION

In summary: never poll by reading the Control and Status word of the message buffers directly. Instead, read the IFLAG registers.

The Identifier field of the received frame is always stored in the matching message buffer. If the match was due to masking, the contents of the ID field in a message buffer may change. When MCR[SRXDIS] becomes 1, FlexCAN does not store frames transmitted by itself in any MB, even if it contains a matching receive MB. Also, no interrupt flag or interrupt signal is generated. Otherwise, when MCR[SRXDIS] becomes 0, if a matching receive MB exists, FlexCAN can receive frames transmitted by itself.

To be able to receive CAN frames through the Legacy RX FIFO, the CPU must enable and configure the Legacy RX FIFO during Freeze mode (see Legacy RX FIFO). Upon receiving the Frames Available in the Legacy RX FIFO interrupt (see MCR[BUF5I]), the CPU must service the received frame using the following procedure:

1. If a mask was used for IDE and RTR bits, read the Control and Status word.
2. If a mask was used, read the ID field.
3. Read the data field.
4. If the Identifier Acceptance Filter Hit Indicator (IDHIT) is required in the application, read Legacy RX FIFO Information (RXFIR).
5. Clear the Frames Available in Legacy RX FIFO interrupt by writing one to IFLAG1[BUF5I]. This step is mandatory; it releases the MB and allows the CPU to read the next RX FIFO entry.

When MCR[DMA]) becomes 1, upon receiving a frame in the Legacy FIFO, IFLAG1[BUF5I] generates a DMA request and does not generate a CPU interrupt (see Legacy RX FIFO in DMA Operation). The IMASK1 fields in the Legacy RX FIFO region are not used.

The DMA controller must service the received frame using the following procedure:

1. Read the Control and Status word (read 80h address, optional).
2. Read the ID field (read 84h address, optional).
3. Read all data bytes (start read at 88h address, optional).
4. Read the last data bytes (read 8Ch address, mandatory).

76.3.5 Matching process

The matching process scans the message buffer memory for RX MBs programmed with the same ID as the one received from the CAN bus. If the Legacy RX or Enhanced RX FIFO is enabled, the priority of scanning can be selected between MBs and FIFO filters The matching starts from the lowest number message buffer and continues toward the higher-numbered ones. If no match is found within the first structure, the other is scanned afterward. If the FIFO is full, the matching algorithm always looks for a matching MB outside the FIFO region.

For enhanced RX FIFO, see Enhanced RX FIFO.

For legacy RX FIFO, see Legacy RX FIFO.

As the frame is received, it is stored in a hidden auxiliary MB called Receive Serial Message Buffer (RX SMB).

The starting point of the matching process depends on the following conditions:

- If the received frame is a remote frame, the starting point is the CRC field of the frame.
- If the received frame is a data frame with DLC field equal to zero, the starting point is the CRC field of the frame.
- If the received frame is a data frame and the DLC field has a nonzero value, the starting point is the DATA field of the frame.

If a matching ID is found in the FIFO table or in one of the message buffers, the move-in process transfers the contents of the RX SMB to the FIFO or to the matched MB. If any CAN protocol error is detected, no match results are transferred to the FIFO or to the matched MB at the end of reception.

The matching process scans all matching elements of the RX FIFO (if enabled) and active receive MBs (CODE is EMPTY, FULL, OVERRUN, or RANSWER). The process searches for a successful comparison to the matching elements of the RX SMB that is receiving the frame on the CAN bus. The RX SMB has the same structure as a message buffer. The reception structures (RX FIFO or message buffers) associated with the matching elements that had a successful comparison are the matched structures. The matching winner is selected at the end of the scan among those matched structures. The matching winner depends on conditions described in Table 546.

Table 546. Matching architecture

Structure	SMB[RTR]	CTRL2[RRS]	CTRL2[EACEN]	MB[IDE]	MB[RTR]	MB[ID[1]]	MB[CODE]
Message buffer	0	—	0	cmp[2]	no_cmp[3]	cmp_msk[4]	EMPTY, FULL, or OVERRUN
Message buffer	0	—	1	cmp_msk	cmp_msk	cmp_msk	EMPTY, FULL, or OVERRUN
Message buffer	1	0	—	cmp	no_cmp	cmp	RANSWER
Message buffer	1	1	0	cmp	no_cmp	cmp_msk	EMPTY, FULL, or OVERRUN
Message buffer	1	1	1	cmp_msk	cmp_msk	cmp_msk	EMPTY, FULL, or OVERRUN
Legacy RX FIFO[5]	—	—	—	cmp_msk	cmp_msk	cmp_msk	—

1. For message buffer structure, if SMB[IDE] is 1, the ID is 29 bits (ID Standard plus ID Extended). If SMB[IDE] is 0, the ID is 11 bits (ID Standard). For Legacy RX FIFO structure, the ID depends on IDAM.
2. cmp: Compares the RX SMB contents to the MB contents regardless of masks.
3. no_cmp: The RX SMB contents are not compared to the MB contents.
4. cmp_msk: Compares the RX SMB contents to MB contents, accounting for masks.
5. SMB[IDE] and SMB[RTR] are not considered when IDAM is type C.

NOTE

For Enhanced RX FIFO, see Enhanced RX FIFO matching process.

A reception structure is free-to-receive when any of the following conditions is satisfied:

- The CODE field of the message buffer is EMPTY.
- The CODE field of the message buffer is either FULL or OVERRUN, and it has already been serviced (the CPU has read the Control and Status word and unlocked it as described in Message buffer lock mechanism).
- The CODE field of the message buffer is either FULL or OVERRUN and an inactivation (see Message buffer inactivation) is performed.
- The Legacy RX FIFO or Enhanced RX FIFO is not full.

The scan order for message buffers and Legacy Receive FIFO is from the matching element with the lowest number to the higher ones.

76.3.5.1 Matching priority

MCR[IRMQ] affects the matching winner search for MBs. If the field is 0, the matching winner is the first matched MB whether it is free-to-receive or not. If it is 1, the matching winner is selected according to this priority:

1. The first free-to-receive matched message buffer
2. The last non-free-to-receive matched message buffer

It is possible to select the priority of scan between MBs and Legacy RX FIFO or Enhanced RX FIFO with CTRL2[MRP].

If the selected priority is RX FIFO first:

- If the RX FIFO is a matched structure and is free-to-receive, the RX FIFO is the matching winner regardless of the scan for MBs.
- Otherwise, the matching winner is searched for among MBs as described above.

If the selected priority is MBs first:

- If a free-to-receive matched MB is found, it is the matching winner regardless of the scan for RX FIFO.
- If no matched MB is found, then the matching winner is searched for in the scan for the RX FIFO.
- If both conditions above are not satisfied and a non-free-to-receive matched MB is found, then the matching winner depends on the value of MCR[IRMQ]:
  - If MCR[IRMQ] = 0, the matching winner is the first matched MB.
  - If MCR[IRMQ] = 1, the matching winner is the RX FIFO if it is a free-to-receive matched structure. Otherwise, the matching winner is the last non-free-to-receive matched MB.

Table 547. Matching possibilities and resulting reception structures

RFEN or ERFEN	IRMQ	MRP	Matched in MB	Matched in FIFO	Reception structure	Description
No FIFO, only MB, match is always MB first						
0	0	X[1]	None[2]	—[3]	None	Frame lost by no match
0	0	X	Free[4]	—	First MB	—
0	1	X	None	—	None	Frame lost by no match
0	1	X	Free	—	First MB	—
0	1	X	Not free	—	Last MB	Overrun
FIFO enabled, no match in FIFO; is as if FIFO does not exist						
1	0	X	None	None[5]	None	Frame lost by no match
1	0	X	Free	None	First MB	—
1	1	X	None	None	None	Frame lost by no match
1	1	X	Free	None	First message buffer	—
1	1	X	Not free	None	Last message buffer	Overrun

Table continues on the next page...

Table 547. Matching possibilities and resulting reception structures (continued)

RFEN or ERFEN	IRMQ	MRP	Matched in MB	Matched in FIFO	Reception structure	Description
FIFO enabled, queue disabled						
1	0	0	X	Not full[6]	FIFO	—
1	0	0	None	Full[7]	None	Frame lost by FIFO full (FIFO overflow)
1	0	0	Free	Full	First MB	—
1	0	0	Not free	Full	First MB	
1	0	1	None	Not full	FIFO	
1	0	1	None	Full	None	Frame lost by FIFO full (FIFO overflow)
1	0	1	Free	X	First message buffer	—
1	0	1	Not free	X	First message buffer	Overrun
FIFO enabled, queue enabled						
1	1	0	X	Not full	FIFO	—
1	1	0	None	Full	None	Frame lost by FIFO full (FIFO overflow)
1	1	0	Free	Full	First message buffer	—
1	1	0	Not free	Full	Last message buffer	Overrun
1	1	1	None	Not full	FIFO	—
1	1	1	Free	X	First message buffer	—
1	1	1	Not free	Not full	FIFO	—
1	1	1	Not free	Full	Last message buffer	Overrun

1. Indicates a don't care condition.
2. Matched in message buffer "None" means that the frame has not matched any message buffer (free-to-receive or non-free-to-receive).
3. This condition is forbidden.
4. Matched in message buffer "Free" means that the frame matched at least one message buffer free-to-receive regardless of whether it has matched MBs that are non-free-to-receive.
5. Matched in FIFO, "None" means that the frame has not matched any filter in FIFO. It is as if the FIFO did not exist (CTRL2[RFFN] = 0 and ERFCR[ERFEN] = 0).
6. Matched in FIFO, "Not full" means that the frame has matched a FIFO filter and has empty slots to receive it.
7. Matched in FIFO, "Full" means that the frame matched a FIFO filter but could not store it, because it has no empty slots to receive it.

76.3.5.2 Special cases

If a non-safe MB inactivation (see Message buffer inactivation) occurs during the matching process and the inactivated MB is the temporary matching winner, the temporary matching winner is invalidated. The matching elements scan is not stopped and not restarted; it continues normally. The consequence is that the current matching process works as if the matching elements compared before the inactivation did not exist. In this case, a message may be lost.

Consider an example where:

- The FIFO is disabled.
- MCR[IRMQ] is 1.
- There are two message buffers with the same ID: the second and fifth MBs in the array.
- FlexCAN starts receiving messages with that ID.

When the first message arrives, the matching algorithm finds the first match in message buffer number 2. The code of this message buffer is EMPTY, so the message is stored in that MB. When the second message arrives, the matching algorithm finds MB number 2 again, but it is not "free-to-receive." It continues looking, finds MB number 5, and stores the message in that MB. If yet another message with the same ID arrives, the matching algorithm finds no matching free-to-receive MBs, so it overwrites the last matched message buffer (MB number 5). In doing so, it updates the CODE field of the message buffer to OVERRUN.

The ability to match the same ID in more than one MB can be used to implement a reception queue (in addition to the full-featured FIFO) to allow more time for the CPU to service the MBs. By programming more than one MB with the same ID, received messages are queued into the message buffers. The CPU can examine the Timestamp field of the message buffers to determine the order in which the messages arrived.

Matching a range of IDs is possible via ID acceptance masks. FlexCAN supports individual masking per message buffer (see Receive Individual Mask (RXIMR0 - RXIMR95)). During the matching algorithm, if a mask field is 1, the corresponding ID bit is compared. If the mask field is 0, the corresponding ID bit is a "don't care". Individual Mask Registers are implemented in RAM, so they are not initialized out of reset. Also, they can only be programmed when the module is in Freeze mode; otherwise, the module blocks them.

FlexCAN also supports an alternate masking scheme with only Legacy RX FIFO Global Mask (RXFGMASK), RX Message Buffers Global Mask (RXMGMASK), Receive 14 Mask (RX14MASK), and Receive 15 Mask (RX15MASK) for backward compatibility with legacy applications. This alternate masking scheme is enabled when the MCR[IRMQ] = 0.

76.3.6 Move process

There are two types of move process: move-in and move-out.

76.3.6.1 Move-in

The move-in process is the copying of a message received by an RX SMB to an RX message buffer or FIFO that has matched it. If the move destination is the Legacy RX FIFO, attributes of the message are also copied to the CAN_RXFIR FIFO. Each RX SMB has its own move-in process, but only one is performed at a given time. The move-in starts only when the message held by the RX SMB has a corresponding match (see Matching process) and all of the following conditions are true:

- The CAN bus has reached or already gone past:
  - The second bit of Intermission field next to the frame that carried the message that is in the RX SMB.
  - The first bit of an overload frame next to the frame that carried the message in the RX SMB.
- There is no ongoing matching process.
- The CPU is not locking the destination message buffer.
- No move-in process from another RX SMB is ongoing. If more than one move-in process is to be started at the same time, both are performed and the newest process substitutes for the oldest.

The term "pending move-in" is used throughout the documentation and stands for a move-to-be that does not satisfy all of the above conditions.

If any of the following conditions is satisfied, the move-in is canceled and the RX SMB is able to receive another message:

- The destination message buffer is inactivated after the CAN bus has reached the first bit of the Intermission field next to the frame that carried the message. Also, its matching process has finished.
- There is a previous pending move-in to the same destination message buffer.
- The RX SMB is receiving a frame transmitted by FlexCAN itself and self-reception is disabled (MCR[SRXDIS] = 1).
- Any CAN protocol error is detected.

If the module enters Freeze or Low-Power mode, the pending move-in is not canceled. It remains on hold, waiting for Freeze and Low-Power mode to be exited and for the module to be unlocked. If a message buffer is unlocked during Freeze mode, the move-in occurs immediately.

The move-in process is FlexCAN executing the following steps:

1. Push IDHIT into the RXFIR FIFO if the message is destined for the Legacy RX FIFO.
2. Read all data words from the RX SMB in accordance with the selected payload size for the RX storage element.
3. Write all data words to the RX message buffer according to the selected payload size for the RX storage element. If the data size of the storage element is smaller than the original payload size described in the DLC field of the message, the payload is truncated. The high-order bytes that do not fit the destination size are lost.
4. Read the Control and Status and ID words from the RX SMB.
5. Write the Control and Status and ID words to the RX message buffer, and update the CODE field.

The move-in process is not atomic; the inactivation of the destination message buffer immediately cancels it (see Message buffer inactivation). In this case, the message buffer may remain partially updated, and therefore incoherent. When the move-in destination is a Legacy or Enhanced RX FIFO message buffer, however, the process cannot be canceled.

To alert the CPU that the message buffer content is temporarily incoherent, the BUSY Bit (least significant bit of the CODE field) of the destination message buffer becomes 1 during move-in.

76.3.6.2 Move-out

The move-out process is the copying of content from a TX message buffer to the TX SMB when a message for transmission is available (see Arbitration process). The move-out occurs in the following conditions:

- In the first bit of Intermission field
- During the Bus Off state, when TX Error Counter is in the 124 to 128 range
- During the Bus Idle state
- During the Wait For Bus Idle state

The move-out process is not atomic. Only the CPU has priority to access the memory concurrently outside the Bus Idle state. In Bus Idle, the move-out has the lowest priority of the concurrent memory accesses.

76.3.7 Data coherence

In order to maintain data coherency and proper FlexCAN operation, the CPU must obey the rules described in Transmission process and Receive process.

76.3.7.1 Transmission abort mechanism

The abort mechanism provides a safe way to request the abortion of a pending transmission. A feedback mechanism is provided to inform the CPU whether the transmission was aborted or the frame could not be aborted and was transmitted instead.

These primary conditions must be fulfilled in order to abort a transmission:

- MCR[AEN] must be 1.
- The first CPU action must be the writing of abort code (1001b) into the CODE field of the Control and Status word.

Active message buffers configured for transmission must be aborted before they can be updated. The write operation is blocked and the transmission is not disturbed when the abort code is written to:

- A message buffer currently being transmitted.
- A message buffer that was already loaded into the TX SMB for transmission.

In this case, the abort request is captured and kept pending until one of the following conditions is satisfied:

- The module loses the bus arbitration.
- There is an error during the transmission.
- The module is put into Freeze mode.
- The module enters the Bus Off state.
- There is an overload frame.

If none of the conditions above are reached:

1. The message buffer is transmitted correctly.
2. The interrupt flag is set in the proper IFLAG register.
3. If enabled, an interrupt to the CPU is generated.

The abort request is automatically cleared when the interrupt flag is set. If only one of the above conditions is reached, the frame is not transmitted. In this case:

1. The abort code is written into the CODE field.
2. The interrupt flag is set in the proper IFLAG register.
3. Optionally, an interrupt is generated to the CPU.

If the CPU writes the abort code before the transmission begins internally, the write operation is not blocked. The MB is updated and the interrupt flag is set. In this way, the CPU only needs to read the abort code to verify that the active MB was safely inactivated. In this case, although MCR[AEN] = 1 and the CPU wrote the abort code, the MB is inactivated and not aborted, because the transmission did not start yet. A message buffer is aborted only when the abort request is captured and kept pending until one of the previous conditions is satisfied.

76.3.7.2 Message buffer inactivation

Inactivation protects the message buffer against updates by FlexCAN internal processes. It allows the CPU to rely on message buffer data coherence after having updated it, even in Normal mode.

Inactivation of transmission message buffers must be performed only when MCR[AEN] = 0.

If a message buffer is inactivated, it does not participate in the arbitration process or the matching process until it is reactivated. See Transmission process and Receive process for detailed instructions on how to inactivate and reactivate a message buffer.

To inactivate a message buffer, the CPU must update its CODE field to INACTIVE (either 0b or 1000b).

Because you cannot synchronize the CODE field update with FlexCAN internal processes, an inactivation can have the following consequences:

- A frame in the bus that matches the filtering of an inactivated RX message buffer may be lost without notice. This loss can occur even if there are other message buffers with the same filter.
- A frame containing the message within an inactivated TX message buffer may be transmitted without setting the respective IFLAG flag.

To perform a safe inactivation and avoid the above consequences for TX message buffers, the CPU must use the transmission abort mechanism (see Transmission abort mechanism).

The inactivation automatically unlocks the message buffer (see Message buffer lock mechanism).

NOTE

Message buffers that are part of the Legacy RX FIFO or Enhanced RX FIFO cannot be inactivated. There is no write protection on the Legacy FIFO region by FlexCAN. The CPU must maintain data coherency in the Legacy FIFO region when MCR[RFEN] = 1.

76.3.7.3 Message buffer lock mechanism

In addition to message buffer inactivation, FlexCAN uses a message buffer lock mechanism to maintain data coherence for the receive process. When the CPU reads the Control and Status word of an RX message buffer with codes FULL or OVERRUN, FlexCAN is configured to allow the CPU to read the whole message buffer in an atomic operation. FlexCAN sets an internal lock flag for that message buffer.

The lock is released in any of the following events:

- The CPU reads the free-running timer (global unlock operation).
- The CPU reads the Control and Status word of another message buffer, regardless of its code.
- The CPU writes into the Control and Status word. This procedure is not recommended for normal unlocking, because it cancels a pending move and may lose a received message.

The message buffer lock prevents a new frame from being written into the message buffer when the CPU is reading it.

NOTE

The locking mechanism applies only to RX message buffers that are not part of the Legacy RX FIFO and have a code other than INACTIVE (0b) or EMPTY[1] (0100b). TX message buffers cannot be locked.

Consider an example where:

- The Legacy RX FIFO is disabled.
- The second and the fifth message buffers of the array are programmed with the same ID.
- FlexCAN has already received and stored messages into these two message buffers.
- The CPU reads message buffer number 5 while another message with the same ID is arriving.

When the CPU reads the Control and Status word of message buffer number 5, this message buffer is locked. The new message arrives and the matching algorithm finds no free-to-receive message buffers, so it overrides message buffer number 5. This message buffer is locked, so the new message cannot be written to it. The message remains in the RX SMB until the message buffer is unlocked, and only then is it written to the message buffer.

If the message buffer remains locked and another new message with the same ID arrives, the new message overwrites the one in the RX SMB. There is no indication of lost messages in the CODE field of the message buffer or in Error and Status 1 (ESR1).

When the message is moved from the RX SMB to the message buffer, the BUSY bit on the CODE field becomes 1. If the CPU reads the Control and Status word and identifies that the BUSY bit is 1, it must wait until the BUSY bit becomes 0 to access the MB.

NOTE

If the BUSY bit is 1 or the message buffer is empty, reading the Control and Status word does not lock the message buffer.

Inactivation takes precedence over locking. If the CPU inactivates a locked receive message buffer, then its lock status is negated and the message buffer is marked as invalid for the current matching round. Any pending message on the RX SMB is not transferred to the message buffer. A message buffer is unlocked when the CPU reads Free-Running Timer (TIMER) or the Control and Status word of another message buffer.

The lock and unlock mechanisms have the same functionality in Normal and Freeze modes.

[1] In previous FlexCAN versions, reading the Control and Status word locked the message buffer even when CODE indicates it is EMPTY. This behavior is maintained when the IRMQ bit is 0.

An unlock during Normal or Freeze mode results in the move-in of the pending message. If unlocking occurs during a low-power mode, however, the move-in is postponed (see Modes of operation). Move-in takes place only when the module returns to Normal or Freeze mode.

76.3.8 Enhanced RX FIFO

FlexCAN supports an enhanced RX FIFO engine which can store up to 20 CAN FD messages. The region 2000h–204Fh contains the output of the FIFO, which the CPU should read. To enable the enhanced RX FIFO, write 1 to ERFCR[ERFEN]. FlexCAN has two FIFO options, Legacy RX FIFO and Enhanced RX FIFO, but both options cannot be enabled at the same time. See Legacy RX FIFO for additional information.

To configure the enhanced RX FIFO watermark, write a value to ERFCR[ERFWM]. If ERFCR[ERFWM] is configured, the CPU is notified only if a minimum number of messages is stored in the FIFO. When the number of stored messages is greater than the value in ERFCR[ERFWM], the module sets ERFSR[ERFWMI]. Optionally, if MCR[DMA] or ERFIER[ERFWMIIE] are enabled, a DMA transfer or an interrupt can be triggered, respectively.

For the enhanced RX FIFO to receive, the CPU must execute the configuration procedure below. If the CPU must change any configurations of the Enhanced RX FIFO, the same procedure must be followed.

Prerequisites

MCR[RFEN] must be 0.

Procedure

Step	Purpose	Programming	Notes
1	Enter Freeze mode.	See Freeze mode.	—
2	If enhanced RX FIFO is not already enabled, enable it.	Write 1 to ERFCR[ERFEN].	—
3	Reset enhanced RX FIFO engine.	Write 1 to ERFSR[ERFCLR].	—
4	If the enhanced RX FIFO error flags are set, clear them.	Write 1 to these flags: • ERFSR[ERFUFW] • ERFSR[ERFOVF] • ERFSR[ERFWMI] • ERFSR[ERFDA]	—
5	Specify the total number of enhanced RX FIFO filter elements to be used in Enhanced RX FIFO reception.	Write the number to ERFCR[NFE].	—
6	Specify the number of extended ID and standard ID filter elements to be used in Enhanced RX FIFO reception.	Write the number to ERFCR[NEXIF].	ERFCR[NEXIF] ≤ ERFCR[NFE] + 1.
7	If you are using DMA, enable DMA.	Write 1 to MCR[DMA].	—
8	If you are using DMA, specify the number of words to transfer for each Enhanced RX FIFO data element.	Write the number to ERFCR[DMALW].	—
9	Specify the Enhanced RX FIFO watermark.	Write the number to ERFCR[ERFWM].	If MCR[DMA] = 1, ERFCR[ERFWM] should be 0h.

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Step	Purpose	Programming	Notes
10	If you are using interrupts, enable the interrupts.	Write 1 to the interrupt enables in Enhanced RX FIFO Interrupt Enable (ERFIER).	—
11	Configure the filter elements.	Write to the ERFFEL*n* registers.	ERFFEL*n* registers are implemented in RAM; you must explicitly initialize them before prior any reception.
12	Exit Freeze mode.	See Freeze mode.	—

There are two types of enhanced RX FIFO filter elements that can be stored in ERFFEL*n* registers: extended-ID filter elements and standard-ID filter elements. Each extended-ID filter element is stored in two ERFFEL*n* registers, and each standard-ID filter element is stored in one ERFFEL*n* register. ERFCR[NFE] defines the total number of Enhanced RX FIFO filter elements.

In addition, the filter memory space can be split into two regions: one for extended-ID filter elements and another for standard-ID filter elements, according to ERFCR[NEXIF]. Figure 521 shows how the enhanced RX filter elements are defined. See Enhanced RX FIFO matching process for information about the Enhanced RX FIFO matching process and filter element formats.

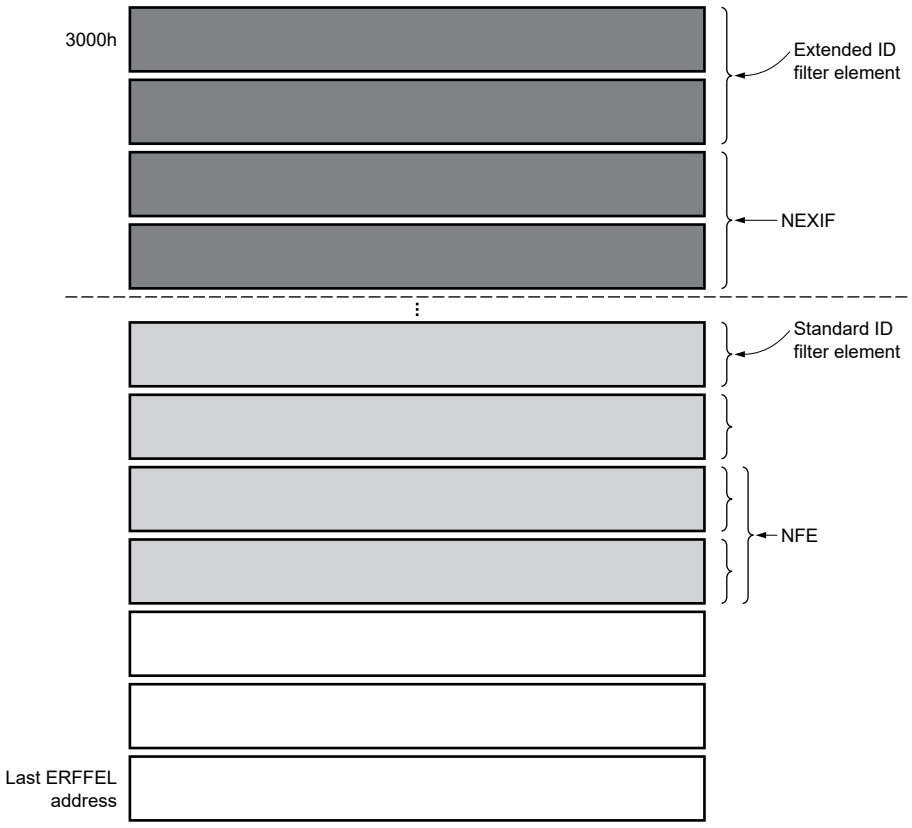

Figure 521. Number of enhanced RX FIFO filter elements

76.3.8.1 Enhanced RX FIFO matching process

When ERFCR[ERFEN] = 1, FlexCAN scans the ERFFEL*n* memory region. If at least one filter element satisfies the matching criteria, the CAN message content is transferred to the enhanced RX FIFO memory. If multiple filters match the incoming message ID, the first matching filter found by the matching process must be indicated in IDHIT.

Each ERFFEL*n* register can store one standard filter element. ERFFEL*n*[FEL][31:30], also called FSCH, determines the matching criteria in this way:

- If FSCH = b00, the filter scheme is based on mask and filter. A CAN message matches a standard ID filter element only if these criteria are reached:
  1. CAN message is base-frame format (IDE = 0).
  2. (ID[*n*] = STD ID filter [*n*]) or (STD ID Mask[*n*] = 0) for each bit *n* from 0 to 10.
  3. (RTR = RTR Filter) or (RTR MASK = 0).

In this explanation, RTR and ID are the Remote Transmit Request field and the ID from a CAN message, respectively.

If FSCH = b00, the filters and masks are defined as shown in Table 548.

Table 548. Standard ID filter element with filter and mask scheme (FSCH = b00)

31	30	29	28	27	26	16	15	12	11	10	0
FSCH = b00		Reserved		RTR Filter	STD ID Filter		Reserved		RTR MASK	STD ID MASK	

- If FSCH = b01, the filter scheme is based on range. A CAN message matches a standard ID filter element only if these criteria are reached:
  1. CAN message is base frame format (IDE = 0).
  2. ID ≥ STD ID Filter1.
  3. ID ≤ STD ID Filter2.
  4. (RTR = RTR filter) or (RTR MASK = 0).

RTR and ID are the Remote Transmit Request bit and ID from a CAN message, respectively. If FSCH = b01, the filters and mask are defined as shown in Table 549.

Table 549. Standard ID filter element with range scheme (FSCH = b01)

31	30	29	28	27	26	16	15	12	11	10	0
FSCH = b01		Reserved		RTR Filter	STD ID Filter2		Reserved		RTR MASK	STD ID Filter1	

- If FSCH = b10, the filter scheme is based on two filters without masks. A CAN message matches a standard ID filter element only if these criteria are reached:
  1. CAN message is base frame format (IDE = 0).
  2. (ID[*n*] = STD ID Filter1[*n*]) or (ID[*n*] = STD ID Filter2[*n*]) for each bit *n* from 0 to 10.
  3. (RTR = RTR Filter1) or (RTR = RTR Filter2).

RTR and ID are the Remote Transmit Request bit and ID from a CAN message, respectively. If FSCH = b10, the filters are defined as shown in Table 550.

Table 550. Standard ID filter element with two-filter scheme (FSCH = b10)

31	30	29	28	27	26	16	15	12	11	10	0
FSCH = b10		Reserved		RTR Filter 2	STD ID Filter2		Reserved		RTR Filter 1	STD ID Filter1	

Each pair of ERFFEL*n* registers can store one extended filter element. ERFFEL*n*[FSCH] determines the matching criteria in this way:

- If FSCH = b00, the filter scheme is based on mask and filter. A CAN message matches an extended ID filter element only if these criteria are reached:
  1. CAN message is extended frame format (IDE = 1).
  2. (ID[*n*] = EXT ID filter [*n*]) or (EXT ID Mask[*n*] = 0) for each bit *n* from 0 to 28.
  3. (RTR = RTR Filter) or (RTR MASK = 0).

If FSCH = b00, the filters and masks are defined as shown in Table 551.

Table 551. Extended ID filter element with filter + mask scheme (FSCH = b00)

31	30	29	28	0
FSCH		RTR Filter	EXT ID Filter	
Reserved		RTR MASK	EXT ID MASK	

- If FSCH = b01, the filter scheme is based on range. A CAN message matches an extended ID filter element only if the following criteria are reached:
  1. CAN message is extended frame format (IDE = 1).
  2. ID ≥ EXT ID Filter1.
  3. ID ≤ EXT ID Filter2.
  4. (RTR = RTR Filter) or (RTR MASK = 0).

If FSCH = b01, the filters and masks are defined as shown in Table 552.

Table 552. Extended ID filter element with range scheme (FSCH = b01)

31	30	29	28	0
FSCH		RTR Filter	EXT ID Filter2	
Reserved		RTR MASK	EXT ID Filter 1	

- If FSCH = b10, the filter scheme is based on two filters without masks. A CAN message matches an extended ID filter element only if these criteria are reached:
  1. CAN message is extended frame format (IDE = 1).
  2. (ID[*n*] = EXT ID Filter1[*n*]) or (ID[*n*] = EXT ID Filter2[*n*]) for each bit *n* from 0 to 28.
  3. (RTR = RTR Filter1) or (RTR = RTR Filter2).

If FSCH = b10, the filters are defined as shown in Table 553.

Table 553. Extended ID filter element with two-filter scheme (FSCH = b10)

31	30	29	28	0
FSCH		RTR Filter2	EXT ID Filter2	
Reserved		RTR Filter1	EXT ID Filter 1	

76.3.8.2 Enhanced RX FIFO under DMA operation

You can enable the DMA feature by writing 1 to both ERFCR[ERFEN] and MCR[DMA]. The DMA controller can read the received message by reading a message buffer structure at the enhanced FIFO output port at the address range defined in Enhanced RX FIFO structure.

NOTE

FlexCAN supports 32-bit access only for DMA transfers.

For proper FIFO engine operation, the CPU should not access the Enhanced FIFO output port address range during DMA operation. Before writing 1 to MCR[DMA], the CPU must service Enhanced RX FIFO status bits. Otherwise, these bits may show that the FIFO has data to be serviced, and mistakenly generate a DMA request. Before writing 0 to MCR[DMA], the CPU must first clear the ERFSR[ERFUFW], ERFSR[ERFOVF], ERFSR[ERFWMI], and ERFSR[ERFDA] flags. It must then clear the enhanced RX FIFO engine by writing one to ERFSR[ERFCLR].

When there is one frame available to be read from the Enhanced RX FIFO, FlexCAN sets ERFSR[ERFDA]. Upon receiving the request, the DMA controller can read the message in the Enhanced RX FIFO output. Each message reading process must end by the address defined in ERFCR[DMALW].

Follow these rules for Enhanced RX FIFO DMA operation:

- Because a DMA transfer cannot be changed dynamically, program ERFCR[DMALW] so the enhanced RX FIFO element can store the largest CAN message present on the CAN bus.
- Data bytes are valid according to the DLC field. See Table 581.

Each time the DMA controller reads one message from the FIFO, FlexCAN clears ERFSR[ERFDA]. If there is at least one message stored in the FIFO, FlexCAN sets it again.

Consider an example where the maximum number of bytes in the data field of a CAN frame for a certain application is eight, and high-resolution timestamp is enabled. In that case, the last enhanced RX FIFO address offset can be found in Table 591 and Table 592. Using this address offset, ERFCR[DMALW] can be determined in this way:

- Maximum number of data bytes = 8
- HR_TIME_STAMP enabled
- Last address offset = TS_OFF = 2014h
- DMALW = 5

76.3.8.3 Enhanced RX FIFO clear operation

When ERFCR[ERFEN] is 1, the CPU can clear the Enhanced RX FIFO by writing 1 to ERFSR[ERFCLR]. The clear operation resets the internal FIFO pointers, but the FIFO content stored in RAM is not changed. This operation can only be performed in Freeze mode; the module blocks the operation in other modes. This operation does not clear ERFSR[ERFUFW], ERFSR[ERFOVF], ERFSR[ERFDA], or ERFSR[ERFWMI]. The CPU must service all these fields before executing the clear FIFO operation.

76.3.9 Legacy RX FIFO

The Legacy RX FIFO is receive-only. To enable it, write 1 to MCR[RFEN]. To maintain software backward compatibility with previous versions of FlexCAN that did not have the Legacy FIFO feature, the reset value of this field is zero.

CAUTION

Do not enable Legacy RX FIFO when the CAN FD feature is enabled.

The Legacy FIFO is six messages deep. The memory region the Legacy FIFO structure occupies (both message buffers and Legacy FIFO engine) is described in Legacy RX FIFO structure. The CPU can read the received messages sequentially, in the order they were received, by repeatedly reading a message buffer structure at the output of the Legacy FIFO.

IFLAG1[BUF5I] (Frames Available in Legacy RX FIFO) is set when at least one frame is available to be read from the Legacy FIFO. If the corresponding mask bit enables it, an interrupt is generated. Upon receiving the interrupt, the CPU can read the message (accessing the output of the Legacy FIFO as a message buffer) and Legacy RX FIFO Information (RXFIR), then clear the interrupt. If there are more messages in the Legacy FIFO, clearing the interrupt:

1. Updates the output of the Legacy FIFO with the next message.
2. Updates RXFIR with the attributes of that message.
3. Reissues the interrupt to the CPU.

Otherwise, the flag remains cleared. The output of the Legacy FIFO is valid only when IFLAG1[BUF5I] is set.

IFLAG1[BUF6I] (Legacy RX FIFO Warning) is set when the Legacy RX FIFO receives a new message that increases the number of unread messages from four to five. This change means that the Legacy RX FIFO is almost full. The flag remains set until the CPU clears it.

IFLAG1[BUF7I] (Legacy RX FIFO Overflow) is set when an incoming message is lost because the Legacy RX FIFO is full. The flag is not set when the Legacy RX FIFO is full and a message buffer captures the message. The flag remains set until the CPU clears it.

Clearing one of the three flags above does not affect the state of the other two.

If an IFLAG flag is set and the corresponding mask bit is 1, an interrupt is generated.

A powerful filtering scheme is provided to accept only frames intended for the target application, reducing the interrupt servicing workload. The filtering criteria are specified by programming a table of up to 128 32-bit registers, according to CTRL2[RFFN]. This table can be configured to one of the following formats (see also Legacy RX FIFO structure):

- Format A: 128 Identifier Acceptance Filters (IDAFs) — extended or standard IDs including IDE and RTR
- Format B: 256 IDAFs — standard IDs or extended 14-bit ID slices including IDE and RTR
- Format C: 512 IDAFs — standard or extended 8-bit ID slices

NOTE

A chosen format is applied to all entries of the filter table. It is not possible to mix formats within the table.

Every frame available in the Legacy RX FIFO has a corresponding Identifier Acceptance Filter Hit Indicator (IDHIT). The IDHIT can be read in the IDHIT field in the Control and Status word, as shown in the Legacy RX FIFO Structure description. The CPU can also obtain this information by accessing Legacy RX FIFO Information (RXFIR). RXFIR[IDHIT] refers to the message at the output of the Legacy FIFO, and is valid when IFLAG1[BUF5I] is set. RXFIR must be read only before clearing the flag, guaranteeing that the information refers to the correct frame within the Legacy FIFO.

The Individual Mask Registers (RXIMR*n*) individually affect up to 32 elements of the filter table, according to the value of CTRL2[RFFN]. This configuration allows very powerful filtering criteria to be defined. If MCR[IRMQ] is 0, the Legacy RX FIFO filter table is affected by Legacy RX FIFO Global Mask (RXFGMASK).

NOTE

See Table 542 for information about the difference between FD and non-FD regarding this feature.

76.3.9.1 Legacy RX FIFO in DMA Operation

The receive-only Legacy FIFO can support DMA. To enable this feature, write 1 to both MCR[RFEN] and MCR[DMA]. To maintain backward compatibility with previous versions of the module that did not have the DMA feature, the reset value of MCR[DMA] is zero.

The DMA controller can read the received message by reading a message buffer structure at the Legacy FIFO output port in the 80h–8Ch address range.

NOTE

FlexCAN supports 32-bit access only for DMA transfers.

When MCR[DMA] = 1, the CPU must not access the Legacy FIFO output port address range. Before writing 1 to MCR[DMA], the CPU must service the IFLAG flags set in the Legacy RX FIFO region. Otherwise, these flags may indicate that the FIFO has data to be serviced, and mistakenly generate a DMA request. Before writing 0 to MCR[DMA], the CPU must perform a clear Legacy FIFO operation.

When at least one frame available to be read from the FIFO, IFLAG1[BUF5I] (Frames available in Legacy RX FIFO) is set. A DMA request is generated simultaneously. Upon receiving the request, the DMA controller can read the message (accessing the output of the Legacy FIFO as a message buffer). The DMA reading process must end by reading address 8Ch. This read operation:

- Clears IFLAG1[BUF5I].
- Updates the FIFO output with the next message (if the FIFO is not empty).
- Updates Legacy RX FIFO Information (RXFIR) with the attributes of the new message.

If there are more messages stored in the FIFO, IFLAG1[BUF5I] is reasserted and another DMA request is issued. Otherwise, the flag remains cleared.

NOTE

RXFIR contents cannot be read after DMA completes the Legacy FIFO read. The IDHIT information is also available in the Control and Status word at address 080h (see Legacy RX FIFO structure).

IFLAG1[BUF6I] and IFLAG1[BUF7I] are not used when the DMA feature is enabled.

When FlexCAN is working with DMA, the CPU does not receive any Legacy RX FIFO interruption and must not clear the related IFLAG flags. The related IMASK bits are not used to mask the generation of DMA requests.

NOTE

See Table 542 for information about the difference between FD and non-FD regarding this feature.

76.3.9.2 Clear Legacy FIFO

When MCR[RFEN] = 1, you can use the clear Legacy FIFO operation to empty Legacy FIFO contents. When the CPU writes 1 to IFLAG1[BUF0I], the clear FIFO operation occurs. This operation can only be performed in Freeze mode; FlexCAN blocks it in other modes. This operation does not clear the FIFO IFLAG flags; the CPU must service all FIFO IFLAG flags before executing the clear FIFO operation.

When Legacy RX FIFO is working with DMA, the clear FIFO operation clears IFLAG1[BUF5I], and the DMA request is canceled.

CAUTION

The clear Legacy FIFO operation does not clear IFLAG flags, except when MCR[DMA] = 1; in this case, only IFLAG1[BUF5I] is cleared.

76.3.10 CAN protocol-related features

76.3.10.1 CAN FD ISO compliance

The CAN FD protocol has been improved to increase the failure-detection capability that was in the original CAN FD protocol. This original protocol is also called non-ISO CAN FD, by CAN in Automation (CiA). A three-bit stuff counter and a parity bit have been introduced in the improved CAN FD protocol, now called ISO CAN FD. The CRC calculation has also been modified. All these improvements make the ISO CAN FD protocol incompatible with the non-ISO CAN FD protocol. FlexCAN still supports non-ISO CAN FD, so it can be used during an intermediate phase, for evaluation and development purposes.

It is recommended that you configure FlexCAN with the ISO CAN FD protocol by writing 1 to CTRL2[ISOCANFDEN].

76.3.10.2 CAN FD frames

ISO 11898-1:2015 specifies the Classical Frame format compliant to ISO 11898-1:2003 (2003) and introduces the CAN Flexible Data Rate Frame format (CAN FD). The Classical Frame format allows bit rates up to one Mbit/s and payloads up to eight bytes per frame. The Flexible Data Rate Frame format allows bit rates faster than one Mbit/s and payloads longer than eight bytes per frame. FlexCAN can receive and transmit CAN FD messages interleaved with Classical CAN messages.

There are additional control bits in the CAN FD frame:

- The Extended Data Length (EDL) bit enables a longer data payload with different data length coding.
- The Bit Rate Switch (BRS) bit decides whether the bit rate is switched inside a CAN FD format frame.
- The Error State Indicator (ESI) flag is transmitted dominant by error active nodes, and recessive by error passive nodes.

There are no Remote Frames (see Remote frames) in the CAN FD format. A message configured to transmit a Remote Frame is always sent out in Classical CAN format. When an FD frame is received and matches a message buffer, the RTR bit in the receiving message buffer becomes 0. The RTR bit must be considered in classical frames only.

76.3.10.2.1 CAN FD messages

CAN FD messages may be formatted as long frames where the data field exceeds eight bytes, and may range from 12 up to 64 bytes. They can also be configured to support bit rate switching. In this case, the control field, data field, and CRC field of a CAN frame are transmitted with a higher bit rate than the beginning and end of the frame. Messages in Classical CAN format are limited to transport a maximum payload of eight bytes at nominal rate. Figure 522 illustrates the message formats for Classical and FD frames with either standard or extended ID.

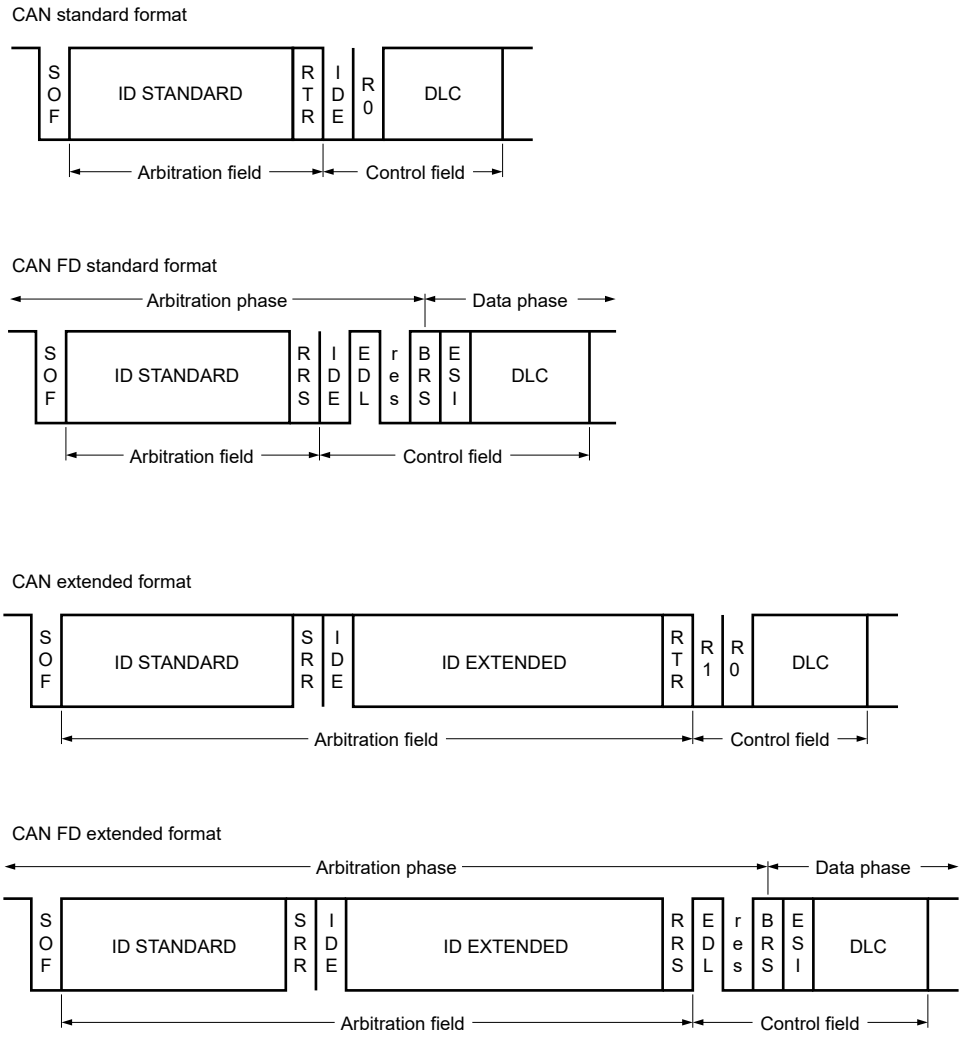

Figure 522. CAN message formats

MCR[FDEN] enables the ability to receive and transmit CAN FD messages. A recessive R0 bit in CAN frames with 11-bit identifiers, or a recessive R1 bit in CAN frames with 29-bit identifiers, is decoded as an EDL bit (not a reserved one). A recessive EDL bit identifies a CAN FD frame, and a dominant EDL bit identifies a Classical CAN frame. The BRS bit specifies whether this frame switches the bit rate in its data phase. A long frame is decoded according to the DLC field value (see DLC definition in Message buffer structure).

CAN FD messages can be transmitted with two different bit rates. The first part of a CAN FD frame, from the Start of Frame (SOF) bit until the Bit Rate Switch (BRS) bit is called the arbitration phase. This part is transmitted with the nominal bit rate based on a set of nominal CAN bit timing configuration values. The second part, from the BRS bit until the CRC Delimiter bit, is called the data phase. When this second part is transmitted, a second set of CAN data bit timing configuration values determines the data bit rate. Finally, from the CRC delimiter until the Intermission bits, the transmission returns to nominal bit rate.

76.3.10.2.2 BRS in CAN FD

In CAN FD frames with bit rate switching, the bit timing changes inside the frame at the sample point of the BRS bit if this bit is recessive. Before the BRS bit, in the CAN FD arbitration phase, the nominal CAN bit timing is used as defined by CAN Bit Timing (CBT). (Control 1 (CTRL1) also defines this timing for backward compatibility.) Upon detecting a recessive BRS bit, the CAN data bit timing is used as defined by CAN FD Bit Timing (FDCBT).

NOTE

If the time quantum length in nominal bit timing and in the data bit timing are not identical, a quantization error of up to one time quantum of the arbitration phase may be present as a phase error. This situation can occur after the switch from arbitration to data phase, and it lasts until the next synchronization event. The length of the time quantum should be the same in nominal and data bit timing. This configuration minimizes the chance of error frames on the CAN bus, and optimizes the clock tolerance in networks that use FD frames.

If BRS = 1 in the selected TX MB, FDCTRL[FDRATE] enables the transmission of all frames with bit rate switching. If FDCTRL[FDRATE] = 0, the transmission is performed at nominal rate regardless of the BRS bit value. FDCTRL[FDRATE] can be written at any time but takes effect only for the next message transmitted or received.

Nominal bit timing is resumed at the sample point of the CRC Delimiter bit or when an error is detected, whichever occurs first. Figure 523 describes the mechanism for entering and leaving the data phase when the BRS bit is recessive.

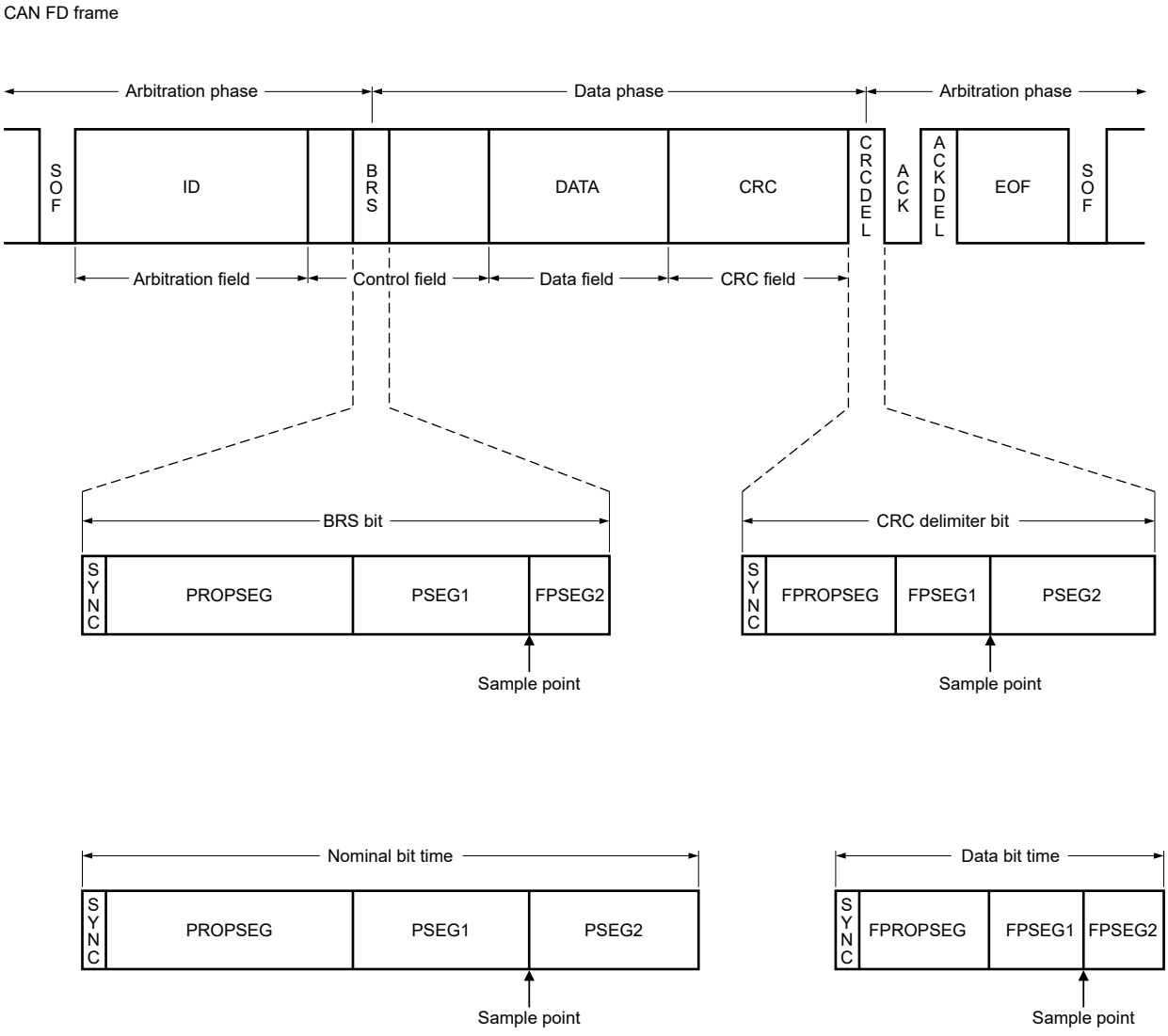

Figure 523. Bit rate switching mechanism for CAN FD messages

NOTE

In Classical CAN frames, the CRC delimiter is one recessive bit. In CAN FD frames, the CRC delimiter may consist of one or two recessive bits. FlexCAN sends only one recessive bit as the CRC delimiter. It accepts two recessive bits before the recessive-to-dominant edge that starts the acknowledge slot. As a receiver, FlexCAN sends its acknowledge bit after the first CRC delimiter bit. In CAN FD frames, FlexCAN accepts a two-bit dominant ACK slot as a valid ACK to compensate for phase shifts between the receivers.

The maximum configurable bit rate in the CAN FD data phase depends on the clock frequency of the CAN_PE subblock. For example, for a CAN_PE clock frequency of 40 MHz and the shortest configurable bit time of 5 time quanta, the bit rate in the data phase is 8 Mbit/s.

NOTE

The frequency used in this example may not be supported on this chip. It is shown only to demonstrate how the maximum configurable bit rate is calculated.

76.3.10.2.3 ESI in CAN FD

The value of the ESI bit is determined:

- By the error state of the transmitter at the start of the transmission, if the frame is originated in the FlexCAN node,
- Or by the original transmitting node when FlexCAN is acting as a gateway for the message.

If the transmitter is error-passive, ESI is transmitted recessive; otherwise, it is transmitted dominant. The permutations of the relationship between the written value and the transmitted value of the ESI are shown in Table 554.

Table 554. Written versus transmitted values of ESI field

FlexCAN fault confinement status at start of frame	ESI bit of TX MB	Transmitted ESI
Error active	0	0 (Error Active)
Error passive	0	1 (Error Passive)
Error active	1	1 (Error Passive)
Error passive	1	1 (Error Passive)

76.3.10.2.4 CRC calculations in CAN FD

Different CAN frame formats have different CRC polynomials. The first polynomial, CRC_15, is used for all frames in Classical CAN format. The second, CRC_17, is used for frames in CAN FD format with a data field up to 16 bytes long. The third, CRC_21, is used for frames in CAN FD format with a data field longer than 16 bytes. Each polynomial results in a Hamming distance of 6. At the start of the frame, all three CRC polynomials are calculated concurrently. The values of the EDL bit and the DLC field select the CRC sequence to be transmitted. When receiving a message, FlexCAN decodes EDL and DLC to select the adequate CRC polynomial to check for a CRC error.

In CAN FD format frames, stuff bits are included in the bit stream for CRC calculation. In Classical CAN format frames, stuff bits are not included. After the transmission of the last bit relevant to the CRC calculation, CAN FD CRC (FDCRC) stores the calculated CRC for the transmitted message. This storage is performed with adequate length for the type of message, for CAN FD and non-FD messages. Cyclic Redundancy Check (CRCR) reports a valid CRC for Classical CAN messages only.

In CAN FD format frames, the CAN bit stuffing method changes for the CRC sequence, so the stuff bits are inserted at fixed positions. When FlexCAN is transmitting a CAN FD frame, a fixed stuff bit is inserted just before the first bit of the CRC sequence. This insertion occurs even if the last bits of the preceding field do not fulfill the CAN stuff condition. Additional stuff bits are inserted after each fourth bit of the CRC sequence. The value of any fixed stuff bit is the inverse value of its preceding bit. When FlexCAN receives a CAN FD frame, it discards the fixed stuff bits from the bit stream for the CRC check. A stuff error is detected if the fixed stuff bit has the same value as its preceding bit.

76.3.10.2.5 CAN FD errors

FlexCAN detects errors in CAN FD frames the same way as in Classical CAN frames. The error counters ECR[RXERRCNT] and ECR[TXERRCNT] accumulate the counts of RX and TX errors, respectively, for both FD and non-FD frames indiscriminately. Two extra error counters, ECR[RXERRCNT_FAST] and ECR[TXERRCNT_FAST], accumulate RX and TX errors occurring in the data phase of CAN FD frames with BRS = 1 only. The rules for updating the error counters are the same for both CAN FD and non-FD frames (see Error Counter (ECR)).

These error flags report errors in both CAN FD and non-FD frames:

- ESR1[BIT1ERR]
- ESR1[BIT0ERR]
- ESR1[ACKERR]
- ESR1[CRCERR]
- ESR1[FRMERR]
- ESR1[STFERR]

If CTRL1[ERRMSK] = 1, they also generate the ERRINT interrupt.

These additional error flags indicate the occurrence of errors in the data phase of CAN FD frames with BRS = 1:

- ESR1[BIT1ERR_FAST]
- ESR1[BIT0ERR_FAST]
- ESR1[CRCERR_FAST]
- ESR1[FRMERR_FAST]
- ESR1[STFERR_FAST]

No ACKERR is detected in the data phase of a CAN FD frame. Fault confinement status reported in ESR1[FLTCONF] is the same for both CAN FD and Classical CAN frames, and is based on ECR[RXERRCNT] and ECR[TXERRCNT] only. Information in ECR[RXERRCNT_FAST] and ECR[TXERRCNT_FAST] may be considered as status to help detect the error nature related to the bit rate value.

When FlexCAN detects an error while transmitting or receiving a CAN FD message in the data phase, it immediately switches:

- Back to the arbitration phase, and
- Back to the nominal rate to start an error flag.

76.3.10.2.6 CAN FD synchronization

Resynchronization and hard synchronization occur in CAN FD frames in the same way as in Classical CAN ones. A hard synchronization is also performed at the recessive-to-dominant edge from EDL to R0 in CAN FD format frames. FlexCAN does not resynchronize when transmitting in the CAN FD data phase.

76.3.10.3 Transceiver delay compensation

The CAN FD protocol allows the transmission and reception of data at a higher bit rate than the nominal rate used in the arbitration phase, when BRS = 1 in the message. This feature enables the use of rates up to 8 Mbit/s.

During the data phase of a CAN FD frame, if the transmitter cannot receive its own latest transmitted bit at the sample point of that bit, it detects a bit error. When bit rate switching is enabled (BRS = 1), the CAN bit time in the data phase can become shorter than the loop delay of the transceiver. This condition impedes the correct comparison between the transmitted bit and the received bit within the current CAN bit time interval.

The transceiver delay compensation (TDC) process defines a secondary sample point where the transmitted bit is correctly compared to the received bit to check for bit errors.

You can enable the TDC mechanism via FDCTRL[TDCEN] or ETDC[ETDCEN]. The TDC mechanism is effective only during the data phase of FD frames with BRS = 1. It has no effect on either non-FD frames or FD frames transmitted at the normal bit rate. When the transmitted message has BRS = 1, TDC is active from the sample point of the BRS bit until the sample point of the CRC Delimiter bit. When TDC is active, the real received bit is compared to the delayed transmitted bit, where the delay is calculated based on the measured transceiver loop delay.

NOTE

The transmitters using TDC disregard the value of the CRC delimiter bit. A global error at the end of the CRC field causes the receivers to send error frames that the transmitter detects during Acknowledge or End of Frame.

For every transmitted FD frame with BRS = 1, the transition from the recessive EDL bit to the dominant R0 bit triggers the delay measurement (as shown in Figure 524). The loop delay is measured in Protocol Engine (PE) clock periods (CANCLK, see Protocol timing), from the transmitted EDL-R0 edge to the received EDL-R0 edge. The measured loop delay time added to an offset value specified in FDCTRL[TDCOFF] or ETDC[ETDCOFF] determines the position of the secondary sample point. FDCTRL[TDCVAL] or ETDC[ETDCVAL] stores the result of this calculation. The TDCVAL and ETDCVAL value saturates at its maximum value of 63 CANCLK and 255 CANCLK when the delay measurement is too long.

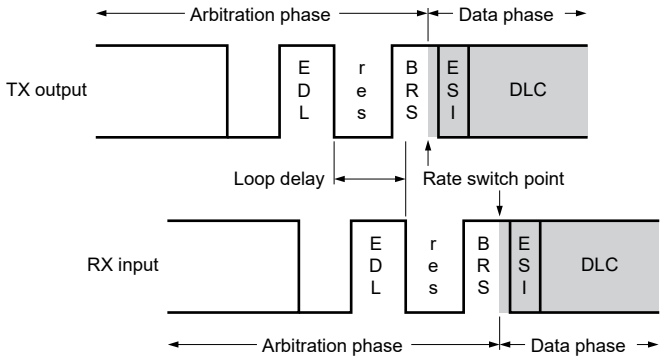

Figure 524. Transceiver loop delay measurement

The measured loop delay is not enough to define the secondary sample point, because it relates to the CAN bit edges. The transceiver delay compensation offset FDCTRL[TDCOFF] or ETDC[ETDCOFF] is used to shift the secondary sample point to an intermediate point inside the bit time, far away from its edges. The value of FDCTRL[TDCOFF] or ETDC[ETDCOFF] cannot be larger than the CAN bit duration in the data phase.

If the secondary sample point is set very near the CAN bit edge (SYNC field), problems may occur during the bit sampling in the data phase. For the TDC to work reliably, the offset must use optimal settings. To ensure that bit sampling is performed in the best region, configure the TDC offset as shown in this equation:

$$Offset = (FPSEG1 + FPROPSEG + 2) \times (FPRESDIV + 1)$$
or
$$Offset = (DTSEG1 + 2) \times (EDPRESDIV + 1), \textit{ if ETDCEN}$$

Equation 13. TDC offset calculation

Figure 525 shows the SSP position when these settings are used.

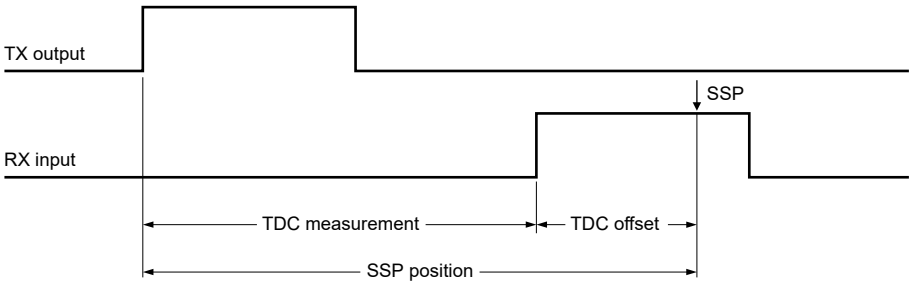

Figure 525. SSP position with optimal values

Alternatively, if CTRL2[BTE] and ETDC[ETDCEN] are 1, you can write 1 to ETDC[TDMDIS] to disable the transceiver delay measurement. In this case, only ETDC[ETDCOFF] defines the SSP position. Figure 526 shows the secondary sample point position when the transceiver delay measurement is disabled.

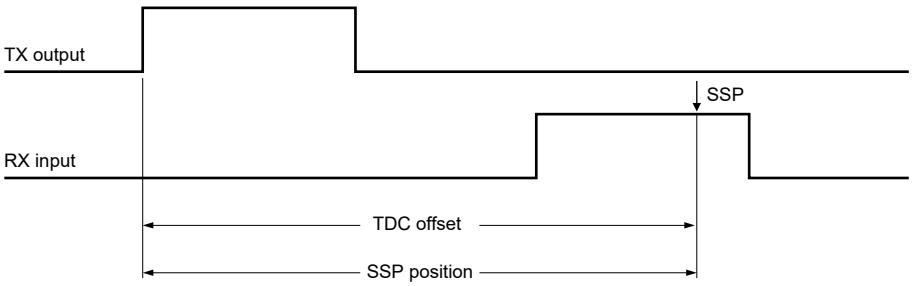

Figure 526. SSP position with TDC measurement disabled by ETDCEN and TDMDIS

During the data phase of CAN FD frames with bit rate switching enabled, at the onset of every TX CAN bit:

- The transmitted TX bit value is temporarily stored in a buffer.
- A time countdown based on FDCTRL[TDCVAL] or ETDC[ETDCVAL] is started. This countdown ends with the comparison of the received RX bit (delayed by the external loop delay plus the specified offset) to the stored TX bit.

If a bit error is detected at the secondary sample point, FlexCAN issues an error flag to the CAN bus at the next sample point.

During the arbitration phase, delay compensation is always disabled. During the data phase, the TDC mechanism of FlexCAN can compensate a maximum delay of 3 CAN bit times − 2 Tq. Beyond this limit, the FDCTRL[TDCFAIL] or ETDC[ETDCFAIL] flag is set. The flag indicates when the TDC mechanism is out of range and is unable to compensate the transceiver loop delay.

76.3.10.4 Remote frames

A remote frame is a special type of frame. You can program a message buffer to be a remote request frame by configuring the message buffer as Transmit with the RTR = 1. After the remote request frame is transmitted successfully, the message buffer becomes a receive message buffer, with the same ID as before.

When FlexCAN receives a remote request frame, the frame can be treated in different ways, depending on remote request storing (CTRL2[RRS]) and RX FIFO Enable (MCR[RFEN]):

- If RRS = 0, the ID of the frame is compared to the IDs of the transmit message buffers with the CODE field 1010b. If a matching ID exists, this message buffer frame is transmitted. If the matching message buffer has the RTR = 1, FlexCAN transmits a remote frame as a response. The received remote request frame is not stored in a receive buffer. It is only used to trigger a transmission of a frame in response.

  The mask registers are not used in remote frame matching, and all ID bits (except RTR) of the incoming received frame should match. If a remote request frame is received and matches a message buffer, this message buffer immediately enters the internal arbitration process. However, it is considered a normal TX message buffer, with no higher priority. The data length of this frame is independent of the DLC field in the remote frame that initiated its transmission.

- If CTRL2[RRS] = 1, the ID of the frame is compared to the IDs of the receive message buffers with the CODE field 0100b, 0010b, or 0110b. If a matching ID exists, this message buffer stores the remote frame in the same fashion as a data frame. No automatic remote response frame is generated. The mask registers are used in the matching process.
- If MCR[RFEN] = 1, FlexCAN does not generate an automatic response for remote request frames that match the Legacy FIFO filtering criteria. If the remote frame matches one of the target IDs, it is stored in the Legacy FIFO and presented to the CPU.

  For filtering formats A and B (see Legacy RX FIFO structure), it is possible to select whether remote frames are accepted or not. For format C, remote frames are always accepted if they match the ID. Remote request frames are considered as normal frames. They generate a Legacy FIFO overflow when a successful reception occurs and the Legacy FIFO is already full.
- If ERFCR[ERFEN] = 1, FlexCAN does not generate an automatic response for remote request frames that match the Enhanced RX FIFO filtering criteria. Remote Request Frames are considered normal frames. They generate an Enhanced RX FIFO overflow when a successful reception occurs and the enhanced RX FIFO is already full.

NOTE

There is no remote frame in the CAN FD format. A fixed dominant RRS bit replaces the RTR bit. FlexCAN receives and transmits remote frames in the Classical CAN format.

76.3.10.5 Overload frames

When a dominant bit is detected on the CAN bus in these locations, FlexCAN transmits overload frames:

- The first or second bit of Intermission.
- The seventh bit (last) of End of Frame field (RX frames).
- The eighth bit (last) of Error Frame Delimiter or Overload Frame Delimiter.

76.3.10.6 Message buffer timestamp

The value of the free-running timer is sampled at the beginning of the Identifier field on the CAN bus. This value is stored at the end of move-in in the TIME_STAMP field of a message buffer, providing network behavior regarding time.

When CTRL2[TIMER_SRC] = 1, an external time tick continuously clocks the free-running timer.

When CTRL2[TIMER_SRC] = 0, the FlexCAN bit clock clocks the free-running timer, which defines the baud rate on the CAN bus. During a message transmission or reception, it increments by one for each bit that is received or transmitted. When there is no message on the bus, it counts using the previously programmed baud rate.

The free-running timer is not incremented during Disable and Freeze modes. It can be reset upon a specific frame reception, enabling network time synchronization. See CTRL1[TSYN].

Alternatively, by configuring CTRL2[MBTSBASE], the timestamp of the message buffer can capture the lower or higher 16 bits of the high-resolution dedicated counter. See the chip-specific FlexCAN timestamp implementation.

76.3.10.7 High-resolution timestamp

The high-resolution timestamp (HR_TIME_STAMP) uses a dedicated timer with a 32-bit counter operating in free-running mode. CTRL2[TSTAMPCAP] enables the high-resolution timestamp. When this field is not zero, the dedicated 32-bit counter value is captured during a valid CAN frame and stored in an HR_TIME_STAMP*n* register.

Each HR_TIME_STAMP*n* corresponds to a specific message buffer. For example, HR_TIME_STAMP0 stores the 32-bit timestamp associated with message buffer 0. HR_TIME_STAMP1 stores the 32-bit timestamp associated with message buffer 1, and so on.

The counter value is captured according to CTRL2[TSTAMPCAP]. For classical CAN frames, the capture points can be the start of frame bit or the point in time a CAN frame is considered valid. This valid point is the seventh bit of end of frame for transmission and the sixth bit of end of frame for reception.

For CAN FD frames, the capture points can be:

- The start of frame

- The point in time a CAN FD frame is considered valid
- The res bit of a CAN FD frame

The 16-bit timestamp of the message buffer can be configured to capture the lower or higher 16 bits of the high-resolution timer. This configuration is made by CTRL2[MBTSBASE]. See the chip-specific FlexCAN timestamp implementation.

76.3.10.8 Protocol timing

Figure 527 shows the structure of the clock generation circuitry that feeds the CAN Protocol Engine (PE) submodule.

NOTE

To identify the proper clock source, see the clock distribution chapter (module clocks table).

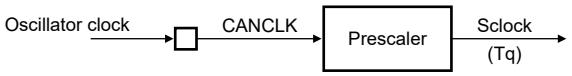

Figure 527. CAN engine clocking scheme

76.3.10.8.1 Bit timing configuration

FlexCAN supports various means to configure bit timing parameters required by the CAN protocol. Control 1 (CTRL1) has various fields to control bit timing parameters:

- CTRL1[PRESDIV]
- CTRL1[PROPSEG]
- CTRL1[PSEG1]
- CTRL1[PSEG2]
- CTRL1[RJW]

CAN Bit Timing (CBT) extends the range of the CAN bit timing variables in CTRL1. Enhanced Data Phase CAN Bit Timing (EDCBT) provides a second set of CAN bit timing variables to be applied at the data phase of CAN FD frames with the Bit Rate Switch (BRS) = 1.

Enhanced Nominal CAN Bit Timing (ENCBT) extends the range of CAN bit timing variables in CBT. Enhanced Nominal CAN Bit Timing (ENCBT) extends the range of CAN bit timing variables in FDCBT. When using ENCBT and EDCBT, you must program the nominal bit timing and data phase serial clock (Sclock) dividers in Enhanced CAN Bit Timing Prescalers (EPRS).

NOTE

When the CAN FD feature is enabled, always write 1 to CBT[BTF] or CTRL2[BTE] and specify the CAN bit timing variables in CBT or ENCBT. See CAN Bit Timing (CBT) or Enhanced Nominal CAN Bit Timing (ENCBT).

CTRL1[PRESDIV], and its extended range CBT[EPRESDIV] (or EPRS[ENPRESDIV]) and FDCBT[FPRESDIV] (or EPRS[EDPRESDIV]) for the data phase bits of CAN FD messages, defines the prescaler value that generates the serial clock (Sclock). (See Equation 14.) The period of Sclock defines the time quantum used to compose the CAN waveform. A time quantum (Tq) is the atomic unit of time managed by the CAN engine. It is the smallest time unit for all configuration values.

$$Tq = \frac{(PRESDIV + 1)}{f_{CANCLK}}$$

Equation 14. Time quantum

The bit rate, which defines the rate the CAN message is received or transmitted, is calculated with the formula:

$$CAN\ bit\ time = (Number\ of\ time\ quanta\ in\ 1\ bit\ time) \times Tq$$

$$Bit\ rate = \frac{1}{CAN\ bit\ time}$$

Equation 15. CAN bit time and baud rate

76.3.10.8.2 Bit time segments

A bit time is subdivided into three segments as shown in Figure 528. See also Figure 529 , Figure 530, and Table 555.

NOTE

For further explanation of the underlying concepts, see ISO 11898-1:2015. See also *CAN Specification Version 2.0, Part A and Part B* for bit timing.

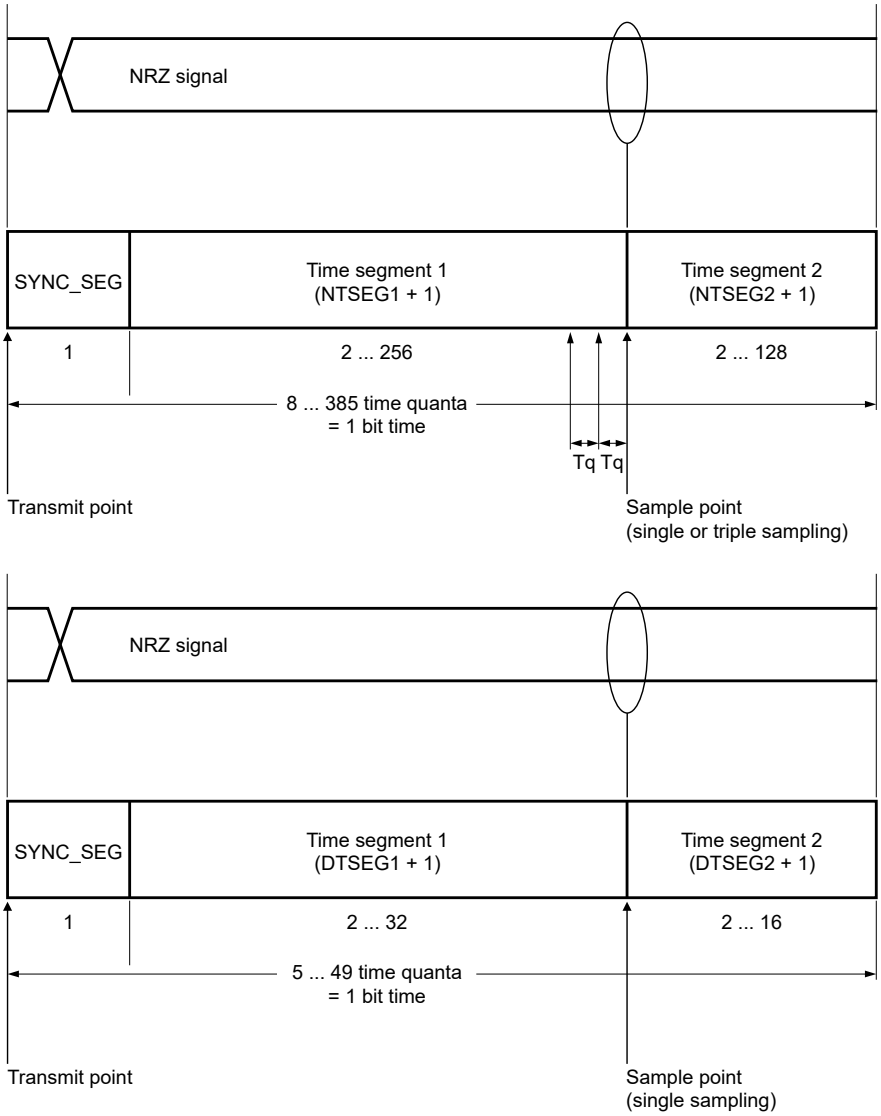

Figure 528. Segments within the bit timing (example using ENCBT and EDCBT bit timing variables)

The three bit time segments are:

- SYNC_SEG—this segment has a fixed length of one time quantum. Signal edges are expected to occur within this section.
- Time Segment 1—this segment includes the propagation segment and the phase segment 1 of the CAN standard.

  It can be programmed by configuring CTRL1[PROPSEG] and CTRL1[PSEG1] so that the sum (plus 2) is 2–16 time quanta. When CBT[BTF] = 1, FlexCAN uses CBT[EPROPSEG] and CBT[EPSEG1] so that the sum (plus 2) is 2–96 time quanta. For messages in CAN FD format with the BRS = 1, FlexCAN uses FDCBT[FPROPSEG] and FDCBT[FPSEG1] so that the sum (plus 1) is 2–39 time quanta.

  If CTRL2[BTE] = 1, FlexCAN uses ENCBT[NTSEG1] to configure time segment 1 to 2–256 time quanta. For the data phase in CAN FD messages with BRS = 1, EDCBT[DTSEG1] must be used for configuring time segment 1 to 2–32 time quanta.
- Time Segment 2—this segment represents the phase segment 2 of the CAN standard.

  It can be programmed by configuring CTRL1[PSEG2] (plus 1) to be 2–8 time quanta. When CBT[BTF] = 1, FlexCAN uses CBT[EPSEG2] so that its value (plus 1) is 2–32 time quanta. For messages in CAN FD format with the BRS = 1, FlexCAN uses FDCBT[FPSEG2] instead, so that its value (plus 1) is 2–8 time quanta. Time segment 2 cannot be smaller than the Information Processing Time (IPT), which is 2 time quanta in FlexCAN.

  If CTRL2[BTE] = 1, FlexCAN uses ENCBT[NTSEG2] to configure time segment 2 to 2–128 time quanta. For the data phase in CAN FD messages with BRS = 1, EDCBT[DTSEG2] must configure time segment 2 to 2–16 time quanta.

NOTE

The bit time defined by the above time segments must not be smaller than five time quanta. For bit time calculations, use an Information Processing Time (IPT) of two, which is the value implemented in the FlexCAN module.

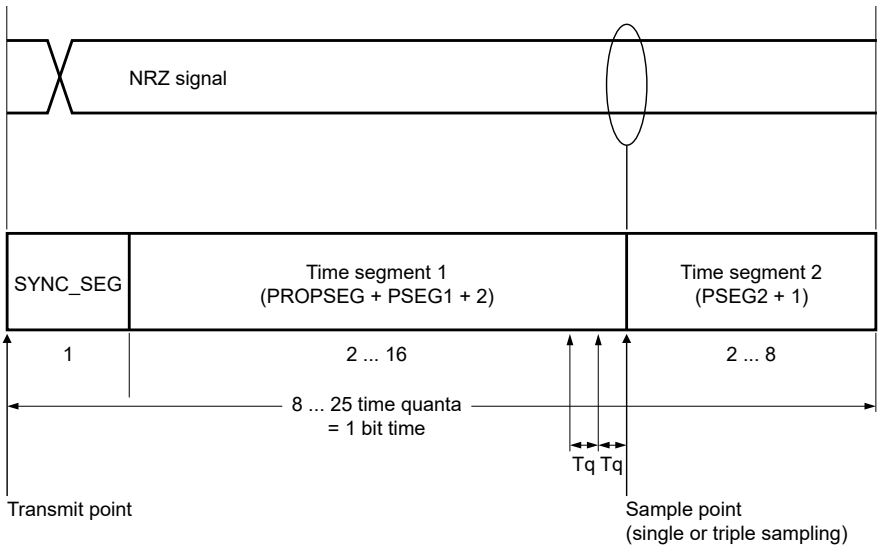

Figure 529. Segments within the bit time (example using CTRL1 bit timing variables for Classical CAN format)

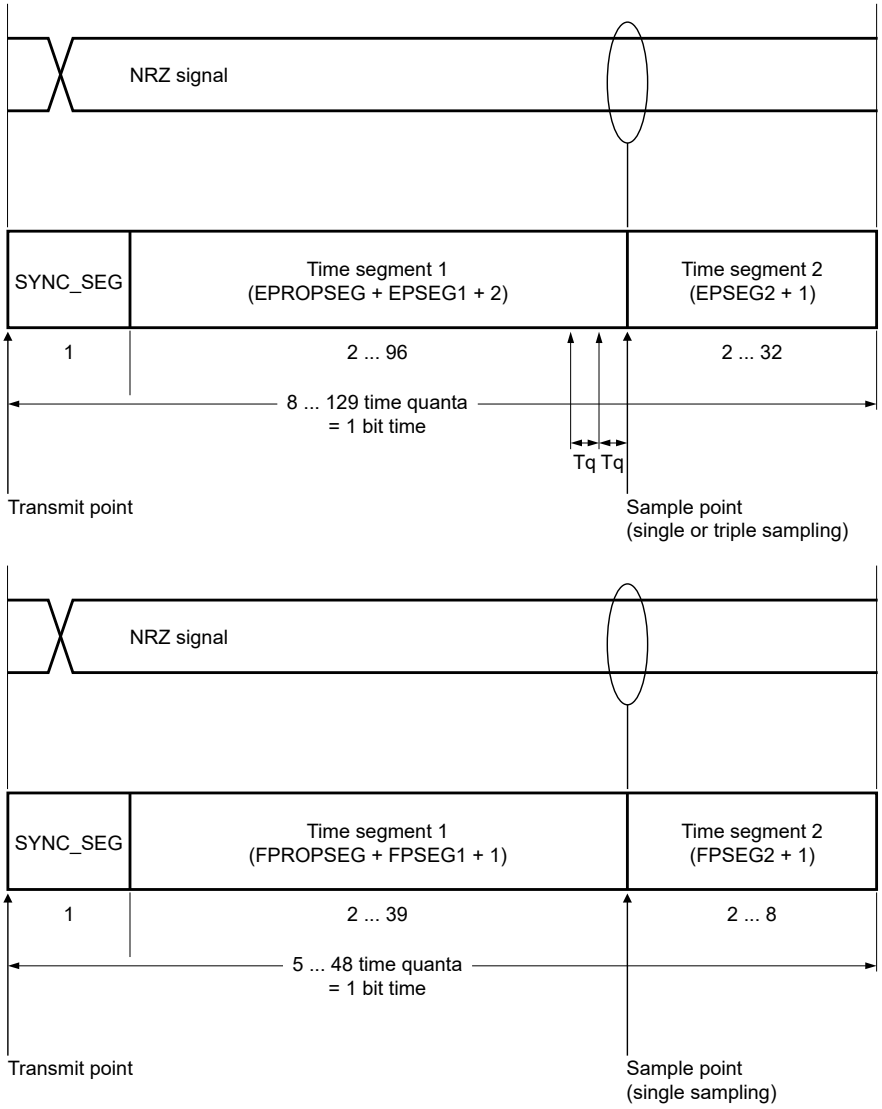

Figure 530. Segments within the bit time (example using CBT and FDCBT bit timing variables for CAN FD format)

Table 555. Time segment syntax

Syntax	Description
SYNC_SEG	Period during which the system expects transitions to occur on the bus
TSEG1	Period corresponding to the sum of PROPSEG and PSEG1
TSEG2	Period corresponding to the PSEG2 value
Transmit point	Point at which a node in Transmit mode transfers a new value to the CAN bus
Sample point	Point at which a node samples the bus. If the option of three samples per bit is selected, this point marks the position of the third sample.

Table 556 gives some examples of the CAN-compliant segment settings for Classical CAN format (Bosch CAN 2.0B) (non-FD) messages.

Table 556. Bosch CAN 2.0B standard compliant bit time segment settings

Time segment 1	Time segment 2	Resynchronization jump width
5 to 10	2	1 to 2
4 to 11	3	1 to 3
5 to 12	4	1 to 4
6 to 13	5	1 to 4
7 to 14	6	1 to 4
8 to 15	7	1 to 4
9 to 16	8	1 to 4

NOTE

You must ensure the bit time settings comply with the CAN Protocol standard (ISO 11898-1:2015).

76.3.10.8.3 Calculating peripheral clocks

A CAN bit can be used as a measure of duration (for example, estimating the occurrence of a CAN bit event in a message). When a CAN bit is used in this way, the number of peripheral clocks in one CAN bit (NumClkBit) can be calculated as:

$$NumClkBit = \frac{f_{SYS}}{f_{CANCLK}} \times (PRESDIV + 1) \times (PROPSEG + PSEG1 + PSEG2 + 4)$$

Equation 16. Number of peripheral clocks per CAN bit when CTRL2[BTE] = 0

Or, if CTRL2[BTE] = 1:

$$NumClkBit = \frac{f_{SYS}}{f_{CANCLK}} \times (ENPRESDIV + 1) \times (NTSEG1 + NTSEG2 + 3)$$

Equation 17. Number of peripheral clocks per CAN bit when CTRL2[BTE] = 1

Where:

- NumClkBit is the number of peripheral clocks in one CAN bit.
- f_{CANCLK} is the Protocol Engine (PE) Clock (see Figure 527), in Hz.
- f_{SYS} is the frequency of operation of the system (CHI) clock, in Hz.
- PSEG1 is the value of CTRL1[PSEG1].
- PSEG2 is the value of CTRL1[PSEG2].
- PROPSEG is the value of CTRL1[PROPSEG].
- PRESDIV is the value in CTRL1[PRESDIV].
- ENPRESDIV is the value of EPRS[ENPRESDIV].
- NTSEG1 is the value of ENCBT[NTSEG1].
- NTSEG2 is the value of ENCBT[NTSEG2].

The formula above is also applicable to the alternative CAN bit timing variables described in:

- CAN Bit Timing (CBT)

- Enhanced Nominal CAN Bit Timing (ENCBT)
- CAN FD Bit Timing (FDCBT)
- Enhanced Nominal CAN Bit Timing (ENCBT)

For example, 180 CAN bits = (180 × NumClkBit) peripheral clock periods.

76.3.10.9 Arbitration and matching timing

During normal reception and transmission, the matching, arbitration, move-in, and move-out processes are executed during certain time windows inside the CAN frame. These windows are shown in the following figures.

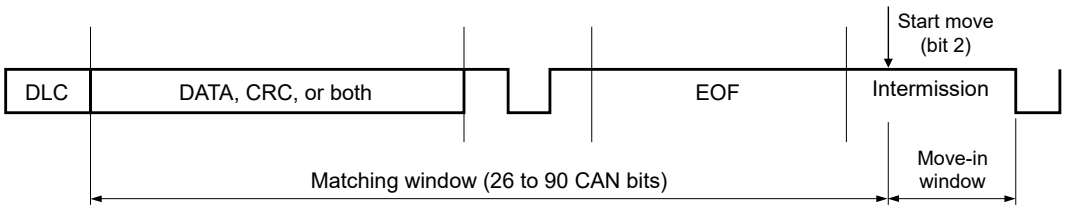

Figure 531. Matching and move-in time windows

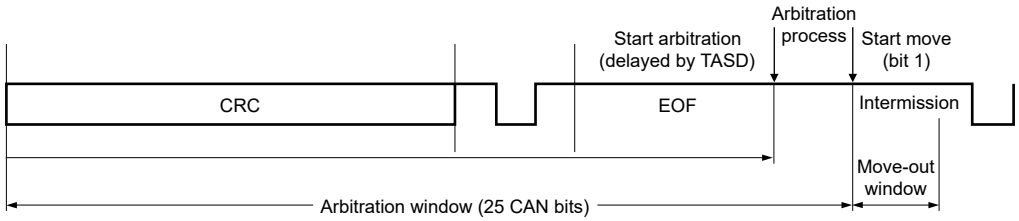

Figure 532. Arbitration and move-out time windows

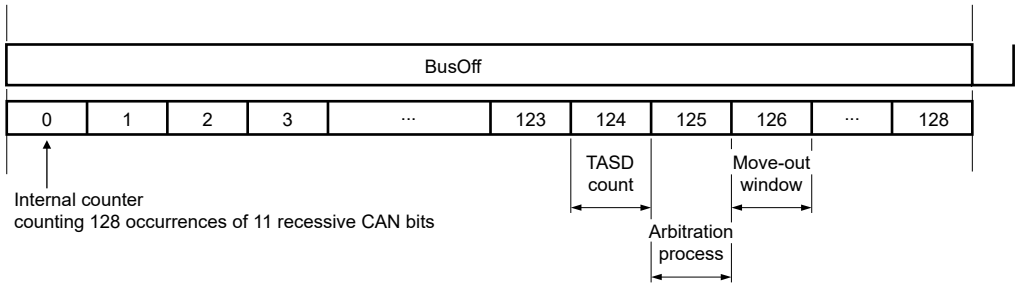

Figure 533. Arbitration at the end of bus off and move-out time windows

NOTE

In these figures, the matching and arbitration timing do not consider delays caused by concurrent memory access due to the CPU or other internal FlexCAN subblocks.

76.3.10.10 TX arbitration start delay

TX Arbitration Start Delay (CTRL2[TASD]) indicates the number of CAN bits that FlexCAN uses to delay the TX arbitration process starting point from the first bit of the CRC field of the current frame. This variable can be written only in Freeze mode; FlexCAN blocks it in other modes.

The ability of the CPU to reconfigure message buffers for transmission after the end of the internal arbitration process impacts transmission performance. In the arbitration process, FlexCAN finds the winner MB for transmission (see Arbitration process). If

the arbitration ends too early (before the first bit of the Intermission field) the CPU may reconfigure some TX message buffers. It is possible that the winning message buffer is no longer the best candidate to be transmitted.

TASD can optimize the transmission performance by defining the arbitration start point, as shown in Figure 534, based on factors such as:

- Peripheral-to-oscillator clock ratio
- CAN bit timing variables that determine the CAN bit rate
- Number of message buffers in use by the matching and arbitration processes

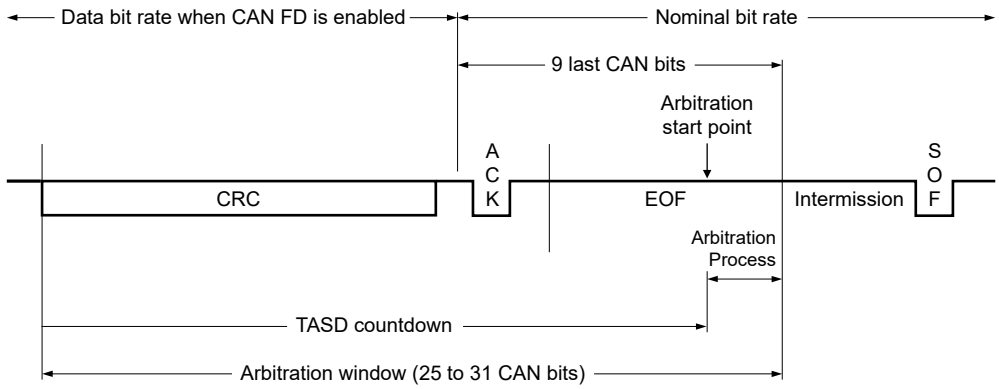

Figure 534. Optimal TX arbitration start point

The duration of an arbitration process, in terms of CAN bits, is:

- Directly proportional to the number of available message buffers
- Directly proportional to the CAN bit rate
- Inversely proportional to the peripheral clock frequency

The optimal arbitration timing occurs when the last message buffer is scanned immediately before the first bit of the Intermission field of a CAN frame. For instance, if the following are true:

- There are few message buffers.
- The peripheral-to-oscillator clock ratio is high.
- The CAN baud rate is low.

Then the arbitration can be placed closer to the end of the frame, adding more delay to its starting point, and vice versa.

If CTRL2[TASD] = 0, the arbitration start is not delayed, and more time is reserved for arbitration. Alternatively, if CTRL2[TASD] is close to 24, the CPU can configure a TX message buffer later, and less time is reserved for arbitration. If too little time is reserved for arbitration, FlexCAN may not be able to find a winner MB in time. The transmitted arbitration winner may not have the best chance to win the bus arbitration against external nodes on the CAN bus.

The optimal TASD value can be calculated as follows:

For CAN FD frames and (MAXMB + 1) ≤ NMB_{END}

$$TASD = 31 - \frac{2 * (MAXMB + 1) + 4}{CPCB_N}$$

For CAN FD frames and (MAXMB + 1) > NMB_{END}

$$TASD = 22 - \frac{2 * (MAXMB + 1) - NMB_{END}}{CPCB_F}$$

For non-FD frames

$$TASD = 25 - \frac{2 * (MAXMB + 1) + 4}{CPCB}$$

Equation 18. Optimal value for TASD

Where:

$$NMB_{END} = \frac{(9 \times CPCB_N) - 4}{2}$$

$$BITRATE_N = \left(\frac{f_{CANCLK}}{[1 + (EPSEG1 + 1) + (EPSEG2 + 1) + (EPROPSEG + 1)] \times (EPRESDIV + 1)} \right)$$

$$BITRATE_F = \left(\frac{f_{CANCLK}}{[1 + (FPSEG1 + 1) + (FPSEG2 + 1) + FPROPSEG] \times (FPRESDIV + 1)} \right)$$

$$CPCB_N = \frac{f_{SYS}}{BITRATE_N}$$

$$CPCB_F = \frac{f_{SYS}}{BITRATE_F}$$

$$CPCB = CPCB_N$$

Equation 19. Variables used in TASD calculation

- MAXMB is the value in MCR[MAXMB].
- NMB_{END} is the number of message buffers that the arbitration process can scan during the last nine CAN bits at the end of a frame. (See Equation 19.)
- $BITRATE_N$ is the CAN bit rate in bits per second calculated by the nominal CAN bit time variables.
- $BITRATE_F$ is the CAN bit rate in bits per second calculated by the data CAN bit time variables.
- $CPCB_N$ is the number of peripheral clocks per CAN bit in nominal bit rate for CAN FD frames.
- $CPCB_F$ is the number of peripheral clocks per CAN bit in data bit rate for CAN FD frames.
- CPCB is the number of peripheral clocks per CAN bit for non-FD frames.
- f_{CANCLK} is the oscillator clock, in Hz.
- f_{SYS} is the peripheral clock, in Hz.
- EPSEG1 is the value in CBT[EPSEG1] (CTRL1[PSEG1] can also be used).
- EPSEG2 is the value in CBT[EPSEG2] (CTRL1[PSEG2] can also be used).
- EPROPSEG is the value in CBT[EPROPSEG] (CTRL1[PROPSEG] can also be used).
- EPRESDIV is the value in CBT[EPRESDIV] (CTRL1[PRESDIV] can also be used).
- FPSEG1 is the value in FDCBT[FPSEG1].

- FPSEG2 is the value in FDCBT[FPSEG2].
- FPROPSEG is the value in FDCBT[FPROPSEG].
- FPRESDIV is the value in FDCBT[FPRESDIV].
- NTSEG1 is the value in ENCBT[NTSEG1].
- NTSEG2 is the value in ENCBT[NTSEG2].
- ENPRESDIV is the value in EPRS[ENPRESDIV].
- DTSEG1 is the value in EDCBT[DTSEG1].
- DTSEG2 is the value in EDCBT[DTSEG2].
- EDPRESDIV is the value in EPRS[EDPRESDIV].

If CTRL2[BTE] = 1, then:

$$BITRATE_N = \frac{f_{CANCLK}}{[1 + (NTSEG1 + 1) + (NTSEG2 + 1)] \times (ENPRESDIV + 1)}$$

Equation 20. Nominal baud rate when CTRL2[BTE] = 1

$$BITRATE_F = \frac{f_{CANCLK}}{[1 + (DTSEG1 + 1) + (DTSEG2 + 1)] \times (EDPRESDIV + 1)}$$

Equation 21. Fast baud rate when CTRL2[BTE] = 1

See also Protocol timing for more details.

76.3.10.10.1 TASD configuration examples

The following tables show the TASD value calculated for some configuration cases.

Case 1:

- Clock ratio = 2:1 (for example, peripheral clock 80 MHz and oscillator clock 40 MHz)
- Bit rate in arbitration phase = 1 Mbaud

Table 557. TASD values in Case 1

Number of message buffers	TASD value	Maximum bit rate in data phase (MBd)
16	24	Invalid
32	24	8.0
64	23	8.0
96	22	8.0

Case 2:

- Clock ratio = 1:1 (for example, peripheral clock 40 MHz and oscillator clock 40 MHz)
- Bit rate in arbitration phase = 1 Mbaud

Table 558. TASD values in Case 2

Number of message buffers	TASD value	Maximum bit rate in data phase (MBd)
16	24	Invalid

Table continues on the next page...

Table 558. TASD values in Case 2 (continued)

Number of message buffers	TASD value	Maximum bit rate in data phase (MBd)
32	23	6.67
54	22	5.0
64	21	3.33
96	20	1.6

Case 3:

- Clock ratio = 2:1 (for example, peripheral clock 40 MHz and oscillator clock 20 MHz)
- Bit rate in arbitration phase = 1 Mbaud

Table 559. TASD values in Case 3

Number of message buffers	TASD value	Maximum bit rate in data phase (MBd)
16	24	Invalid
32	23	4.0
54	22	4.0
64	21	3.33
96	20	1.54

76.3.11 Clocks

The following table describes the clock sources for FlexCAN. See the chip clocking chapter for clock setting, configuration, and gating information.

Table 560. FlexCAN clocks

Clock name	Description
MODULE_CLK (system_clk)	Peripheral clock
MODULE_CLK_CHI (host_clock)	Control Host Interface (CHI) clock
MODULE_CLK_PE (protocol_engine_clock)	Protocol Engine (PE) clock
MODULE_CLK_PE_NOGATE (protocol_engine_clock_nogate)	Protocol Engine clock (no gating)
MODULE_CLK_S (system_clock_nogate)	Peripheral access clock

76.3.11.1 Clock domains and restrictions

FlexCAN has two clock domains asynchronous to each other:

- The bus domain feeds the Control Host Interface (CHI) submodule.
- The oscillator domain feeds the CAN Protocol Engine (PE) submodule.

When the two domains are connected to clocks with different frequencies or phases, the frequency relationship between the two clock domains is restricted. In asynchronous operation, the bus domain clock frequency must always be greater than the oscillator domain clock frequency.

NOTE

Asynchronous operation with a 1:1 ratio between peripheral and oscillator clocks is not allowed.

When performing matching and arbitration, FlexCAN must scan the whole message buffer memory during the time slot of one CAN frame, comprised of a number of CAN bits. To provide sufficient time for the scan, observe the following requirements:

- The peripheral clock frequency cannot be less than the oscillator clock frequency.
- There must be a minimum number of peripheral clocks per CAN bit, as specified in Table 561.

Table 561. Minimum number of peripheral clocks per CAN bit for Classical CAN format

Number of message buffers	Value of MCR[RFEN]	Value of ERFCR[ERFEN]	Minimum number of peripheral clocks per CAN bit
16	0	0	16
32	0	0	16
64	0	0	25
96	0	0	37
16	1	0	16
32	1	0	17
64	1	0	30
96	1	0	42
16	0	1	16
32	0	1	19
64	0	1	31
96	0	1	42

For classical frame format, the minimum number of peripheral clocks per CAN bit specified in Table 561 determines the minimum peripheral clock frequency for a given number of message buffers and for an expected CAN bit rate. The CAN bit rate depends on the number of time quanta in a CAN bit. This number can be defined by adjusting one or more of the bit timing values contained in:

- Control 1 (CTRL1)
- CAN Bit Timing (CBT)
- Enhanced Nominal CAN Bit Timing (ENCBT)

The time quantum (Tq) is defined in Protocol timing. The minimum number of time quanta per CAN bit must be eight, so the oscillator clock frequency should be at least eight times the CAN bit rate.

76.3.11.1.1 Clock restrictions for CAN FD

For CAN FD frame format, some constraints must be satisfied. The equation below calculates the number of peripheral clocks per CAN bit in nominal bit rate (NumClkNomBit).

$$NumClkNomBit = \frac{f_{SYS}}{f_{CANCLK}} \times (PRESDIV + 1) \times (PROPSEG + PSEG1 + PSEG2 + 4)$$

$$= \frac{f_{SYS}}{NomBitRate}$$

Equation 22. Number of peripheral clocks per nominal CAN bit

Where PRESDIV, PSEG1, and PSEG2 are CAN bit time values in Control 1 (CTRL1). Alternatively, EPRESDIV, EPSEG1, and EPSEG2 values in CAN Bit Timing (CBT) or the values of EPRS[ENPRESDIV], ENCBT[NTSEG1], and ENCBT[NTSEG2] can be used instead. NumClkNomBit can also be calculated as a function of the expected nominal bit rate used in the arbitration phase (NomBitRate), as shown in the equation above.

The number of CAN bits in the data phase of an FD frame with BRS = 1 (fast CAN bits) depends on the number of data bytes in the payload. The number of fast CAN bits (NumOfFastBits) can be determined in Table 562. Having fewer data bytes means having fewer fast CAN bits. It also means that less time is available for FlexCAN to scan the whole message buffer memory during the internal matching and arbitration processes.

Table 562. Number of fast CAN bits in a CAN FD frame

Minimum number of data bytes	DLC field	NumOfFastBits
0	0h	21
1	1h	29
2	2h	37
3	3h	45
4	4h	53
5	5h	61
6	6h	69
7	7h	77
8	8h	85
12	9h	117
16	Ah	149
20	Bh	186
24	Ch	218
32	Dh	282
48	Eh	410
64	Fh	538

The critical part of a CAN FD frame is during the data phase, where the CAN bit rate is faster than in the arbitration phase. The minimum number of peripheral clocks per fast CAN bit (MinNumClkFastBit) can be calculated to guarantee that enough time is available for FlexCAN to scan the message buffer memory during reception and transmission. The equation below calculates this constraint.

$$MinNumClkFastBit_A = \frac{(8.5 \times MaxNumOfMb) + [ERFEN \times (2 \times NFE + 4)] + 64 - (9 \times NumClkNomBit)}{NumOfFastBits}$$

Equation 23. Minimum number of peripheral clocks per fast CAN bit for FlexCAN scan process

Where MaxNumOfMb is the maximum number of available message buffers defined in MCR[MAXMB]. NFE and ERFEN are the fields defined in Enhanced RX FIFO Control (ERFCR).

The clock-domain-crossing circuit between the CHI and PE subblocks also imposes a minimum number of peripheral clocks per fast CAN bit. This minimum is required for the handshake mechanism to work properly without losing status information through the interface, as shown in the equation below.

$$MinNumClkFastBit_B = 3 \times \left(1 + \frac{f_{SYS}}{f_{CANCLK}}\right)$$

Equation 24. Minimum number of peripheral clocks per fast CAN bit for FlexCAN clock domain interface

Therefore, the larger of the two values calculated above determines the minimum number of peripheral clocks per fast CAN bit (MinNumClkFastBit).

$$MinNumClkFastBit = Maximum\ (MinNumClkFastBitA, MinNumClkFastBitB)$$

Equation 25. Minimum number of peripheral clocks per fast CAN bit

Then, the maximum CAN bit rate in the data phase of CAN FD frames (DataBitRateMAX) can be calculated as below.

$$DataBitrate_{MAX} = \frac{f_{CANCLK}}{ROUNDUP\left(\frac{MinNumClkFastBit \times f_{CANCLK}}{f_{SYS}}\right)}$$

Equation 26. Maximum achievable baud rate for data phase

These factors affect the maximum data bit rate attainable by FlexCAN in CAN FD mode:

- The peripheral and oscillator clock frequencies
- The maximum number of message buffers
- The expected nominal bit rate

Also, the data bit rate depends on the minimum payload size of FD frames used in a given application.

To illustrate how the configuration of FlexCAN variables affects the CAN FD bit rate, consider this application example:

- The peripheral clock frequency is set to 50 MHz
- The oscillator clock frequency is set to 40 MHz

1. Considering the nominal bit rate as 1 Mbit/s, the number of peripheral clocks per CAN bit in nominal bit rate is calculated as below.

   $$NumClkNomBit = \frac{50 \times 10^6}{1 \times 10^6} = 50$$

   Equation 27. Calculation example for number of peripheral clocks per nominal CAN bit

2. The number of fast CAN bits (NumOfFastBits) is determined in Table 562. For example, if the minimum payload in FD frames is 8 bytes, there are 85 CAN bits in the data phase.
3. Assuming the maximum number of message buffers is 96, and Enhanced RX FIFO is disabled, the minimum number of peripheral clocks per fast CAN bit (MinNumClkFastBit) can be calculated.

   $$MinNumClkFastBit_A = \frac{(8.5 \times 96) + 64 - (9 \times 50)}{85} = 5.06$$

   Equation 28. Calculation example for number of peripheral clocks per fast CAN bit for FlexCAN scan process

$$MinNumClkFastBit_B = 3 \times \left(1 + \frac{50}{40}\right) = 6.75$$

Equation 29. Calculation example for number of peripheral clocks per fast CAN bit for FlexCAN clock domain interface

$$MinNumClkFastBit = Maximum\ (\ 5.06, 6.75\ ) = 6.75$$

Equation 30. Calculation example for number of peripheral clocks per fast CAN bit

4. The maximum CAN bit rate in the data phase can finally be found.

$$DataBitRate_{MAX} = \frac{40 \times 10^6}{ROUNDUP\left(\frac{6.75 \times 40 \times 10^6}{50 \times 10^6}\right)} = 6.667\ Mbps$$

Equation 31. Calculation example for maximum achievable baud rate

Even though the oscillator clock frequency (40 MHz) is adequate to generate a data rate of 8 Mbit/s in CAN FD mode, the specific FlexCAN configuration limits this rate to 6.667 Mbit/s. This limitation is mainly due to the low peripheral clock frequency that imposes the MinNumClkFastBitB bound.

Table 563 shows the maximum data rate for CAN FD with Enhanced RX FIFO disabled according to clock frequencies, payload size, and number of available message buffers. For some cases, if the number of available message buffers is reduced, FlexCAN can then achieve a data rate up to 8 Mbit/s.

Table 563. Maximum CAN bit rate in data phase on CAN FD frames with Enhanced RX FIFO disabled

Peripheral clock frequency (MHz)	Payload size	Number of available message buffers	Maximum data rate (Mbit/s)
40	8	94	6.667
40	8	114	>5.0
40	12	>117	6.667
40	12	128	5.714
50	12–64	128	6.667
60	8	126	8.0
60	12	128	8.0
67	6	128	8.0
80	3	128	8.0
100	0	128	8.0

76.3.12 Reset

You can reset FlexCAN in the following ways:

- Chip-level hard reset, which resets all memory-mapped registers asynchronously.
- Soft reset:
  - MCR[SOFTRST], which resets some of the memory-mapped registers synchronously. To see which registers soft reset affects, see Table 566.

— Chip-level soft reset, which has the same effect as MCR[SOFTRST].

Soft reset is synchronous and must follow an internal request-and-acknowledge procedure across clock domains. Therefore, it may take some time to propagate its effects fully. MCR[SOFTRST] remains 1 when soft reset is pending, so software can poll this field to identify when the reset has completed. Soft reset cannot be applied when clocks are shut down in a low-power mode. The low-power mode should be exited and the clocks resumed before applying soft reset.

When the module is enabled (MCR[MDIS] becomes 0), FlexCAN automatically enters Freeze mode. In Freeze mode:

1. FlexCAN is unsynchronized to the CAN bus.
2. MCR[HALT] and MCR[FRZ] become 1.
3. The internal state machines are disabled.
4. MCR[FRZACK] and MCR[NOTRDY] become 1.

The TX pin is in the recessive state and FlexCAN does not initiate any transmission or reception of CAN frames. Reset does not affect the message buffers and the RX Individual Mask registers, so they are not automatically initialized.

76.3.13 Interrupts

FlexCAN has many interrupt sources:

- Interrupts due to message buffers
- Interrupts due to interrupts combined via an OR operator from:
  - Message buffers
  - Bus Off
  - Bus Off Done
  - Error
  - Error Fast (errors detected in the data phase of CAN FD format messages with BRS = 1)
  - TX Warning
  - RX Warning

If its corresponding IMASK bit is 1, each message buffer can be an interrupt source. There is no distinction between TX and RX interrupts for a particular buffer, under the assumption that the buffer is initialized for either transmission or reception. Each buffer has an assigned flag bit in the IFLAG registers. When the corresponding buffer completes a successful transfer, the flag is set. When the CPU writes 1 to it, the flag is cleared (unless another interrupt is generated at the same time).

NOTE

The CPU must clear only the bit causing the current interrupt. For this reason, do not use bit manipulation instructions (BSET) to clear interrupt flags. These instructions may cause accidental clearing of interrupt flags which are set after entering the current interrupt handler.

If the Legacy RX FIFO is enabled (MCR[RFEN] = 1) and DMA is disabled (MCR[DMA] = 0), the interrupts corresponding to message buffers 0–7 have different meanings.

- Bit 7 of Interrupt Flags 1 (IFLAG1) becomes the Legacy FIFO Overflow flag
- Bit 6 becomes the Legacy FIFO Warning flag
- Bit 5 becomes the Frames Available in Legacy FIFO flag
- Bits 4–0 are unused.

See Interrupt Flags 1 (IFLAG1) for more information.

If both Legacy RX FIFO and DMA are enabled (MCR[RFEN] = 1 and MCR[DMA] = 1), FlexCAN does not generate any Legacy FIFO interrupt. Bit 5 of IFLAG1 still indicates Frames Available in Legacy FIFO and generates a DMA request. Bits 7, 6, and 4–0 are unused.

CAUTION

Legacy FIFO cannot be enabled when CAN FD is enabled.

When multiple message buffer interrupt sources are combined via an OR operator into a single interrupt, the interrupt is generated when any associated message buffer (or FIFO, if applicable) generates an interrupt. In this case, the CPU must read the IFLAG registers to determine which message buffer or FIFO source caused the interrupt.

These interrupt sources generate interrupts like the message buffer interrupt sources, and can be read from Error and Status 1 (ESR1):

- Bus Off
- Bus Off Done
- Error
- Error Fast
- TX Warning
- RX Warning

The Bus Off, Error, TX Warning, and RX Warning interrupt masks are located in Control 1 (CTRL1).

76.3.14 Bus interface

CPU access to FlexCAN registers is subject to the following rules:

- Unrestricted read and write access to supervisor registers results in an access error. In Table 566, supervisor registers are registers identified with an S, and registers that are identified with S/U that are in Supervisor Mode
- Read and write access to implemented reserved address space results in an access error.
- Write access to positions whose bits are all currently read-only results in an access error. If at least one of the bits is not read-only, no access error is issued. Write permission to specific positions or some of their bits can change depending on the mode of operation or transitory state. See register and field descriptions for details.
- Read and write access to unimplemented address space results in an access error.
- Read and write access to RAM-located positions during Low-Power mode results in an access error.
- The RXIMR memory region can be considered as general-purpose memory and available for access via these methods:
  - If you write 0 to MCR[IRMQ], the individual masks (RXIMR) are disabled. In this case, the RXIMR memory region is considered general-purpose memory.
  - If MCR[MAXMB] is programmed with a value smaller than the available number of message buffers, the unused memory space can be used as general-purpose RAM space. Reserved words within RAM cannot be used.
    For example, suppose the RAM in FlexCAN can support up to 16 message buffers, CTRL2[RFFN] = 0h, and MCR[MAXMB] = 0.
    - In this case, the maximum number of message buffers becomes one.
    - The RAM starts at 0080h, and the space 0080h–008Fh is used by the one message buffer.
    - The memory space 0090h–017Fh is available.
    - The space 0180h–087Fh is reserved.
    - The space 0880h–0883h is used by the one individual mask and the available memory in the mask register space is 0884h–08BFh.
    - In the space from 08C0h–09DFh, there are reserved words for internal use which cannot be used as general-purpose RAM.

    As a rule, free memory space for general purpose depends only on MCR[MAXMB].
  - If MCR[FDEN] = 1, general-purpose memory can be used only outside Freeze mode.

Table 564. Access permissions

Supervisor access	0			1			
Supervisor mode MCR[SUPV] = 1	0			1	Any		
Modes of operation	Normal	Freeze	Low-power	Any	Normal	Freeze	Low-power
MCR	Bus error	Bus error	Bus error	Bus error	Read and write	Read and write	Read and write
CTRL1	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
TIMER	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
TCR	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error
RXMGMASK[1]	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
RX14MASK[1]	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
RX15MASK[1]	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
ECR	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
ESR1	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
IMASK2	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
IMASK1	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
IFLAG2	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
IFLAG1	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
CTRL2	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
ESR2	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
CRCR	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error	Bus error for write operation	Bus error for write operation	Bus error for write operation

Table continues on the next page...

Table 564. Access permissions (continued)

Supervisor access	0			1			
Supervisor mode MCR[SUPV] = 1	0			1	Any		
Modes of operation	Normal	Freeze	Low-power	Any	Normal	Freeze	Low-power
RXFGMASK[1]	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
RXFIR[1]	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error	Bus error for write operation	Bus error for write operation	Bus error for write operation
CBT	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
DBG1	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation
DBG2	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error for write operation
IMASK3	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
IFLAG3	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
MB[1] [2]	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
Legacy FIFO header[1]	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
Legacy FIFO reserved space[1]	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error
Legacy FIFO filters[1]	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
RXIMR[1]	Bus error	Read and write	Bus error	Bus error	Bus error	Read and write	Bus error
MECR	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
ERRIAR	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
ERRIDPR	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
ERRIPPR	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write

Table continues on the next page...

Table 564. Access permissions (continued)

Supervisor access	0			1			
Supervisor mode MCR[SUPV] = 1	0			1	Any		
Modes of operation	Normal	Freeze	Low-power	Any	Normal	Freeze	Low-power
RERRAR [3]	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
RERRDR[3]	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
RERRSYNR[3]	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
ERRSR	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
EPRS	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
ENCBT	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
EDCBT	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
ETDC	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
FDCTRL	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
FDCBT	Read and write[3]	Read and write	Read and write[3]	Bus error	Read and write[3]	Read and write	Read and write[3]
FDCRC	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error	Bus error for write operation	Bus error for write operation	Bus error for write operation
ERFCR	Read and write[3]	Read and write	Read and write[3]	Bus error	Read and write[3]	Read and write	Read and write[3]
ERFIER	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
ERFSR	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
HR_TIME_STAMP	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write

Table continues on the next page...

Table 564. Access permissions (continued)

Supervisor access	0				1		
Supervisor mode MCR[SUPV] = 1	0			1	Any		
Modes of operation	Normal	Freeze	Low-power	Any	Normal	Freeze	Low-power
Enhanced Rx FIFO header[4]	Bus error for write operation	Bus error for write operation	Bus error for write operation	Bus error	Bus error for write operation	Bus error for write operation	Bus error for write operation
Enhanced Rx FIFO reserved space[4]	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error
ERFFEL	Bus error for write operation	Read and write	Bus error for write operation	Bus error	Bus error for write operation	Read and write	Bus error for write operation
General purpose RAM[1]	Read and write	Read and write	Read and write	Bus error	Read and write	Read and write	Read and write
Reserved space (used)[1]	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error
Reserved space (empty)[1]	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error	Bus error

1. Access in low power is only possible if RAM_clk and MODULE_CLK are enabled.
2. If MCR[RFEN] = 1, see Legacy FIFO access rules in the rows below.
3. Write operation has no effect.
4. If MCR[RFEN] = 1, do not access Enhanced RX FIFO.

76.3.15 Detection and correction of memory errors

To update the parity bits in memory properly, all FlexCAN memory must be initialized before starting its operation. CTRL2[WRMFRZ] grants write access to all memory positions that require initialization, from 080h–ADFh and from C20h–31FFh. You must also initialize these registers:

- RX Message Buffers Global Mask (RXMGMASK)
- Receive 14 Mask (RX14MASK)
- Receive 15 Mask (RX15MASK)
- Legacy RX FIFO Global Mask (RXFGMASK)

MCR[RFEN] and ERFCR[ERFEN] must not be 1 during memory initialization.

FlexCAN supports detection and correction of errors in memory read accesses. Each byte of FlexCAN memory is associated with five parity bits that ensure a Hamming distance of 4. The error correction mechanism ensures that in this 13-bit word, errors in one bit can be corrected (correctable errors). Errors in two bits can be detected but not corrected (uncorrectable errors). Errors in more than two bits may not be detected. For uncorrectable errors, the error correction logic does not change the corrupted data. When a read access is performed, the parity bits are used to calculate a syndrome, which indicates the error in each byte.

When an all-zeroes or an all-ones read occurs, FlexCAN detects an uncorrectable error. See Error Report Syndrome (RERRSYNR).

Memory errors are indicated to the host via status register (Error Status (ERRSR)) and bus transfer errors. Memory errors are reported via these report registers:

- Error Report Address (RERRAR)
- Error Report Data (RERRDR)

- Error Report Syndrome (RERRSYNR)

MECR[ECCDIS] determines whether the error detection and correction mechanism can be activated. When disabled, updates on indications and reporting registers are stopped. To ensure that memory has consistent parity bits associated with the data, the parity bits are still calculated and written with data in memory write operations.

To avoid accidentally changing the critical error correction configuration, follow this protocol to enable the update of Memory Error Control (MECR):

1. Write 1 to CTRL2[ECRWRE]. (By default, CTRL2[ECRWRE] is 0 and MECR[ECRWRDIS] is 1.)
2. Write 0 to MECR[ECRWRDIS].
3. All writes to Memory Error Control (MECR) must keep MECR[ECRWRDIS] = 0.
4. After configuration is done, lock MECR by writing 1 to MECR[ECRWRDIS] or writing 0 to CTRL2[ECRWRE].

76.3.15.1 Sources of memory access

These major sources (or requestors) can access FlexCAN memory:

- Host (CPU). The largest word accessed is 32-bit.
- FlexCAN internal processes:
  - RX matching
  - TX arbitration
  - Move-in on reception
  - Move-out on transmission

  The largest word accessed is 64-bit.

The source of access determines the way that uncorrectable errors are indicated and reported.

76.3.15.2 Error indication

These flags indicate memory errors:

- ERRSR[HANCEIF]
- ERRSR[FANCEIF]
- ERRSR[CEIF]

Uncorrectable errors detected in memory reads requested by the host are indicated separately from the errors detected in requests by FlexCAN internal processes. When correctable errors are detected, FlexCAN makes no distinction of the source of the access. There are three independent flags for these three cases, and each flag raises an interrupt unless a mask in Memory Error Control (MECR) masks it. If both uncorrectable and correctable errors are found in different bytes in the same read operation, both flags are set.

An uncorrectable error detected in host access is also indicated as a bus transfer error. A bus wait request may be asserted to extend the memory transaction to the moment the report registers are updated. This indication cannot be masked. If ERRSR[HANCEIF] is not masked, the same uncorrectable error raises a bus transfer error and an interrupt request.

Each indication flag has one overrun flag in Error Status (ERRSR). The overrun flags do not request interrupts. Overrun flags for uncorrectable errors indicate that other errors of the same nature were detected after the current error being treated. Overrun flags for correctable errors indicate that other errors of the same nature were detected before the current error being treated.

The recommended handling sequence for error indication is:

1. Get error report information from report registers.
2. Use this information to take proper measures in the application.
3. Clear the ERRSR[HANCEIF], ERRSR[FANCEIF], and ERRSR[CEIF] flags.

4. If the overrun flag is active:
    a. Alert the application that at least one error could not be managed.
    b. Clear the overrun flag.

FlexCAN internal processes can access memory in transactions larger than 32 bits. For the indication, this kind of access is considered a consecutive sequence of 32-bit accesses. If errors are found in two or more 32-bit words, the interrupt and overrun flags are set simultaneously.

76.3.15.3 Error reporting

The error report registers provide detailed information about the address read, raw data, and syndrome read with error. The flags described in Error indication indicate these report registers:

- Error Report Address (RERRAR)
- Error Report Data (RERRDR)
- Error Report Syndrome (RERRSYNR)

The address, data, and syndrome registers are updated simultaneously with the error flags, according to these rules:

1. If either of the uncorrectable error flags is set, the report registers are not updated. The previous uncorrectable error reporting is preserved.
2. Otherwise, either no error flag is set or only the correctable error flag is set. The report registers are updated according to the new error, or according to the most severe new error, if uncorrectable and correctable errors are simultaneously detected.

Reporting of errors detected in accesses larger than 32 bits follows the rules described in Error indication and in the description of Error Report Address (RERRAR).

The addresses reported in RERRAR and defined in ERRIAR are not the same as the addresses listed in the module memory map. The relation between the reported addresses and the respective ones in the module memory map is shown in the description of Error Injection Address (ERRIAR).

Addresses reported when reading memory portions organized as FIFOs refer to the address of the specific entry accessed in the FIFO, not to the FIFO base address. Such memory portions include:

- Legacy RX FIFO Structure
- Enhanced RX FIFO Structure
- Legacy RX FIFO Information (RXFIR)

To ensure coherence of error report registers, disable the report update by writing 1 to MECR[RERRDIS] before reading the report registers.

76.3.15.4 Error response

Correctable errors have no consequence to FlexCAN operation because the host or FlexCAN internal processes corrects affected data before its use.

For host-initiated reads, an uncorrectable error may affect the host, but does not affect FlexCAN operation.

Uncorrectable errors detected on memory read operations requested by FlexCAN internal processes may result in incorrect operation depending on the state of MECR[NCEFAFRZ], as follows:

- During reception (either matching or move-in process), when an uncorrectable error occurs:
    — An incorrect destination may be selected to store the incoming frame.
    — A corrupted frame may be stored in the correct destination.
    — Both of these events may occur.

If MECR[NCEFAFRZ] = 1, FlexCAN stops operation automatically and enters Freeze mode to prevent corrupted data from being treated as valid by FlexCAN internal processes. If MECR[NCEFAFRZ] = 0, FlexCAN continues working, and a corrupted frame is received.

- During arbitration, when an uncorrectable error occurs:
  - A non-highest-priority TX message buffer may be mistakenly selected for transmission.
  - Its data may be corrupted.

  If MECR[NCEFAFRZ] = 1, FlexCAN stops operation automatically and enters Freeze mode before starting the move-out. If MECR[NCEFAFRZ] = 0, FlexCAN proceeds to move-out with a corrupted frame that will be transmitted on the CAN bus.
- During move-out, when an uncorrectable error occurs, a corrupted frame is copied from the selected TX MB that won the arbitration to the TX SMB for transmission. If MECR[NCEFAFRZ] = 1, FlexCAN stops operation automatically and enters Freeze mode before starting the transmission. When MECR[NCEFAFRZ] = 0, the corrupted frame is transferred from the TX SMB to the Protocol Engine (PE) subblock and is transmitted on the CAN bus.
- An uncorrectable error can also be detected beyond move-out, when TX data is read from TX SMB (buffer located in RAM) to be transferred to the PE subblock for transmission. In this case, a frame with corrupted ID or data is transmitted on the CAN bus.

  To prevent the external nodes from successfully receiving the frame, FlexCAN inverts all bits in the CRC field (CRC sequence plus CRC delimiter). Also, it transmits an error flag just after CRC delimiter due to self-detecting a Bit1 error and a form error due to the CRC field inversion. When MECR[NCEFAFRZ] = 1, FlexCAN stops operation automatically and enters Freeze mode just after the error frame. When MECR[NCEFAFRZ] = 0, FlexCAN may attempt to retransmit the same frame, as long as no other higher-priority TX MB is configured for transmission after.

  If the uncorrectable error persists, FlexCAN eventually reaches the Bus Off state due to consecutive error detections. ECR[TXERRCNT] is updated every time FlexCAN inverts the CRC field, causing errors as described above.

When MECR[NCEFAFRZ] = 1 and FlexCAN enters Freeze mode, only the CPU can cause FlexCAN to exit Freeze mode and resume Normal mode. MECR[NCEFAFRZ] becoming 1 is the only way to prevent corrupted frames from being transmitted on the CAN bus to the move-out internal process.

The error report registers can provide information to the application for customized management of these situations.

76.3.15.5 Error injection

These error injection registers are used to inject errors in memory reads to force errors and update the indication and reporting registers:

- Error Injection Address (ERRIAR)
- Error Injection Data Pattern (ERRIDPR)
- Error Injection Parity Pattern (ERRIPPR)

The relation between the error injection addresses and the corresponding addresses in the module memory map is shown in Error Injection Address (ERRIAR).

The injection is done by flipping the data and parity bits corresponding to the bits set to 1 in ERRIDPR and ERRIPPR. You can select injection specifically for memory accesses requested by the host or by FlexCAN internal processes.

For accesses larger than 32 bits, MECR[EXTERRIE] extends the injection pattern, replicating it in 32-bit words to fill the width of the access.

NOTE

It is possible, but very unlikely, for error injection to correct a bit with error. This correction does not raise the error flags and reports as expected.

To ensure coherence among error injection registers and avoid spurious error injections, you must clear MECR[HAERRIE] and MECR[FAERRIE] when configuring the memory injection registers.

76.4 External signal descriptions

FlexCAN has two I/O signals connected to the external chip pins. These signals are summarized in Table 565 and described in the following subsections.

Table 565. FlexCAN signal descriptions

Signal	Description	I/O
CAN RX	CAN receive pin	Input
CAN TX	CAN transmit pin	Output

76.4.1 CAN RX

This pin is the receive pin from the CAN bus transceiver. Logic level 0 represents its dominant state. Logic level 1 represents its recessive state.

76.4.2 CAN TX

This pin is the transmit pin to the CAN bus transceiver. Logic level 0 represents its dominant state. Logic level 1 represents its recessive state.

76.5 Initialization and application information

76.5.1 FlexCAN initialization sequence

For any configuration change or initialization, you must put FlexCAN into Freeze mode (see Freeze mode). The module must be initialized after every reset. FlexCAN memory must be initialized before switching to functional mode.

The following is a generic initialization sequence applicable to FlexCAN:

1. Initialize Module Configuration (MCR).
    a. Enable the individual filtering per message buffer and reception queue features by writing 1 to MCR[IRMQ].
    b. Enable the warning interrupts by writing 1 to MCR[WRNEN].
    c. If required, disable frame self-reception by writing 1 to MCR[SRXDIS].
    d. Enable the Legacy RX FIFO by writing 1 to MCR[RFEN] or enable the Enhanced RX FIFO by writing 1 to ERFCR[ERFEN].
    e. If Legacy RX FIFO or Enhanced RX FIFO is enabled and DMA is required, write 1 to MCR[DMA].
    f. Enable the abort mechanism by writing 1 to MCR[AEN].
    g. Enable the local priority feature by writing 1 to MCR[LPRIOEN].
2. Initialize Control 1 (CTRL1) and CAN FD Bit Timing (FDCBT). Optionally initialize CAN Bit Timing (CBT).
    a. Determine the bit timing parameters: CTRL1[PROPSEG], CTRL1[PSEG1], CTRL1[PSEG2], and CTRL1[RJW].
    b. Optionally determine the bit timing parameters: CBT[EPROPSEG], CBT[EPSEG1], CBT[EPSEG2], and CBT[ERJW].
    c. Determine the CAN FD bit timing parameters: FDCBT[FPROPSEG], FDCBT[FPSEG1], FDCBT[FPSEG2], and FDCBT[FRJW].
    d. Determine the bit rate by programming CTRL1[PRESDIV] and optionally programming CBT[EPRESDIV].
    e. Determine the CAN FD bit rate by programming FDCBT[FPRESDIV].
    f. Determine the internal arbitration mode by programming CTRL1[LBUF].

3. If Error Code Correction (ECC) is enabled, you must initialize all FlexCAN memory. See Detection and correction of memory errors.
4. Initialize the message buffers. (See Message buffer structure for message buffer details.)
    a. The control and status word of all message buffers must be initialized.
    b. If RX FIFO is enabled, the ID filter table must be initialized.
    c. Other entries in each message buffer should be initialized as required.
5. Initialize Receive Individual Mask (RXIMR0 - RXIMR95).
6. Write 1 to required interrupt mask bits in:
    - IMASK registers (for all message buffer interrupts)
    - Control 1 (CTRL1) and Control 2 (CTRL2) (for Bus Off and Error interrupts)
7. Write 0 to MCR[HALT].

After the last step listed above, FlexCAN attempts to synchronize to the CAN bus.

76.6 Memory map and register definition

This section describes the registers and data structures in FlexCAN. The base address of the module depends on the particular memory map of the chip.

76.6.1 FlexCAN memory mapping

The address space occupied by FlexCAN has 128 bytes for registers starting at the module base address, followed by embedded RAM starting at address offset 0080h.

Each individual register is identified by its complete name and corresponding mnemonic. The access type can be Supervisor (S) or Unrestricted (U). Most registers can be configured to have either Supervisor or Unrestricted access by programming MCR[SUPV]. These registers are identified as S/U in the Access column of Table 566.

NOTE

An invalid register access results in a bus error. Invalid accesses include reading a write-only register, writing a read-only register, and accessing an invalid address.

NOTE

To update the parity bits in memory properly, all FlexCAN memory must be initialized before reading registers which are implemented in memory. CTRL2[WRMFRZ] grants write access to all memory positions that require initialization, from 080h–ADFh and from C20h–31FFh. You must also initialize RX Message Buffers Global Mask (RXMGMASK), Receive 14 Mask (RX14MASK), Receive 15 Mask (RX15MASK) and Legacy RX FIFO Global Mask (RXFGMASK). MCR[RFEN] and ERFCR[ERFEN] must not be 1 during memory initialization.

Table 566. Register access and reset information

Register	Access type	Affected by hard reset	Affected by soft reset
Module Configuration (MCR)	S	Yes	Yes
Control 1 (CTRL1)	S/U	Yes	No
Free-Running Timer (TIMER)	S/U	Yes	Yes
RX Message buffers Global Mask (RXMGMASK)	S/U	No	No

Table continues on the next page...

Table 566. Register access and reset information (continued)

Register	Access type	Affected by hard reset	Affected by soft reset
RX Buffer 14 Mask (RX14MASK)	S/U	No	No
RX Buffer 15 Mask (RX15MASK)	S/U	No	No
Error Counter (ECR)	S/U	Yes	Yes
Error and Status 1 (ESR1)	S/U	Yes	Yes
Interrupt Masks 2 (IMASK2)	S/U	Yes	Yes
Interrupt Masks 1 (IMASK1)	S/U	Yes	Yes
Interrupt Flags 2 (IFLAG2)	S/U	Yes	Yes
Interrupt Flags 1 (IFLAG1)	S/U	Yes	Yes
Control 2 (CTRL2)	S/U	Yes	No
Error and Status 2 (ESR2)	S/U	Yes	Yes
Cyclic Redundancy Check (CRCR)	S/U	Yes	Yes
RX FIFO Global Mask (RXFGMASK)	S/U	No	No
RX FIFO Information (RXFIR)	S/U	No	No
CAN Bit Timing (CBT)	S/U	Yes	No
Interrupt Masks 3 (IMASK3)	S/U	Yes	Yes
Interrupt Flags 3 (IFLAG3)	S/U	Yes	Yes
Message buffers	S/U	No	No
RX Individual Masks	S/U	No	No
Memory Error Control (MECR)	S/U	Yes	Yes
Error Injection Address (ERRIAR)	S/U	Yes	Yes
Error Injection Data Pattern (ERRIDPR)	S/U	Yes	Yes
Error Injection Parity Pattern (ERRIPPR)	S/U	Yes	Yes
Error Report Address (RERRAR)	S/U	Yes	Yes
Error Report Data (RERRDR)	S/U	Yes	Yes
Error Report Syndrome (RERRSYNR)	S/U	Yes	Yes

Table continues on the next page...

Table 566. Register access and reset information (continued)

Register	Access type	Affected by hard reset	Affected by soft reset
Error Status (ERRSR)	S/U	Yes	Yes
Enhanced CAN Bit Timing Prescalers (EPRS)	S/U	Yes	No
Enhanced Nominal CAN Bit Timing (ENCBT)	S/U	Yes	No
Enhanced Data Phase CAN bit Timing (EDCBT)	S/U	Yes	No
Enhanced Transceiver Delay Compensation (ETDC)	S/U	Yes	No
CAN FD Control (FDCTRL)	S/U	Yes	No
CAN FD Bit Timing (FDCBT)	S/U	Yes	No
CAN FD CRC (FDCRC)	S/U	Yes	Yes
Enhanced RX FIFO Control (ERFCR)	S/U	Yes	Yes
Enhanced RX FIFO Interrupt Enable (ERFIER)	S/U	Yes	Yes
Enhanced RX FIFO Status (ERFSR)	S/U	Yes	Yes
High-Resolution Timestamp (HR_TIME_STAMP)	S/U	No	No
Enhanced RX FIFO	S/U	No	No
Enhanced RX FIFO Filter Element (ERFFEL)	S/U	No	No

FlexCAN can store CAN messages for transmission and reception using message buffers and RX FIFO structures.

76.6.2 CAN register descriptions

The table below shows the FlexCAN memory map.

The address range from offset 80h–67Fh allocates the ninety-six 128-bit message buffers. The memory maps for the message buffers are in FlexCAN message buffer memory map.

The address range from offset 2000h–204Ch allocates the Enhanced RX FIFO output, and the address range from offset 2050h–263Ch allocates the rest of Enhanced RX FIFO 19 elements. The memory map for the Enhanced RX FIFO is in Enhanced RX FIFO structure.

76.6.2.1 CAN memory map

CAN_0 base address: 4030_4000h

CAN_1 base address: 4030_8000h

CAN_2 base address: 4030_C000h

CAN_3 base address: 4031_0000h

CAN_4 base address: 4031_4000h

CAN_5 base address: 4031_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration (MCR)	32	RW	D890_000Fh
4h	Control 1 (CTRL1)	32	RW	0000_0000h
8h	Free-Running Timer (TIMER)	32	RW	0000_0000h
10h	RX Message Buffers Global Mask (RXMGMASK)	32	RW	See section
14h	Receive 14 Mask (RX14MASK)	32	RW	See section
18h	Receive 15 Mask (RX15MASK)	32	RW	See section
1Ch	Error Counter (ECR)	32	RW	0000_0000h
20h	Error and Status 1 (ESR1)	32	RW	0000_0000h
24h	Interrupt Masks 2 (IMASK2)	32	RW	0000_0000h
28h	Interrupt Masks 1 (IMASK1)	32	RW	0000_0000h
2Ch	Interrupt Flags 2 (IFLAG2)	32	RW	0000_0000h
30h	Interrupt Flags 1 (IFLAG1)	32	RW	0000_0000h
34h	Control 2 (CTRL2)	32	RW	See section
38h	Error and Status 2 (ESR2)	32	R	0000_0000h
44h	Cyclic Redundancy Check (CRCR)	32	R	0000_0000h
48h	Legacy RX FIFO Global Mask (RXFGMASK)	32	RW	See section
4Ch	Legacy RX FIFO Information (RXFIR)	32	R	See section
50h	CAN Bit Timing (CBT)	32	RW	0000_0000h
6Ch	Interrupt Masks 3 (IMASK3)	32	RW	0000_0000h
74h	Interrupt Flags 3 (IFLAG3)	32	RW	0000_0000h
880h - 9FCh	Receive Individual Mask (RXIMR0 - RXIMR95)	32	RW	See section
AE0h	Memory Error Control (MECR)	32	RW	800C_0080h
AE4h	Error Injection Address (ERRIAR)	32	RW	0000_0000h
AE8h	Error Injection Data Pattern (ERRIDPR)	32	RW	0000_0000h
AECh	Error Injection Parity Pattern (ERRIPPR)	32	RW	0000_0000h
AF0h	Error Report Address (RERRAR)	32	R	0000_0000h
AF4h	Error Report Data (RERRDR)	32	R	0000_0000h
AF8h	Error Report Syndrome (RERRSYNR)	32	R	0000_0000h
AFCh	Error Status (ERRSR)	32	RW	0000_0000h
BF0h	Enhanced CAN Bit Timing Prescalers (EPRS)	32	RW	0000_0000h
BF4h	Enhanced Nominal CAN Bit Timing (ENCBT)	32	RW	0000_0000h
BF8h	Enhanced Data Phase CAN Bit Timing (EDCBT)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
BFCh	Enhanced Transceiver Delay Compensation (ETDC)	32	RW	0000_0000h
C00h	CAN FD Control (FDCTRL)	32	RW	8000_0100h
C04h	CAN FD Bit Timing (FDCBT)	32	RW	0000_0000h
C08h	CAN FD CRC (FDCRC)	32	R	0000_0000h
C0Ch	Enhanced RX FIFO Control (ERFCR)	32	RW	0000_0000h
C10h	Enhanced RX FIFO Interrupt Enable (ERFIER)	32	RW	0000_0000h
C14h	Enhanced RX FIFO Status (ERFSR)	32	RW	0000_0000h
C30h - DACh	High-Resolution Timestamp (HR_TIME_STAMP0 - HR_TIME_STAMP95)	32	RW	See section
3000h - 31FCh	Enhanced RX FIFO Filter Element (ERFFEL0 - ERFFEL127)	32	RW	See section

76.6.2.2 Module Configuration (MCR)

Offset

Register	Offset
MCR	0h

Function

Defines global system configurations, including the module operation modes and the maximum message buffer configuration.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MDIS	FRZ	RFEN	HALT	NOTRDY	Reserved	SOFTRST	FRZACK	SUPV	Reserved	WRNEN	LPMACK	Reserved	Reserved	SRXDIS	IRMQ
W																
Reset	1	1	0	1	1	0	0	0	1	0	0	1	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DMA	0	LPRIOEN	AEN	FDEN	0	IDAM		0	MAXMB						
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

Fields

Field	Function
31 MDIS	Module Disable Disables FlexCAN. When disabled, FlexCAN disables the clocks to the CAN Protocol Engine and Controller Host Interface submodules. Soft reset does not affect this field. 0b - Enable 1b - Disable
30 FRZ	Freeze Enable Specifies FlexCAN behavior when MCR[HALT] = 1 or when Debug mode is requested at chip level. When this field becomes 1, FlexCAN can enter Freeze mode. Writing 0 to this field causes FlexCAN to exit from Freeze mode. The chip writes 1 to this field when a noncorrectable error is detected (MECR[NCEFAFRZ] becomes 1). 0b - Disable 1b - Enable
29 RFEN	Legacy RX FIFO Enable Enables the Legacy RX FIFO feature. When this field is 1, message buffers 0–5 cannot be used for normal reception and transmission. The corresponding memory region (80h–DCh) is used by the FIFO engine and additional message buffers (up to 32, depending on CTRL2[RFFN]). These message buffers are used as Legacy RX FIFO ID filter table elements. This field also impacts the definition of the minimum number of peripheral clocks per CAN bit as described in Table 561. This field can be written in Freeze mode only; the module blocks it in other modes. **NOTE** When CAN FD operation is enabled (see MCR[FDEN]), you cannot write 1 to this field. **NOTE** This field must not be 1 if ERFCR[ERFEN] = 1. 0b - Disable 1b - Enable
28 HALT	Halt FlexCAN Puts FlexCAN into Freeze mode. The CPU should write 0 to this field after initializing the message buffers and Control 1 (CTRL1) and Control 2 (CTRL2). FlexCAN performs no reception or transmission before this field becomes 0. Freeze mode cannot be entered when FlexCAN is in a low-power mode. The module writes 1 to this field when a noncorrectable error is detected and MECR[NCEFAFRZ] = 1. 0b - No request 1b - Enter Freeze mode, if MCR[FRZ] = 1.
27 NOTRDY	FlexCAN Not Ready Indicates whether FlexCAN is in Disable mode or Freeze mode. When FlexCAN has exited these modes, this field becomes 0. Soft reset does not affect this field.

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Field	Function
	0b - FlexCAN is in Normal mode, Listen-Only mode, or Loopback mode. 1b - FlexCAN is in Disable mode or Freeze mode.
26 —	Reserved When writing to this field, always write the reset value.
25 SOFTRST	Soft Reset Resets internal state machines of FlexCAN and some memory-mapped registers. The CPU can write 1 to this field directly. Because soft reset is synchronous and must follow a request-and-acknowledge procedure across clock domains, it may take some time to propagate its effect fully. When reset is pending, this field remains 1; it automatically becomes 0 when reset completes. You can poll this field to know when the soft reset has completed. Soft reset cannot be applied when clocks are shut down in a low-power mode. Transfer the module out of the low-power mode before applying soft reset. Soft reset does not affect this field. **NOTE** This field becomes 0 within 2 CAN bits after assertion of this bit. 0b - No reset 1b - Soft reset affects reset registers
24 FRZACK	Freeze Mode Acknowledge Indicates whether FlexCAN is in Freeze mode and its prescaler is stopped. The Freeze mode request cannot be granted until current transmission or reception processes have finished. Therefore you can poll this field to know when FlexCAN has entered Freeze mode. If the Freeze mode request is negated, this field becomes 0 after the FlexCAN prescaler is running again. If Freeze mode is requested when FlexCAN is in a low-power mode, this field becomes 1 only when the low-power mode is exited. See Freeze mode. Soft reset does not affect this field. **NOTE** This field becomes 1 within 180 CAN bits if current transmission or reception is ongoing for classical frames and 730 CAN bits if current transmission or reception is ongoing for FD frames after the low-power mode requested by CPU. This field becomes 0 within 2 CAN bits after the Freeze mode request removal (see Protocol timing). 0b - Not in Freeze mode, prescaler running. 1b - In Freeze mode, prescaler stopped.
23 SUPV	Supervisor Mode Configures FlexCAN to be either in Supervisor or User mode. The registers that this field affects are marked as S/U in the Access type column of Table 566. The affected registers start with Supervisor access allowance only. In User mode, affected registers allow both Supervisor and Unrestricted accesses. In Supervisor mode, affected registers allow only Supervisor access. Unrestricted access behaves as though the access is performed on an unimplemented register location. This field can be written only in Freeze mode; the module blocks it in other modes.

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Field	Function
	0b - User mode 1b - Supervisor mode
22 —	Reserved When writing to this field, always write the reset value.
21 WRNEN	Warning Interrupt Enable Enables the generation of the flags ESR1[TWRNINT] and ESR1[RWRNINT]. When this field is 1, TWRNINT and RWRNINT flags are set when the respective error counter transitions from less than 96 to greater than or equal to 96. When this field is 0, the TWRNINT and RWRNINT flags are always zero, independent of the values of the error counters. No warning interrupt is generated. This field can be written in Freeze mode only; the module blocks it in other modes. 0b - Disable 1b - Enable
20 LPMACK	Low-Power Mode Acknowledge Indicates whether FlexCAN is in a low-power mode (Disable mode). A low-power mode cannot be entered until all current transmission and reception processes have finished. The CPU can poll this field to know when FlexCAN has entered low-power mode. Soft reset does not affect this field. **NOTE** This field becomes 1 within 180 CAN bits if current transmission or reception is ongoing for classical frames and 730 CAN bits if current transmission or reception is ongoing for FD frames after the low-power mode requested by CPU. This field becomes 0 within 2 CAN bits after the low-power mode request removal (see Protocol timing). 0b - Not in a low-power mode 1b - In a low-power mode
19 —	Reserved When writing to this field, always write the reset value.
18 —	Reserved When writing to this field, always write the reset value.
17 SRXDIS	Self-Reception Disable Determines whether FlexCAN can receive frames transmitted by itself. If 1, frames transmitted by the module are not stored in any MB, regardless of whether the MB is programmed with an ID that matches the transmitted frame. No interrupt flag or interrupt signal is generated due to the frame reception. This field can be written only in Freeze mode; the module blocks it in other modes. 0b - Enable 1b - Disable
16	Individual RX Masking and Queue Enable

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Field	Function
IRMQ	Indicates whether RX matching process is based on individual masking and queue, or based on a masking scheme with RX Message Buffers Global Mask (RXMGMASK), Receive 14 Mask (RX14MASK), Receive 15 Mask (RX15MASK), and Legacy RX FIFO Global Mask (RXFGMASK). When this field is disabled, for backward compatibility with legacy applications, reading the Control and Status word locks the MB even if it is empty. This field can be written in Freeze mode only. The module blocks it in other modes. 0b - Disable 1b - Enable
15 DMA	DMA Enable Enables DMA. The DMA feature can only be used in Legacy RX FIFO or Enhanced RX FIFO, so MCR[RFEN] or ERFCR[ERFEN] must be 1. When DMA and RFEN are 1, IFLAG1[BUF5I] generates the DMA request, and no RX FIFO interrupt is generated. This field can be written in Freeze mode only; the module blocks it in other modes. 0b - Disable 1b - Enable
14 —	Reserved
13 LPRIOEN	Local Priority Enable Enables the local priority feature. It is used to expand the ID used during the arbitration process. With this expanded ID concept, the arbitration process is done based on the full 32-bit word. However, the actual transmitted ID is 11 bits for standard frames and 29 bits for extended frames. This field can be written only in Freeze mode; the module blocks it in other modes. This bit is provided for backward compatibility with legacy applications. 0b - Disable 1b - Enable
12 AEN	Abort Enable Enables the TX abort mechanism. This mechanism guarantees a safe procedure for aborting a pending transmission, so that no frame is sent in the CAN bus without notification. This field can be written only in Freeze mode; the module blocks it in other modes. **NOTE** When this field is 1, only use the abort mechanism (see Transmission abort mechanism) to update message buffers configured for transmission. **CAUTION** Writing the abort code into RX message buffers can cause unpredictable results when this field is 1.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
11 FDEN	CAN FD Operation Enable Enables the CAN with flexible data rate (CAN FD) operation. This field can be written in Freeze mode only. FlexCAN can receive and transmit messages in CAN 2.0 format. If this field is enabled, FlexCAN can also receive and transmit messages in CAN FD format. FlexCAN can transmit FD frame format according to ISO 11898-1:2015. **NOTE** If the value of this field is 1, the Legacy RX FIFO Enable (MCR[RFEN]) field cannot be 1. 0b - Disable 1b - Enable
10 —	Reserved
9-8 IDAM	ID Acceptance Mode Identifies the format of the Legacy RX FIFO ID filter table elements. This field configures all elements of the table at the same time; they are all the same format. See Legacy RX FIFO structure. This field can be written only in Freeze mode; the module blocks it in other modes. 00b - Format A: One full ID (standard and extended) per ID filter table element. 01b - Format B: Two full standard IDs or two partial 14-bit (standard and extended) IDs per ID filter table element. 10b - Format C: Four partial 8-bit standard IDs per ID filter table element. 11b - Format D: All frames rejected.
7 —	Reserved
6-0 MAXMB	Number of the Last Message Buffer Defines the number of the last message buffer that takes part in the matching and arbitration processes. The reset value (0Fh) is equivalent to a 16-MB configuration. This field can be written only in Freeze mode; the module blocks it in other modes. **NOTE** You must write a value smaller than or equal to the number of available message buffers to this field, as described in FlexCAN memory partition for CAN FD. Additionally, the MAXMB value must consider the region of message buffers occupied by Legacy RX FIFO and its ID filters table space defined by CTRL2[RFFN]. MAXMB also impacts the definition of the minimum number of peripheral clocks per CAN bit, as described in Table 561.

76.6.2.3 Control 1 (CTRL1)

Offset

Register	Offset
CTRL1	4h

Function

Contains specific FlexCAN control features related to the CAN bus. These features include bit rate, programmable sampling point within an RX bit, Loopback mode, Listen-Only mode, Bus Off recovery behavior, and interrupt enabling (Bus-Off, Error, Warning). It also determines the division factor for the clock prescaler.

The CAN bit timing variables (CTRL1[PRESDIV], CTRL1[PROPSEG], CTRL1[PSEG1], CTRL1[PSEG2], and CTRL1[RJW]) can also be configured in CAN Bit Timing (CBT), which extends the range of all these variables. If CBT[BTF] = 1, CTRL1[PRESDIV], CTRL1[PROPSEG], CTRL1[PSEG1], CTRL1[PSEG2], and CTRL1[RJW] become read-only.

If CTRL2[BTE] = 1, CTRL1[PRESDIV], CTRL1[PROPSEG], CTRL1[PSEG1], CTRL1[PSEG2], and CTRL1[RJW] are not used by the module. Instead, these fields are read as zero, and a write operation to them has no effect.

NOTE

When the CAN FD feature is enabled, do not use CTRL1[PRESDIV], CTRL1[PROPSEG], CTRL1[PSEG1], CTRL1[PSEG2], and CTRL1[RJW] for CAN bit timing. Instead use CBT[EPRESDIV], CBT[ERJW], CBT[EPSEG1], CBT[EPSEG2], and CBT[EPROPSEG].

The CAN bit variables in CTRL1 and in CBT are stored in the same internal register.

Soft reset does not affect the contents of this register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PRESDIV								RJW		PSEG1		PSEG2			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BOFF MSK	ERRM SK	Reserv ed	LPB	TWRN MSK	RWRN MSK	0	0	SMP	BOFF REC	TSYN	LBUF	LOM	PROPSEG		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 PRESDIV	Prescaler Division Factor Determines the ratio between the PE clock frequency and the serial clock (Sclock) frequency. The Sclock period defines the time quantum of the CAN protocol. For the reset value, the Sclock frequency is equal to the PE clock frequency. The maximum value of this field is FFh, which gives a minimum Sclock frequency

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Field	Function
	equal to the PE clock frequency divided by 256. See Protocol timing for more information. This field can be written only in Freeze mode; the module blocks it in other modes. Sclock frequency = PE clock frequency ÷ (PRESDIV + 1).
23-22 RJW	Resync Jump Width Defines the maximum number of time quanta that one resynchronization can change a bit time. One time quantum is equal to one Sclock period. The valid programmable values are 0–3. See Protocol timing for more information. This field can be written only in Freeze mode; the module blocks it in other modes. Resync Jump Width = RJW + 1.
21-19 PSEG1	Phase Segment 1 Defines the length of phase segment 1 in the bit time. The valid programmable values are 0–7. See Protocol timing for more information. This field can be written only in Freeze mode; the module blocks it in other modes. Phase Buffer Segment 1 = (PSEG1 + 1) × Time Quanta.
18-16 PSEG2	Phase Segment 2 Defines the length of phase segment 2 in the bit time. The valid programmable values are 1–7. See Protocol timing for more information. This field can be written only in Freeze mode; the module blocks it in other modes. Phase Buffer Segment 2 = (PSEG2 + 1) × Time Quanta.
15 BOFFMSK	Bus Off Interrupt Mask Provides a mask for the Bus Off interrupt ESR1[BOFFINT]. 0b - Interrupt disabled 1b - Interrupt enabled
14 ERRMSK	Error Interrupt Mask Provides a mask for the Error interrupt ESR1[ERRINT]. 0b - Interrupt disabled 1b - Interrupt enabled
13 —	Reserved **NOTE** Writeable only if the module is disabled. Otherwise the access type is read-only.
12 LPB	Loopback Mode Configures FlexCAN to operate in Loopback mode. In this mode, FlexCAN performs an internal loopback that can be used for self-test operation. The bit stream output of the transmitter is fed back internally to the receiver input. The RX CAN input pin is ignored and the TX CAN output goes to the recessive state (logic 1). FlexCAN behaves as it normally does when transmitting, and treats its own transmitted message as a message received from a remote node.

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Field	Function
	In this mode, FlexCAN ignores the bit sent during the ACK slot in the CAN frame acknowledge field. It generates an internal acknowledge bit to ensure proper reception of its own message. Both transmit and receive interrupts are generated. This field can be written only in Freeze mode; the module blocks it in other modes. **NOTE** In this mode, MCR[SRXDIS] cannot become 1, because it would impede the self-reception of a transmitted message. **NOTE** FDCTRL[TDCEN] and MCR[ETDCEN] must be 0 when this field is 1. 0b - Disabled 1b - Enabled
11 TWRNMSK	TX Warning Interrupt Mask Provides a mask for the TX Warning interrupt associated with the ESR1[TWRNINT] flag. When MCR[WRNEN] = 0, this field is read as 0. This field can be written only if MCR[WRNEN] = 1. 0b - Disabled 1b - Enabled
10 RWRNMSK	RX Warning Interrupt Mask Provides a mask for the RX Warning interrupt associated with the ESR1[RWRNINT] flag. When MCR[WRNEN] = 0, this field is read as 0. This field can be written only if MCR[WRNEN] = 1. 0b - Disabled 1b - Enabled
9 —	Reserved
8 —	Reserved
7 SMP	CAN Bit Sampling Determines the sampling mode of CAN bits at the RX input. This field can be written in Freeze mode only; the module blocks it in other modes. **NOTE** For proper operation, to write 1 to this field, you must guarantee a minimum value of two time quanta in CTRL1[PSEG1] (or CBT[EPSEG1]).This bit cannot become 1 when CAN FD is enabled (MCR[FDEN] = 1). 0b - One sample is used to determine the bit value.

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Field	Function
	1b - Three samples are used to determine the value of the received bit: the regular one (sample point) and two preceding samples. A majority rule is used.
6 BOFFREC	Bus Off Recovery Determines how FlexCAN recovers from Bus Off state. If 0, automatic recovering from Bus Off state occurs according to the CAN Specification 2.0B. If 1, automatic recovering from Bus Off is disabled. The module remains in Bus Off state until you write 1 to this field. If this field becomes 0 before 128 sequences of 11 recessive bits are detected on the CAN bus, Bus Off recovery happens as if this field had never become 1. If this field becomes 0 after 128 sequences of 11 recessive bits occurred, FlexCAN resynchronizes to the bus. It waits for 11 recessive bits before joining the bus. After this field becomes 0, it can become 1 again during Bus Off, but it will only be effective the next time the module enters Bus Off. If this field becomes 0 when the module is in Bus Off, writing 1 to this field is not effective for the current Bus Off recovery. **NOTE** See Bus Off in the CAN Protocol standard (ISO 11898-1:2015) for details. 0b - Enabled 1b - Disabled
5 TSYN	Timer Sync Enables a mechanism that resets the free-running timer each time a message is received in message buffer 0. This feature provides the means to synchronize multiple FlexCAN stations with a special "SYNC" message (that is, global network time). If MCR[RFEN] = 1 (Legacy RX FIFO enabled), the first available message buffer, according to CTRL2[RFFN], is used for timer synchronization instead of MB0. This field can be written in Freeze mode only; the module blocks it in other modes. 0b - Disable 1b - Enable
4 LBUF	Lowest Buffer Transmitted First Determines the ordering mechanism for message buffer transmission. When 1, MCR[LPRIOEN] does not affect the priority arbitration. This field can be written in Freeze mode only; the module blocks it in other modes. 0b - Buffer with highest priority is transmitted first. 1b - Lowest number buffer is transmitted first.
3 LOM	Listen-Only Mode Configures FlexCAN to operate in Listen-Only mode. In this mode, transmission is disabled, all error counters described in Error Counter (ECR) are frozen, and the module operates in CAN Error Passive mode. Only messages acknowledged by another CAN station are received. If FlexCAN detects an unacknowledged message, it flags a BIT0 error without changing the receive error counter (ECR[RXERRCNT]), as if it is trying to acknowledge the message.

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Field	Function
	FlexCAN acknowledges Listen-Only mode when ESR1[FLTCONF] = 1, indicating the Error Passive state. There can be some delay between the Listen-Only mode request and its acknowledgment. This field can be written in Freeze mode only; the module blocks it in other modes. 0b - Listen-Only mode is deactivated. 1b - FlexCAN module operates in Listen-Only mode.
2-0 PROPSEG	Propagation Segment Defines the length of the propagation segment in the bit time. The valid programmable values are 0–7. This field can be written only in Freeze mode; the module blocks it in other modes. Propagation segment time = (PROPSEG + 1) × Time Quanta. One Time Quantum = one Sclock period.

76.6.2.4 Free-Running Timer (TIMER)

Offset

Register	Offset
TIMER	8h

Function

Represents a 16-bit free-running counter that the CPU can read and write. The timer starts from 0h after reset, counts linearly to FFFFh, and wraps around.

When CTRL2[TIMER_SRC] = 1, an external time tick continuously increments the timer. The time tick must be synchronous to the peripheral clock, with a minimum pulse width of one clock cycle.

When CTRL2[TIMER_SRC] = 0, the CAN bit clock increments the timer, which defines the baud rate on the CAN bus. During a message transmission or reception, it increments by one for each bit that is received or transmitted. When there is no message on the bus, it counts using the previously programmed baud rate. The timer is not incremented during Disable and Freeze modes.

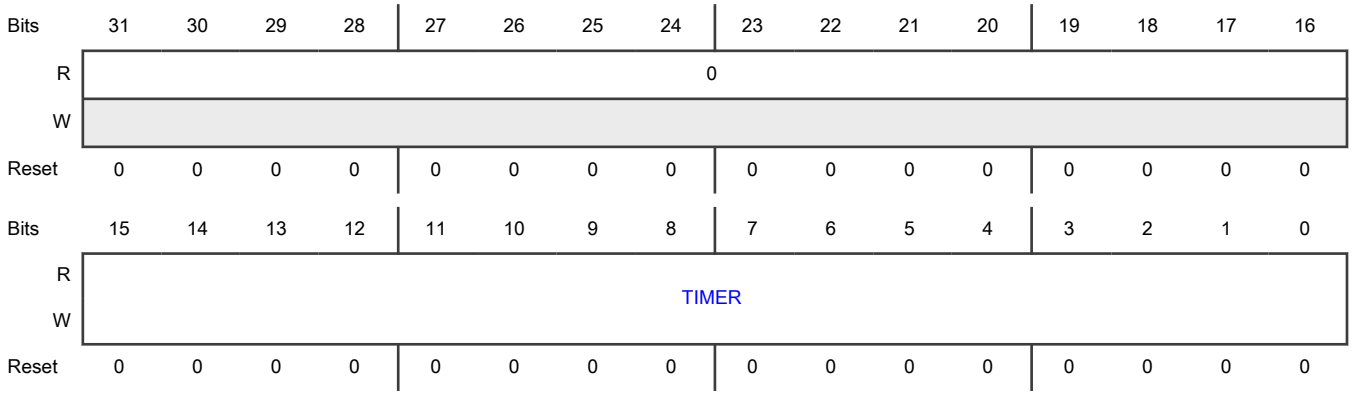
The timer value is captured when the second bit of the identifier field of any frame is on the CAN bus. This captured value is written into the timestamp entry in a message buffer after a successful reception or transmission of a message.

If CTRL1[TSYN] = 1, the timer is reset whenever a message is received in the first available message buffer, according to CTRL2[RFFN].

The CPU can write to this register anytime. However, if the write occurs simultaneously with the timer being reset by a reception in the first message buffer, the write value is discarded.

Reading this register affects the message buffer unlocking procedure (see Message buffer lock mechanism).

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 TIMER	Timer Value Contains the free-running counter value.

76.6.2.5 RX Message Buffers Global Mask (RXMGMASK)

Offset

Register	Offset
RXMGMASK	10h

Function

Masks the filter bits of all RX message buffers, excluding MB14 and MB15, which have individual mask registers.

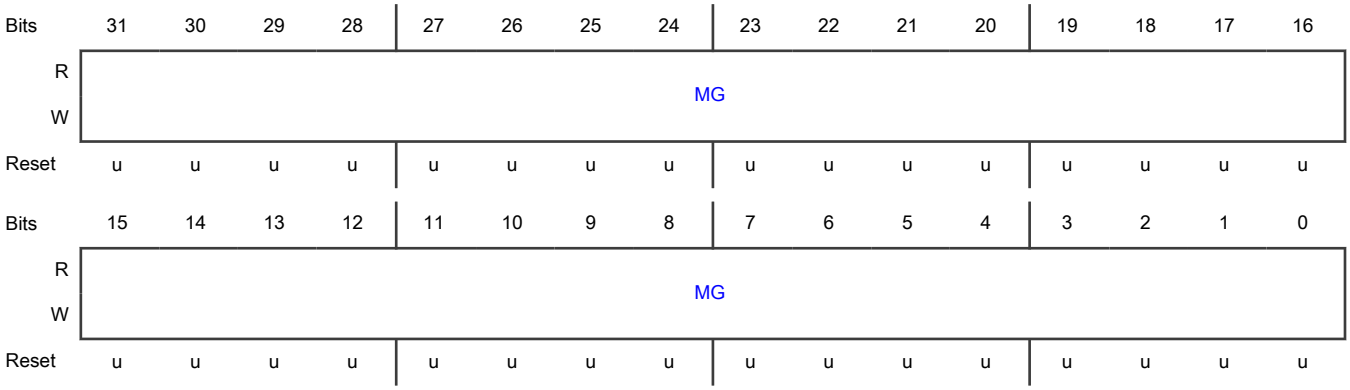
This register is located in RAM.

RXMGMASK is provided for legacy application support.

- When MCR[IRMQ] is 0, RXMGMASK is always in effect. The bits in RXMGMASK[MG] mask the MB filter bits.
- When MCR[IRMQ] is 1, RXMGMASK has no effect. The bits in RXMGMASK[MG] do not mask the MB filter bits.

This register can only be written in Freeze mode; the module blocks it in other modes.

Diagram



Fields

Field	Function
31-0 MG	Global Mask for RX Message Buffers Masks the message buffer filter bits. The alignment with the ID word of the message buffer is imperfect. The two most significant MG bits affect the fields RTR and IDE, which are located in the Control and Status word of the MB. The following table shows which MG bits mask each MB filter field.

SMB[RTR] [1]	CTRL2[RRS]	CTRL2[EACEN]	Message buffer filter fields			
			MB[RTR]	MB[IDE]	MB[ID]	Reserved
0	-	0	Note [2]	Note [3]	MG[28:0]	MG[31:29]
0	-	1	MG[31]	MG[30]	MG[28:0]	MG[29]
1	0	-	-	-	-	MG[31:0]
1	1	0	-	-	MG[28:0]	MG[31:29]
1	1	1	MG[31]	MG[30]	MG[28:0]	MG[29]

1. RTR bit of the incoming frame. It is saved into an auxiliary MB called RX serial message buffer (RX SMB).
2. If CTRL2[EACEN] is 0, the RTR bit of MB is never compared with the RTR bit of the incoming frame.
3. If CTRL2[EACEN] is 0, the IDE bit of MB is always compared with the IDE bit of the incoming frame.

0b - The corresponding bit in the filter is "don't care."

1b - The corresponding bit in the filter is checked.

76.6.2.6 Receive 14 Mask (RX14MASK)

Offset

Register	Offset
RX14MASK	14h

Function

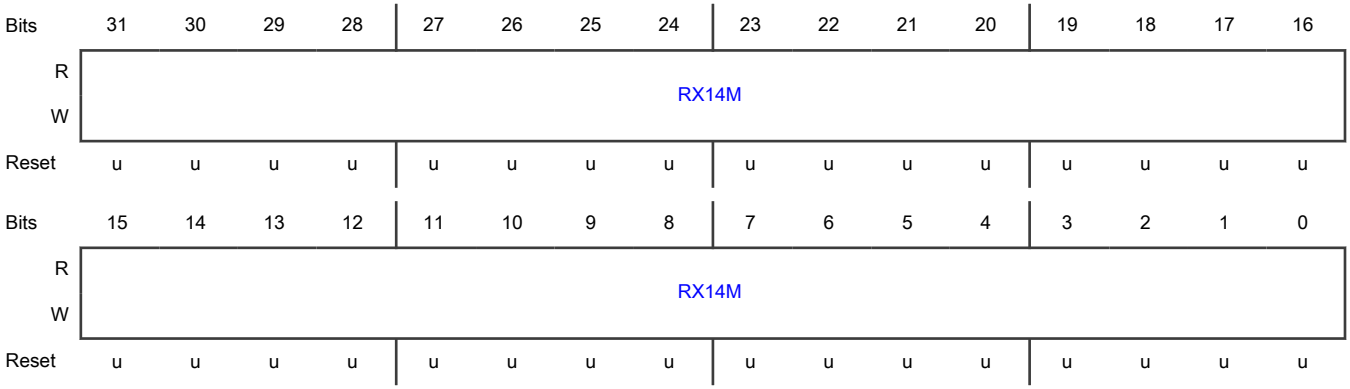
Masks the filter fields of MB14.

This register is located in RAM.

RX14MASK is provided for legacy application support. When MCR[IRMQ] = 1, RX14MASK has no effect.

This register can only be programmed when the module is in Freeze mode; the module blocks it in other modes.

Diagram



Fields

Field	Function
31-0 RX14M	RX Buffer 14 Mask Bits Masks the corresponding MB14 filter field in the same way that RX Message Buffers Global Mask (RXMGMASK) masks the filters of the other message buffers. 0b - The corresponding bit in the filter is "don't care." 1b - The corresponding bit in the filter is checked.

76.6.2.7 Receive 15 Mask (RX15MASK)

Offset

Register	Offset
RX15MASK	18h

Function

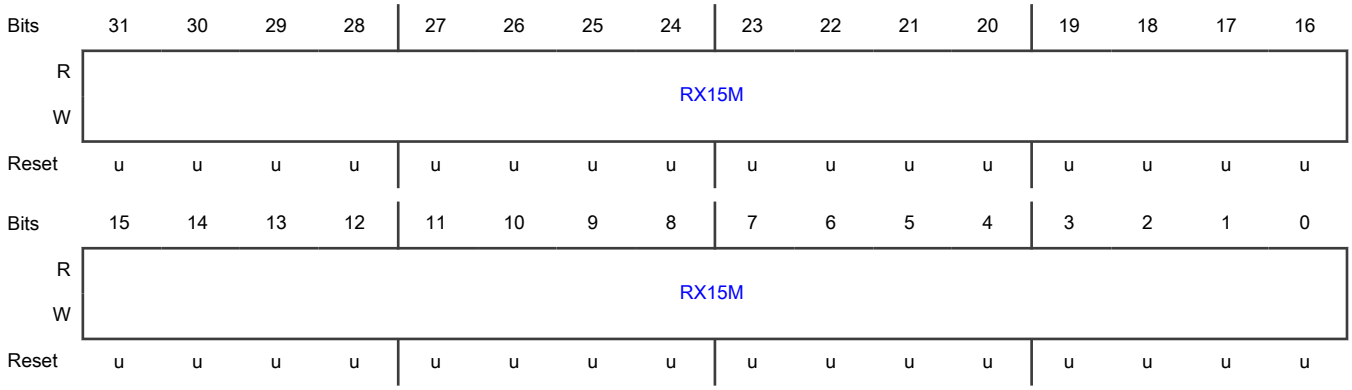
Masks the filter fields of MB15.

This register is located in RAM.

RX15MASK is provided for legacy application support. When MCR[IRMQ] = 1, RX15MASK has no effect.

This register can be programmed only when the module is in Freeze mode; the module blocks it in other modes.

Diagram



Fields

Field	Function
31-0 RX15M	RX Buffer 15 Mask Bits Masks the corresponding MB15 filter field in the same way that RX Message Buffers Global Mask (RXMGMASK) masks the filters of other message buffers. 0b - The corresponding bit in the filter is "don't care." 1b - The corresponding bit in the filter is checked.

76.6.2.8 Error Counter (ECR)

Offset

Register	Offset
ECR	1Ch

Function

Contains error counters for received and transmitted messages.

TXERRCNT and RXERRCNT consider all errors in both CAN FD and non-FD message formats. TXERRCNT_FAST and RXERRCNT_FAST count only the errors that occur in the data phase of CAN FD frames that have BRS = 1.

The Fault Confinement state (ESR1[FLTCONF]) is updated based on TXERRCNT and RXERRCNT counters only. The rules for increasing and decreasing these counters are described in the CAN protocol and are entirely implemented in FlexCAN.

The basic rules for FlexCAN bus state transitions are:

- If the value of TXERRCNT or RXERRCNT becomes greater than or equal to 128, ESR1[FLTCONF] is updated to reflect Error Passive state.
- If the state of FlexCAN is Error Passive, and TXERRCNT or RXERRCNT decrements to a value less than 128 when the other already satisfies this condition, ESR1[FLTCONF] is updated to reflect Error Active state.
- If the value of TXERRCNT becomes greater than 255, ESR1[FLTCONF] is updated to reflect Bus Off state, and an interrupt may be issued. The value of TXERRCNT is then reset to zero.
- If FlexCAN is in Bus Off, TXERRCNT is cascaded with another internal counter to count the occurrences of 11 consecutive recessive bits on the bus. TXERRCNT is reset to zero. It counts in a manner where the internal counter

counts 11 such bits and then wraps around when incrementing the TXERRCNT. When TXERRCNT reaches the value of 128, ESR1[FLTCONF] is updated to Error Active, and both error counters are reset to zero. Upon any instance of a dominant bit following a stream of less than 11 consecutive recessive bits, the internal counter resets itself to zero without affecting the TXERRCNT value. The TXERRCNT_FAST counter is frozen during Bus Off.

- If only one node is operating during system startup, its TXERRCNT increases upon each attempted message transmission, as a result of acknowledge errors (indicated by ESR1[ACKERR]). After the transition to Error Passive state, TXERRCNT no longer increments upon acknowledge errors. The chip never goes into the Bus Off state.
- If RXERRCNT increases to a value greater than 127, it is not incremented further, even if more errors are detected when being a receiver. At the next successful message reception, the counter is set to a value between 119 and 127 to return to the Error Active state.
- TXERRCNT_FAST and RXERRCNT_FAST error counter values increment and decrement based on errors detected only in the data phase of CAN FD frames that have BRS = 1. These counters follow the same increment and decrement rules as TXERRCNT and RXERRCNT. These counters do not wrap around and get stuck at their maximum value (255). They stop counting and keep their values frozen when FlexCAN is in the Bus Off state. They are reset when FlexCAN leaves the Bus Off state and resume counting after FlexCAN returns to the Error Active state.

NOTE

See Fault confinement in the CAN Protocol standard (ISO 11898-1:2015) for details.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXERRCNT_FAST								TXERRCNT_FAST							
W	0								0							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXERRCNT								TXERRCNT							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 RXERRCNT_FAST	Receive Error Counter for Fast Bits Counts errors detected in the data phase of received CAN FD messages that have BRS = 1. This field is read-only except in Freeze mode, when the CPU can write an 8-bit zero value only.
23-16 TXERRCNT_FAST	Transmit Error Counter for Fast Bits Counts errors detected in the data phase of transmitted CAN FD messages that have BRS = 1. This field is read-only except in Freeze mode, when the CPU can write an 8-bit zero value only.
15-8 RXERRCNT	Receive Error Counter Counts all errors detected in received messages. This field is read-only except in Freeze mode, when the CPU can write to it.

Table continues on the next page...

Table continued from the previous page...

Field	Function
7-0 TXERRCNT	Transmit Error Counter Counts all errors detected in transmitted messages. This field is read-only except in Freeze mode, when the CPU can write to it.

76.6.2.9 Error and Status 1 (ESR1)

Offset

Register	Offset
ESR1	20h

Function

Reports various error conditions detected in the reception and transmission of a CAN frame. This register provides status information about the chip, and is the source of some interrupts to the CPU. The reported error conditions are:

NOTE

Reading host can clear these fields.

- Errors detected in CAN frames of any format:
  - BIT1ERR
  - BIT0ERR
  - ACKERR
  - CRCERR
  - FRMERR
  - STFERR
- Errors detected in the data phase of CAN FD frames with the BRS bit set only:
  - BIT1ERR_FAST
  - BIT0ERR_FAST
  - CRCERR_FAST
  - FRMERR_FAST
  - STFERR_FAST

One or more error flags may report an error detected in a single CAN frame. To account for more error events occurring in subsequent frames when the CPU does not attempt to read this register, error reporting is cumulative.

Status flags:

- TXWRN
- RXWRN
- IDLE
- TX

- FLTCONF
- RX
- SYNCH

Interrupt flags:

- BOFFINT
- BOFFDONEINT
- ERRINT
- ERRINT_FAST
- TWRNINT
- RWRNINT

The CPU should follow this procedure when servicing interrupt requests generated by these flags:

1. Read this register to capture all error condition and status flags. This action clears the respective flags that were set since the last read access.
2. Write 1 to clear the interrupt flag that triggered the interrupt request.
3. Write 1 to clear the ERROVR flag, if it is set.

Starting from all error flags cleared, a first error event sets either ERRINT or ERRINT_FAST (provided the corresponding mask bit is 1). If other error events in subsequent frames occur before the CPU serves the interrupt request, the ERROVR flag is set to indicate that errors from different frames have accumulated.

Table 567. CAN bus status

SYNCH	IDLE	TX	RX	FlexCAN state
0	0	0	0	Not synchronized to CAN bus
1	1	X	X	Idle
1	0	1	0	Transmitting
1	0	0	1	Receiving

NOTE

See Fault confinement in the CAN Protocol standard (ISO 11898-1:2015) for details.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BIT1ERR...	BIT0ERR...	0	CRCERR_...	FRMERR_...	STFERR_...	0		0	0	ERROVR	ERRINT_...	BOFFDON...	SYNCH	TWRNINT	RWRNINT
W											W1C	W1C	W1C		W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BIT1ERR	BIT0ERR	ACKERR	CRCERR	FRMERR	STFERR	TXWRN	RXWRN	IDLE	TX	FLTCONF		RX	BOFFINT	ERRINT	0
W														W1C	W1C	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 BIT1ERR_FAST	Fast Bit1 Error Flag Indicates when an inconsistency occurs between the transmitted and the received bit in the data phase of CAN FD frames that have BRS = 1. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - At least one bit transmitted as recessive is received as dominant.
30 BIT0ERR_FAST	Fast Bit0 Error Flag Indicates when an inconsistency occurs between the transmitted and the received bit in the data phase of CAN FD frames that have BRS = 1. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - At least one bit transmitted as dominant is received as recessive.
29 —	Reserved
28 CRCERR_FAST	Fast Cyclic Redundancy Check Error Flag Indicates that the receiver node has detected a CRC error in the CRC field of CAN FD frames that have BRS = 1. This error means that the calculated CRC is different from the received CRC. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - A CRC error occurred since last read of this register.
27 FRMERR_FAST	Fast Form Error Flag Indicates whether the receiver node has detected a form error in the data phase of CAN FD frames that have BRS = 1. This error means that a fixed-form bit field contains at least one illegal bit. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - A form error occurred since last read of this register.
26 STFERR_FAST	Fast Stuffing Error Flag Indicates that a stuffing error has been detected in the data phase of CAN FD frames that have BRS = 1. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - A stuffing error occurred since last read of this register.
25-24 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
23 —	Reserved
22 —	Reserved
21 ERROVR	Error Overrun Flag Indicates that an error condition occurred when any error flag is already set. 0b - No overrun 1b - Overrun
20 ERRINT_FAST	Fast Error Interrupt Flag Indicates that at least one error flag detected in the data phase of CAN FD frames that have BRS = 1 (BIT1ERR_FAST, BIT0ERR_FAST, CRCERR_FAST, FRMERR_FAST, or STFERR_FAST) is set. If CTRL2[ERRMSK_FAST] = 1, an interrupt is generated to the CPU. 0b - No such occurrence. 1b - Error flag set in the data phase of CAN FD frames that have BRS = 1.
19 BOFFDONEINT	Bus Off Done Interrupt Flag Indicates whether ECR[TXERRCNT] has finished counting 128 occurrences of 11 consecutive recessive bits on the CAN bus and is ready to leave Bus Off. If CTRL2[BOFFDONEMSK] = 1, an interrupt is generated to the CPU. 0b - No such occurrence 1b - FlexCAN module has completed Bus Off process.
18 SYNCH	CAN Synchronization Status Flag Indicates whether FlexCAN is synchronized to the CAN bus and able to participate in the communication process. FlexCAN sets and clears this flag. See the table in Error and Status 1 (ESR1). 0b - Not synchronized 1b - Synchronized
17 TWRNINT	TX Warning Interrupt Flag Indicates whether TX error counter changed from less than 96 to greater than or equal to 96. If MCR[WRNEN] = 1, this flag is set when the TXWRN flag transitions from 0 to 1, meaning that the TX error counters reached 96. If CTRL1[TWRNMSK] = 1, an interrupt is sent to the CPU. When MCR[WRNEN] = 0, this flag is masked. The CPU must clear this flag before writing 0 to MCR[WRNEN]. Otherwise, this flag is set when MCR[WRNEN] = 1 again. Writing 0 has no effect. This flag is not generated when in the Bus Off state. This flag is not updated during Freeze mode. 0b - No such occurrence 1b - TX error counter changed from less than 96 to greater than or equal to 96.

Table continues on the next page...

Table continued from the previous page...

Field	Function
16 RWRNINT	RX Warning Interrupt Flag Indicates whether the RX error counter changed from less than 96 to greater than or equal to 96. If MCR[WRNEN] = 1, this flag is set when the RXWRN flag transitions from 0 to 1, meaning that the RX error counters reached 96. If CTRL1[RWRNMSK] = 1, an interrupt is sent to the CPU. When MCR[WRNEN] = 0, this flag is masked. The CPU must clear this flag before writing 0 to MCR[WRNEN]. Otherwise, this flag is set when MCR[WRNEN] = 1 again. Writing 0 has no effect. This flag is not updated during Freeze mode. 0b - No such occurrence 1b - RX error counter changed from less than 96 to greater than or equal to 96.
15 BIT1ERR	Bit1 Error Flag Indicates when an inconsistency occurs between the transmitted and the received bit in a non-CAN FD message or in the arbitration or data phase of a CAN FD message. **NOTE** A transmitter does not set this flag for an arbitration field or ACK slot. It is not set for a node sending a error passive flag that detects dominant bits. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - At least one bit sent as recessive is received as dominant.
14 BIT0ERR	Bit0 Error Flag Indicates when an inconsistency occurs between the transmitted and the received bit in a non-CAN FD message or in the arbitration or data phase of a CAN FD message. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - At least one bit sent as dominant is received as recessive.
13 ACKERR	Acknowledge Error Flag Indicates whether the transmitter node has detected an acknowledge error. This error means that a dominant bit has not been detected during the ACK SLOT. After a read operation, the field's value clears to 0. 0b - No error 1b - Error occurred since last read of this register.
12 CRCERR	Cyclic Redundancy Check Error Flag Indicates whether the receiver node has detected a cyclic redundancy check (CRC) error either in a non-FD message or in the arbitration or data phase of a frame in CAN FD format. This error means that the calculated CRC is different from the received. After a read operation, the field's value clears to 0.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No error 1b - Error occurred since last read of this register.
11 FRMERR	Form Error Flag Indicates whether a form error has been detected in a non-FD message or in the arbitration or data phase of an FD message by the receiver node. This error means that a fixed-form field contains at least one illegal bit. After a read operation, the field's value clears to 0. 0b - No error 1b - Error occurred since last read of this register.
10 STFERR	Stuffing Error Flag Indicates that a stuffing error has been detected in a non-FD message or in the arbitration or data phase of an FD message by the receiver node. After a read operation, the field's value clears to 0. 0b - No error 1b - Error occurred since last read of this register.
9 TXWRN	TX Error Warning Flag Indicates when repetitive errors occur during message transmission. Only the value of ECR[TXERRCNT] affects this flag. This flag is not updated during Freeze mode. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - TXERRCNT is 96 or greater.
8 RXWRN	RX Error Warning Flag Indicates when repetitive errors occur during message reception. Only the value of ECR[RXERRCNT] affects this flag. This flag is not updated during Freeze mode. After a read operation, the field's value clears to 0. 0b - No such occurrence. 1b - RXERRCNT is greater than or equal to 96.
7 IDLE	Idle Indicates whether CAN bus is in IDLE state. See Table 567. 0b - Not IDLE 1b - IDLE
6 TX	FlexCAN In Transmission Indicates whether FlexCAN is transmitting a message. See Table 567.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not transmitting 1b - Transmitting
5-4 FLTCONF	Fault Confinement State Indicates the confinement state of FlexCAN. If CTRL1[LOM] = 1, after a delay that depends on the CAN bit timing, this field indicates Error Passive. The same delay affects the way that this field reflects an update to ECR register by the CPU. It may be necessary to wait up to one CAN bit time for coherence to be restored. Soft reset affects this field, but if CTRL1[LOM] = 1, its reset value lasts for only one CAN bit. After that time, this field reports Error Passive. 00b - Error Active 01b - Error Passive 1xb - Bus Off
3 RX	FlexCAN in Reception Flag Indicates whether FlexCAN is receiving a message. See the table in Error and Status 1 (ESR1). 0b - Not receiving 1b - Receiving
2 BOFFINT	Bus Off Interrupt Flag Indicates whether FlexCAN has entered Bus Off state. If CTRL1[BOFFMSK]) = 1, an interrupt is generated to the CPU. Writing 0 to this field has no effect. 0b - No such occurrence. 1b - FlexCAN module entered Bus Off state.
1 ERRINT	Error Interrupt Flag Indicates that at least one of the error flags (ESR1[BIT1ERR], ESR1[BIT0ERR], ESR1[ACKERR], ESR1[CRCERR], ESR1[FRMERR], or ESR1[STFERR]) is set. If the corresponding mask CTRL1[ERRMSK] = 1, an interrupt is generated to the CPU. Writing 0 to this field has no effect. 0b - No such occurrence. 1b - Indicates setting of any error flag in the Error and Status register.
0 —	Reserved

76.6.2.10 Interrupt Masks 2 (IMASK2)

Offset

Register	Offset
IMASK2	24h

Function

Masks interrupt flags. This register allows any of the 32 message buffer interrupts to be enabled or disabled for MB63–MB32. It contains one interrupt mask bit per buffer. This configuration allows the CPU to determine which buffer generates an interrupt after a successful transmission or reception when the corresponding Interrupt Flags 2 (IFLAG2) flag is set.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	BUF63TO32M															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	BUF63TO32M															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 BUF63TO32M	Buffer MBi Mask Masks the corresponding FlexCAN message buffer interrupt for MB63–MB32. **NOTE** If the corresponding Interrupt Flags 2 (IFLAG2) flag is set, writing 1 or 0 to a field in IMASK2 can set or clear an interrupt request. 0b - The corresponding buffer interrupt is disabled. 1b - The corresponding buffer interrupt is enabled.

76.6.2.11 Interrupt Masks 1 (IMASK1)

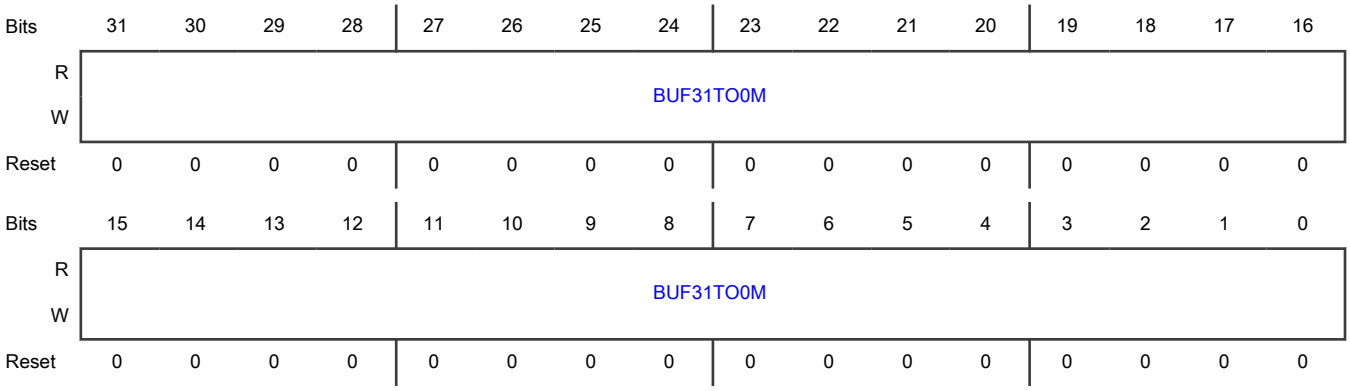
Offset

Register	Offset
IMASK1	28h

Function

Masks interrupt flags. This register allows any of the 32 message buffer interrupts to be enabled or disabled for MB31–MB0. It contains one interrupt mask bit per buffer. This configuration allows the CPU to determine which buffer generates an interrupt after a successful transmission or reception when the corresponding Interrupt Flags 1 (IFLAG1) flag is set.

Diagram



Fields

Field	Function
31-0 BUF31TO0M	Buffer MBi Mask Enables or disables the corresponding FlexCAN message buffer interrupt for MB31–MB0. **NOTE** If the corresponding Interrupt Flags 1 (IFLAG1) flag is set, writing 1 or 0 to a field in IMASK1 can set or clear an interrupt request. 0b - The corresponding buffer interrupt is disabled. 1b - The corresponding buffer interrupt is enabled.

76.6.2.12 Interrupt Flags 2 (IFLAG2)

Offset

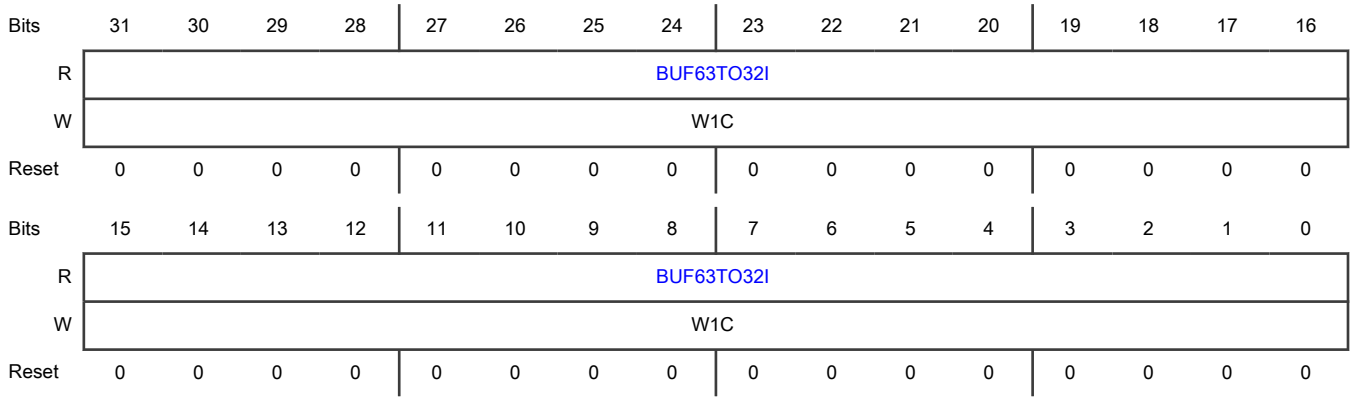
Register	Offset
IFLAG2	2Ch

Function

Contains the flags for the 32 message buffer interrupts for MB63–MB32. It contains one interrupt flag bit per buffer. Each successful transmission or reception sets the respective flag in this register. If the corresponding Interrupt Masks 2 (IMASK2) bit is set, an interrupt is generated.

Before updating MCR[MAXMB], the CPU must service the IFLAG2 flags whose MB value is greater than the MAXMB to be updated. Otherwise, those flags remain set and are inconsistent with the number of message buffers available.

Diagram



Fields

Field	Function
31-0 BUF63TO32I	Buffer MBi Interrupt Flags the corresponding FlexCAN message buffer interrupt for MB63–MB32. 0b - The corresponding buffer has no occurrence of successfully completed transmission or reception. 1b - The corresponding buffer has successfully completed transmission or reception.

76.6.2.13 Interrupt Flags 1 (IFLAG1)

Offset

Register	Offset
IFLAG1	30h

Function

Contains the flags for the 32 message buffer interrupts for MB31–MB0. It contains one interrupt flag bit per buffer. Each successful transmission or reception sets the corresponding IFLAG1 bit. If the corresponding Interrupt Masks 1 (IMASK1) bit is set, an interrupt is generated. There is an exception when DMA for Legacy RX FIFO is enabled, as described below.

The BUF7I–BUF5I flags also represent Legacy FIFO interrupts when the Legacy RX FIFO is enabled. When MCR[RFEN] is 1 and MCR[DMA] is 0, the function of the eight least significant interrupt flags changes:

- BUF7I, BUF6I, and BUF5I indicate operating conditions of the Legacy FIFO.
- BUF4I–BUF1I fields are reserved.
- BUF0I empties the Legacy FIFO.

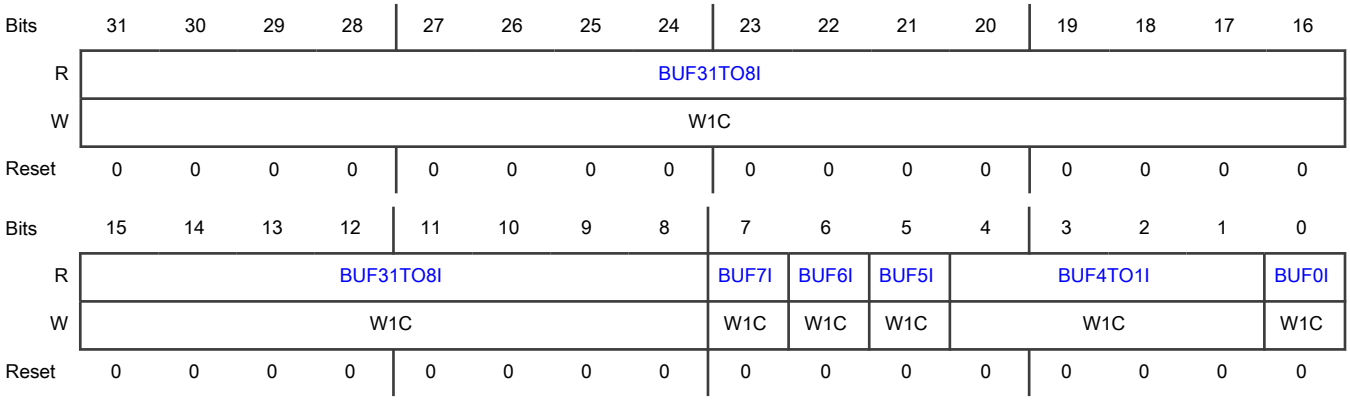
Before writing 1 to MCR[RFEN], the CPU must service the IFLAG flags set in the Legacy RX FIFO region; see Legacy RX FIFO. Otherwise, these IFLAG flags mistakenly show the related message buffers now belonging to Legacy FIFO as having contents to be serviced. When MCR[RFEN] is 0, the Legacy FIFO flags must be cleared. The same care must be taken when a CTRL2[RFFN] value is selected, extending Legacy RX FIFO filters beyond MB7. For example, when RFFN is 8h, Legacy RX FIFO filters occupy the MB23–MB0 range, and related IFLAG flags must be cleared.

When MCR[RFEN] and MCR[DMA] are 1 (DMA feature for Legacy RX FIFO enabled), the function of the eight least significant interrupt flags (BUF7I–BUF0I) changes to support DMA operation. BUF7I, BUF6I, and BUF4I–BUF1I are not used.

BUF5I indicates the operating condition of the Legacy FIFO, and BUF0I empties the Legacy FIFO. Moreover, BUF5I does not generate a CPU interrupt, but it does generate a DMA request. IMASK1 bits in the Legacy RX FIFO region are not considered when bit MCR[DMA] = 1. In addition, the CPU must not clear the BUF5I flag when DMA is enabled. Before writing 1 to MCR[DMA], the CPU must service the IFLAG flags set in the Legacy RX FIFO region. When MCR[DMA] is 0, the Legacy FIFO must be empty. Legacy FIFO must be disabled when MCR[FDEN] = 1.

Before updating MCR[MAXMB], the CPU must service the IFLAG1 flags whose MB value is greater than the MCR[MAXMB] to be updated. Otherwise, those flags remain set and are inconsistent with the number of message buffers available.

Diagram



Fields

Field	Function
31-8 BUF31TO8I	Buffer MBi Interrupt Flags the corresponding FlexCAN message buffer interrupt for MB31–MB8. 0b - The corresponding buffer has no occurrence of successfully completed transmission or reception. 1b - The corresponding buffer has successfully completed transmission or reception.
7 BUF7I	Buffer MB7 Interrupt or Legacy RX FIFO Overflow Flags the interrupt for MB7 when MCR[RFEN] = 0 (Legacy RX FIFO disabled). **NOTE** When a CPU write changes the value of MCR[RFEN], FlexCAN clears this flag. When MCR[RFEN] = 1, this flag represents a Legacy RX FIFO overflow. In this case, the flag indicates that a message was lost because the Legacy RX FIFO is full. When the Legacy RX FIFO is full and a message buffer captures the message, this flag is not set. 0b - No occurrence of MB7 completing transmission or reception, or no FIFO overflow. 1b - MB7 completed transmission or reception, or FIFO overflow.
6 BUF6I	Buffer MB6 Interrupt or Legacy RX FIFO Warning Flags the interrupt for MB6 when MCR[RFEN] = 0 (Legacy RX FIFO disabled).

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Field	Function
	NOTE When a CPU write changes the value of MCR[RFEN], FlexCAN clears this flag. When MCR[RFEN] = 1, this flag represents a Legacy RX FIFO warning. In this case, the flag indicates when the number of unread messages within the Legacy RX FIFO is increased to five from four due to the reception of a new message. In other words, the Legacy RX FIFO is almost full. If this flag is cleared when there are more than four unread messages, it does not set again until the number of unread messages in the Legacy RX FIFO decreases to four or fewer. 0b - No occurrence of MB6 completing transmission or reception, or FIFO not almost full. 1b - MB6 completed transmission or reception, or FIFO almost full.
5 BUF5I	Buffer MB5 Interrupt or Frames available in Legacy RX FIFO Flags the interrupt for MB5 when MCR[RFEN] = 0 (Legacy RX FIFO disabled). **NOTE** When a CPU write changes the value of MCR[RFEN], FlexCAN clears this flag. When MCR[RFEN] = 1, the BUF5I flag represents frames available in Legacy RX FIFO. In this case, the flag indicates that at least one frame is available to be read from the Legacy RX FIFO. When MCR[DMA] = 1, this flag generates a DMA request. The CPU must not clear this field by writing 1 to BUF5I. 0b - No occurrence of completed transmission or reception, or no frames available 1b - MB5 completed transmission or reception, or frames available
4-1 BUF4TO1I	Buffer MBi Interrupt or Reserved Flags the interrupts for MB4–MB1 when MCR[RFEN] = 0 (Legacy RX FIFO disabled). **NOTE** When a CPU write changes the value of MCR[RFEN], FlexCAN clears these flags. When MCR[RFEN] = 1, the BUF4TO1I flags are reserved. 0b - The corresponding buffer has no occurrence of successfully completed transmission or reception. 1b - The corresponding buffer has successfully completed transmission or reception.
0 BUF0I	Buffer MB0 Interrupt or Clear Legacy FIFO bit Flags the interrupt for MB0 when MCR[RFEN] = 0 (Legacy RX FIFO disabled). If MCR[RFEN] = 1, this field is used to trigger the clear Legacy FIFO operation. This operation empties the Legacy FIFO contents. Before performing this operation, the CPU must service all Legacy FIFO-related IFLAG flags. When MCR[DMA] = 1, this operation also clears the BUF5I flag, aborting the DMA request. The clear Legacy FIFO operation occurs when the CPU writes 1 to BUF0I. This operation is only allowed in Freeze mode; the module blocks it in other conditions.

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Field	Function
	0b - MB0 has no occurrence of successfully completed transmission or reception. 1b - MB0 has successfully completed transmission or reception.

76.6.2.14 Control 2 (CTRL2)

Offset

Register	Offset
CTRL2	34h

Function

Complements Control 1 (CTRL1), providing control bits for memory write-access in Freeze mode. This register extends Legacy FIFO filter quantity, and adjusts the operation of internal FlexCAN processes such as matching and arbitration.

Soft reset does not affect the contents of this register.

Table 568 shows how the value of CTRL2[RFFN] determines the Legacy RX FIFO filter structure.

Table 568. Possible Legacy RX FIFO filter structures

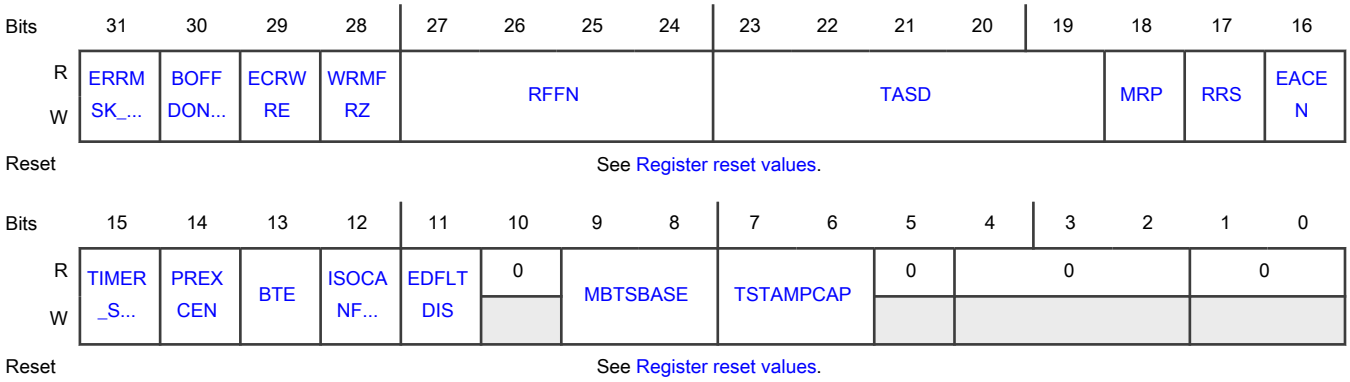
RFFN[3:0]	Number of Legacy RX FIFO filter elements	Message buffers occupied by Legacy RX FIFO and ID filter table	Remaining available message buffers	Legacy RX FIFO ID filter table elements affected by RX individual masks	Legacy RX FIFO ID filter table elements affected by Legacy RX FIFO global mask
0h	8	MB 0–7	MB 8–95	Elements 0–7	None
1h	16	MB 0–9	MB 10–95	Elements 0–9	Elements 10–15
2h	24	MB 0–11	MB 12–95	Elements 0–11	Elements 12–23
3h	32	MB 0–13	MB 14–95	Elements 0–13	Elements 14–31
4h	40	MB 0–15	MB 16–95	Elements 0–15	Elements 16–39
5h	48	MB 0–17	MB 18–95	Elements 0–17	Elements 18–47
6h	56	MB 0–19	MB 20–95	Elements 0–19	Elements 20–55
7h	64	MB 0–21	MB 22–95	Elements 0–21	Elements 22–63
8h	72	MB 0–23	MB 24–95	Elements 0–23	Elements 24–71
9h	80	MB 0–25	MB 26–95	Elements 0–25	Elements 26–79
Ah	88	MB 0–27	MB 28–95	Elements 0–27	Elements 28–87
Bh	96	MB 0–29	MB 30–95	Elements 0–29	Elements 30–95
Ch	104	MB 0–31	MB 32–95	Elements 0–31	Elements 32–103
Dh	112	MB 0–33	MB 34–95	Elements 0–31	Elements 32–111

Table continues on the next page...

Table 568. Possible Legacy RX FIFO filter structures (continued)

RFFN[3:0]	Number of Legacy RX FIFO filter elements	Message buffers occupied by Legacy RX FIFO and ID filter table	Remaining available message buffers	Legacy RX FIFO ID filter table elements affected by RX individual masks	Legacy RX FIFO ID filter table elements affected by Legacy RX FIFO global mask
Eh	120	MB 0–35	MB 36–95	Elements 0–31	Elements 32–119
Fh	128	MB 0–37	MB 38–95	Elements 0–31	Elements 32–127

Diagram



Register reset values

Register	Reset value
CTRL2	CAN_0–CAN_2: 0060_0000h CAN_3–CAN_5: 0080_0000h

Fields

Field	Function
31 ERRMSK_FAST	Error Interrupt Mask for Errors Detected in the Data Phase of Fast CAN FD Frames Enables the ESR1[ERRINT_FAST] interrupt. 0b - Disable 1b - Enable
30 BOFFDONEMSK	Bus Off Done Interrupt Mask Enables the Bus Off Done interrupt, ESR1[BOFFDONEINT]. 0b - Disable 1b - Enable
29 ECRWRE	Error Correction Configuration Register Write Enable

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Field	Function
	Enables updates for Memory Error Control (MECR). If the protocol described in Detection and correction of memory errors is not followed, this field is automatically 0. 0b - Disable 1b - Enable
28 WRMFRZ	Write Access to Memory in Freeze Mode Enables unrestricted write access to FlexCAN memory in Freeze mode. When this field is 0, write access restrictions are maintained. This field can only be written in Freeze mode, and has no effect out of Freeze mode. **NOTE** Do not write 1 to MCR[RFEN] during FlexCAN memory initialization. 0b - Disable 1b - Enable
27-24 RFFN	Number of Legacy Receive FIFO Filters Defines the number of Receive Legacy FIFO filters, as shown in Table 568. The chip determines the maximum selectable number of filters. Do not program this field with values that cause the number of message buffers occupied by Legacy RX FIFO and Legacy RX FIFO ID Filter to exceed MCR[MAXMB]. MCR[MAXMB] defines the number of message buffers present. This field can only be written in Freeze mode; the module blocks it in other modes. Each group of eight filters occupies a memory space equivalent to two message buffers. The more filters are implemented, the fewer message buffers are available. The Legacy RX FIFO occupies the memory space originally reserved for MB5–MB0. This field should be programmed with a value corresponding to a number of filters less than the number of available memory words. The number of available words can be calculated as follows: (SETUP_MB - 6) × 4 Where SETUP_MB is the smaller of the parameter NUMBER_OF_MB and MCR[MAXMB]. The number of remaining message buffers available is: (SETUP_MB - 8) - (RFFN × 2) If the number of Legacy RX FIFO filters programmed through RFFN exceeds the SETUP_MB value (memory space available), the exceeding ones are not functional. **NOTE** • The number of the last remaining available message buffers is the smaller of (NUMBER_OF_MB - 1) and MCR[MAXMB]. • If RX Individual Mask registers are not enabled, the Legacy RX FIFO Global Mask affects all Legacy RX FIFO filters.
23-19 TASD	Transmission Arbitration Start Delay

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>Indicates by how many CAN bits the transmission arbitration process start point can be delayed from the first bit of CRC field on CAN bus. See TX arbitration start delay for details. This field can be written only in Freeze mode; the module blocks it in other modes.</td></tr>
<tr><td>18
MRP</td><td>Message Buffers Reception Priority
Sets the priority for the matching process.
This field can be written only in Freeze mode; the module blocks it in other modes.
NOTE
The descriptions of the field settings vary by module instance.
<table><tr><th>Instance</th><th>Field value and description</th></tr><tr><td>CAN_0</td><td>0b - Matching starts from Legacy RX FIFO or Enhanced RX FIFO and continues on message buffers.
1b - Matching starts from message buffers and continues on Legacy RX FIFO or Enhanced RX FIFO.</td></tr><tr><td>CAN_1</td><td>0b - Matching starts from Legacy RX FIFO or Enhanced RX FIFO and continues on message buffers.
1b - Matching starts from message buffers and continues on Legacy RX FIFO or Enhanced RX FIFO.</td></tr><tr><td>CAN_2</td><td>0b - Matching starts from Legacy RX FIFO or Enhanced RX FIFO and continues on message buffers.
1b - Matching starts from message buffers and continues on Legacy RX FIFO or Enhanced RX FIFO.</td></tr><tr><td>CAN_3</td><td>0b - Matching starts from RX FIFO and continues on message buffers.
1b - Matching starts from message buffers and continues on RX FIFO.</td></tr><tr><td>CAN_4</td><td>0b - Matching starts from RX FIFO and continues on message buffers.
1b - Matching starts from message buffers and continues on RX FIFO.</td></tr><tr><td>CAN_5</td><td>0b - Matching starts from RX FIFO and continues on message buffers.
1b - Matching starts from message buffers and continues on RX FIFO.</td></tr></table></td></tr>
<tr><td>17
RRS</td><td>Remote Request Storing
Determines what the module does with a remote request. The remote request frame is submitted to a matching process.
If this field is 1, the frame is stored in the corresponding message buffer in the same fashion as a data frame. No automatic remote response frame is generated.</td></tr>
</table>

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Field	Function
	If this field is 0, an automatic remote response frame is generated if a message buffer with CODE = 1010b is found with the same ID. You can only write to this field in Freeze mode. The module blocks it in other modes. 0b - Generated 1b - Stored
16 EACEN	Entire Frame Arbitration Field Comparison Enable for RX Message Buffers Controls the comparison of IDE and RTR fields within RX message buffer filters with their corresponding bits in the incoming frame by the matching process. If enabled, the IDE and RTR fields of the RX message buffer are compared to their corresponding bits within the incoming frame (mask bits apply). If disabled, the IDE field of the RX message buffer filter is always compared and RTR is never compared despite mask bits. This field does not affect matching for Legacy RX FIFO or Enhanced RX FIFO. You can only write to this field in Freeze mode; the module blocks it in other modes. 0b - Disable 1b - Enable
15 TIMER_SRC	Timer Source Selects the time tick source used for incrementing the free-running timer counter. If CAN bit clock is selected, it defines the baud rate on the CAN bus. If External time tick is selected, the period can be adjusted to match the baud rate on the CAN bus. It can also be adjusted to a different value as required. See the chip-specific section for details about the external time tick. You can only write to this field in Freeze mode. 0b - CAN bit clock 1b - External time tick
14 PREXCEN	Protocol Exception Enable Enables the protocol exception feature. You can only write to this field in Freeze mode. **NOTE** See Protocol exception event in the CAN Protocol standard (ISO 11898-1:2015) for details. 0b - Disabled 1b - Enabled
13 BTE	Bit Timing Expansion Enable Enables the use of Enhanced CAN Bit Timing Prescalers (EPRS), Enhanced Data Phase CAN Bit Timing (EDCBT), and Enhanced Nominal CAN Bit Timing (ENCBT) to configure the CAN bit timing segments, instead of using the bit timing fields of CAN Bit Timing (CBT), CAN FD Bit Timing (FDCBT), and Control 1 (CTRL1).

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Field	Function
	If this field is 1: • CTRL1[PRESDIV], CTRL1[PROPSEG], CTRL1[PSEG1], CTRL1[PSEG2], and CTRL1[RJW] are read as zero. A write operation to these fields has no effect. • CBT[EPRESDIV], CBT[ERJW], CBT[EPROPSEG], CBT[EPSEG1], and CBT[EPSEG2], and the corresponding fields in CAN FD Bit Timing (FDCBT), are read as zero. A write operation to these fields has no effect. • ETDC[ETDCOFF], ETDC[ETDCEN], ETDC[ETDCFAIL], and ETDC[ETDCVAL] are used by FlexCAN instead of FDCTRL[TDCOFF], FDCTRL[TDCEN], FDCTRL[TDCFAIL], and FDCTRL[TDCVAL]. These fields are read as zero, and a write operation to them has no effect. • ETDC[TDMDIS] can be used to disable transceiver delay measurement. 0b - Disable 1b - Enable
12 ISOCANFDEN	ISO CAN FD Enable Enables the CAN FD protocol according to ISO specification (ISO 11898-1:2015) (see CAN FD ISO compliance). When disabled, FlexCAN operates using the non-ISO CAN FD protocol. You can only write to this field in Freeze mode. **NOTE** FlexCAN is able to transmit FD frame format according to CAN Protocol standard (ISO 11898-1:2015). 0b - Disable 1b - Enable
11 EDFLTDIS	Edge Filter Disable Disables the edge filter used during the Bus Integration state. When the Edge Filter is enabled, two consecutive nominal time quanta with dominant bus states are required to detect an edge that causes synchronization. When synchronization occurs, the counting of the sequence of 11 consecutive recessive bits is restarted. The edge filter prevents dominant pulses that are shorter than a nominal bit time (present during the data phase of an FD frame) from being mistaken for an idle condition. You can only write to this field in Freeze mode. **NOTE** See Bus Integration state in the CAN Protocol standard (ISO 11898-1:2015) for details. 0b - Enabled 1b - Disabled
10 —	Reserved

Table continues on the next page...

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Field	Function
9-8 MBTSBASE	Message Buffer Timestamp Base Selects the timebase used for capturing the 16-bit TIME_STAMP field of the message buffer register. This field can be written in Freeze Mode only. 00b - TIMER 01b - Lower 16 bits of high-resolution timer 10b - Upper 16 bits of high-resolution timer 11b - Reserved
7-6 TSTAMPCAP	Timestamp Capture Point Configures the point in time when a 32-bit timebase is captured during a CAN frame. This base is stored in the high-resolution timestamp register (HR_TIME_STAMP). For classical CAN frames, capture points can be the start-of-frame bit or the point when CAN frame is considered valid. This point is the seventh bit of the end-of-frame for transmission and the sixth bit of the end-of-frame for reception. For CAN FD frames, the high-resolution timestamp can be captured at the start of frame, when a CAN FD frame is considered valid, or the res bit. You can only write to this field in Freeze mode. 00b - Disabled 01b - End of the CAN frame 10b - Start of the CAN frame 11b - Start of frame for classical CAN frames; res bit for CAN FD frames
5 —	Reserved
4-2 —	Reserved
1-0 —	Reserved

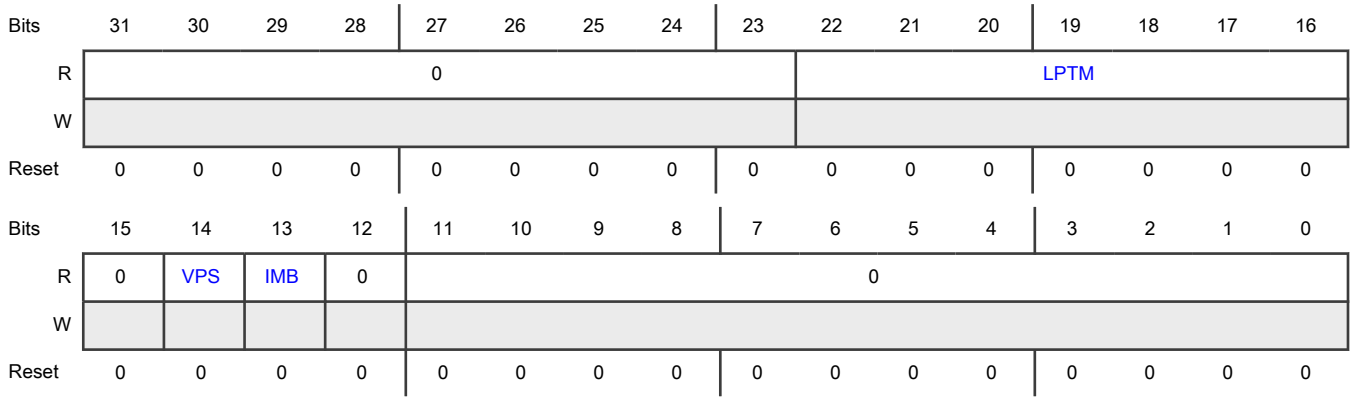
76.6.2.15 Error and Status 2 (ESR2)

Offset

Register	Offset
ESR2	38h

Function
Reports general status information.

Diagram



Fields

Field	Function
31-23 —	Reserved
22-16 LPTM	Lowest Priority TX Message Buffer Indicates the lowest number inactive message buffer when ESR2[VPS] = 1 (see ESR2[IMB]). If no message buffer is inactive, the message buffer indicated depends on the value of CTRL1[LBUF]. If CTRL1[LBUF] = 0, the message buffer indicated is the one with the greatest arbitration value (see Highest-priority message buffer first). If CTRL1[LBUF] = 1, the message buffer indicated is the active TX message buffer with the highest number. If a TX message buffer is being transmitted, it is not considered in the LPTM calculation. If ESR2[IMB] is not 0 and a frame is transmitted successfully, the value of LPTM is updated with its message buffer number.
15 —	Reserved
14 VPS	Valid Priority Status Indicates whether the contents of ESR2[IMB] and ESR2[LPTM] are valid. It becomes 1 upon every complete TX arbitration process, unless the CPU writes to the Control and Status word of a message buffer already scanned. In other words, it is behind the TX Arbitration Pointer, during the TX arbitration process. If there is no inactive message buffer and only one TX message buffer that is being transmitted, this field remains 0. This field becomes 0 upon the start of every TX arbitration process or upon a write to the Control and Status word of any message buffer. **NOTE** No CPU write to the Control and Status of a message buffer that the abort mechanism blocks affects this field. When MCR[AEN] = 1, the abort code write to the Control and Status of an MB being transmitted (pending abort) is blocked. Any write attempt to a TX MB with its IFLAG flag set is also blocked. 0b - Invalid 1b - Valid

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Field	Function
13 IMB	Inactive Message Buffer Indicates whether any message buffer is inactive (CODE field is either 1000b or 0b) when ESR2[VPS] = 1. This field becomes 1 when: • A lowest-priority TX message buffer (ESR2[LPTM]) is found and it is inactive during arbitration. • This field is not 1, and a frame is transmitted successfully. This field always becomes 0 at the start of arbitration (see Arbitration process). If a message buffer is successfully transmitted and this field is 0 (no inactive message buffer), ESR2[VPS] and this field both become 1. The index related to the MB transmitted is loaded into ESR2[LPTM]. In this case, the value of ESR2[LPTM] is the number of the first inactive message buffer. 0b - Message buffer indicated by ESR2[LPTM] is not inactive. 1b - At least one message buffer is inactive.
12 —	Reserved
11-0 —	Reserved

76.6.2.16 Cyclic Redundancy Check (CRCR)

Offset

Register	Offset
CRCR	44h

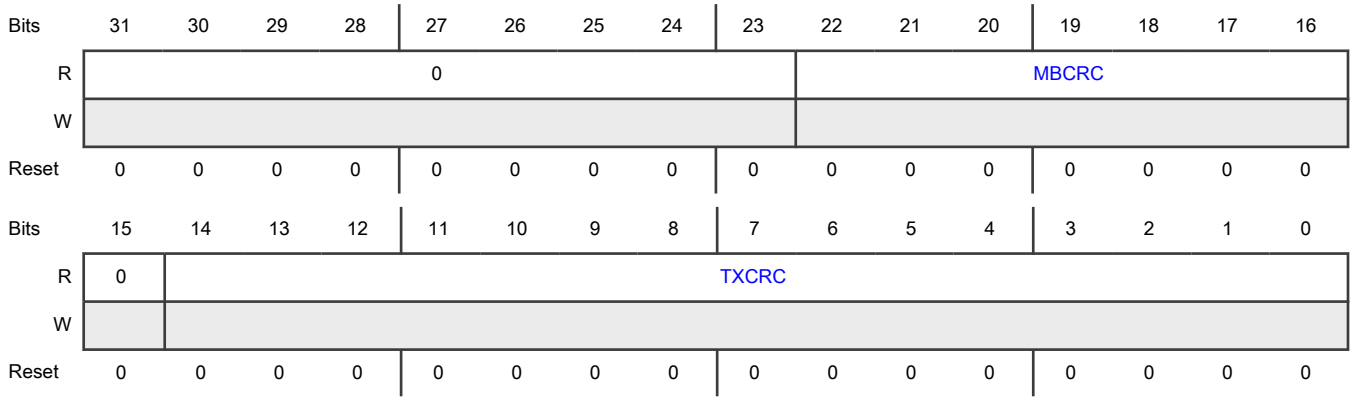
Function

Provides information about the CRC of transmitted messages for non-FD messages. This register only reports the 15 low-order bits of CRC calculations for messages in CAN FD format that require either 17 or 21 bits. For CAN FD format frames, you must use the CAN FD CRC (FDCRC). This register is updated at the same time that the TX interrupt flag is set.

NOTE

See CRC sequence calculation in the CAN Protocol standard (ISO 11898-1:2015) for details.

Diagram



Fields

Field	Function
31-23 —	Reserved
22-16 MBCRC	CRC Message Buffer Indicates the number of the message buffer corresponding to the value in CRCR[TXCRC].
15 —	Reserved
14-0 TXCRC	Transmitted CRC value Indicates the CRC value of the last transmitted message for non-FD frames. For FD frames, CRC value is reported in CAN FD CRC (FDCRC).

76.6.2.17 Legacy RX FIFO Global Mask (RXFGMASK)

Offset

Register	Offset
RXFGMASK	48h

Function

Masks the Legacy RX FIFO ID filter table elements that do not have a corresponding RXIMR according to CTRL2[RFFN], when Legacy RX FIFO is enabled.

This register is located in RAM.

You can only write to this register in Freeze mode; the module blocks it in other modes.

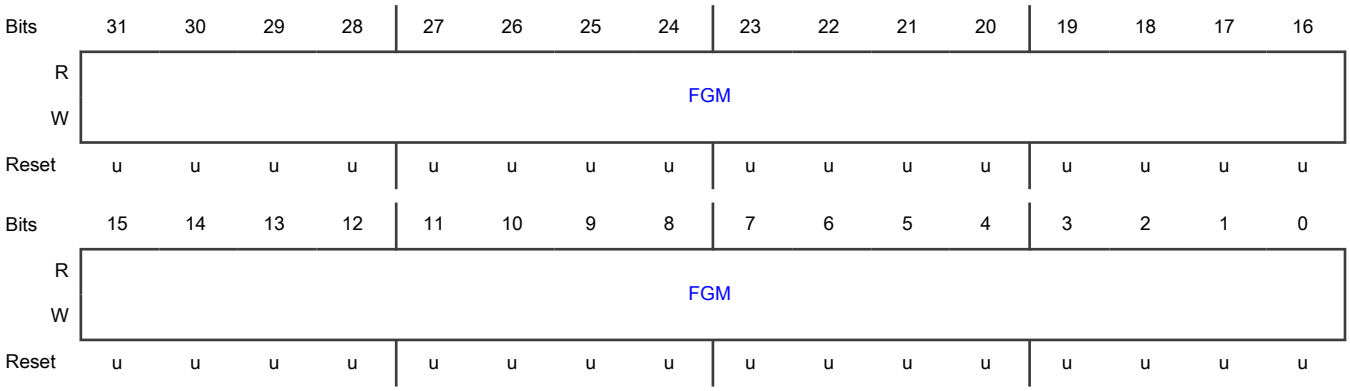
The following table shows how the FGM bits correspond to each IDAF field.

Table 569. Correspondence of Legacy RX FIFO global mask bits to IDF fields

Legacy RX FIFO ID filter table elements format (MCR[IDAM])	Identifier acceptance filter fields					
	RTR	IDE	RXIDA	RXIDB [1]	RXIDC [2]	Reserved
A	FGM[31]	FGM[30]	FGM[29:1]	—	—	FGM[0]
B	FGM[31], FGM[15]	FGM[30], FGM[14]	—	FGM[29:16], FGM[13:0]		—
C	—	—		—	FGM[31:24], FGM[23:16], FGM[15:8], FGM[7:0]	

1. If MCR[IDAM] is equivalent to format B, only the 14 most significant bits of the identifier of the incoming frame are compared with the Legacy RX FIFO filter.
2. If MCR[IDAM] is equivalent to format C, only the eight most significant bits of the identifier of the incoming frame are compared with the Legacy RX FIFO filter.

Diagram



Fields

Field	Function
31-0 FGM	Legacy RX FIFO Global Mask Bits Masks the ID filter table elements bits in a perfect alignment. 0b - The corresponding bit in the filter is "don't care." 1b - The corresponding bit in the filter is checked.

76.6.2.18 Legacy RX FIFO Information (RXFIR)

Offset

Register	Offset
RXFIR	4Ch

Function

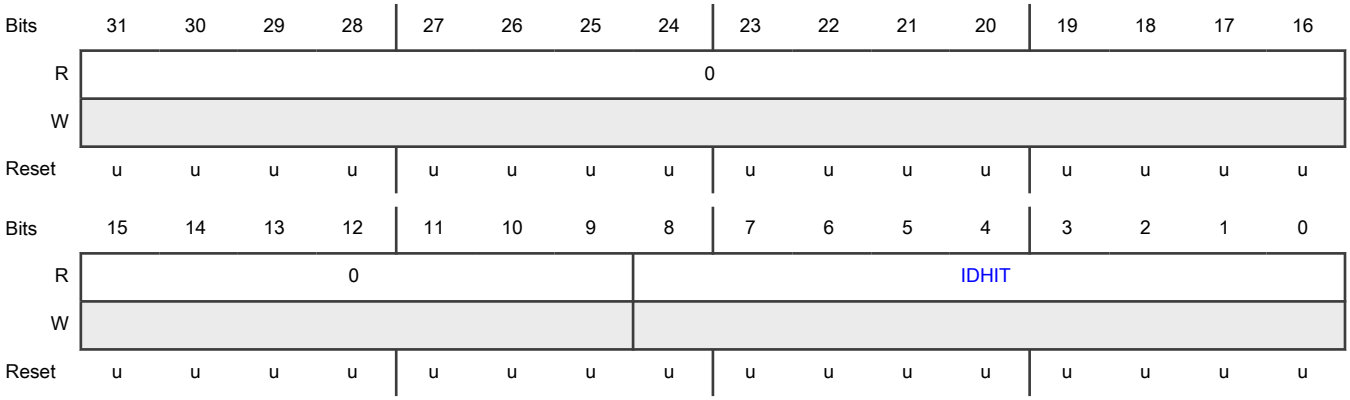
Provides information about Legacy RX FIFO.

This register is the port through which the CPU accesses the output of the Legacy RXFIR FIFO located in RAM. FlexCAN writes to the Legacy RXFIR FIFO when a new message is moved into the Legacy RX FIFO. Also, its output is updated whenever the output of the Legacy RX FIFO is updated with the next message. See Legacy RX FIFO for instructions on reading this register.

NOTE

RXFIR can be written only during memory initialization, due to the error code correction (ECC) feature. In every other case, this register is read-only.

Diagram



Fields

Field	Function
31-9 —	Reserved
8-0 IDHIT	Identifier Acceptance Filter Hit Indicator Indicates which Identifier Acceptance filter that the received message hit in the output of the Legacy RX FIFO. If multiple filters match the incoming message ID, the first matching IDAF found (lowest number) by the matching process is indicated. This field is valid only when IFLAG1[BUF5I] is set.

76.6.2.19 CAN Bit Timing (CBT)

Offset

Register	Offset
CBT	50h

Function

Provides an alternative way to store the CAN bit timing variables described in Control 1 (CTRL1). EPRESDIV, EPROPSEG, EPSEG1, EPSEG2, and ERJW are extended versions of CTRL1[PRESDIV], CTRL1[PROPSEG], CTRL1[PSEG1], CTRL1[PSEG2], and CTRL1[RJW] respectively.

NOTE

The CAN bit variables in CTRL1 and in CBT are stored in the same register.

CBT[BTF] selects the use of the timing variables defined in this register.

When the CAN FD feature is enabled (MCR[FDEN] = 1), always write 1 to CBT[BTF].

Soft reset does not affect the contents of this register.

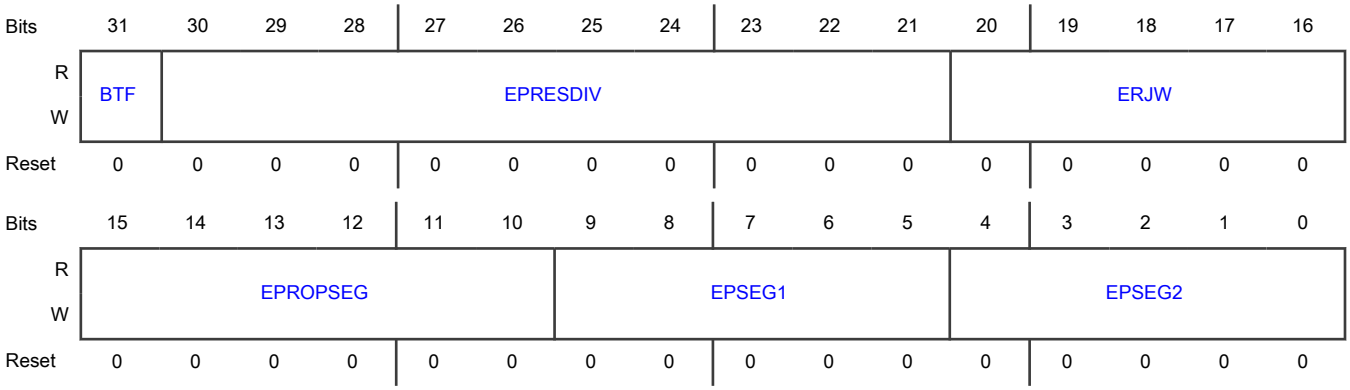
NOTE

Ensure that bit time settings and protocol engine tolerance are in compliance with the CAN Protocol standard (ISO 11898-1:2015).

NOTE

If CTRL2[BTE] = 1, EPRESDIV, ERJW, EPROPSEG, EPSEG1, and EPSEG2 are read as zero. A write operation to them has no effect.

Diagram



Fields

Field	Function
31 BTF	Bit Timing Format Enable Enables the use of extended CAN bit timing fields EPRESDIV, EPROPSEG, EPSEG1, EPSEG2, and ERJW. These fields replace the CAN bit timing variables defined in Control 1 (CTRL1). This field can be written in Freeze mode only. 0b - Disable 1b - Enable
30-21 EPRESDIV	Extended Prescaler Division Factor Defines the ratio between the PE clock frequency and the serial clock (Sclock) frequency when CBT[BTF] = 1, otherwise it has no effect. It extends the CTRL1[PRESDIV] value range. The Sclock period defines the time quantum of the CAN protocol. For the reset value, the Sclock frequency is equal to the PE clock frequency (see Protocol timing). This field can be written only in Freeze mode; the module blocks it in other modes. Sclock frequency = PE clock frequency ÷ (EPRESDIV + 1)

Table continues on the next page...

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Field	Function
20-16 ERJW	Extended Resync Jump Width Defines the maximum number of time quanta that one resynchronization can change a bit time when CBT[BTF] = 1. Otherwise, it has no effect. It extends the CTRL1[RJW] value range. This field can be written only in Freeze mode; the module blocks it in other modes. Resync Jump Width = ERJW + 1. One Time Quantum = one Sclock period.
15-10 EPROPSEG	Extended Propagation Segment Defines the length of the propagation segment in the bit time when CBT[BTF] = 1, otherwise it has no effect. It extends the CTRL1[PROPSEG] value range. This field can be written only in Freeze mode; the module blocks it in other modes. Propagation Segment Time = (EPROPSEG + 1) × Time Quanta. One Time Quantum = one Sclock period.
9-5 EPSEG1	Extended Phase Segment 1 Defines the length of phase segment 1 in the bit time when CBT[BTF] = 1, otherwise it has no effect. It extends the CTRL1[PSEG1] value range. This field can be written only in Freeze mode; the module blocks it in other modes. Phase Buffer Segment 1 = (EPSEG1 + 1) × Time Quanta. One Time Quantum = one Sclock period.
4-0 EPSEG2	Extended Phase Segment 2 Defines the length of phase segment 2 in the bit time when CBT[BTF] = 1, otherwise it has no effect. It extends the CTRL1[PSEG2] value range. This field can be written only in Freeze mode; the module blocks it in other modes. Phase Buffer Segment 1 = (EPSEG2 + 1) × Time Quanta. One Time Quantum = one Sclock period.

76.6.2.20 Interrupt Masks 3 (IMASK3)

Offset

Register	Offset
IMASK3	6Ch

Function

Enables or disables any number of the 32 message buffer interrupts for MB95–MB64. It contains one interrupt mask bit per buffer. This configuration allows the CPU to determine which buffer generates an interrupt after a successful transmission or reception when the corresponding IFLAG3 flag is set.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
CAN_0	IMASK3	—
CAN_1	IMASK3	—
CAN_2	IMASK3	—
CAN_3	—	IMASK3
CAN_4	—	IMASK3
CAN_5	—	IMASK3

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	BUF95TO64M															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	BUF95TO64M															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 BUF95TO64M	Buffer MBi Mask Enables or disables the corresponding FlexCAN message buffer interrupt for MB95–MB64. When CAN FD is enabled, the MB range is defined in accordance with FDCTRL[MBDSRn]. **NOTE** If the corresponding IFLAG3 flag is set, writing 1 or 0 to a field in IMASK3 can set or clear an interrupt request. 0b - The corresponding buffer interrupt is disabled. 1b - The corresponding buffer interrupt is enabled.

76.6.2.21 Interrupt Flags 3 (IFLAG3)

Offset

Register	Offset
IFLAG3	74h

Function

Defines the flags for the 32 message buffer interrupts for MB95–MB64. It contains one interrupt flag bit per buffer. Each successful transmission or reception sets the corresponding IFLAG3 flag. If the corresponding IMASK3 bit is 1, an interrupt is generated. The interrupt flag must be cleared by writing 1 to it. Writing 0 has no effect.

Before updating MCR[MAXMB], the CPU must service the IFLAG3 flags whose MB value is greater than the MAXMB to be updated. Otherwise, they remain set and are inconsistent with the number of message buffers available.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
CAN_0	IFLAG3	—
CAN_1	IFLAG3	—
CAN_2	IFLAG3	—
CAN_3	—	IFLAG3
CAN_4	—	IFLAG3
CAN_5	—	IFLAG3

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BUF95TO64															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BUF95TO64															
W	W1C															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 BUF95TO64	Buffer MBi Interrupt Flags the corresponding FlexCAN message buffer interrupt for MB95–MB64.When CAN FD is enabled, the MB range is defined in accordance with FDCTRL[MBDSRn]. 0b - The corresponding buffer has no occurrence of successfully completed transmission or reception. 1b - The corresponding buffer has successfully completed transmission or reception.

76.6.2.22 Receive Individual Mask (RXIMR0 - RXIMR95)

Offset

For n = 0 to 95:

Register	Offset
RXIMRn	880h + (n × 4h)

Function

Stores the acceptance masks for ID filtering in RX message buffers and the Legacy RX FIFO.

When the Legacy RX FIFO is disabled (MCR[RFEN] = 0), an individual mask is provided for each available RX message buffer on a one-to-one correspondence. When the Legacy RX FIFO is enabled (MCR[RFEN] = 1), an individual mask is provided for each Legacy RX FIFO ID filter table element on a one-to-one correspondence. This correspondence depends on the setting of CTRL2[RFFN] (see Legacy RX FIFO).

RXIMR0 stores the individual mask associated with either MB0 or ID filter table element 0. RXIMR1 stores the individual mask associated with either MB1 or ID filter table element 1, and so on.

The CPU can only access the RXIMR registers when the module is in Freeze mode; otherwise, the module blocks them. Reset does not affect these registers. They are located in RAM and must be explicitly initialized prior to any reception.

It is possible for the RXIMR memory region to be accessed as general-purpose memory. See Bus interface for more information.

NOTE

Each module instance supports a different number of registers.

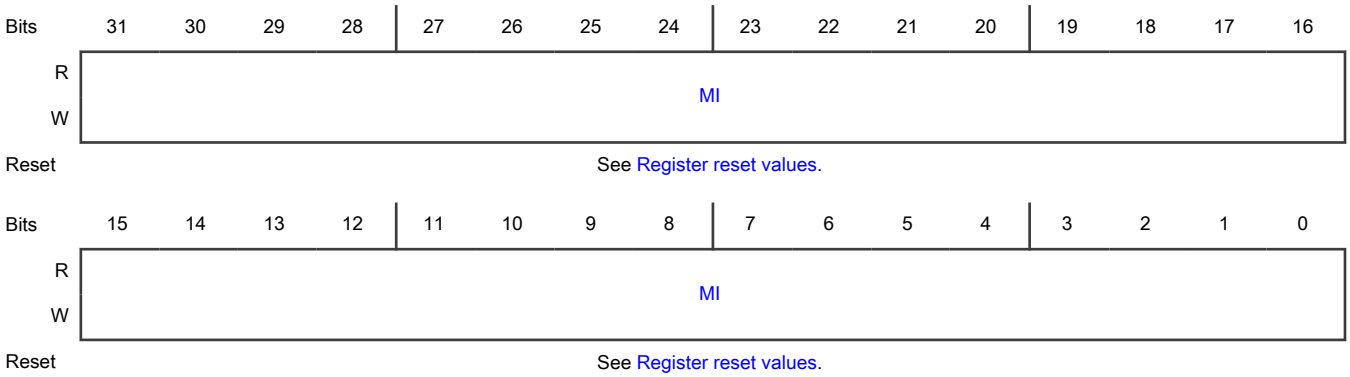
Instance	Register supported	Register not supported
CAN_0	RXIMR0–RXIMR95	—
CAN_1	RXIMR0–RXIMR95	—
CAN_2	RXIMR0–RXIMR95	—
CAN_3	RXIMR0–RXIMR63	RXIMR64–RXIMR95
CAN_4	RXIMR0–RXIMR63	RXIMR64–RXIMR95

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
CAN_5	RXIMR0–RXIMR63	RXIMR64–RXIMR95

Diagram



Register reset values

Register	Reset value
RXIMR0–RXIMR63	CAN_0–CAN_5: undefined
RXIMR64–RXIMR95	CAN_0–CAN_2: undefined CAN_3–CAN_5: Register not supported

Fields

Field	Function
31-0 MI	Individual Mask Bits Masks the corresponding bit in both the message buffer filter and Legacy RX FIFO ID filter table element in distinct ways. For message buffer filters, see RX Message Buffers Global Mask (RXMGMASK). For Legacy RX FIFO ID filter table elements, see Legacy RX FIFO Global Mask (RXFGMASK). 0b - The corresponding bit in the filter is "don't care." 1b - The corresponding bit in the filter is checked.

76.6.2.23 Memory Error Control (MECR)

Offset

Register	Offset
MECR	AE0h

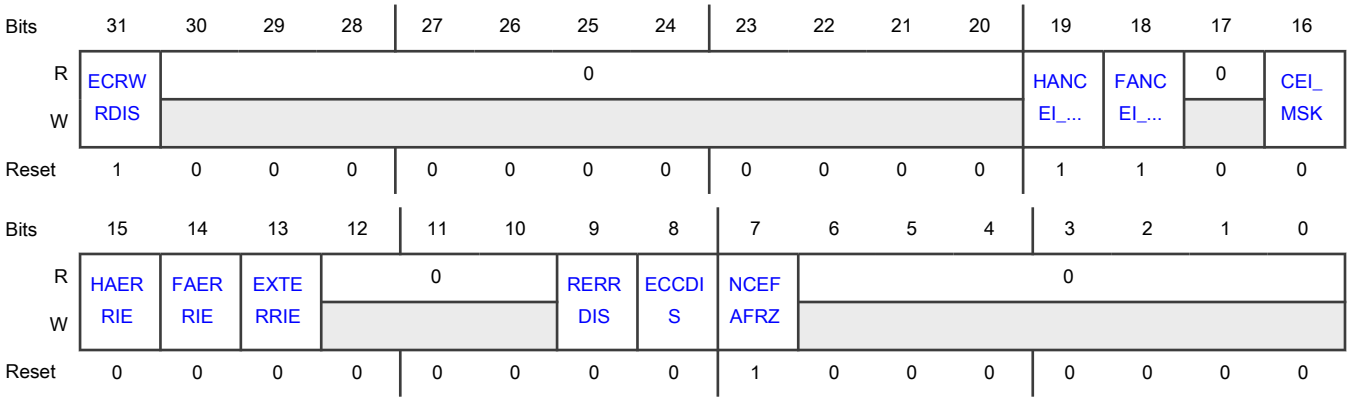
Function

Contains control bits for memory error detection and correction (ECC).

NOTE

When CTRL2[ECRWRE] = 0, writes to this register are blocked, except for MECR[ECRWRDIS].

Diagram



Fields

Field	Function
31 ECRWRDIS	Error Configuration Register Write Disable Disables writes on this register. This field automatically becomes 1 (disabled) when CTRL2[ECRWRE] is 1. The protocol described in Detection and correction of memory errors must be followed. 0b - Enable 1b - Disable
30-20 —	Reserved
19 HANCEI_MSK	Host Access with Noncorrectable Errors Interrupt Mask Enables the interrupt for noncorrectable errors detected in memory reads issued by the host (CPU). 0b - Disable 1b - Enable
18 FANCEI_MSK	FlexCAN Access with Noncorrectable Errors Interrupt Mask Enables the interrupt for noncorrectable errors detected in memory reads issued by FlexCAN internal processes. 0b - Disable 1b - Enable
17	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
16 CEI_MSK	Correctable Errors Interrupt Mask Enables the interrupt for correctable errors detected in memory reads issued by the host or FlexCAN internal processes. 0b - Disable 1b - Enable
15 HAERRIE	Host Access Error Injection Enable Enables the injection of errors only in memory reads issued by the host (CPU). 0b - Disable 1b - Enable
14 FAERRIE	FlexCAN Access Error Injection Enable Enables the injection of errors only in memory reads issued by FlexCAN internal processes. 0b - Disable 1b - Enable
13 EXTERRIE	Extended Error Injection Enable Extends the error injection on 32-bit memory accesses to the complementary 32-bit word. This feature uses the same 32-bit error injection data and parity words used for 64-bit memory accesses performed by internal FlexCAN processes. See Error Injection Data Pattern (ERRIDPR) and Error Injection Parity Pattern (ERRIPPR). 0b - Disable. Apply error injection only to the 32-bit word. 1b - Enable. Apply error injection to the 64-bit word.
12-10 —	Reserved
9 RERRDIS	Error Report Disable Disables the update of the error report registers. The update of error-related flags and the generation of bus transfer errors are still active. **NOTE** When reading the report registers, this field must be 1 to ensure coherence on the consecutive register reads. 0b - Enable 1b - Disable
8 ECCDIS	Error Correction Disable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Completely disables the memory detection and correction mechanism. Besides disabling the error report mechanism, it also stops the update of the error-related flags and the generation of bus transfer errors. The parity bits continue to be calculated and written into memory on write transactions. 0b - Enable 1b - Disable
7 NCEFAFRZ	Noncorrectable Errors in FlexCAN Access Put Chip in Freeze Mode Determines whether to put FlexCAN into Freeze mode when a noncorrectable error is detected in a memory read performed by FlexCAN internal processes. In this case, entering Freeze mode prevents FlexCAN internal processes from treating corrupted data as valid. See Freeze mode for more information. 0b - Normal operation 1b - Freeze mode
6-0 —	Reserved

76.6.2.24 Error Injection Address (ERRIAR)

Offset

Register	Offset
ERRIAR	AE4h

Function

Contains the address where error is to be injected.

Use the following table to convert from the memory map address to the location in the physical FlexCAN RAM. Where pairs of values are provided, the first is the address for MCR[FDEN] = 0, the second is for MCR[FDEN] = 1.

Table 570. Error injection address for classical CAN format

RAM contents	Injection address	Memory map
FlexCAN registers	Not mapped	—
Message buffers	0000h	0080h
RXIMRs	600h	0880h
RXFIR_0	780h	0A80h
RXFIR_1	784h	0A84h
RXFIR_2	788h	0A88h
RXFIR_3	78Ch	0A8Ch

Table continues on the next page...

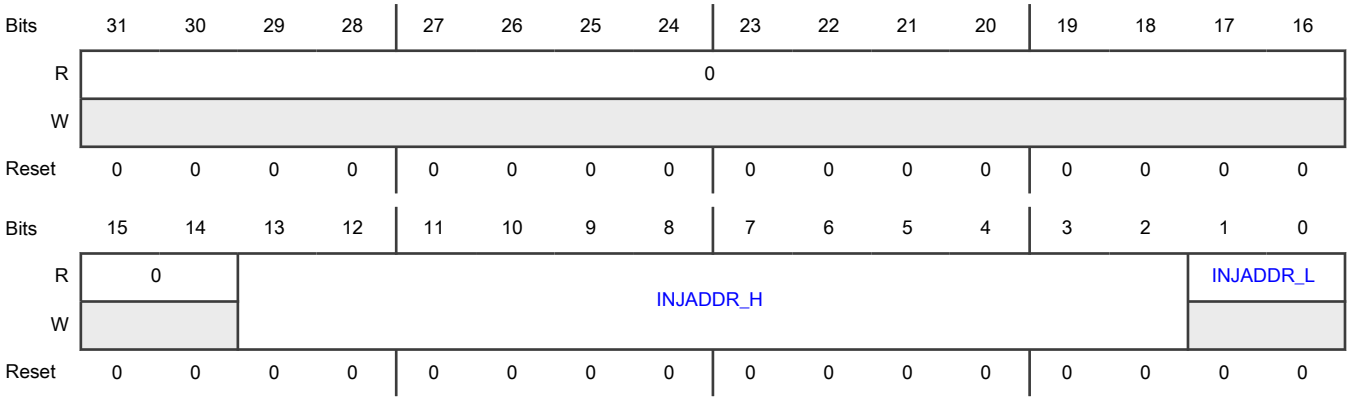
Table 570. Error injection address for classical CAN format (continued)

RAM contents	Injection address	Memory map
RXFIR_4	790h	0A90h
RXFIR_5	794h	0A94h
Reserved	—	0A98h
RXMGMASK	7A0h	0AA0h
RXFGMASK	7A4h	0AA4h
RX14MASK	7A8h	0AA8h
RX15MASK	7ACh	0AACh
Tx_SMB	7B0h	0AB0h / 0F28h
Rx_SMB0	7C0h / 7F8h	0AC0h / 0F70h
Rx_SMB1	7D0h / 840h	0AD0h / 0FB8h
Rx_SMB0_TIME_STAMP	888h	0C20h
Rx_SMB1_TIME_STAMP	88Ch	0C24h
HR_TIME_STAMP	890h	0C30h
Enhanced RX FIFO	A10h	2000h
ERFFEL	1050h	3000h

NOTE

For RXFIR, Enhanced RX FIFO, and HR_TIME_STAMP addresses, you must inject ECC errors in host access only.

Diagram



Fields

Field	Function
31-14	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
13-2 INJADDR_H	Error Injection Address High Defines the 12 most significant bits of the physical RAM address where error is to be injected (see table above).
1-0 INJADDR_L	Error Injection Address Low Defines the two least significant bits of the physical RAM address where error is to be injected. These bits ensure that the address is on a 32-bit boundary.

76.6.2.25 Error Injection Data Pattern (ERRIDPR)

Offset

Register	Offset
ERRIDPR	AE8h

Function

Contains the error pattern to be injected in the data word read from memory.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	DFLIP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DFLIP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DFLIP	Data Flip Pattern Contains the flip pattern. Bits set to 1 in the flip pattern cause the corresponding data bit in the word read from memory to invert.

76.6.2.26 Error Injection Parity Pattern (ERRIPPR)

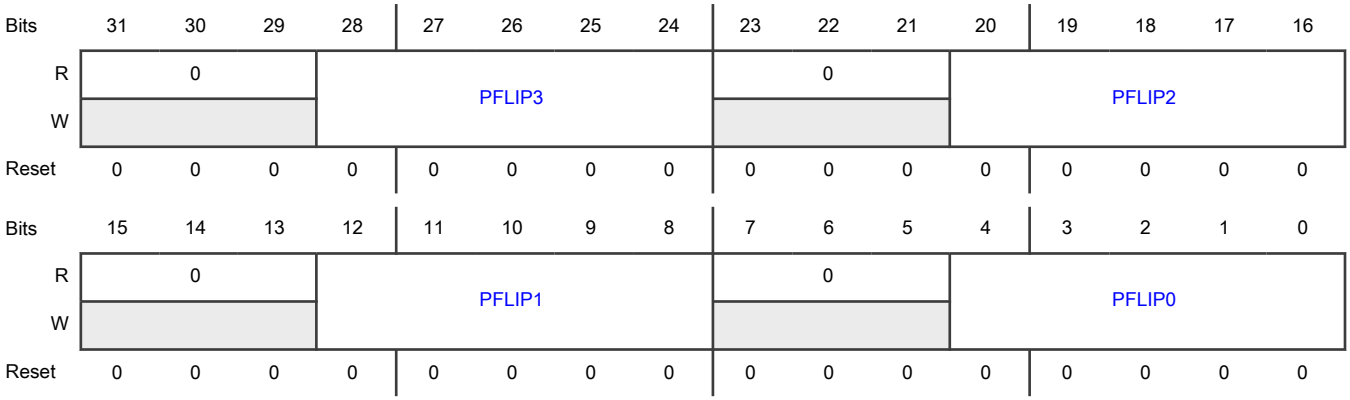
Offset

Register	Offset
ERRIPPR	AECh

Function

Contains the error pattern to be injected in parity bits read from memory with the data word. Bits set to 1 in the flip pattern cause the corresponding parity bit in the word read from memory to invert.

Diagram



Fields

Field	Function
31-29 —	Reserved
28-24 PFLIP3	Parity Flip Pattern for Byte 3 (Most Significant) Contains the error injection pattern for Byte 3.
23-21 —	Reserved
20-16 PFLIP2	Parity Flip Pattern for Byte 2 Contains the error injection pattern for Byte 2.
15-13 —	Reserved
12-8 PFLIP1	Parity Flip Pattern for Byte 1 Contains the error injection pattern for Byte 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
7-5 —	Reserved
4-0 PFLIP0	Parity Flip Pattern for Byte 0 (Least Significant) Contains the error injection pattern for Byte 0.

76.6.2.27 Error Report Address (RERRAR)

Offset

Register	Offset
RERRAR	AF0h

Function

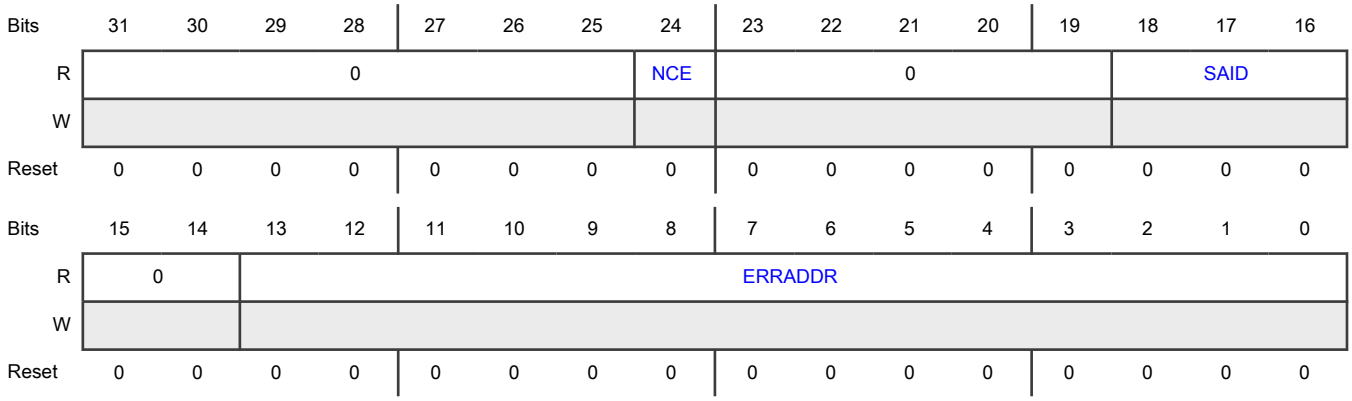
Reports the address used for an access operation in which an error (correctable or noncorrectable) was detected. Also reports the identification of the source of that access.

This address is always reported using a 32-bit alignment. Non-aligned accesses (ERRADDR[1:0] nonzero) are reported with the address aligned, and data is reported in Error Report Data (RERRDR) shifted accordingly. When errors are detected in accesses larger than 32-bit (as performed by FlexCAN internal processes), the address of the 32-bit word where the error was detected is reported. For errors detected in more than one 32-bit word, only the least significant address is reported.

Table 571. Source of memory access

SAID[2:0]	Error during...
0	Move-out FlexCAN access
1	Move-in
2	TX arbitration
3	RX matching
4	Move-out host access
5–7	Reserved

Diagram



Fields

Field	Function
31-25 —	Reserved
24 NCE	Noncorrectable Error Indicates that the report is due to a noncorrectable error. 0b - Reporting a correctable error 1b - Reporting a noncorrectable error
23-19 —	Reserved
18-16 SAID	SAID SAID[2] — Identification of the requester of the memory read request: • 0 = Requested by FlexCAN internal processes • 1 = Requested by host (CPU) SAID[1] — Details of FlexCAN operation: • 0 = Move • 1 = Scanning SAID[0] — Operation that requested the memory read: • 0 = Transmission • 1 = Reception For more information, see Table 571.
15-14 —	Reserved
13-0	Address Where Error Detected

Table continues on the next page...

Table continued from the previous page...

Field	Function
ERRADDR	See description of Error Injection Address (ERRIAR).

76.6.2.28 Error Report Data (RERRDR)

Offset

Register	Offset
RERRDR	AF4h

Function

Reports the raw data (unmodified by the correction performed by ECC logic) read from memory with error. The value reported does not represent the transient values of the BUSY bit (see Table 577) when reading a message buffer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RDATA	Raw Data Word Read from Memory with Error

76.6.2.29 Error Report Syndrome (RERRSYNR)

Offset

Register	Offset
RERRSYNR	AF8h

Function

Contains the syndrome detected in a memory read with error. It also reports the bytes which were read in this 32-bit read transaction.

Each SYND*n* field indicates the type of error and which bit in byte (*n*) the error affects. SYND3 corresponds to the most significant byte in the data word read from memory; SYND0 corresponds to the least significant.

Table 572. Syndrome definition

SYND*n* (hex)	Type	Bit affected
00	—	None (no error)
01	Code	0
02	Code	1
04	Code	2
07	Data	5
08	Code	3
0E	Data	7
10	Code	4
13	Data	2
15	Data	6
16	Data	1
19	Data	3
1A	Data	4
1C	Data	0
06	—	All-zeroes noncorrectable error
1F	—	All-ones noncorrectable error
All others	—	Noncorrectable error

Each BEn field indicates which byte in the 32-bit word reported was effectively read. The syndrome bits are calculated for all bytes, including the non-read ones. Errors detected in non-read bytes are indicated (see Error indication) and reported (see Error reporting).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	BE3	0			SYND3				BE2	0			SYND2			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	BE1	0			SYND1				BE0	0			SYND0			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 BE3	Byte Enabled for Byte 3 (Most Significant) 0b - Byte was not read. 1b - Byte was read.
30-29 —	Reserved
28-24 SYND3	Error Syndrome for Byte 3 (Most Significant) See Table 572.
23 BE2	Byte Enabled for Byte 2 0b - Byte was not read. 1b - Byte was read.
22-21 —	Reserved
20-16 SYND2	Error Syndrome for Byte 2 See Table 572.
15 BE1	Byte Enabled for Byte 1 0b - Byte was not read. 1b - Byte was read.
14-13 —	Reserved
12-8 SYND1	Error Syndrome for Byte 1 See Table 572.
7 BE0	Byte Enabled for Byte 0 (Least Significant) 0b - Byte was not read. 1b - Byte was read.
6-5 —	Reserved
4-0 SYND0	Error Syndrome for Byte 0 (Least Significant) See Table 572.

76.6.2.30 Error Status (ERRSR)

Offset

Register	Offset
ERRSR	AFCh

Function

Contains the status bits of the error correction and detection operations. These flags can be cleared by writing 1 to them. Writing 0 has no effect.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0												HANCEIF	FANCEIF	0	CEIF
W													W1C	W1C		W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												HANCEIOF	FANCEIOF	0	CEIOF
W													W1C	W1C		W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20 —	Reserved
19 HANCEIF	Host Access with Noncorrectable Error Interrupt Flag Indicates that a noncorrectable error was detected in a memory read initiated by host. A bus transfer error is asserted for that access. If MECR[HANCEI_MSK] = 1, the interrupt is 1. 0b - No errors detected 1b - Error detected
18 FANCEIF	FlexCAN Access with Noncorrectable Error Interrupt Flag Indicates that a noncorrectable error was detected in a memory read initiated by FlexCAN internal processes. If MECR[FANCEI_MSK] = 1, the interrupt is 1. 0b - No errors detected 1b - Error detected
17	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
16 CEIF	Correctable Error Interrupt Flag Indicates that a correctable error was detected in a memory read. If MECR[CEI_MSK] = 1, the interrupt is 1. 0b - No errors detected 1b - Error detected
15-4 —	Reserved
3 HANCEIOF	Host Access With Noncorrectable Error Interrupt Overrun Flag Indicates that a noncorrectable error was detected in a memory read initiated by host when ERRSR[HANCEIF] was set. No interrupt is associated with this flag. See Error indication. 0b - No errors detected 1b - Error detected
2 FANCEIOF	FlexCAN Access with Noncorrectable Error Interrupt Overrun Flag Indicates that a noncorrectable error was detected in a memory read initiated by FlexCAN internal processes when ERRSR[FANCEIF] was set. No interrupt is associated with this flag. See Error indication. 0b - No errors detected 1b - Error detected
1 —	Reserved
0 CEIOF	Correctable Error Interrupt Overrun Flag Indicates that a correctable error was detected in a memory read when ERRSR[CEIF] was set. No interrupt is associated with this flag. See Error indication. 0b - No errors detected 1b - Error detected

76.6.2.31 Enhanced CAN Bit Timing Prescalers (EPRS)

Offset

Register	Offset
EPRS	BF0h

Function

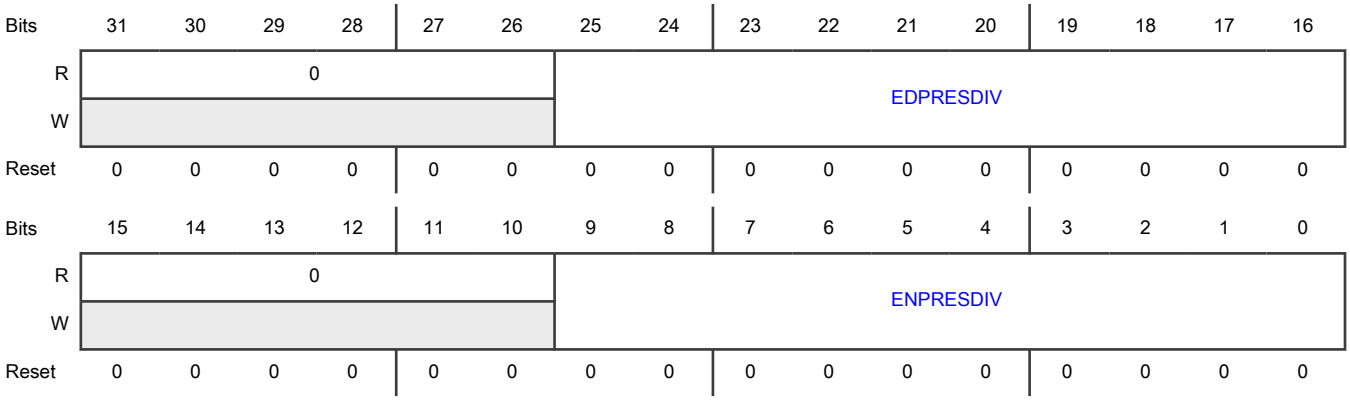
Defines the CAN bit timing prescalers for the nominal phase and data phase when CTRL2[BTE] = 1.

Used by the module only if CTRL2[BTE] = 1; otherwise a write operation has no effect and all fields are read as zero.

This register can be written only in Freeze mode; the module blocks it in other modes.

Soft reset does not affect the contents of this register.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-16 EDPRESDIV	Extended Data Phase Prescaler Division Factor Defines the ratio between the PE clock frequency and the Sclock frequency in the data phase of a CAN FD message when CTRL2[BTE] = 1. The Sclock period defines the time quantum of the CAN FD protocol for the data bit rate. Sclock frequency = PE clock frequency ÷ (EDPRESDIV + 1) **NOTE** To minimize errors when processing FD frames, use the same value for this field and for EPRS[ENPRESDIV]. See the first note in CAN FD frames for details.
15-10 —	Reserved
9-0 ENPRESDIV	Extended Nominal Prescaler Division Factor Defines the ratio between the PE clock frequency and the Sclock frequency when CTRL2[BTE] = 1. Otherwise, it reads as 0 and a write operation has no effect. The Sclock period defines the time quantum of the CAN protocol in the nominal phase. For the reset value, the Sclock frequency is equal to the PE clock frequency (see Protocol timing). Sclock frequency = PE clock frequency ÷ (ENPRESDIV + 1)

76.6.2.32 Enhanced Nominal CAN Bit Timing (ENCBT)

Offset

Register	Offset
ENCBT	BF4h

Function

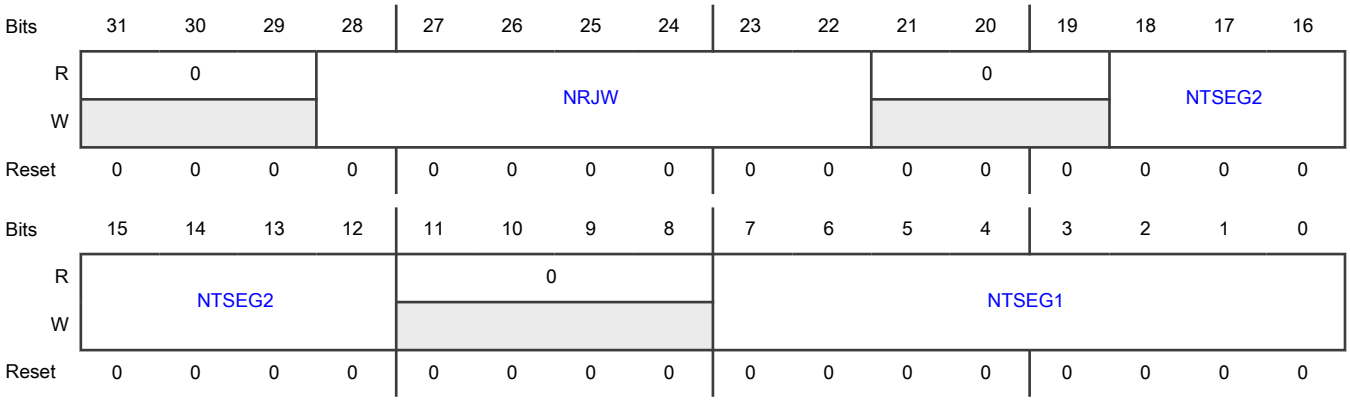
Provides an alternative way to store the CAN bit timing variables described in Control 1 (CTRL1) and CAN Bit Timing (CBT), to get higher CAN bit timing resolution.

This register is used by the module only if CTRL2[BTE] = 1. Otherwise, a write operation has no effect and all fields are read as zero.

Soft reset does not affect the contents of this register.

This register can be written only in Freeze mode; the module blocks it in other modes.

Diagram



Fields

Field	Function
31-29 —	Reserved
28-22 NRJW	Nominal Resynchronization Jump Width Defines the maximum number of time quanta that one resynchronization can change a nominal bit time when CTRL2[BTE] = 1. Otherwise, it has no effect. One time quantum = one Sclock period Nominal Resync Jump Width = NRJW + 1
21-19 —	Reserved

Table continues on the next page...

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Field	Function
18-12 NTSEG2	Nominal Time Segment 2 Defines the length of Time Segment 2 in the nominal bit time when CTRL2[BTE] = 1. Otherwise, it has no effect. Nominal Time Segment 2 = (NTSEG2 + 1) × Time Quanta One time quantum = one Sclock period
11-8 —	Reserved
7-0 NTSEG1	Nominal Time Segment 1 Defines the length of Time Segment 1 in the bit time when CTRL2[BTE] = 1. Otherwise, it has no effect. Nominal Time Segment 1 = (NTSEG1 + 1) × Time Quanta One time quantum = one Sclock period

76.6.2.33 Enhanced Data Phase CAN Bit Timing (EDCBT)

Offset

Register	Offset
EDCBT	BF8h

Function

Provides an alternative way to store the data phase CAN bit timing variables described in CAN FD Bit Timing (FDCBT) to achieve higher CAN bit timing resolution.

This register is used by the module only if CTRL2[BTE] = 1; otherwise a write operation has no effect and all fields are read as zero.

Soft reset does not affect the contents of this register.

This register can be written only in Freeze mode; the module blocks it in other modes.

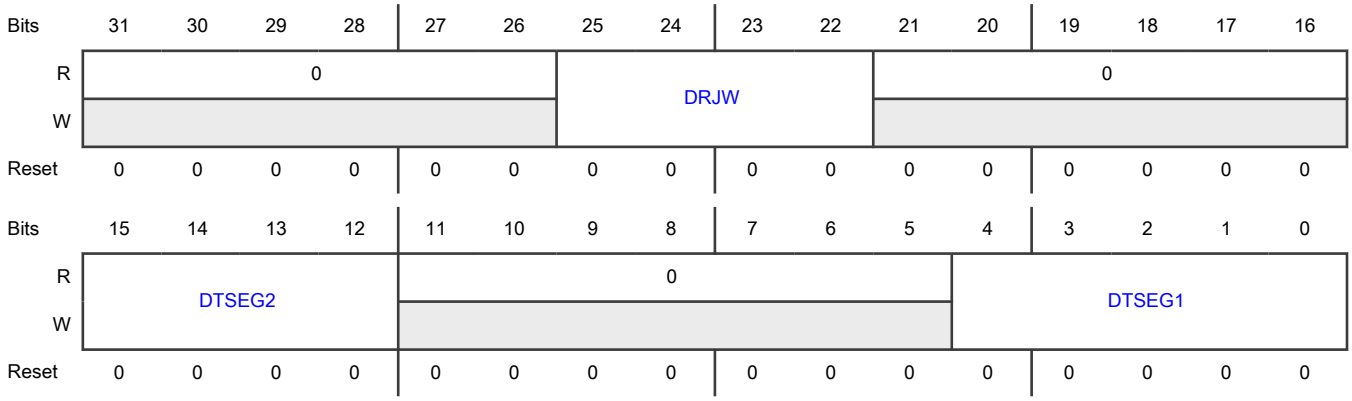
NOTE

Ensure that bit time settings and protocol engine tolerance are in compliance with the CAN Protocol standard (ISO 11898-1:2015).

NOTE

DTSEG1 must be at least two time quanta.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-22 DRJW	Data Phase Resynchronization Jump Width Defines the maximum number of time quanta that one resynchronization can change a data phase bit time when CTRL2[BTE] = 1. Otherwise, it has no effect. Data Phase Resync Jump Width = DRJW + 1.
21-16 —	Reserved
15-12 DTSEG2	Data Phase Time Segment 2 Defines the length of time segment 2 in the data phase bit time when CTRL2[BTE] = 1. Otherwise, it has no effect. Data Phase Time Segment 2 = (DTSEG2 + 1) × Time Quanta. One Time Quantum = one Sclock period.
11-5 —	Reserved
4-0 DTSEG1	Data Phase Segment 1 Defines the length of time segment 1 in the data phase bit time when CTRL2[BTE] = 1. Otherwise, it has no effect. Data Phase Time Segment 1 = (NTSEG1 + 1) × Time Quanta. One Time Quantum = one Sclock period.

76.6.2.34 Enhanced Transceiver Delay Compensation (ETDC)

Offset

Register	Offset
ETDC	BFCh

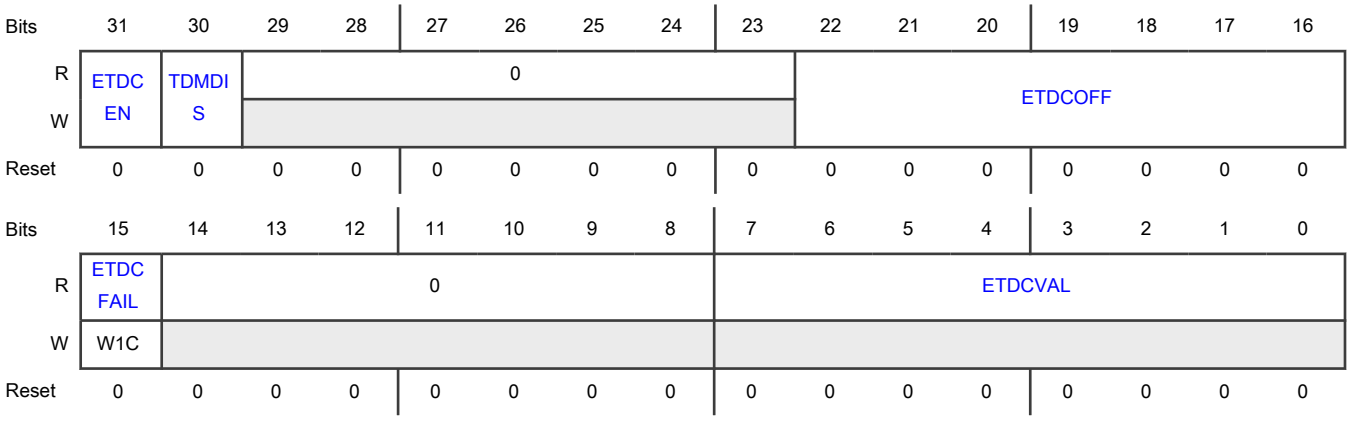
Function

Contains extended versions of FDCTRL[TDCOFF] and FDCTRL[TDCVAL]. This register is used by the module only if CTRL2[BTE] = 1. Otherwise, a write operation has no effect and all fields are read as zero.

NOTE

See Transmitter delay compensation in the CAN Protocol standard (ISO 11898-1:2015) for details.

Diagram



Fields

Field	Function
31 ETDCEN	Transceiver Delay Compensation Enable Enables the TDC feature. It can be written in Freeze mode only. **NOTE** See Transmitter delay compensation in the CAN Protocol standard (ISO 11898-1:2015) for details. **NOTE** TDC must be disabled when the Loop Back Mode is enabled. See CTRL1[LPB]. 0b - Disable 1b - Enable
30 TDMDIS	Transceiver Delay Measurement Disable

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Disables the transceiver delay measurement. When the TDC measurement is disabled, only ETDC[ETDCOFF] determines the secondary sample point position. If TCD measurement is enabled, the sum of the transceiver delay measurement plus the enhanced TDC offset determines the secondary sample point position. Soft reset does not affect this field. **NOTE** This bit can be enabled only if CTRL2[BTE] = 1. 0b - Enable 1b - Disable
29-23 —	Reserved
22-16 ETDCOFF	Enhanced Transceiver Delay Compensation Offset Contains the offset value to be added to the loop delay of the measured transceiver. This value defines the position of the delayed comparison point when bit rate switching is active. See Transceiver delay compensation for details on how the loop delay measurement is performed. This field can be written in Freeze mode only. Its value can be defined in protocol engine (PE) clock periods (CANCLK, see Protocol timing for more details). It must be smaller than the CAN bit duration in the data bit rate for proper operation. Do not write 0 to this field. **NOTE** If CTRL2[BTE] becomes 1 after a chip-level hard reset, this field is read as 1h.
15 ETDCFAIL	Transceiver Delay Compensation Fail Indicates whether the transceiver delay compensation (TDC) mechanism is out of range. In this case, it is unable to compensate the loop delay of the transceiver and successfully compare the delayed received bits to the transmitted ones. (See Transceiver delay compensation.) This field becomes 0 the first time FlexCAN detects the out of range condition. 0b - In range 1b - Out of range
14-8 —	Reserved
7-0 ETDCVAL	Enhanced Transceiver Delay Compensation Value Contains ETDC[ETDCOFF] added to the measured value of the transceiver loop delay in the latest transmitted CAN FD frame, with BRS = 1. The module only updates this field when ETDC[ETDCEN] = 1. Soft reset affects this field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE If ETDC[TDMDIS] = 1, this field stores ETDC[ETDCOFF] only.

76.6.2.35 CAN FD Control (FDCTRL)

Offset

Register	Offset
FDCTRL	C00h

Function

Contains control bits for CAN FD operation. It also defines the data size of message buffers allocated in different partitions of RAM (memory blocks) as described in Table 573.

When an 8-byte payload is selected:

- Block R0 allocates MB0–MB31.
- Block R1 allocates MB32–MB63.
- Block R2 allocates MB64–MB95.

When a payload larger than eight bytes is selected, the maximum number of message buffers in a block is limited as described below.

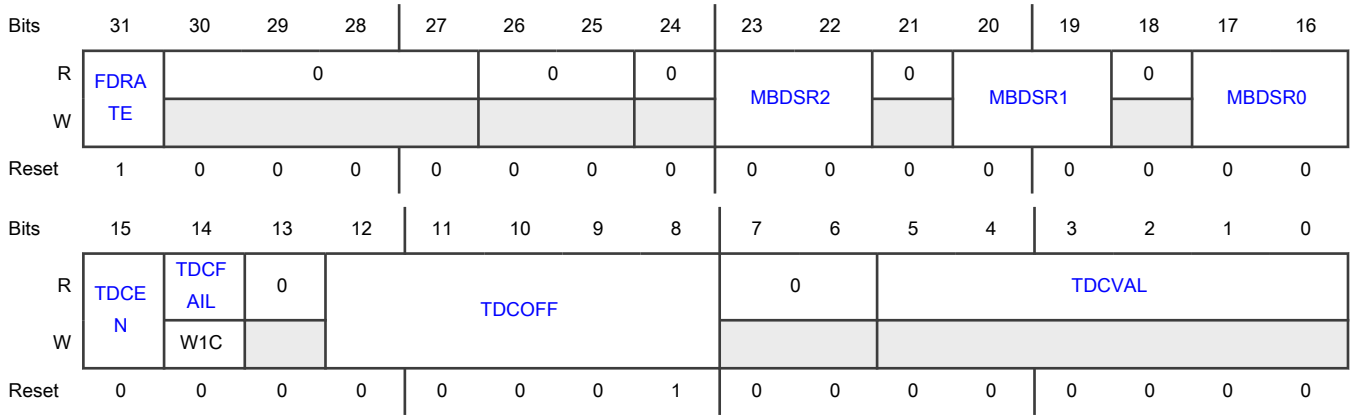
Table 573. Number of message buffers

Payload size	Maximum number of message buffers per RAM block
8 bytes	32
16 bytes	21
32 bytes	12
64 bytes	7

One memory block fits exactly 32 message buffers with an 8-byte payload. For other possible payload sizes, empty memory may exist between the last message buffer in a block and the beginning of the next block. This empty memory corresponds to less than one message buffer, and must not be used.

Soft reset does not affect the contents of this register.

Diagram



Fields

Field	Function
31 FDRATE	Bit Rate Switch Enable Enables the effect of the Bit Rate Switch (BRS bit) during the data phase of TX messages. When 1, if BRS = 1 in the TX message buffer, frames are transmitted with bit rate switching. When 0, frames are transmitted at a nominal rate, and the BRS bit in the TX MB has no effect. The CPU can write to this field at any time. However, its effect becomes active only under one of these conditions: • The CAN bus is in the Wait for Bus Idle state. • The CAN bus is in the Bus Idle state. • The CAN bus is in the Bus Off state. • The current frame under reception or transmission reaches the interframe space. By writing 0 to FDCTRL[FDRATE], the CPU can force all bits in CAN FD messages to be transmitted at nominal bit rate. This transmission occurs regardless of the value in the BRS bit of the TX message buffers. 0b - Disable 1b - Enable
30-27 —	Reserved
26-25 —	Reserved
24 —	Reserved
23-22 MBDSR2	Message Buffer Data Size for Region 2 Selects the data size per message buffer for region R2 of message buffers allocated in RAM. This field can be written in Freeze mode only.

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>CAN_0</td><td>FDCTRL</td><td>—</td></tr>
<tr><td>CAN_1</td><td>FDCTRL</td><td>—</td></tr>
<tr><td>CAN_2</td><td>FDCTRL</td><td>—</td></tr>
<tr><td>CAN_3</td><td>—</td><td>FDCTRL</td></tr>
<tr><td>CAN_4</td><td>—</td><td>FDCTRL</td></tr>
<tr><td>CAN_5</td><td>—</td><td>FDCTRL</td></tr>
</table>
00b - 8 bytes
01b - 16 bytes
10b - 32 bytes
11b - 64 bytes
</td></tr>
<tr><td>21
—</td><td>Reserved</td></tr>
<tr><td>20-19
MBDSR1</td><td>Message Buffer Data Size for Region 1
Selects the data size per message buffer for region R1 of message buffers allocated in RAM.
This field can be written in Freeze mode only.
00b - 8 bytes
01b - 16 bytes
10b - 32 bytes
11b - 64 bytes</td></tr>
<tr><td>18
—</td><td>Reserved</td></tr>
<tr><td>17-16
MBDSR0</td><td>Message Buffer Data Size for Region 0
Selects the data size per message buffer for region R0 of message buffers allocated in RAM.
This field can be written in Freeze mode only.</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function
	00b - 8 bytes 01b - 16 bytes 10b - 32 bytes 11b - 64 bytes
15 TDCEN	Transceiver Delay Compensation Enable Enables the TDC feature. It can be written in Freeze mode only. See Transmitter delay compensation in the CAN Protocol standard (ISO 11898-1:2015) for details. TDC must be disabled when Loopback mode is enabled (see CTRL1[LPB]). **NOTE** If CTRL2[BTE] = 1, this field is read as 0 and a write operation has no effect. 0b - Disable 1b - Enable
14 TDCFAIL	Transceiver Delay Compensation Fail Indicates whether the Transceiver Delay Compensation (TDC) mechanism is out of range. In this case, the mechanism cannot compensate for the loop delay of the transceiver and successfully compare the delayed received bits to the transmitted ones (see Transceiver delay compensation). The first time that FlexCAN detects the out-of-range condition, this field becomes 1. **NOTE** If CTRL2[BTE] = 1, this field is read as 0 and a write operation has no effect. 0b - In range 1b - Out of range
13 —	Reserved
12-8 TDCOFF	Transceiver Delay Compensation Offset Contains the offset value to be added to the loop delay of the measured transceiver. This value defines the position of the delayed comparison point when bit rate switching is active. See Transceiver delay compensation for details about loop delay measurement. This field can be written in Freeze mode only. Its value can be defined in Protocol Engine Clock periods (CANCLK, see Protocol timing for more details). The value must be smaller than the CAN bit duration in the data bit rate for proper operation. **NOTE** If CTRL2[BTE] = 1, TDCOFF is read as 0 and a write operation has no effect. Do not write 0 to this field.
7-6	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
5-0 TDCVAL	Transceiver Delay Compensation Value Contains the value of the transceiver loop delay measured from the transmitted EDL-to-R0 transition edge to the respective received one added to FDCTRL[TDCOFF]. This value is an integer multiple of the Protocol Engine Clock period (CANCLK). If CTRL2[BTE] = 1, this field is read as 0. See Protocol timing for details on the loop delay measurement.

76.6.2.36 CAN FD Bit Timing (FDCBT)

Offset

Register	Offset
FDCBT	C04h

Function

Stores the CAN bit timing variables used in the data phase of CAN FD messages when the FDCTRL[FDRATE] = 1, compatible with the CAN FD specification. Fields in this register define:

- The time quantum duration
- The number of time quanta per CAN bit
- The sample point position for the data bit rate portion of a CAN FD message with BRS = 1

Soft reset does not affect the contents of this register.

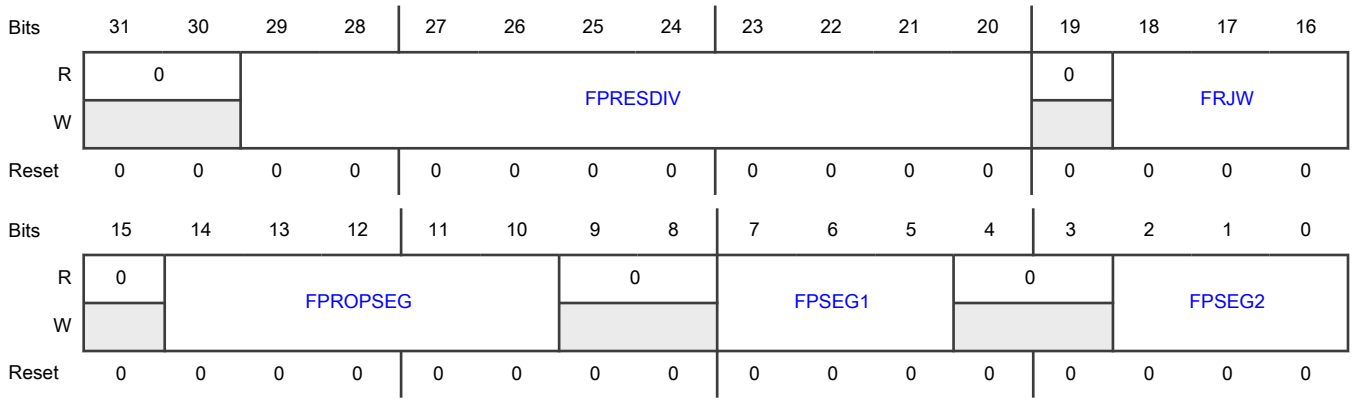
The sum of the Fast Propagation Segment (FPROPSEG) and Fast Phase Segment 1 (FPSEG1) must be at least two time quanta.

Ensure bit time settings and protocol engine tolerance are in compliance with the CAN Protocol standard (ISO 11898-1:2015).

NOTE

If CTRL2[BTE] = 1, this register is read as zero and a write operation has no effect.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-20 FPRESDIV	Fast Prescaler Division Factor Defines the ratio between the PE clock frequency and the serial clock (Sclock) frequency in the data bit rate portion of a CAN FD message with BRS = 1. The Sclock period defines the time quantum of the CAN FD protocol for the data bit rate. This field can be written only in Freeze mode; the module blocks it in other modes. Sclock frequency = PE clock frequency ÷ (FPRESDIV + 1). **NOTE** To minimize errors when processing FD frames, use the same value for this field and for CTRL1[PRESDIV] or CBT[EPRESDIV]. See the first note in CAN FD frames for details.
19 —	Reserved
18-16 FRJW	Fast Resync Jump Width Defines the maximum number of time quanta that one resynchronization can change a bit time in the data bit rate portion of a CAN FD message with BRS = 1. This field can be written only in Freeze mode; the module blocks it in other modes. Resync Jump Width = FSJW + 1. One Time Quantum = one Sclock period.
15 —	Reserved
14-10 FPROPSEG	Fast Propagation Segment Defines the length of the propagation segment in the bit time in the data bit rate portion of a CAN FD message with BRS = 1. This field can be written only in Freeze mode; the module blocks it in other modes. Propagation Segment Time = FPROPSEG × Time Quanta. One Time Quantum = one Sclock period.
9-8 —	Reserved
7-5 FPSEG1	Fast Phase Segment 1 Defines the length of phase segment 1 in the bit time in the data bit rate portion of a CAN FD message with BRS = 1. This field can be written only in Freeze mode; the module blocks it in other modes. Phase Segment 1 = (FPSEG1 + 1) × Time Quanta. One Time Quantum = one Sclock period.

Table continues on the next page...

Table continued from the previous page...

Field	Function
4-3 —	Reserved
2-0 FPSEG2	Fast Phase Segment 2 Defines the length of phase segment 2 in the data bit rate portion of a CAN FD message with BRS = 1. This field can be written only in Freeze mode; the module blocks it in other modes. Phase Segment 2 = (FPSEG2 + 1) × Time Quanta. One Time Quantum = one Sclock period.

76.6.2.37 CAN FD CRC (FDCRC)

Offset

Register	Offset
FDCRC	C08h

Function

Provides information about the cyclic redundancy check (CRC) of transmitted messages.

FlexCAN uses different CRC polynomials for different frame formats.

- The CRC_15 polynomial is used for all frames in CAN format.
- The CRC_17 polynomial is used for frames in CAN FD format with a DATA FIELD up to 16 bytes.
- The CRC_21 polynomial is used for frames in CAN FD format with a DATA FIELD longer than 16 bytes.

Each polynomial shown below results in a Hamming distance of 6. This register is updated at the same time that the TX Interrupt flag is set.

$$\text{CRC_15} = \text{C599h}: \ (x^{15} + x^{14} + x^{10} + x^{8} + x^{7} + x^{4} + x^{3} + 1)$$

$$\text{CRC_17} = \text{3685Bh}: \ (x^{17} + x^{16} + x^{14} + x^{13} + x^{11} + x^{6} + x^{4} + x^{3} + x^{1} + 1)$$

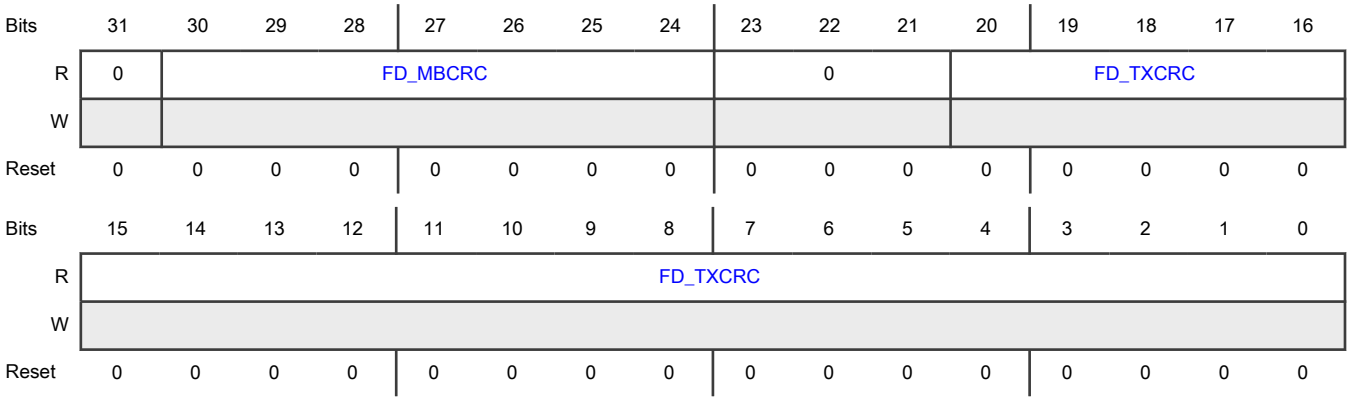
$$\text{CRC_21} = \text{302899h}: \ (x^{21} + x^{20} + x^{13} + x^{11} + x^{7} + x^{4} + x^{3} + 1)$$

Equation 32. CRC polynomial used on CAN frame

NOTE

See CRC sequence calculation in the CAN Protocol standard (ISO 11898-1:2015) for details.

Diagram



Fields

Field	Function
31 —	Reserved
30-24 FD_MBCRC	CRC Message Buffer Number for FD_TXCRC Indicates the number of the message buffer corresponding to the value in FDCRC[FD_TXCRC], for both FD and non-FD frames. It reports the same information as in CRCR[MBCRC].
23-21 —	Reserved
20-0 FD_TXCRC	Extended Transmitted CRC value Contains the CRC value calculated over the most recent transmitted message. Different CRC polynomials are used for different frame formats. For CRC_15 and CRC_17, the six most significant bits and the four most significant bits are reported as zeroes, respectively. For CRC_15, this field has the same content as Cyclic Redundancy Check (CRCR).

76.6.2.38 Enhanced RX FIFO Control (ERFCR)

Offset

Register	Offset
ERFCR	C0Ch

Function

Defines the Enhanced RX FIFO configuration.

This register can be written only in Freeze mode.

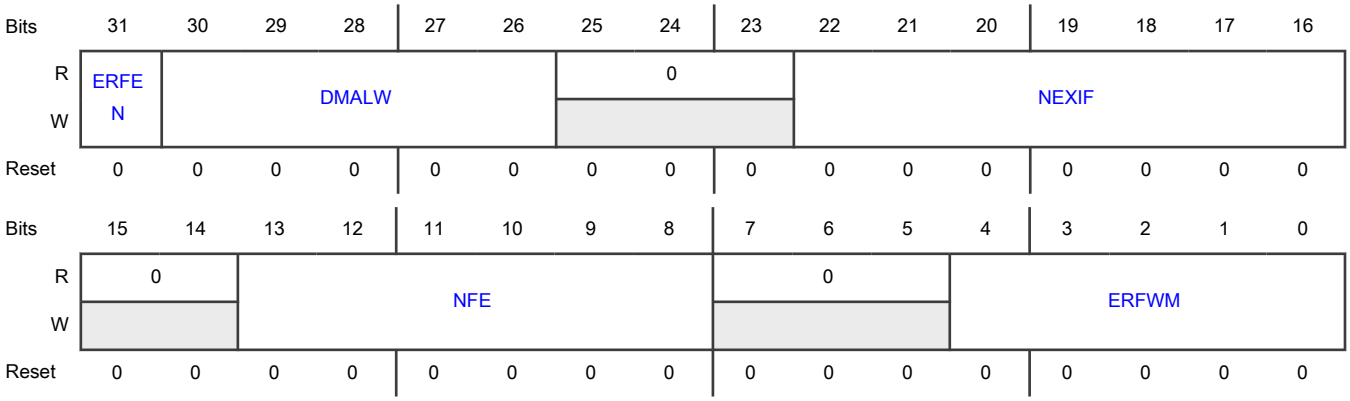
Soft reset does not affect any of the contents of this register.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
CAN_0	ERFCR	—
CAN_1	ERFCR	—
CAN_2	ERFCR	—
CAN_3	—	ERFCR
CAN_4	—	ERFCR
CAN_5	—	ERFCR

Diagram



Fields

Field	Function
31 ERFEN	Enhanced RX FIFO enable Enables the Enhanced RX FIFO. **NOTE** If MCR[RFEN] = 1, do not write 1 to this field. 0b - Disable 1b - Enable
30-26 DMALW	DMA Last Word Defines the last DMA address for each Enhanced RX FIFO element.

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>This table shows the number of elements and the last address for each Enhanced RX FIFO element according to the value of DMALW.
<table>
<tr><th>DMALW</th><th>Number of 32-bit words transferred</th><th>Last FIFO address</th></tr>
<tr><td>0</td><td>1</td><td>2000h</td></tr>
<tr><td>1</td><td>2</td><td>2004h</td></tr>
<tr><td>2</td><td>3</td><td>2008h</td></tr>
<tr><td>3</td><td>4</td><td>200Ch</td></tr>
<tr><td>4</td><td>5</td><td>2010h</td></tr>
<tr><td>5</td><td>6</td><td>2014h</td></tr>
<tr><td>6</td><td>7</td><td>2018h</td></tr>
<tr><td>7</td><td>8</td><td>201Ch</td></tr>
<tr><td>8</td><td>9</td><td>2020h</td></tr>
<tr><td>9</td><td>10</td><td>2024h</td></tr>
<tr><td>10</td><td>11</td><td>2028h</td></tr>
<tr><td>11</td><td>12</td><td>202Ch</td></tr>
<tr><td>12</td><td>13</td><td>2030h</td></tr>
<tr><td>13</td><td>14</td><td>2034h</td></tr>
<tr><td>14</td><td>15</td><td>2038h</td></tr>
<tr><td>15</td><td>16</td><td>203Ch</td></tr>
<tr><td>16</td><td>17</td><td>2040h</td></tr>
<tr><td>17</td><td>18</td><td>2044h</td></tr>
<tr><td>18</td><td>19</td><td>2048h</td></tr>
<tr><td>19</td><td>20</td><td>204Ch</td></tr>
</table>
NOTE
Undefined DMALW values in the table are reserved and must not be used.</td></tr>
<tr><td>25-23
—</td><td>Reserved</td></tr>
<tr><td>22-16
NEXIF</td><td>Number of Extended ID Filter Elements
Defines the number of extended ID filter elements used during the Enhanced RX FIFO matching process.
The value of this field must be less than or equal to NFE + 1.</td></tr>
</table>

Field	Function
	The number of standard ID filter elements is 2 × (NFE - NEXIF + 1). This table shows the number of extended ID filters and standard ID filters available for Enhanced RX FIFO if all filter elements are used.

NEXIF	NFE	Number of Extended ID filter elements	Number of Standard ID filter elements
0	63	0	128
1	63	1	126
2	63	2	124
3	63	3	122
4	63	4	120
5	63	5	118
6	63	6	116
7	63	7	114
8	63	8	112
9	63	9	110
10	63	10	108
11	63	11	106
12	63	12	104
13	63	13	102
14	63	14	100
15	63	15	98
16	63	16	96
17	63	17	94
18	63	18	92
19	63	19	90
20	63	20	88
21	63	21	86
22	63	22	84
23	63	23	82
24	63	24	80
25	63	25	78
26	63	26	76

Table continued from the previous page...

Field	Function			
	NEXIF	NFE	Number of Extended ID filter elements	Number of Standard ID filter elements
	27	63	27	74
	28	63	28	72
	29	63	29	70
	30	63	30	68
	31	63	31	66
	32	63	32	64
	33	63	33	62
	34	63	34	60
	35	63	35	58
	36	63	36	56
	37	63	37	54
	38	63	38	52
	39	63	39	50
	40	63	40	48
	41	63	41	46
	42	63	42	44
	43	63	43	42
	44	63	44	40
	45	63	45	38
	46	63	46	36
	47	63	47	34
	48	63	48	32
	49	63	49	30
	50	63	50	28
	51	63	51	26
	52	63	52	24
	53	63	53	22
	54	63	54	20
	55	63	55	18

Table continues on the next page...

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>
<table>
<tr><th>NEXIF</th><th>NFE</th><th>Number of Extended ID filter elements</th><th>Number of Standard ID filter elements</th></tr>
<tr><td>56</td><td>63</td><td>56</td><td>16</td></tr>
<tr><td>57</td><td>63</td><td>57</td><td>14</td></tr>
<tr><td>58</td><td>63</td><td>58</td><td>12</td></tr>
<tr><td>59</td><td>63</td><td>59</td><td>10</td></tr>
<tr><td>60</td><td>63</td><td>60</td><td>8</td></tr>
<tr><td>61</td><td>63</td><td>61</td><td>6</td></tr>
<tr><td>62</td><td>63</td><td>62</td><td>4</td></tr>
<tr><td>63</td><td>63</td><td>63</td><td>2</td></tr>
<tr><td>64</td><td>63</td><td>64</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>15-14
—</td><td>Reserved</td></tr>
<tr><td>13-8
NFE</td><td>Number of Enhanced RX FIFO Filter Elements
Defines the total number of filter elements used during the enhanced RX FIFO matching process according to the table.
<table>
<tr><th>NFE</th><th>Maximum number of extended ID filter elements (NEXIF = NFE + 1)</th><th>Maximum number of standard ID filter elements (NEXIF = 0)</th></tr>
<tr><td>0</td><td>1</td><td>2</td></tr>
<tr><td>1</td><td>2</td><td>4</td></tr>
<tr><td>2</td><td>3</td><td>6</td></tr>
<tr><td>3</td><td>4</td><td>8</td></tr>
<tr><td>4</td><td>5</td><td>10</td></tr>
<tr><td>5</td><td>6</td><td>12</td></tr>
<tr><td>6</td><td>7</td><td>14</td></tr>
<tr><td>7</td><td>8</td><td>16</td></tr>
<tr><td>8</td><td>9</td><td>18</td></tr>
<tr><td>9</td><td>10</td><td>20</td></tr>
<tr><td>10</td><td>11</td><td>22</td></tr>
<tr><td>11</td><td>12</td><td>24</td></tr>
</table>
</td></tr>
</table>

Table continues on the next page...

Table continued from the previous page...

Field	Function		
	NFE	Maximum number of extended ID filter elements (NEXIF = NFE + 1)	Maximum number of standard ID filter elements (NEXIF = 0)
	12	13	26
	13	14	28
	14	15	30
	15	16	32
	16	17	34
	17	18	36
	18	19	38
	19	20	40
	20	21	42
	21	22	44
	22	23	46
	23	24	48
	24	25	50
	25	26	52
	26	27	54
	27	28	56
	28	29	58
	29	30	60
	30	31	62
	31	32	64
	32	33	66
	33	34	68
	34	35	70
	35	36	72
	36	37	74
	37	38	76
	38	39	78
	39	40	80
	40	41	82

Table continues on the next page...

Table continued from the previous page...

Field	Function
	<table><tr><th>NFE</th><th>Maximum number of extended ID filter elements (NEXIF = NFE + 1)</th><th>Maximum number of standard ID filter elements (NEXIF = 0)</th></tr><tr><td>41</td><td>42</td><td>84</td></tr><tr><td>42</td><td>43</td><td>86</td></tr><tr><td>43</td><td>44</td><td>88</td></tr><tr><td>44</td><td>45</td><td>90</td></tr><tr><td>45</td><td>46</td><td>92</td></tr><tr><td>46</td><td>47</td><td>94</td></tr><tr><td>47</td><td>48</td><td>96</td></tr><tr><td>48</td><td>49</td><td>98</td></tr><tr><td>49</td><td>50</td><td>100</td></tr><tr><td>50</td><td>51</td><td>102</td></tr><tr><td>51</td><td>52</td><td>104</td></tr><tr><td>52</td><td>53</td><td>106</td></tr><tr><td>53</td><td>54</td><td>108</td></tr><tr><td>54</td><td>55</td><td>110</td></tr><tr><td>55</td><td>56</td><td>112</td></tr><tr><td>56</td><td>57</td><td>114</td></tr><tr><td>57</td><td>58</td><td>116</td></tr><tr><td>58</td><td>59</td><td>118</td></tr><tr><td>59</td><td>60</td><td>120</td></tr><tr><td>60</td><td>61</td><td>122</td></tr><tr><td>61</td><td>62</td><td>124</td></tr><tr><td>62</td><td>63</td><td>126</td></tr><tr><td>63</td><td>64</td><td>128</td></tr></table>
7-5 — 	Reserved
4-0 ERFWM	Enhanced RX FIFO Watermark Defines the minimum number of CAN messages stored in the Enhanced RX FIFO. When that number is reached, ERFSR[ERFWMI] becomes 1. Minimum number of CAN messages = ERFWM + 1.

Table continues on the next page...

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Field	Function
	NOTE If MCR[DMA] = 1, write 0h to this field.

76.6.2.39 Enhanced RX FIFO Interrupt Enable (ERFIER)

Offset

Register	Offset
ERFIER	C10h

Function

Contains the interrupt enables for the Enhanced RX FIFO.

Soft reset does not affect this register.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
CAN_0	ERFIER	—
CAN_1	ERFIER	—
CAN_2	ERFIER	—
CAN_3	—	ERFIER
CAN_4	—	ERFIER
CAN_5	—	ERFIER

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ERFUFWIE	ERFOVFIE	ERFWMIIE	ERFDAIE	0											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	0														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 ERFUFWIE	Enhanced RX FIFO Underflow Interrupt Enable Enables interrupt for ERFSR[ERFUFW]. 0b - Disable 1b - Enable
30 ERFOVFIE	Enhanced RX FIFO Overflow Interrupt Enable Enables interrupt for ERFSR[ERFOVF]. 0b - Disable 1b - Enable
29 ERFWMIIE	Enhanced RX FIFO Watermark Indication Interrupt Enable Enables interrupt for ERFSR[ERFWMI]. 0b - Disable 1b - Enable
28 ERFDAIE	Enhanced RX FIFO Data Available Interrupt Enable Enables interrupt for ERFSR[ERFDA]. 0b - Disable 1b - Enable
27-16 —	Reserved
15 —	Reserved
14-0 —	Reserved

76.6.2.40 Enhanced RX FIFO Status (ERFSR)

Offset

Register	Offset
ERFSR	C14h

Function

Contains the status fields of the Enhanced RX FIFO including error indications and a clear FIFO field.

Soft reset does not affect this register.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
CAN_0	ERFSR	—
CAN_1	ERFSR	—
CAN_2	ERFSR	—
CAN_3	—	ERFSR
CAN_4	—	ERFSR
CAN_5	—	ERFSR

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ERFUFW	ERFOVF	ERFWMI	ERFDA	0	0									ERFE	ERFF
W	W1C	W1C	W1C	W1C	ERFCLR											
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	0									ERFEL					
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 ERFUFW	Enhanced RX FIFO Underflow Flag Indicates whether an underflow condition occurred in the enhanced RX FIFO. If ERFIER[ERFUFWIE] = 1, this field generates an interrupt. 0b - No such occurrence 1b - Underflow
30 ERFOVF	Enhanced RX FIFO Overflow Flag Indicates whether an overflow condition occurred in the Enhanced RX FIFO. If ERFIER[ERFOVFIE] = 1, this field generates an interrupt.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No such occurrence 1b - Overflow
29 ERFWMI	Enhanced RX FIFO Watermark Indication Flag Indicates whether the number of messages available in the Enhanced RX FIFO is greater than the watermark defined in ERFCR[ERFWM]. If ERFIER[ERFWMIIE] = 1, this field generates an interrupt. 0b - No such occurrence 1b - Number of messages in FIFO is greater than the watermark
28 ERFDA	Enhanced RX FIFO Data Available Flag Indicates whether there is at least one message stored in the ERX FIFO. If ERFIER[ERFDAIE] = 1, this field generates an interrupt. 0b - No such occurrence 1b - At least one message stored in Enhanced RX FIFO
27 ERFCLR	Enhanced RX FIFO Clear Writing 1 to this field during Freeze mode resets the internal FIFO pointers, but the FIFO content stored in RAM is not changed. Writing to this field outside Freeze mode, or writing 0 to this field, has no effect. 0b - No effect 1b - Clear enhanced RX FIFO content
26-18 —	Reserved
17 ERFE	Enhanced RX FIFO Empty Flag Indicates whether Enhanced RX FIFO is empty. 0b - Not empty 1b - Empty
16 ERFF	Enhanced RX FIFO Full Flag Indicates whether enhanced RX FIFO is full. 0b - Not full 1b - Full
15 —	Reserved
14-6	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
5-0 ERFEL	Enhanced RX FIFO Elements Indicates the number of CAN messages stored in the Enhanced RX FIFO.

76.6.2.41 High-Resolution Timestamp (HR_TIME_STAMP0 - HR_TIME_STAMP95)

Offset

For n = 0 to 95:

Register	Offset
HR_TIME_STAMPn	C30h + (n × 4h)

Function

Stores a copy of a 32-bit timer at the start or end of a CAN frame.

HR_TIME_STAMP0 stores the 32-bit timestamp associated with MB0, HR_TIME_STAMP1 stores the 32-bit timestamp associated with MB1, and so on.

Reset does not affect these registers.

NOTE

Do not write to these registers outside Freeze mode.

Table 574. High-Resolution Timestamp register operation

TSTAMPCAP	Captured timebase	Capture point
b00	None	None
b01	32 bits of high-resolution on-chip timer	Seventh bit of the end-of-frame field for transmission and sixth bit of the end-of-frame field for reception.
b10	32 bits of high-resolution on-chip timer	Start of frame
b11	32 bits of high-resolution on-chip timer	Start of frame for classical CAN frame format and res bit for CAN FD frame format

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
CAN_0	HR_TIME_STAMP0–HR_TIME_STAMP95	—

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
CAN_1	HR_TIME_STAMP0–HR_TIME_STAMP95	—
CAN_2	HR_TIME_STAMP0–HR_TIME_STAMP95	—
CAN_3	HR_TIME_STAMP0–HR_TIME_STAMP63	HR_TIME_STAMP64–HR_TIME_STAMP95
CAN_4	HR_TIME_STAMP0–HR_TIME_STAMP63	HR_TIME_STAMP64–HR_TIME_STAMP95
CAN_5	HR_TIME_STAMP0–HR_TIME_STAMP63	HR_TIME_STAMP64–HR_TIME_STAMP95

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TS															
W																
Reset	See Register reset values.															

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TS															
W																
Reset	See Register reset values.															

Register reset values

Register	Reset value
HR_TIME_STAMP0–HR_TIME_STAMP63	CAN_0–CAN_5: undefined
HR_TIME_STAMP64–HR_TIME_STAMP95	CAN_0–CAN_2: undefined CAN_3–CAN_5: Register not supported

Fields

Field	Function
31-0 TS	High-Resolution Timestamp Captures the copy of the timestamp of corresponding message buffer. This field always captures a 32-bit timer value.

76.6.2.42 Enhanced RX FIFO Filter Element (ERFFEL0 - ERFFEL127)

Offset

For n = 0 to 127:

Register	Offset
ERFFELn	3000h + (n × 4h)

Function

Stores the filter elements of the Enhanced RX FIFO.

For standard ID filtering, each ERFFEL register stores one filter element. For extended ID filtering, each pair of ERFFEL registers stores one filter element.

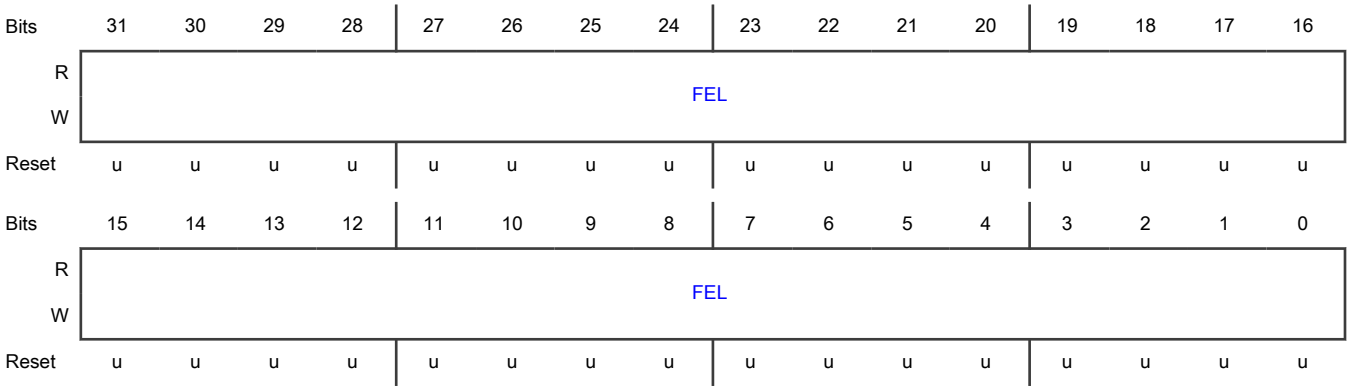
ERFFEL registers can be written only in Freeze mode; otherwise, the module blocks them. Reset does not affect these registers. They are located in RAM and must be explicitly initialized prior to any reception.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
CAN_0	ERFFEL0–ERFFEL127	—
CAN_1	ERFFEL0–ERFFEL127	—
CAN_2	ERFFEL0–ERFFEL127	—
CAN_3	—	ERFFEL0–ERFFEL127
CAN_4	—	ERFFEL0–ERFFEL127
CAN_5	—	ERFFEL0–ERFFEL127

Diagram



Fields

Field	Function
31-0	Filter Element Bits

Table continues on the next page...

Field	Function
FEL	Stores filter elements. Each filter element is used during the match process. If the matching criteria are met, a message is stored in the Enhanced RX FIFO.

76.6.3 Message buffer structure

The message buffer structure used by FlexCAN is represented in the following figure. Both extended (29-bit identifier) and standard (11-bit identifier) frames used in the CAN specification (Version 2.0 Part B) are represented. Each individual message buffer is 16, 24, 40, or 72 bytes, depending on the quantity of data bytes allocated for the message payload: 8, 16, 32, or 64 data bytes, respectively.

The memory area 80h–67Fh is used by the message buffers. When CAN FD is enabled, the exact address for each message buffer depends on the size of its payload. See FlexCAN memory partition for CAN FD.

Table 575. Message buffer structure example with 64-byte payload

	31	30	29	28	27 24	23	22	21	20	19 18 17 16	15 8	7 0
0h	EDL	BRS	ESI		CODE		SRR	IDE	RTR	DLC	TIMESTAMP	
4h	PRIO			ID (standard/extended)						ID (extended)		
8h	Data byte 0			Data byte 1							Data byte 2	Data byte 3
Ch	Data byte 4			Data byte 5							Data byte 6	Data byte 7
10h	Data byte 8			Data byte 9							Data byte 10	Data byte 11
14h	Data byte 12			Data byte 13							Data byte 14	Data byte 15
18h	Data byte 16			Data byte 17							Data byte 18	Data byte 19
1Ch	Data byte 20			Data byte 21							Data byte 22	Data byte 23
20h	Data byte 24			Data byte 25							Data byte 26	Data byte 27
24h	Data byte 28			Data byte 29							Data byte 30	Data byte 31
28h	Data byte 32			Data byte 33							Data byte 34	Data byte 35
2Ch	Data byte 36			Data byte 37							Data byte 38	Data byte 39
30h	Data byte 40			Data byte 41							Data byte 42	Data byte 43
34h	Data byte 44			Data byte 45							Data byte 46	Data byte 47
38h	Data byte 48			Data byte 49							Data byte 50	Data byte 51
3Ch	Data byte 52			Data byte 53							Data byte 54	Data byte 55
40h	Data byte 56			Data byte 57							Data byte 58	Data byte 59
44h	Data byte 60			Data byte 61							Data byte 62	Data byte 63

= Unimplemented or reserved

Table 576. Field descriptions

Mnemonic	Field	Description
EDL	Extended Data Length	Distinguishes between CAN format and CAN FD format frames. EDL must not be 1 for message buffers configured to RANSWER with code field 1010b (see Table 577).
BRS	Bit Rate Switch	Defines whether the bit rate is switched inside a CAN FD format frame.
ESI	Error State Indicator	Indicates whether the transmitting node is error-active or error-passive.
CODE	Message Buffer Code	Can be accessed (read or write) by the CPU and by the FlexCAN module itself, as part of the message buffer matching and arbitration process. The encoding is shown in Table 577 and Table 578. See Functional description.

Table 577. Message buffer code for RX buffers

CODE description	RX code BEFORE RX new frame	SRV[1]	RX code AFTER successful reception[2]	RRS[3]	Comment
0000b: INACTIVE. Message buffer is not active.	INACTIVE	—	—	—	Message buffer does not participate in the matching process.
0100b: EMPTY. Message buffer is active and empty.	EMPTY	—	FULL	—	When a frame is received successfully (after Move-in), CODE is automatically updated to FULL.
0010b: FULL. Message buffer is full.	FULL	Yes	FULL	—	The act of reading the Control and Status word followed by unlocking the message buffer (SRV) does not make CODE return to EMPTY. It remains FULL. If a new frame is moved to the message buffer after the message buffer is serviced, the code remains FULL. See Matching process for matching details related to FULL code.
		No	OVERRUN	—	If the message buffer is FULL and a new frame is moved to this message buffer before the CPU services it, CODE is automatically updated to OVERRUN. See Matching process for details about overrun behavior.

Table continues on the next page...

Table 577. Message buffer code for RX buffers (continued)

CODE description	RX code BEFORE RX new frame	SRV[1]	RX code AFTER successful reception[2]	RRS[3]	Comment
0110b: OVERRUN. Message buffer is being overwritten into a full buffer.	OVERRUN	Yes	FULL	—	If CODE indicates OVERRUN and the CPU has serviced the message buffer, when a new frame is moved to the message buffer, CODE returns to FULL.
		No	OVERRUN	—	If CODE already indicates OVERRUN, and another new frame must be moved, the message buffer is overwritten again, and CODE remains OVERRUN. See Matching process for details about overrun behavior.
1010b: RANSWER[4]. A frame was configured to recognize a Remote Request frame and transmit a Response frame in return.[5]	RANSWER	—	TANSWER (1110b)	0	A Remote Answer was configured to recognize a Remote Request frame received. After that, a message buffer is set to transmit a response frame. CODE is automatically changed to TANSWER (1110b). See Matching process for details. If CTRL2[RRS] = 0, transmit a response frame when a remote request frame with the same ID is received.
		—	—	1	This code is ignored during matching and arbitration process. See Matching process for details.
CODE[0] = 1: BUSY. FlexCAN is updating the contents of the message buffer. The CPU must not access the message buffer.	BUSY[6]	—	FULL	—	Indicates that the message buffer is being updated. It automatically becomes 0 and does not interfere with the next CODE.
		—	OVERRUN	—	

1. SRV: Serviced message buffer. Message buffer was read and unlocked by reading TIMER or other message buffer.
2. A frame is considered a successful reception after the frame is moved to a message buffer (move-in process). See Move-in.

3. Remote Request Stored field. See Control 2 (CTRL2).
4. Code 1010b is not considered TX and a message buffer with this code should not be aborted.
5. Code 1010b must be used in message buffers configured in CAN FD format, with EDL = 1.
6. For TX message buffers, the BUSY bit should be ignored upon read, except when MCR[AEN] = 1. If this field is 1, the corresponding message buffer does not participate in the matching process.

Table 578. Message buffer code for TX buffers

CODE Description	TX Code BEFORE TX frame	MB RTR	TX Code AFTER successful transmission	Comment
1000b: INACTIVE. Message buffer is not active.	INACTIVE	—	—	Message buffer does not participate in arbitration process.
1001b: ABORT. Message buffer is aborted.	ABORT	—	—	Message buffer does not participate in arbitration process.
1100b: DATA. Message buffer is a TX data frame (MB RTR must be 0).	DATA	0	INACTIVE	Transmit data frame unconditionally once. After transmission, the message buffer automatically returns to the INACTIVE state.
1100b: REMOTE. Message buffer is a Transmit Remote Request frame (MB RTR must be 1).	REMOTE	1	EMPTY	Transmit remote request frame unconditionally once. After transmission, the message buffer automatically becomes an RX Empty message buffer with the same ID.
1110b: TANSWER. Message buffer is a Transmit Response frame from an incoming Remote Request frame.	TANSWER	—	RANSWER	This intermediate code is automatically written to the message buffer by the CHI as a result of a match to a Remote Request frame. The Remote Response frame is transmitted unconditionally once, then the code automatically returns to RANSWER (1010b). The CPU can also write this code with the same effect. The Remote Response frame can be a data frame or another remote request frame, depending on the value of RTR. See Matching process and Arbitration process for details.

Table 579. RX and TX message buffer field descriptions

Mnemonic	Field	Description
SRR	Substitute Remote Request	Fixed recessive bit, used only in extended format. Write 1 to SRR for transmission (TX Buffers). SRR is stored with the value received on the CAN bus for RX receiving buffers. It can be received as either recessive or dominant. If FlexCAN receives this bit as dominant, it is interpreted as an arbitration loss. 1: Recessive value is compulsory for transmission in extended format frames. 0: Dominant is not a valid value for transmission in extended format frames.
IDE	ID Extended Bit	Identifies whether the frame format is standard or extended. 1: Frame format is extended 0: Frame format is standard
RTR	Remote Transmission Request	Affects the behavior of remote frames and is part of the reception filter. See Table 577, Table 578, and CTRL2[RRS]. If FlexCAN transmits this field as 1 (recessive) and receives it as 0 (dominant), it is interpreted as an arbitration loss. If this field is transmitted as 0 (dominant) and it is received as 1 (recessive), FlexCAN treats it as a bit error. If the value received matches the value transmitted, it is considered a successful bit transmission. 1: If message buffer is TX, indicates that the current message buffer may have a Remote Request frame to be transmitted. If the message buffer is RX, incoming remote request frames may be stored. 0: Indicates that the current message buffer has a Data frame to be transmitted. In an RX message buffer, it may be considered in matching processes. **NOTE** When configuring CAN FD frames, this field must be 0.
DLC	Data Length Code	Indicates the length (in bytes) of the RX or TX data, which is located in offset 8h–Fh of the message buffer space (see Table 575). In reception, this field is written by FlexCAN, copied from the DLC field of the received frame. In transmission, this field is written by the CPU and corresponds to the DLC field value of the frame to be transmitted. When RTR = 1, the frame to be transmitted is a remote frame and does not include the data field, regardless of the DLC field (see Table 581).
TIMESTAMP	Free-Running Counter Timestamp	Provides a copy of the Free-Running Timer, captured for TX and RX frames when the beginning of the Identifier field appears on the CAN bus. See Table 580 for Timestamp operation.
PRIO	Local priority	Used only when MCR[LPRIOEN] = 1, and only makes sense for transmit message buffers. These bits are not transmitted. They are appended to the regular ID to define the transmission priority. See Arbitration process.

Table continues on the next page...

Table 579. RX and TX message buffer field descriptions (continued)

Mnemonic	Field	Description
ID	Frame Identifier	In standard frame format, only the 11 most significant bits (28 to 18) are used for frame identification in both receive and transmit cases. The 18 least significant bits are ignored. In extended frame format, all bits are used for frame identification in both receive and transmit cases.
DATA BYTE 0–63	Data Field	Up to 64 bytes can be used for a data frame, depending on the size of payload selected for the message buffers. For RX frames, the data is stored as it is received from the CAN bus. DATA BYTE (*n*) is valid only if *n* is less than DLC, as shown in Table 581.

Table 580. Timestamp operation

TSTAMPCAP	MBTSBASE	TIMER_SOURCE	Captured timebase	Capture point
b00	bxx	0	CAN_TIMER incremented by CAN bit clock	Second bit of identifier field
b00	bxx	1	CAN_TIMER incremented by on-chip timer clock	Second bit of identifier field
bxx	b00	0	CAN_TIMER incremented by CAN bit clock	Second bit of identifier field
bxx	b00	1	CAN_TIMER incremented by on-chip timer clock	Second bit of identifier field
b01	b01	x	Lower 16 bits of high-resolution on-chip timer	Seventh bit of the end of frame field for transmission and sixth bit of the end of frame field for reception
b01	b10	x	Upper 16 bits of high-resolution on-chip timer	Seventh bit of the end of frame field for transmission and sixth bit of the end of frame field for reception
b10	b01	x	Lower 16 bits of high-resolution on-chip timer	Start of frame
b10	b10	x	Upper 16 bits of high-resolution on-chip timer	Start of frame
b11	b01	x	Lower 16 bits of high-resolution on-chip timer	Start of frame for classical CAN frame format and res bit for CAN FD frame format
b11	b10	x	Upper 16 bits of high-resolution on-chip timer	Start of frame for classical CAN frame format and res bit for CAN FD frame format

Table 581. DATA BYTE validity

DLC	Valid data bytes
0	None
1	DATA BYTE 0
2	DATA BYTE 0–1
3	DATA BYTE 0–2
4	DATA BYTE 0–3
5	DATA BYTE 0–4
6	DATA BYTE 0–5
7	DATA BYTE 0–6
8	DATA BYTE 0–7
9	DATA BYTE 0–11
10	DATA BYTE 0–15
11	DATA BYTE 0–19
12	DATA BYTE 0–23
13	DATA BYTE 0–31
14	DATA BYTE 0–47
15	DATA BYTE 0–63

76.6.4 FlexCAN memory partition for CAN FD

When CAN FD is enabled, FlexCAN RAM can be partitioned into blocks of 512 bytes each. Each block can accommodate a number of message buffers depending on the configuration provided by FDCTRL[MBDSR*n*] as shown in Table 582.

Table 582. RAM partition

RAM block	Number of MBs with 8 bytes (default range)	Size control field in FDCTRL	Number of MBs of different sizes, per block
0	0 to 31	MBDSR0	MBDSR0 = 00, 32 MBs with 8-byte payload MBDSR0 = 01, 21 MBs with 16-byte payload MBDSR0 = 10, 12 MBs with 32-byte payload MBDSR0 = 11, 7 MBs with 64-byte payload
1	32 to 63	MBDSR1	MBDSR1 = 00, 32 MBs with 8-byte payload MBDSR1 = 01, 21 MBs with 16-byte payload MBDSR1 = 10, 12 MBs with 32-byte payload MBDSR1 = 11, 7 MBs with 64-byte payload
2	64 to 95	MBDSR2	MBDSR2 = 00, 32 MBs with 8-byte payload MBDSR2 = 01, 21 MBs with 16-byte payload

Table continues on the next page...

Table 582. RAM partition (continued)

RAM block	Number of MBs with 8 bytes (default range)	Size control field in FDCTRL	Number of MBs of different sizes, per block
			MBDSR2 = 10, 12 MBs with 32-byte payload MBDSR2 = 11, 7 MBs with 64-byte payload

Payload sizes of 16, 32, or 64 bytes may be configured in some or all of RAM blocks. In those cases, the total number of MBs and their respective number order may differ from the default configuration of 8 bytes. Consider an example where:

- Block0 is configured to an 8-byte payload
- Block1 is configured to a 16-byte payload
- Block2 is configured to 32-byte payload

In this case, Table 583 indicates how the message buffers are arranged in RAM.

Table 583. RAM partition example

RAM block	Payload size	Number of MBs in the RAM block	Message buffer range
0	FDCTRL[MBDSR0] = 00, 8-byte payload	32	0 to 31
1	FDCTRL[MBDSR1] = 01, 16-byte payload	21	32 to 52
2	FDCTRL[MBDSR2] = 10, 32-byte payload	12	53 to 64

76.6.5 FlexCAN message buffer memory map

The FlexCAN memory buffers are allocated in memory according to the tables below.

Table 584. 8-byte message buffers

Address offset (hex)	MBDSR = b00 8-byte payload
0080	MB0
0090	MB1
00A0	MB2
00B0	MB3
00C0	MB4
00D0	MB5
00E0	MB6
00F0	MB7
0100	MB8
0110	MB9

Table continues on the next page...

Table 584. 8-byte message buffers (continued)

Address offset (hex)	MBDSR = b00 8-byte payload
0120	MB10
0130	MB11
0140	MB12
0150	MB13
0160	MB14
0170	MB15
0180	MB16
0190	MB17
01A0	MB18
01B0	MB19
01C0	MB20
01D0	MB21
01E0	MB22
01F0	MB23
0200	MB24
0210	MB25
0220	MB26
0230	MB27
0240	MB28
0250	MB29
0260	MB30
0270	MB31
0280	MB32
0290	MB33
02A0	MB34
02B0	MB35
02C0	MB36
02D0	MB37
02E0	MB38
02F0	MB39
0300	MB40

Table continues on the next page...

Table 584. 8-byte message buffers (continued)

Address offset (hex)	MBDSR = b00 8-byte payload
0310	MB41
0320	MB42
0330	MB43
0340	MB44
0350	MB45
0360	MB46
0370	MB47
0380	MB48
0390	MB49
03A0	MB50
03B0	MB51
03C0	MB52
03D0	MB53
03E0	MB54
03F0	MB55
0400	MB56
0410	MB57
0420	MB58
0430	MB59
0440	MB60
0450	MB61
0460	MB62
0470	MB63
0480	MB64
0490	MB65
04A0	MB66
04B0	MB67
04C0	MB68
04D0	MB69
04E0	MB70
04F0	MB71

Table continues on the next page...

Table 584. 8-byte message buffers (continued)

Address offset (hex)	MBDSR = b00 8-byte payload
0500	MB72
0510	MB73
0520	MB74
0530	MB75
0540	MB76
0550	MB77
0560	MB78
0570	MB79
0580	MB80
0590	MB81
05A0	MB82
05B0	MB83
05C0	MB84
05D0	MB85
05E0	MB86
05F0	MB87
0600	MB88
0610	MB89
0620	MB90
0630	MB91
0640	MB92
0650	MB93
0660	MB94
0670	MB95

Table 585. 16-byte message buffers

Address offset (hex)	MBDSR = b01 16-byte payload
0080	MB0
0098	MB1
00B0	MB2

Table continues on the next page...

Table 585. 16-byte message buffers (continued)

Address offset (hex)	MBDSR = b01 16-byte payload
00C8	MB3
00E0	MB4
00F8	MB5
0110	MB6
0128	MB7
0140	MB8
0158	MB9
0170	MB10
0188	MB11
01A0	MB12
01B8	MB13
01D0	MB14
01E8	MB15
0200	MB16
0218	MB17
0230	MB18
0248	MB19
0260	MB20
0280	MB21
0298	MB22
02B0	MB23
02C8	MB24
02E0	MB25
02F8	MB26
0310	MB27
0328	MB28
0340	MB29
0358	MB30
0370	MB31
0388	MB32
03A0	MB33

Table continues on the next page...

Table 585. 16-byte message buffers (continued)

Address offset (hex)	MBDSR = b01 16-byte payload
03B8	MB34
03D0	MB35
03E8	MB36
0400	MB37
0418	MB38
0430	MB39
0448	MB40
0460	MB41
0480	MB42
0498	MB43
04B0	MB44
04C8	MB45
04E0	MB46
04F8	MB47
0510	MB48
0528	MB49
0540	MB50
0558	MB51
0570	MB52
0588	MB53
05A0	MB54
05B8	MB55
05D0	MB56
05E8	MB57
0600	MB58
0618	MB59
0630	MB60
0648	MB61
0660	MB62

Table 586. 32-byte message buffers

Address offset (hex)	MBDSR = b10 32-byte payload
0080	MB0
00A8	MB1
00D0	MB2
00F8	MB3
0120	MB4
0148	MB5
0170	MB6
0198	MB7
01C0	MB8
01E8	MB9
0210	MB10
0238	MB11
0280	MB12
02A8	MB13
02D0	MB14
02F8	MB15
0320	MB16
0348	MB17
0370	MB18
0398	MB19
03C0	MB20
03E8	MB21
0410	MB22
0438	MB23
0480	MB24
04A8	MB25
04D0	MB26
04F8	MB27
0520	MB28
0548	MB29
0570	MB30

Table continues on the next page...

Table 586. 32-byte message buffers (continued)

Address offset (hex)	MBDSR = b10 32-byte payload
0598	MB31
05C0	MB32
05E8	MB33
0610	MB34
0638	MB35

Table 587. 64-byte message buffers

Address offset (hex)	MBDSR = b11 64-byte payload
0080	MB0
00C8	MB1
0110	MB2
0158	MB3
01A0	MB4
01E8	MB5
0230	MB6
0280	MB7
02C8	MB8
0310	MB9
0358	MB10
03A0	MB11
03E8	MB12
0430	MB13
0480	MB14
04C8	MB15
0510	MB16
0558	MB17
05A0	MB18
05E8	MB19
0630	MB20

76.6.6 Legacy RX FIFO structure

When MCR[RFEN] = 1, the memory area 80h–DCh (which is normally occupied by MBs 0–5) is used by the reception Legacy FIFO engine.

The region 80h–8Ch contains the output of the Legacy RX FIFO, which the CPU must read as a message buffer. This output contains the oldest message that has been received but not yet read. The region 90h–DCh is reserved for internal use of the Legacy RX FIFO engine.

An additional memory area, which starts at E0h and may extend up to 2DCh (normally occupied by MBs 6–37) depending on the value of CTRL2[RFFN], contains the ID filter table (configurable from 8 to 128 table elements) that specifies filtering criteria for accepting frames into the Legacy RX FIFO.

Out of reset, the ID filter table flexible memory area defaults to E0h and extends only to FCh, which corresponds to MBs 6 to 7 for RFFN = 0, for backward compatibility with previous versions of FlexCAN.

The following shows the Legacy RX FIFO data structure.

Table 588. Legacy RX FIFO structure

	31 28 24	23 22 21 20	19 18 17 16	15 8	7 0
80h	IDHIT	SRR IDE RTR	DLC	TIMESTAMP	
84h		ID standard		ID extended	
88h	Data byte 0	Data byte 1		Data byte 2	Data byte 3
8Ch	Data byte 4	Data byte 5		Data byte 6	Data byte 7
90h–DCh	Reserved				
E0h	ID filter table element 0				
E4h	ID filter table element 1				
E8h–2D4h	ID filter table elements 2 to 125				
2D8h	ID filter table element 126				
2DCh	ID filter table element 127				
	= Unimplemented or reserved				

Each ID filter table element occupies an entire 32-bit word. One, two, or four Identifier Acceptance Filters (IDAF) can compound each element, depending on MCR[IDAM]. The following tables show the IDAF indexing.

Table 589 shows the three different formats of the ID table elements. All elements of the table must have the same format. See Legacy RX FIFO for more information.

Table 589. ID table structure

Format	31	30	29 24	23 16	15	14	13 8	7 1	0
A	RTR	IDE	RXIDA (standard = 29–19, extended = 29–1)						
B	RTR	IDE	RXIDB_0 (standard = 29–19, extended = 29–16)		RTR	IDE	RXIDB_1 (standard = 13–3, extended = 13–0)		

Table continues on the next page...

Table 589. ID table structure (continued)

C	RXIDC_0 (std and ext = 31–24)	RXIDC_1 (std and ext = 23–16)	RXIDC_2 (std and ext = 15–8)	RXIDC_3 (std and ext = 7–0)
		= Unimplemented or Reserved		

Table 590. Field descriptions

Mnemonic	Field	Description
RTR	Remote Frame	Specifies whether remote frames are accepted into the Legacy FIFO if they match the target ID. 1: Remote frames can be accepted and data frames are rejected. 0: Remote frames are rejected and data frames can be accepted.
IDE	Extended Frame	Specifies whether extended or standard frames are accepted into the Legacy FIFO if they match the target ID. 1: Extended frames can be accepted and standard frames are rejected. 0: Extended frames are rejected and standard frames can be accepted.
RXIDA	RX Frame Identifier (Format A)	Specifies an ID to be used as acceptance criteria for the Legacy FIFO. In the standard frame format, only the 11 most significant bits (29 to 19) are used for frame identification. In the extended frame format, all bits are used.
RXIDB_0, RXIDB_1	RX Frame Identifier (Format B)	Specifies an ID to be used as acceptance criteria for the Legacy FIFO. In the standard frame format, the 11 most significant bits (a full standard ID) (29 to 19 and 13 to 3) are used for frame identification. In the extended frame format, all 14 bits of the field are compared to the 14 most significant bits of the received ID.
RXIDC_0, RXIDC_1, RXIDC_2, RXIDC_3	RX Frame Identifier (Format C)	Specifies an ID to be used as acceptance criteria for the Legacy FIFO. In both standard and extended frame formats, all 8 bits of the field are compared to the 8 most significant bits of the received ID.
IDHIT	Identifier Acceptance Filter Hit Indicator	Indicates which identifier acceptance filter the received message in the output of the Legacy RX FIFO hit. See Legacy RX FIFO for more information.

76.6.7 Enhanced RX FIFO structure

When ERFCR[ERFEN] = 1, the Enhanced RX FIFO is enabled. The region 2000h–204Ch contains the output of the Enhanced RX FIFO, which the CPU must read as a message buffer. This output contains the oldest message that has been received but not yet read.

Table 591. Enhanced RX FIFO structure

	31	30	29	28	24	23	22	21	20	19	18	17	16	15	8	7	6	0
2000h	EDL	BRS	ESI	Reserved			SRR	IDE	RTR	DLC				TIMESTAMP LEGACY				
2004h	Reserved			ID (standard/extended)										ID (extended)				

Table continues on the next page...

Table 591. Enhanced RX FIFO structure (continued)

2008h	Data byte 0	Data byte 1	Data byte 2	Data byte 3
200Ch	Data byte 4	Data byte 5	Data byte 6	Data byte 7
2010h	Data byte 8	Data byte 9	Data byte 10	Data byte 11
2014h	Data byte 12	Data byte 13	Data byte 14	Data byte 15
2018h	Data byte 16	Data byte 17	Data byte 18	Data byte 19
201Ch	Data byte 20	Data byte 21	Data byte 22	Data byte 23
2020h	Data byte 24	Data byte 25	Data byte 26	Data byte 27
2024h	Data byte 28	Data byte 29	Data byte 30	Data byte 31
2028h	Data byte 32	Data byte 33	Data byte 34	Data byte 35
202Ch	Data byte 36	Data byte 37	Data byte 38	Data byte 39
2030h	Data byte 40	Data byte 41	Data byte 42	Data byte 43
2034h	Data byte 44	Data byte 45	Data byte 46	Data byte 47
2038h	Data byte 48	Data byte 49	Data byte 50	Data byte 51
203Ch	Data byte 52	Data byte 53	Data byte 54	Data byte 55
2040h	Data byte 56	Data byte 57	Data byte 58	Data byte 59
2044h	Data byte 60	Data byte 61	Data byte 62	Data byte 63
IH_OFF	Reserved			ID HIT
TS_OFF	HR TIMESTAMP			
2050h	19 Enhanced FIFO Elements (Reserved)			
...				
263Ch				

NOTE

ID HIT offset and high-resolution timestamp offset change dynamically according to data length code (DLC) as shown in Table 592.

Table 592. ID HIT offset and high-resolution timestamp offset

Data Length Code (DLC)	ID HIT offset (IH_OFF)	High-resolution timestamp offset (TS_OFF)
0	2008h	200Ch
1–4	200Ch	2010h
5–8	2010h	2014h
9	2014h	2018h
10	2018h	201Ch
11	201Ch	2020h
12	2020h	2024h

Table continues on the next page...

Table 592. ID HIT offset and high-resolution timestamp offset (continued)

Data Length Code (DLC)	ID HIT offset (IH_OFF)	High-resolution timestamp offset (TS_OFF)
13	2028h	202Ch
14	2038h	203Ch
15	2048h	204Ch

Table 593. Field descriptions

Mnemonic	Field	Description
EDL	Extended Data Length	Distinguishes between classical CAN format and CAN FD format frames. 0: Classical CAN frame format 1: CAN FD frame format
BRS	Bit Rate Switch	Defines whether the bit rate is switched inside a CAN FD format frame. 0: Bit rate is not switched in a CAN FD frame. 1: Bit rate is switched in a CAN FD frame.
ESI	Error State Indicator	Indicates whether the transmitting node is error-active or error-passive. This field is meaningful only if EDL = 1. 0: Error-active 1: Error-passive
SRR	Substitute Remote Request	Fixed recessive bit, used only in extended format. Transmitting nodes always send it as recessive and receiving nodes can receive it as either recessive or dominant. If FlexCAN receives this bit as dominant, it is interpreted as an arbitration loss.
IDE	ID Extended Bit	Identifies whether the frame format is standard or extended. 0: Standard 1: Extended
RTR	Remote Frame	Identifies whether the current frame is a data frame or a remote request. 0: Data frame 1: Remote request
DLC	Data Length Code	Defines the number of bytes in the data field of a CAN frame (Data byte 0 to Data byte 63). When RTR = 1, the frame is a remote request and does not include the data field, regardless of the DLC field. See Table 581 for more details.
LEGACY TIMESTAMP	16-bit Timestamp	Provides a copy of the Free-Running Timer, captured during the CAN frame. See Table 580 for details about legacy timestamp operation.

Table continues on the next page...

Table 593. Field descriptions (continued)

Mnemonic	Field	Description
ID	Frame Identifier	In base frame format, only the 11 most significant bits are used for frame identification. The 18 least significant bits are ignored. In extended frame format, all bits are used for frame identification.
DATA BYTE 0–63	Data Field	Up to 64 bytes can be stored in the data field.
IDHIT	Identifier Acceptance Filter Hit Indicator	Indicates which Enhanced RX FIFO Filter Element (ERFFEL0 - ERFFEL127) the received message in the output of the Enhanced RX FIFO hit. For each filter region, standard-ID filter space, and extended-ID filter space, there is an independent index starting from zero. Table 594 shows how FlexCAN writes IDHIT according to each filter element.
HR TIMESTAMP	High-resolution Timestamp	32-bit timebase captured during the CAN frame. When CTRL2[TSTAMPCAP] is not zero, a 32-bit timebase is captured from a dedicated on-chip timer which operates in free-running mode. See CTRL2[TSTAMPCAP] for details about capture point configuration of the high-resolution timestamp.

Table 594. IDHIT for Enhanced RX FIFO

Enhanced RX FIFO filter element - ERFFEL	IDHIT value	Filter element type
ERFFEL0	0	Extended-ID
ERFFEL1	1	Extended-ID
. . .	. . .	Extended-ID
ERFFEL(m-1)	m-1	Extended-ID
ERFFEL(m)	0	Standard-ID
ERFFEL(m+1)	1	Standard-ID
. . .	. . .	Standard-ID
ERFFEL(2n-m+1)	2x(n-m)+1	Standard-ID

NOTE

Where m = NEXIF and n = NFE. If NEXIF = 0, only standard-ID filter elements exist. If NEXIF > NFE, only extended-ID filter elements exist.

76.7 Glossary

Active message buffer A message buffer is active if it can participate in the current matching or arbitration process.

Bus interface unit FlexCAN submodule responsible for the interface to the CPU.

Bus off	See CAN Specification.[39]
CAN	Controller Area Network, a serial communication protocol defined in CAN Specification[39] and ISO International Standard.[40]
CHI	Controller-host interface, a FlexCAN submodule responsible for message buffer matching and arbitration algorithms.
CRC	Cyclic redundancy check
Dominant bit	A dominant bit wins the arbitration on the CAN bus. It is transmitted as 0.
Doze mode	A system low-power mode where the CPU bus remains active and a global Doze mode request is sent to all peripherals asking them to enter low power mode.
Error active	See CAN Specification.[39]
Error frame	See CAN Specification.[39]
Error passive	See CAN Specification.[39]
Form error	See CAN Specification.[39]
Hard reset	A reset coming from an external pin and/or following power-on. It resets everything.
Idle	See CAN Specification.[39]
Information processing time	See CAN Specification.[39]
Intermission	See CAN Specification.[39]
Matching elements	Data used in the matching process, such as ID, filter, mask, etc.
MB	See Message buffer.
Message buffer	Internal FlexCAN data structure containing bytes received from, or to be transmitted to, the CAN line, as well as information about this data.
Overload frame	See CAN Specification.[39]
Phase buffer segment	See CAN Specification.[39]
Recessive bit	A recessive bit loses the arbitration on the CAN bus. It is transmitted as 1.
Sclock	Serial clock. Obtained by dividing the clock feeding the CAN engine (oscillator or bus clock) by a prescaler factor. The Sclock period defines the time quantum for CAN protocol timing.
Soft reset	Global reset typically used by peripherals to reinitialize some of its registers, but not all of them.
Stop mode	A system low-power mode in which all chip clocks are stopped for maximum power savings.
Stuffing error	See CAN Specification.[39]
Time quantum	This is equal to the Sclock period. It is the minimum time period used to compose the CAN protocol bit timing.

[39] Controller Area Network - CAN Specification Version 2.0 Part A, Part B, Robert Bosch GmbH, 1991.
[40] ISO International Standard - ISO 11898 First Edition 1993 Road Vehicles - Interchange of Digital Information - Controller Area Network (CAN) for high-speed Communication.

Chapter 77
De-serial Serial Peripheral Interface (DSPI)

77.1 Chip-specific DSPI information

77.1.1 DSPI instances and configuration

The chip has only one instance of DSPI which can be used to implement MSC (MicroSecond Channel interface)

- MSC timer channel serialization is supported.
- 64 bit mode is supported.
- DSPI Serialization mode is enabled.

The trigger inputs to DSPI should be stable for 1µs

NOTE

- MTO operation is not supported.
- Slave mode is not supported for DSPI.

NOTE

DSPI/MSC interface is supported only at VDD_HV_A = 5V and not at 3.3V.

77.2 Introduction

The DSPI module provides a synchronous serial bus for communication between a chip and an external peripheral device. The module supports chip pin count reduction through serialization and deserialization of chip internal signals transmitted over the DSPI serial link.

77.2.1 Block diagram

The following figure represents the module's block diagram.

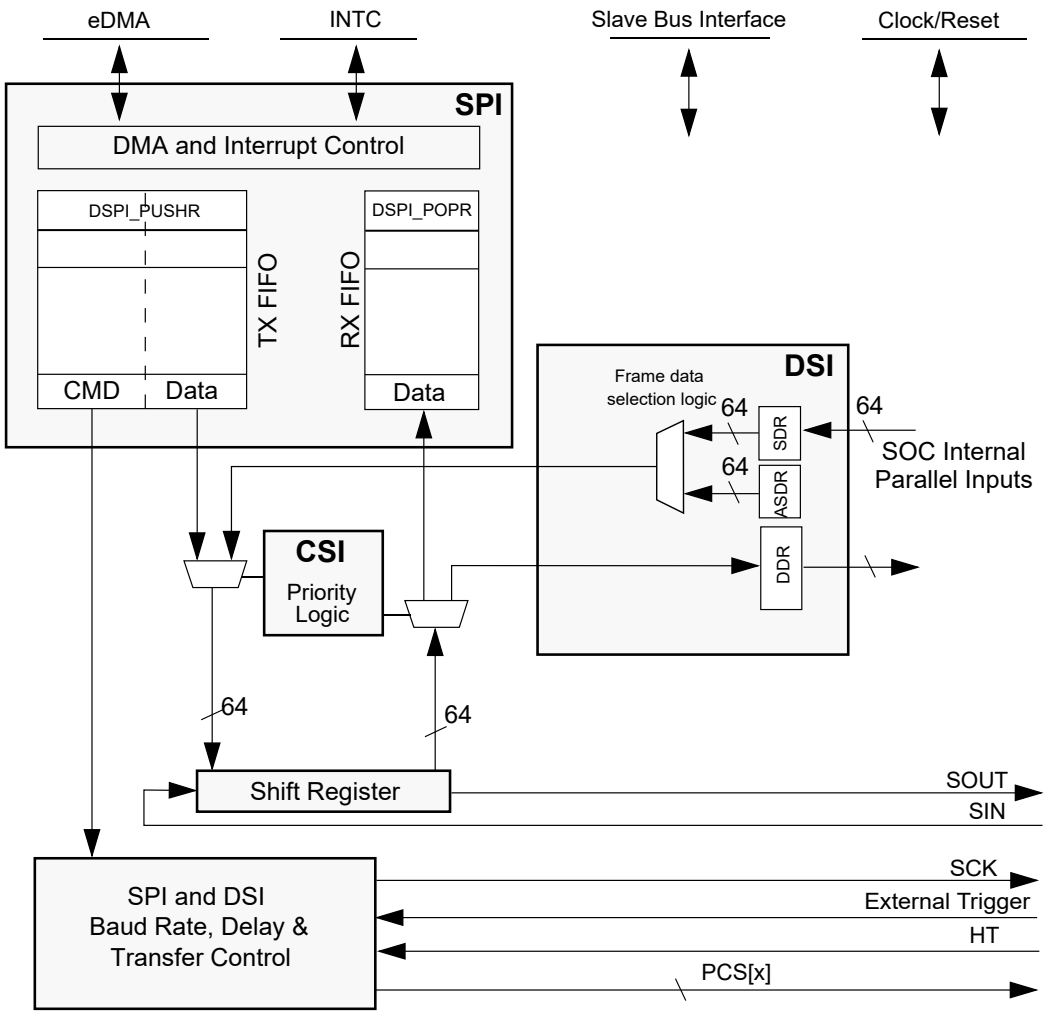


Figure 535. DSPI block diagram

77.2.2 Features

The module supports the following features:

- Full-duplex, three-wire synchronous transfers
- Master mode
- Buffered transmit operation using transmit first in first out (TX FIFO) with a depth of 16 entries
- Buffered receive operation using the Receive FIFO (RX FIFO) with a depth of 16 entries
- TX and RX FIFOs can be disabled individually for low-latency updates to DSPI queues
- Visibility into TX and RX FIFOs for ease of debugging
- Programmable transfer attributes on a per-frame basis:
  - 6 transfer attribute registers
  - 6 extended transfer attribute registers
  - Serial clock (SCK) with programmable polarity and phase
  - Various programmable delays

  - Programmable serial frame size is 4 to 64 bits
    - DSPI frames longer than 32 bits can be supported using the continuous selection format.
  - Continuously held chip-select capability
  - Parity control
- 2 peripheral chip selects (PCSes)
- DMA support for adding entries to TX FIFO and removing entries from RX FIFO when:
  - TX FIFO is not full (TFFF)
  - RX FIFO is not empty (RFDF)
  - Command (CMD) FIFO is not full (CMDFFF)
- Interrupt conditions:
  - End of queue reached (EOQF)
  - TFFF
  - CMDFFF
  - Transfer of current frame complete (TCF)
  - Transfers due from current command frame complete (CMDTCF)
  - Transfer of current DSPI frame complete (SPITCF)
  - RFDF
  - Frame received while RX FIFO is full (RFOF)
  - DSPI Parity Error (SPEF)
  - Data present in TX FIFO while CMD FIFO is empty (TFIWF)
- Global interrupt request line

The DSPI also supports pin reduction through serialization and deserialization, if enabled.

- Two sources of serialized data:
  - Module memory-mapped register
  - Parallel input signals
  - Programmable selection of source data on bit basis
- Deserialized data is provided as parallel output signals and as bits in a memory-mapped register.
- Interrupt conditions and DMA support is provided when:
  - Deserialized data matches pre-programmed pattern (DDIF)
  - Transfer of current DSI frame complete (DSITCF)
  - DSI Parity Error (DPEF)
- Transfer initiation conditions:
  - Continuous
  - Edge-sensitive hardware trigger
  - Change in data
- Pin serialization/deserialization with interleaved DSPI frames for control and diagnostics
- Continuous serial communications clock (SCK)

DSPI supports a combination of DSPI and DSI modes of operation known as the Combined Serial Interface (CSI). It also supports the downstream Micro Second Channel in the Timed Serial Bus (TSB) configuration or Interleaved Frames Configuration; configurable by software.

Both TSB and Interleaved TSB modes have the following common features:

- Transmission of frames is done at frame boundaries
- Frames from DSPI and DSI are identifiable by a bit transmitted at the start of each frame
- Separate interrupts for frame completion from DSPI and DSI

77.2.3 Interface configurations

77.2.3.1 SPI configuration

The SPI configuration allows the module to send and receive serial data. This configuration allows the module to operate as a basic SPI block with internal FIFOs supporting the external queue operation. Transmitted data and received data are included in separate FIFOs. The host CPU or a DMA controller reads the received data from the RX FIFO and writes transmit data to the transmit FIFO.

For queued operations, the SPI queues can be included in system RAM, external to the module. A DMA controller or host CPU accomplishes data transfers between the queues and the module FIFOs. The following figure shows an example with DMA, DSPI, and external queues in system RAM.

NOTE

In the following diagram, SPI is used for both the DSPI and DSI modes.

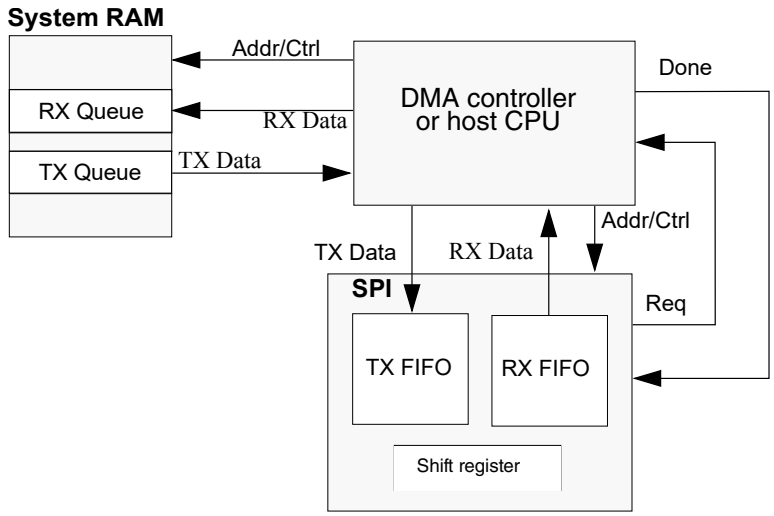


Figure 536. SPI with queues and DMA

77.2.3.2 DSI configuration

In the Deserial Serial Interface (DSI) configuration, DSPI serializes up to 64 parallel input signals or register bits. DSPI also deserializes the received data to parallel output signals or to a memory-mapped register, and transfers the data using SPI-like protocol.

Timed Serial Bus (TSB) mode provides the MicroSecond Channel (MSC) downstream support, serializing from 4 to 64 parallel input signals or register bits. For more information on TSB mode, see Timed serial bus (TSB).

77.2.3.3 CSI configuration

The CSI configuration supports the following modes:

- Normal: It provides a combination of the DSPI and DSI configurations. The DSPI interleaves DSI data frames with SPI data frames, and the interleaving is done on the frame boundaries.
- TSB: Transmission of DSPI data has a higher priority than DSI data.
- Interleaved TSB (ITSB): The frames from DSPI and DSI are interleaved without priority. On every trigger, frames from DSI are sent when there are no frames in the DSPI or the previous transmission was a frame from DSPI. For more information, see Interleaved TSB (ITSB) Mode.

77.3 Module signal descriptions

This table describes the signals on the boundary of the module that may connect off chip (in alphabetical order).

Table 595. Module signal descriptions

Signal	Master mode	I/O
HT	Hardware Trigger	I
PCS0	Peripheral Chip Select 0 (O)	O
PCS1	Peripheral Chip Select 1	O
SCK	Serial Clock (O)	O
SIN	Serial Data In	I
SOUT	Serial Data Out	O

77.3.1 HT

Master mode: Hardware Trigger (I)—

- Is honored only when the module is configured for the DSI or CSI configuration (MCR[DCONF]), the value for DSICR0[TRRE] is 1, and the module is in the Running state (SR[TXRXS])
- Receives hardware triggers that initiate data transfers
- DSICR0[TPOL] specifies whether the module uses the rising or falling edges of HT as hardware triggers

77.3.2 PCS0

Master mode: Peripheral Chip Select 0 (O)—Selects DSPI slave to receive data transmitted from the module

NOTE

Do not tie the DSPI slave select pin to ground. Otherwise, DSPI cannot function properly.

77.3.3 PCS1

Master mode: Peripheral Chip Select 1 (O)—Selects DSPI slave to receive data that the module transmits

77.3.4 SCK

Master mode: Serial Clock (O)—Supplies a clock signal from the module to DSPI slaves

77.3.5 SIN

Master mode: Serial Input (I)—Receives serial data

77.3.6 SOUT

Master mode: Serial Output (O)—Transmits serial data

77.4 Functional description

The module supports full-duplex, synchronous serial communications between chips and peripheral devices. It can also be used to reduce the number of pins that I/O requires, by serializing and deserializing parallel input/output signals. All communications are performed with SPI-like protocol.

The module includes the following configuration:

- SPI configuration in which the module operates as a basic SPI or a queued SPI
- DSI configuration in which the module serializes and deserializes parallel input/output signals or fields from memory-mapped registers
- When the Master mode is enabled, the module also supports CSI configuration, which combines the functionality of the SPI and DSI configurations.

MCR[DCONF] determines the module configuration. See Module Configuration Register (MCR) for the DSPI configuration values.

The CTAR*n* registers hold clock and transfer attributes. The SPI configuration allows to select which CTAR to use, on a frame-by-frame basis, by setting a field in the SPI command. MCR[XSPI] further allows the usage of CTARE*n* registers. This allows you to send multiple data frames using a single command frame.

The DSI configuration statically selects which CTAR to use. In CSI, configuration priority logic determines if SPI data or DSI data is transferred and dictates which CTAR register is used for data transfer.

Typical master-to-slave connections are shown in the following figure. When a data transfer operation is performed, data is serially shifted to a predetermined number of bit positions. Because the modules are linked, data is exchanged between the master and the slave. The data that was included in the master shift register is now in the shift register of the slave, and vice versa. At the end of a transfer, if the value of SR[TCF] is 1, it indicates a completed frame transfer.

NOTE

SPI is used for both the DSPI and DSI modes in the following diagram.

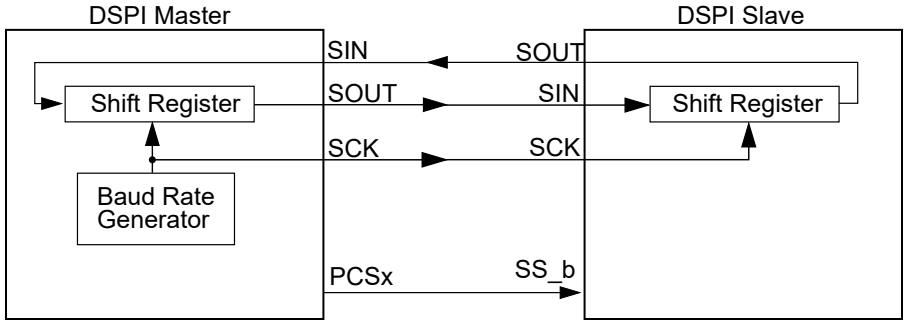


Figure 537. Serial protocol overview

Generally, more than one slave device can be connected to the module master, and 2 PCS signals of the module masters can be used to select which of the slaves to communicate with.

The three DSPI configurations share transfer protocol and timing properties that are described independently of the configuration in Transfer formats. The transfer rate and delay settings are described in Module baud rate and clock delay generation.

77.4.1 Modes of operation

The module supports the following modes of operation that can be divided into two categories:

- Module-specific modes:

- Master mode
- Module Disable mode

- Chip-specific modes:
  - Debug mode

The module enters module-specific modes when the host writes to a module register. The signals external to the module control the chip-specific modes. The chip may enter these modes in parallel to the module-specific modes.

77.4.1.1 Master mode

The Master mode allows the module to initiate and control serial communication. In this mode, the module controls the following signals, which the module configures as outputs:

- SCK
- PCS[*x*]

77.4.1.2 Module Disable mode

The Module Disable mode can be used for chip-power management. In this mode, you can stop the clock to the non-memory mapped logic in the module.

77.4.1.3 Debug mode

The Debug mode is used for system development and debugging. MCR[FRZ] controls module behavior when the chip is in this mode.

- If you write a 1 to this field, the module stops all serial transfers .
- If you write a 0 to the field, this mode has no effect on the module.

77.4.2 Starting and stopping module transfers

The module has two operating states: Stopped and Running. Both the states are independent of their configuration. The default state of the module is Stopped. In this state, the module initiates no serial transfers in the Master mode. The Stopped state is also a safe state for writing to the various configuration registers of the module, without causing undetermined results. In the Running state, serial transfers take place.

SR[TXRXS] indicates the state of the module. The value of this field is 1 if the module is in the Running state.

The module starts or transitions to the Running state when all of the following conditions are true:

- The value of SR[EOQF] = 0.
- The chip is not in the Debug mode or the value of MCR[FRZ] = 0.
- The value of MCR[HALT] = 0.

The module stops or transitions from the Running state to the Stopped state after the current frame, when any one of the following conditions exist:

- The value of SR[EOQF] = 1.
- The chip is in Debug mode and the value of MCR[FRZ] = 1.
- The value of MCR[HALT] = 1.

State transitions from running to stopped occur on the next frame boundary if a transfer is in progress, and occur immediately if no transfers are in progress.

77.4.3 SPI configuration

The SPI configuration transfers data serially using a shift register and a selection of programmable transfer attributes. The module is in SPI configuration when the value of MCR[DCONF] is 0. The SPI frames can be 32-bit long. The host CPU or a DMA controller transfers the external SPI data to the module RAM queues and to a TX FIFO buffer. The received data is stored in the entries of the RX FIFO buffer. The host CPU or the DMA controller transfers the received data from the RX FIFO to a memory external to the module. The operation of FIFO buffers is described in the following sections:

- TX FIFO buffering mechanism
- CMD FIFO buffering mechanism
- RX FIFO buffering mechanism

The interrupt and DMA request conditions are described in Interrupts/DMA requests.

In the Master mode, the module initiates and controls the transfer according to the fields of the executing SPI command.

77.4.3.1 Master mode

In the DSPI Master mode, the module initiates serial transfers by controlling the SCK and the PCS signals. The executing DSPI command determines which CTARs will be used to set the transfer attributes and which PCS signals to assert. The command field also contains various bits that help with queue management and transfer protocol. See PUSH TX FIFO Register In Master Mode (PUSHR) for details on the DSPI command fields. The data in the executing TX FIFO entry is loaded into the shift register and shifted out on the SOUT pin. In the DSPI Master mode, each SPI frame to be transmitted has a command associated with it, allowing for transfer attribute control on a frame by frame basis. In the Extended SPI Master mode, multiple DSPI frames can have a single command associated with them allowing efficient SPI frame transfers requiring common transfer attributes. In addition, the Extended SPI mode allows larger frame sizes of up to 32 bits.

77.4.3.2 FIFO disable operation

The FIFO disable mechanisms allow DSPI transfers without using the TX FIFO, CMD FIFO, or RX FIFO. The module operates as a double-buffered, simplified DSPI when the FIFOs are disabled. The transmit and receive sides of the FIFOs are disabled separately. Writing a 1 to MCR[DIS_TXF] disables the TX FIFO and CMD FIFO, and writing a 1 to MCR[DIS_RXF] disables the RX FIFO.

The FIFO disable mechanisms are transparent to you and to the host software. Transmit data and commands are written to the PUSHR and received data is read from the POPR.

When the TX FIFO and CMD FIFO are disabled:

- SR[TFFF], SR[CMDFFF], SREX[CMDCTR], and SR[TXCTR] behave as if there is a one-entry FIFO.
- The contents of TXFRs, SR[TXNXTPTR], and SREX[CMDNXTPTR] are undefined.

Similarly, when the RX FIFO is disabled, SR[RFDF], SR[RFOF], and SR[RXCTR] behave as if there is a one-entry FIFO, but the contents of the RXFR registers and SR[POPNXTPTR] are undefined.

77.4.3.3 TX FIFO buffering mechanism

The TX FIFO functions as a buffer of DSPI data for transmission. It holds 16 words, each consisting of DSPI data. The number of entries in the TX FIFO is chip-specific. DSPI data is added to the TX FIFO by writing to the data field of PUSHR. TX FIFO entries can only be removed from the TX FIFO if they are shifted out or by flushing the TX FIFO.

SR[TXCTR] indicates the number of valid entries in the TX FIFO. The field updates every time an 8- or 16-bit write takes place on PUSHR[TXDATA] or SPI data is transferred into the Shift register from the TX FIFO.

SR[TXNXTPTR] indicates the TX FIFO entry that will be transmitted during the next transfer. The TXFR*n* registers are invalid in the Extended SPI mode because the TX FIFO and CMD FIFO can be used independently. The TXNXTPTR field increments every time SPI data is transferred from the TX FIFO to the Shift register. The maximum value of this field is equal to the maximum implemented TXFR number and it rolls over after reaching the maximum.

77.4.3.3.1 Filling the TX FIFO

Host software or other intelligent blocks can add (push) entries to the TX FIFO and CMD FIFO by writing to the PUSHR. When the TX FIFO is not full, the value of DR[TFFF] is set to 1, and the value is set to 0 when TX FIFO is full and the DMA controller indicates that a write to PUSHR is complete. You can also write a 1 to clear the field, which can generate a DMA request or an interrupt request. See Transmit FIFO fill interrupt or DMA request for details.

The module ignores attempts to push data to a full TX FIFO, and the state of the TX FIFO does not change and no error condition occurs.

77.4.3.3.2 Draining the TX FIFO

The module removes (drains) the TX FIFO entries by shifting DSPI data out through the Shift register. It transfers entries from the TX FIFO to the Shift register, and the entries are shifted out as long as there are valid entries in the TX FIFO. Every time an entry is transferred from the TX FIFO to the Shift register, the TX FIFO counter decrements by 1. When the value of MCR[XSPI] is 1, and if the frame size of SPI data to be transmitted is more than 16 bits, then it causes two data entries to be popped from TX FIFO simultaneously. These entries are transferred to the Shift register. The first of the two popped entries forms the 16 least significant bits of the SPI frame to be transmitted. Such an operation also causes the TX FIFO counter to decrement by 2. At the end of a transfer, the value of SR[TCF] is set to indicate the completion of a transfer. The TX FIFO is flushed by writing a 1 to MCR[CLR_TXF].

77.4.3.4 CMD FIFO buffering mechanism

The CMD FIFO functions as a buffer of DSPI command used for SPI data transmission. When Extended SPI Mode (MCR[XSPI]) is disabled, the TX FIFO and CMD FIFO must be filled together, i.e. write enables should be given for both the Data and Command fields while performing a PUSHR operation.When Extended SPI Mode (MCR[XSPI]) is enabled, the TX FIFO and CMD FIFO can be filled independently.

The CMD FIFO holds 16 words, each representing SPI command fields. The number of entries in the CMD FIFO is chip-specific. DSPI command is added to the CMD FIFO by writing to the command field of PUSHR. CMD FIFO entries can only be removed from the CMD FIFO by being shifted out (to help transmit SPI data) or by flushing the CMD FIFO.

When Extended SPI Mode (MCR[XSPI]) is disabled, every CMD FIFO entry has a corresponding single TX FIFO entry attached to it because both these FIFO's are filled simultaneously.

When Extended SPI Mode (MCR[XSPI]) is enabled, every CMD FIFO entry can have multiple TX FIFO entries attached to it. Thus a single CMD FIFO entry can be used to transmit multiple TX FIFO entries. The CTARE[DTCP] field decides the number of SPI Data Frames having frame size as {FMSZE, FMSZ} to be transmitted using the current Command Entry. The CTAR/CTARE registers pointed by the CTAS field in the Command frame gives the FMSZ and FMSZE fields respectively. The time for which a command entry is in use is known as a Command Cycle. The Busy Flag SR[BSYF] is asserted for the duration of the Command Cycle except for the last SPI frame in the Command Cycle.

The CMD FIFO Counter field (CMDCTR) in the DSPI Status Register extended(SREX) indicates the number of valid entries in the CMD FIFO. The CMDCTR field is updated every time a 8- or 16-bit write takes place on the lower half of DSPI_PUSHR or SPI data is transferred into the shift register from the TX FIFO.

The TXFRn Registers are invalid in the Extended SPI Mode, since the TX FIFO and CMD FIFO can be used independently. The CMDNXTPTR field indicates which CMD FIFO Entry will be used during the next command cycle. The CMDNXTPTR field is incremented every time the last SPI data in the command cycle is transferred from the TX FIFO to the shift register and it rolls over after reaching the maximum.

77.4.3.5 RX FIFO buffering mechanism

The RX FIFO functions as a buffer for data received on the SIN pin. The FIFO holds 16 received DSPI data frames. The number of entries in the RX FIFO is chip-specific. DSPI data is added to the RX FIFO at the completion of a transfer when the received data in the Shift register is transferred into the RX FIFO. DSPI data is removed (popped) from the RX FIFO by reading the POPR. RX FIFO entries can only be removed from the RX FIFO by reading the POPR or by flushing the RX FIFO.

SR[RXCTR] indicates the number of valid entries in the RX FIFO. The field is updated every time the POPR is read or DSPI data is copied from the Shift register to the RX FIFO.

SR[POPNXTPTR] points to the RX FIFO entry that is returned when the POPR is read. The field contains the positive offset from RXFR0 in a number of 32-bit registers. For example, POPNXTPTR = 2 means that the RXFR2 contains the received DSPI data that is returned after the POPR is read. The POPNXTPTR field increments every time the POPR is read. The maximum value of the field is equal to the maximum implemented RXFR number and it rolls over after reaching the maximum.

77.4.3.5.1 Filling the RX FIFO

The RX FIFO is filled with the received DSPI data from the Shift register. While the RX FIFO is not full, DSPI frames from the Shift register are transferred to the RX FIFO. Every time a DSPI frame is transferred to the RX FIFO, the RX FIFO counter is incremented by 1.

If the RX FIFO and Shift register are full and a transfer is initiated, the value of SR[RFOF] equals 1, indicating an overflow condition. Depending on the state of MCR[ROOE], the data from the transfer that generated the overflow is either ignored or shifted to the Shift register. If the value of the ROOE field is 1, the incoming data is shifted in to the Shift register. If the value of ROOE is 0, the incoming data is ignored.

77.4.3.5.2 Draining the RX FIFO

Host CPU or a DMA can remove (pop) entries from the RX FIFO by reading the POPR. A read of the POPR decrements the RX FIFO counter by 1. Attempts to pop data from an empty RX FIFO are ignored and the RX FIFO counter remains unchanged. The data, read from the empty RX FIFO, is undetermined.

When the RX FIFO is not empty, the value of SR[RFDF] is 1. The value of the RFDF field turns 0 when the RX FIFO is empty and the DMA controller indicates that a read from POPR is complete or by writing a 1 to it.

77.4.4 DSI configuration

The DSI configuration supports pin count reduction by serializing parallel input signals or register fields and shifting them out in SPI-like protocol. The timing and transfer protocols are described in Transfer formats. The received serial frames are converted to a parallel form (deserialized) and placed on the parallel output signals or in the DDRs. The various features of DSI configuration are available in DSI configuration registers (DSICR0/DSICR1). The DSI frames can range from 4 to 32 bits. This can go up to 64 bits when the value of DSICR1[DSI64E] is 1.

77.4.4.1 DSI Master mode

In DSI Master mode, the DSPI initiates and controls the DSI transfers. The DSI master has different conditions that can initiate a transfer:

- Continuous
- Change in data
- Trigger signal
- Trigger signal combined with a change in data

Transfer attributes are set during initialization. The DSICTAS field in the DSI_EXISTSCR0 determines which of the DSPI_CTAR registers will control the transfer attributes.

77.4.4.2 DSI serialization

In the DSI configuration, up to 64 bits can be serialized using two different sources. DSICR0[TXSS] selects between SDR0–1 and ASDR0–1 as the source of serialized data. SDR0 holds the latest 32 parallel input signal values that are sampled at every rising edge of the bus clock. If the value of DSICR1[DSI64E] is 1, 64-bit DSI frames are supported, and hence, SDR1 holds up to 32 most significant parallel input signal values that are sampled at every rising edge of the bus clock. The ASDR0–1 registers are written by the host software and used as alternate sources of serialized data. ASDR1 is only usable when the value of DSICR1[DSI64E] is 1.

NOTE

The parallel input pin state to be transmitted should be selected by DSICR0[TXSS] or SSR0-1 and the frame size should be higher than the bit position in the preselected frame.

The SSR0–1 register provides an additional way to create the frame for transmission. Each field of this register is OR'd with the TXSS field and controls individual transmitted bit source. This way, the transmitted frame can have any combination of the SDR0–1 and ASDR0–1 fields. This feature allows control over SPI-based chips, requiring control and data fields in the frame. A control field may be a part of the ASDR0–1 registers, configured by the chip's CPU, while a data field can be generated by chip peripheral modules, such as PWM timers.

A copy of the last DSI frame shifted out of the Shift register is stored in the COMPR0–1 registers. These registers provide added visibility for debugging and serve as a reference for transfer initiation control. The following figure shows the DSI serialization logic.

NOTE

SPI is used for both the DSPI and DSI modes in this diagram.

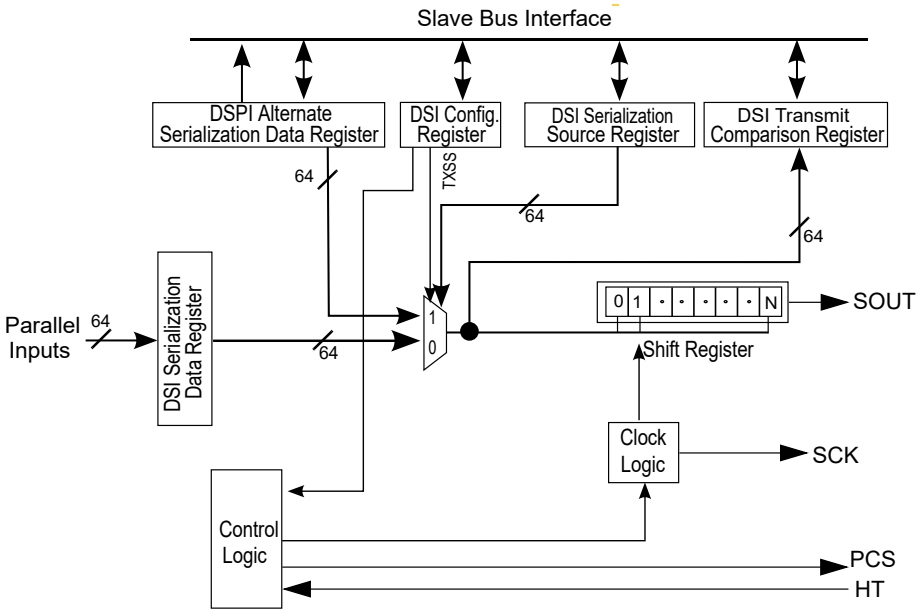


Figure 538. DSI serialization diagram

77.4.4.3 DSI deserialization

When all the bits in a DSI frame are shifted in, the frame is copied to the DDR0/1. This register presents the deserialized data as parallel output signal values. DDR0/1 is memory mapped to allow the host software to read the deserialized data directly.

The received data is compared, bit-wise, to the value of the DPIR0/1, AND'ed with DIMR0/1, and the results OR'ed to produce a DDIF field in the SR. This, in turn, can cause a DDI or DMA request based on RSER[DDIF_RE] and RSER[DDIF_DIRS] and/or stop DSI frame transmissions if the value of DSICR0[DMS] is 1.

The following figure shows the DSI deserialization logic.

NOTE

SPI is used for both DSPI mode and DSI mode in this diagram.

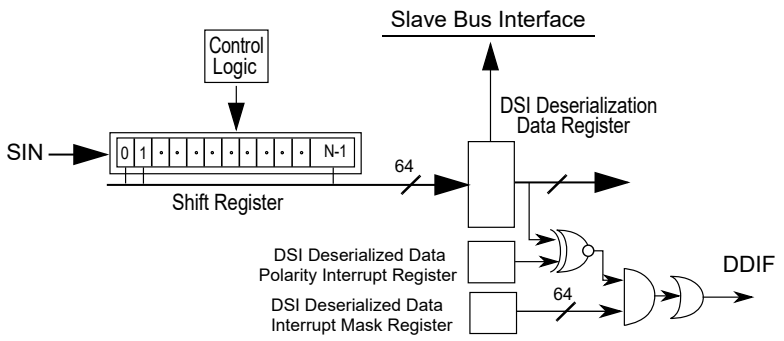


Figure 539. DSI deserialization diagram

77.4.4.4 DSI transfer initiation control

Data transfers for DSPI in DSI configuration are initiated by a condition. DSICR0[TRRE] and DSICR0[CID] select the transfer initiation conditions. The following table lists the four transfer initiation conditions.

Table 596. DSI data transfer initiation control

DSICR0 fields		Transfer initiation control
TRRE	CID	
0	0	Continuous
0	1	Change in data
1	0	Triggered
1	1	Triggered or change in data

77.4.4.4.1 Continuous control

For Continuous control, a new DSI frame shifts out when the previous transfer cycle is compete and the Delay after Transfer (t_{DT}) has elapsed.

77.4.4.4.2 Change in data control

For Change in Data Control, a transfer is initiated when the data to be serialized has changed since the transfer of the last DSI frame. A copy of the previously transferred DSI data is stored in COMPR0/1. When the data selected for the transfer from the SDR0/1 and ASDR0/1 registers is different from the data in COMPR0/1, a new DSI frame is transmitted.

NOTE

It is not advisable to configure a DSPI slave with the combination of DSICR0[DCONT] = 1 and DSICR0[CID] = 1 because the following statement then holds true.

After slave select is asserted, there is a very small window (of up to t module clocks) after every Start of Frame (SOF) during which if a write on ASDR/SDR registers occurs, the next frame to be transmitted is loaded into the Shift register. However, it is not feasible that such a write be initiated and completed within this short span of time; hence, the data transmitted by DSPI slave lags by one data frame.

77.4.4.4.3 Triggered control

For Triggered Control initiation of a transfer is controlled by the Hardware Trigger signal (HT). The TPOL bit in the DSI_EXISTSCR0 selects the active edge of HT. For HT to have any affect, the TRRE bit in the DSI_EXISTSCR0 must be set.

77.4.4.4.4 Triggered or change in data control

For Triggered or Change in Data Control, initiation of a transfer is controlled by the HT signal or by the detection of a change in data to be serialized.

77.4.5 CSI configuration

The CSI Configuration of the DSPI is used to support SPI and DSI functions on a frame by frame basis. CSI Configuration allows interleaving of DSI data frames from the parallel input signals with DSPI data frames from the TX FIFO. The data returned from the bus slave is either used to drive the Parallel Output signals or it is stored in the RX FIFO. The CSI Configuration allows serialized data and configuration or diagnostic data to be transferred to a slave device using only one serial link. The DSPI is in CSI Configuration when the DCONF field in the DSPI_MCR is 0b10. The following figure shows an example of how a DSPI can be used with a deserializing peripheral that supports DSPI control for control and diagnostic frames.

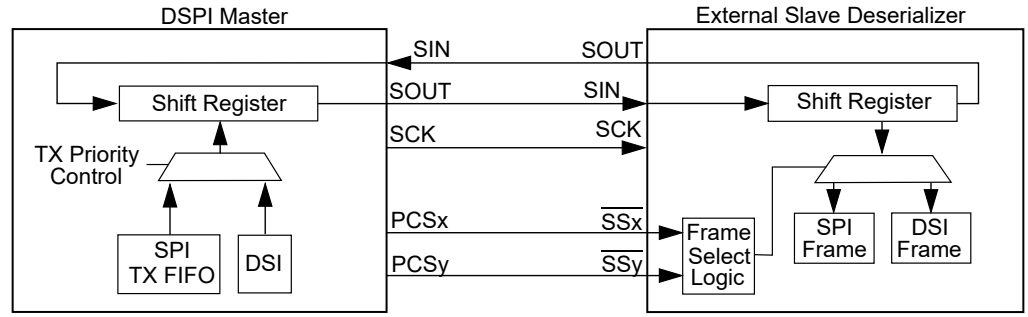


Figure 540. Example of System using DSPI in CSI Configuration

When DSPI commands are in the TX FIFO, the SPI frames have priority over the DSI frames. When the TX FIFO or CMD FIFO is empty, DSI transfer resumes.

Two peripheral chip select signals indicate whether DSI data or DSPI data is transmitted. The user must configure the DSPI so that the two CTAR registers associated with DSI data and DSPI data assert different peripheral chip select signals denoted in the figure as PCSx and PCSy. The CSI Configuration is only supported in master mode.

Data returned from the external slave while a DSI frame is transferred is placed on the Parallel Output signals. Data returned from the external slave while a DSPI frame is transferred is moved to the RX FIFO. The TX FIFO, CMD FIFO and RX FIFO are fully functional in CSI mode.

77.4.5.1 CSI serialization

Serialization in the CSI configuration is similar to serialization in DSI Configuration. The transfer attributes for SPI frames are determined by the DSPI_CTAR register selected by the CTAS field in the SPI command halfword. The transfer attributes for the DSI frames are determined by the DSPI_CTAR register selected by the DSICTAS field in the DSI_EXISTSCR0.

The Parallel Inputs signal states are latched into the DSPI DSI Serialization Data Register (DSPI_SDR0/1) and serialized based on the transfer initiation control settings in the DSI_EXISTSCR0. When SPI frames are written to the TX FIFO (and when CMD FIFO is not empty) they have priority over DSI data from the DSPI_SDR and are transferred at the next frame boundary. A copy of the most recently transferred DSI frame is stored in DSPI_COMPR0/1. The Transfer Priority Logic selects the source of the serialized data and asserts the appropriate PCS signal.

Separate frame completion interrupts are available to indicate frame transmission completion from SPI and DSI frames.

77.4.5.2 CSI deserialization

The deserialized frames in CSI configuration go into the DDR0/1 registers or the RX FIFO based on the transfer priority logic. When DSI frames are transferred, the returned frames are deserialized and latched into the DDR0/1 registers. When SPI frames are transferred, the returned frames are deserialized and written to the RX FIFO.

77.4.6 Module baud rate and clock delay generation

The SCK frequency and the delay values for serial transfer are generated by dividing the system clock frequency by a prescaler and a scaler with the option for doubling the baud rate. The following figure shows conceptually how the SCK signal is generated.

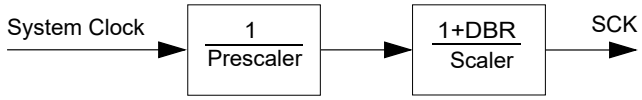


Figure 541. Communications clock prescalers and scalers

77.4.6.1 Baud rate generator

The baud rate is the frequency of the SCK. The protocol clock is divided by a prescaler (PBR) and scaler (BR) to produce SCK with the possibility of halving the scaler division. The DBR, PBR, and BR fields in the CTARs select the frequency of SCK by the formula in the BR field description. The following table shows an example of how to compute the baud rate.

Table 597. Baud rate computation example

f_P	PBR	Prescaler	BR	Scaler	DBR	Baud rate
100 MHz	0b00	2	0b0000	2	0	25 Mb/s
20 MHz	0b00	2	0b0000	2	1	10 Mb/s

NOTE

The clock frequencies mentioned in the preceding table are provided as an example. See the Clocking chapter for the frequency used to drive this module in the chip.

77.4.6.2 PCS to SCK delay (t_{CSC})

The "PCS to SCK delay" is the duration from assertion of the PCS signal to the first SCK edge. See Figure 542 for an illustration of the PCS to SCK delay. The PCSSCK and CSSCK fields in the CTAR*x* registers select the PCS to SCK delay by the formula in the CSSCK field description. The following table shows an example of how to compute the PCS to SCK delay.

Table 598. PCS to SCK delay computation example

f_{SYS}	PCSSCK	Prescaler	CSSCK	Scaler	PCS to SCK Delay
100 MHz	0b01	3	0b0100	32	0.96 µs

PCSCSK and CSSCK fields have no effect in TSB configuration.

NOTE

The clock frequency mentioned in the preceding table is given as an example. See the Clocking chapter for the frequency used to drive this module in the chip.

77.4.6.3 After SCK delay (t_{ASC})

The "After SCK Delay" is the duration between the last edge of SCK and the negation of PCS. See Figure 542 and Figure 543 for illustrations of this type of delay. The PASC and ASC fields in the CTAR*x* registers select the "After SCK Delay" by the formula in the ASC field description. The following table shows an example of how to compute the "After SCK Delay".

Table 599. After SCK Delay computation example

f_P	PASC	Prescaler	ASC	Scaler	After SCK Delay
100 MHz	0b01	3	0b0100	32	0.96 µs

PCASC and ASC fields have no effect in TSB configuration.

NOTE

The clock frequency mentioned in the preceding table is given as an example. See the Clocking chapter for the frequency used to drive this module in the chip.

77.4.6.4 Delay after transfer (t_{DT})

The "Delay after Transfer" is the minimum time between negation of the PCS signal for a frame and the assertion of the PCS signal for the next frame. See Figure 542 for an illustration of this type of delay. The PDT and DT fields in the CTAR*x* registers select the "Delay after Transfer" by the formula in the DT field description. The following table shows an example of how to compute the "Delay after Transfer".

Table 600. "Delay after Transfer" computation example

f_P	PDT	Prescaler	DT	Scaler	Delay after Transfer
100 MHz	0b01	3	0b1110	32768	0.98 ms

NOTE

The clock frequency mentioned in the preceding table is given as an example. See the Clocking chapter for the frequency used to drive this module in the chip.

When in Non-Continuous Clock mode, the t_{DT} delay is configured according to the equation specified in the CTAR[DT] field description. When in Continuous Clock mode and TSB is not enabled, the delay is fixed at 1 SCK period.

In TSB mode, the Delay after Transfer is equal to a number formed by concatenation of PDT and DT fields plus 1 of the SCK clock periods. See detailed information on Timed serial bus (TSB)".

77.4.7 Transfer formats

The DSPI serial communication is controlled by the SCK signal and the PCS signals. The SCK signal provided by the master device synchronizes shifting and sampling of the data on the SIN and SOUT pins. The PCS signals serve as enable signals for the slave devices.

In Master mode, CTAR*n*[CPOL] and CTAR*n*[CPHA] select the polarity and phase of the serial clock, SCK.

- CPOL - Selects the idle state polarity of the SCK
- CPHA - Selects if the data on SOUT is valid before or on the first SCK edge

The module supports two different transfer formats:

- Classic DSPI with CPHA = 0
- Classic DSPI with CPHA = 1

In the interface configurations, the module provides the option of having the PCS signals asserted between frames. See Continuous selection format for details.

77.4.7.1 Classic DSPI transfer format (CPHA = 0)

The transfer format shown in the following figure is used to communicate with peripheral DSPI slave devices where the first data bit is available on the first clock edge. In this format, the master and slave sample their SIN pins on the odd-numbered SCK edges and change the data on their SOUT pins on the even-numbered SCK edges.

NOTE

SPI is used for both DSPI and DSI modes in this diagram.

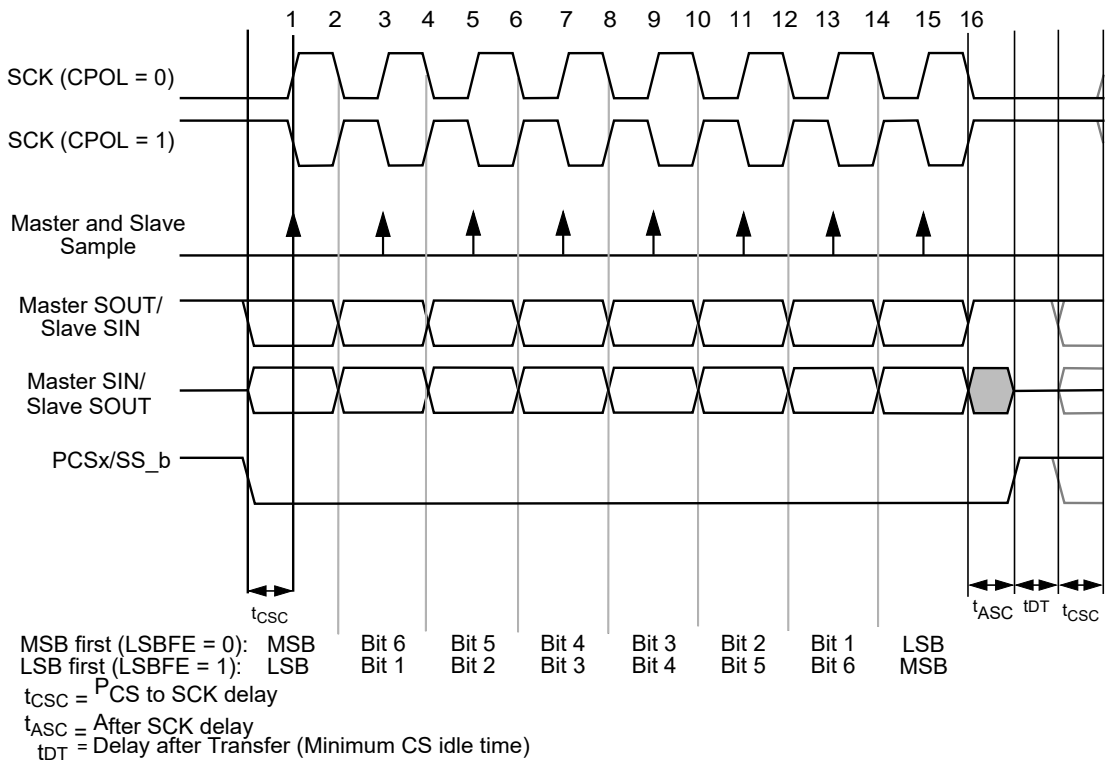


Figure 542. Module transfer timing diagram (CPHA = 0, FMSZ = 8)

The master initiates the transfer by placing its first data bit on the SOUT pin and asserting the appropriate PCS signals to the slave device. The slave responds by placing its first data bit on its SOUT pin. After the t_{CSC} delay elapses, the master outputs the first edge of SCK. The master and slave devices use this edge to sample the first input data bit on their serial data input signals. At the second edge of the SCK, the master and slave devices place their second data bit on their serial data output signals. For the rest of the frame, the master and the slave sample their SIN pins on the odd-numbered clock edges and change the data on their SOUT pins for the even-numbered clock edges. After the last clock edge occurs, a delay of t_{ASC} is inserted before the master negates the PCS signals. A delay of t_{DT} is inserted before a new frame transfer can be initiated by the master.

77.4.7.2 Classic DSPI transfer format (CPHA = 1)

This transfer format shown in the following figure is used to communicate with peripheral DSPI slave devices that require the first SCK edge before the first data bit becomes available on the slave SOUT pin. In this format, the master and slave devices change the data on their SOUT pins on the odd-numbered SCK edges and sample the data on their SIN pins for the even-numbered SCK edges.

NOTE

SPI is used for both DSPI and DSI modes in this diagram.

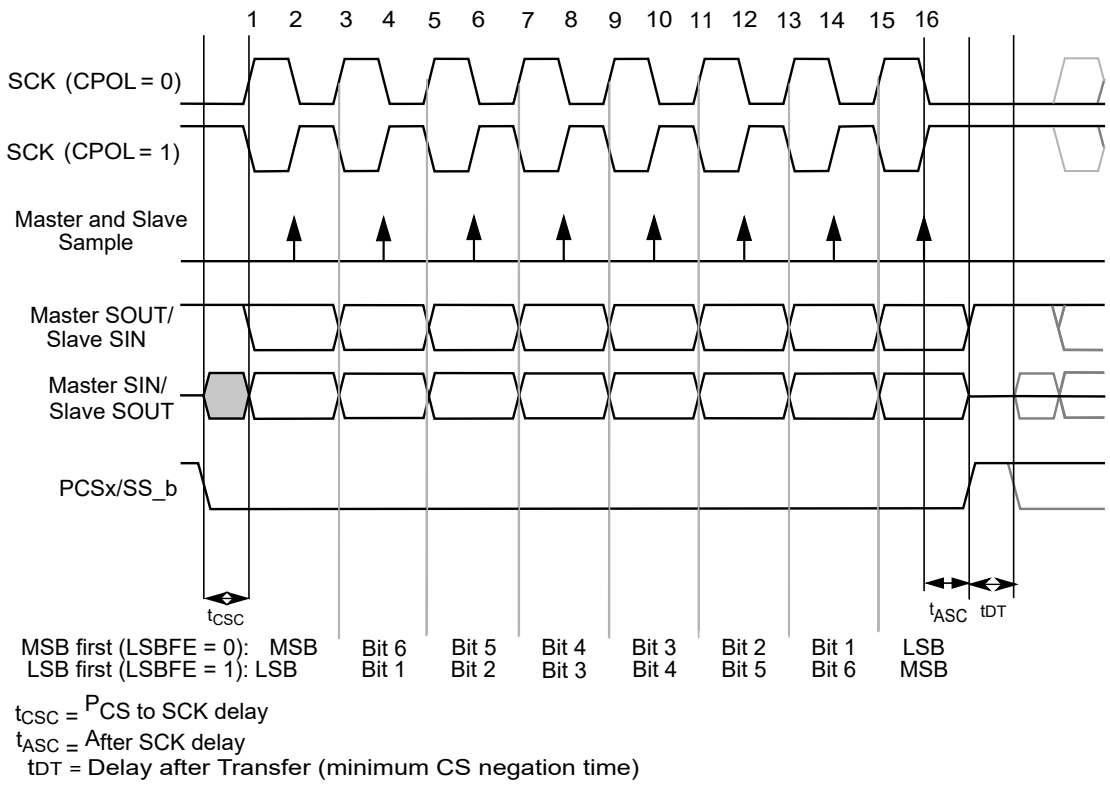


Figure 543. Module transfer timing diagram (CPHA = 1, FMSZ = 8)

The master initiates the transfer by asserting the PCS signal to the slave. After the t_{CSC} delay elapses, the master generates the first SCK edge and at the same time places valid data on the master SOUT pin. The slave responds to the first SCK edge by placing its first data bit on its slave SOUT pin.

At the second edge of the SCK, the master and slave sample their SIN pins. For the rest of the frame, the master and the slave change the data for their SOUT pins on the odd-numbered clock edges and sample their SIN pins on the even-numbered clock edges. After the last clock edge occurs, a delay of t_{ASC} is inserted before the master negates the PCS signal. A delay of t_{DT} is inserted before the master can initiate a new frame transfer.

77.4.7.3 Continuous selection format

Some peripherals must be deselected between every transfer. Other peripherals must remain selected between several sequential serial transfers. The continuous selection format provides the flexibility to handle both the following cases. The format is enabled for the DSPI configuration by setting the CONT bit in the DSPI command. Continuous Selection is enabled for the DSI configuration by setting the DCONT bit in the DSICR0.The behavior of the PCS signals in the two configurations is identical so only SPI configuration will be described.

When the value of CONT is 0, the module drives the asserted Chip Select signals to their idle states in between frames. The idle states of these signals are selected by the PCSIS*n* fields in the MCR. The following figure shows the timing diagram for two 4-bit transfers with CPHA = 1 and CONT = 1.

NOTE

SPI is used for both DSPI Mode and DSI mode in this diagram.

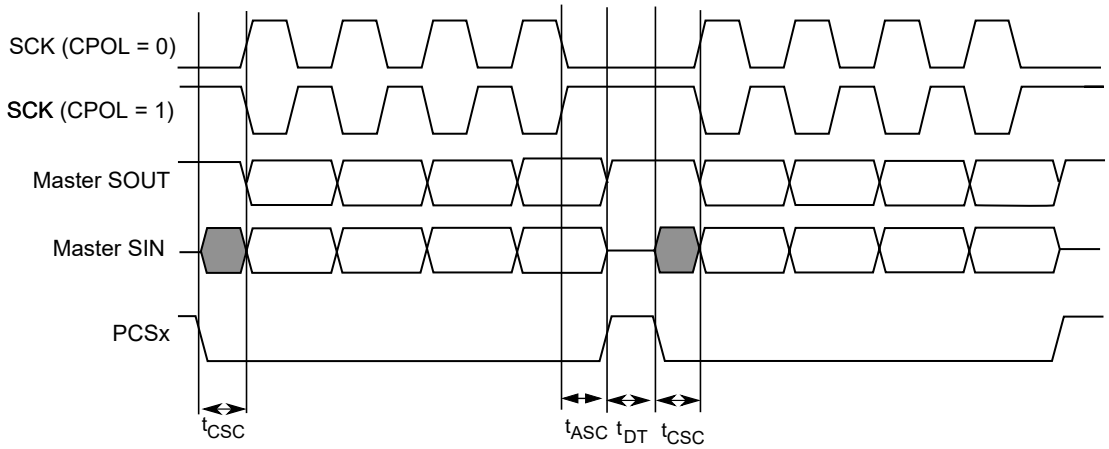


Figure 544. Example of non-continuous format (CPHA=1, CONT=0)

When CONT = 1, the PCS signal remains asserted for the duration of the two transfers. The "Delay between Transfers" (t_{DT}) is not inserted between the transfers. The following figure shows the timing diagram for two 4-bit transfers with CPHA = 1 and CONT = 1.

NOTE

SPI is used for both DSPI Mode and DSI mode in this diagram.

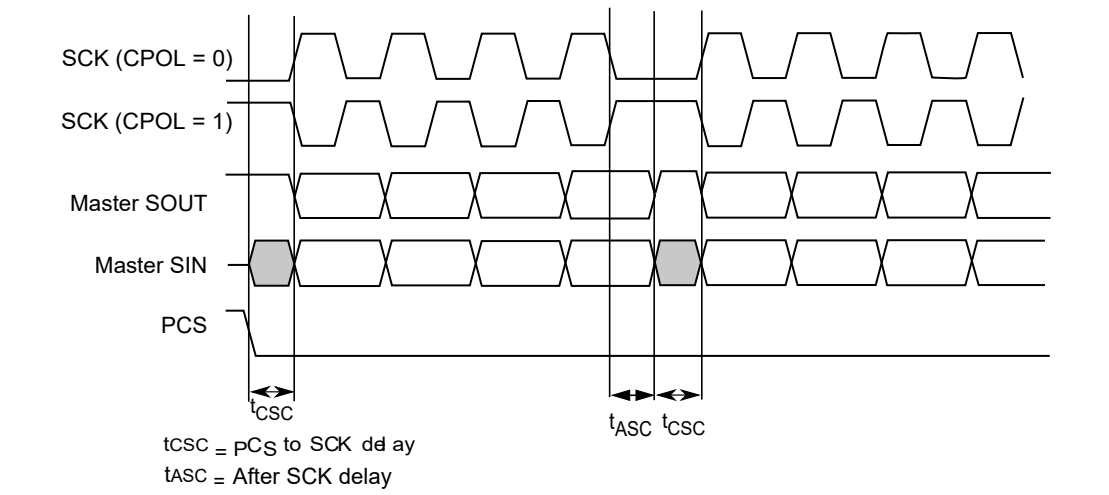


Figure 545. Example of continuous transfer (CPHA=1, CONT=1)

When using the module with continuous selection, follow these rules:

- All transmit commands must have the same PCS*n* field programming.
- The CTARs, selected by transmit commands, must be programmed with the same transfer attributes. Only the FMSZ and LSBFE field can be programmed differently in these CTARs.
- When transmitting multiple frames in this mode, the software must ensure that the last frame has PUSHR[CONT] deasserted in Master mode and the software must provide sufficient frames in the TX_FIFO to be sent out in Slave mode and the master deasserts the PCSn at end of transmission of the last frame.

- PUSHR[CONT] and DSICR0[DCONT] must be deasserted before asserting MCR[HALT] in master mode. This ensures that the PCSn signals are deasserted. Asserting MCR[HALT] during continuous transfer causes the PCSn signals to be in unknown state and hence the slave device cannot transition from Running to Stopped state.

NOTE

You must fill the TX FIFO with the number of entries that are concatenated together under one PCS assertion for both master before the TX FIFO is empty.

77.4.8 Continuous SCK

The module provides the option of generating a Continuous SCK signal for slave peripherals that require a continuous clock.

Continuous SCK is enabled by writing a 1 to MCR[CONT_SCKE]. Enabling this field generates the Continuous SCK only if MCR[HALT] is low. Continuous SCK is valid for all configurations.

Continuous SCK is only supported for CPHA = 1. Clearing CPHA is ignored if the value of the CONT_SCKE field is 1.

Clock and transfer attributes for the Continuous SCK mode are set according to the following rules:

- When the module is in DSPI configuration, CTAR0 is used initially. At the start of each SPI frame transfer, the CTAR specified by the CTAS for the frame is used.
- When the module is in DSI configuration, the CTAR specified by DSICR0[DSICTAS] is used at all times.
- When the module is in CSI configuration, the CTAR selected by the DSICTAS field is used initially.
  - At the start of a DSPI frame transfer, the CTAR specified by the CTAS value for the frame is used.
  - At the start of a DSI frame transfer, the CTAR specified by the DSICTAS field is used.
- In all configurations, the currently selected CTAR remains in use until the start of a frame with a different CTAR specified, or the Continuous SCK mode is terminated.

It is recommended to keep the baud rate the same while using continuous SCK. Switching clock polarity between frames while using continuous SCK can cause errors in the transfer. The Continuous SCK operation is not guaranteed if the module is put into the Module Disable mode.

Enabling continuous SCK disables the PCS to SCK delay, and the Delay after Transfer (t_{DT}) is fixed to one SCK cycle. When TSB configuration is enabled the t_{DT} is programmable from 1 to 64 SCK cycles. The following figure is the timing diagram for the Continuous SCK format with continuous selection disabled.

NOTE

In the Continuous SCK mode, for the DSPI transfer, CTAR0 should always be used and the TX FIFO must be cleared through MCR[CLR_TXF] before initiating a transfer.

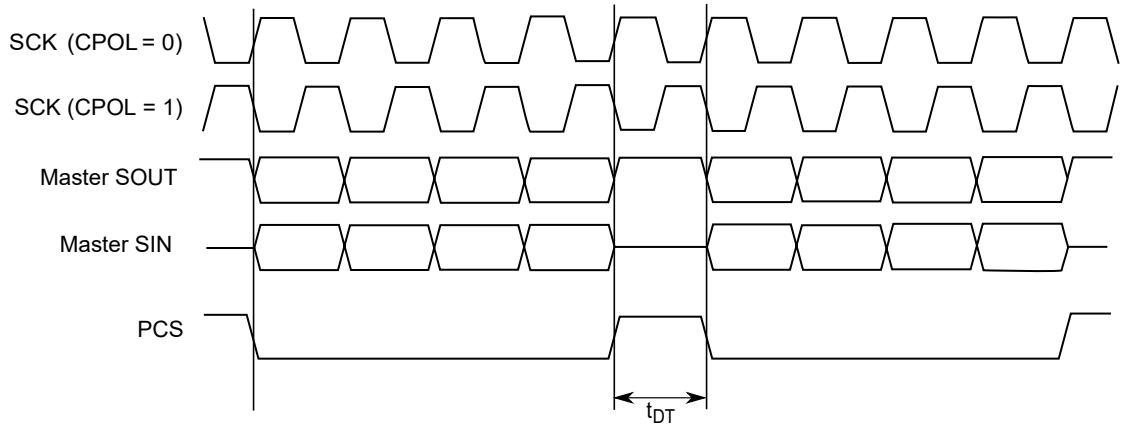


Figure 546. Continuous SCK timing diagram (CONT = 0)

If the CONT bit in the TX FIFO entry is set or the value of DSICR0[DCONT] is 1, PCS remains asserted between the transfers. Under certain conditions, SCK can continue with PCS asserted, but with no data being shifted out of SOUT, which means when SOUT is pulled high. This can cause the slave to receive incorrect data. Those conditions include:

- Continuous SCK with CONT bit set, but no data in the TX FIFO
- Continuous SCK with CONT bit set and entering the Stopped state (see Starting and stopping module transfers)
- Continuous SCK with CONT bit set and entering the Module Disable mode

The following figure shows the timing diagram for the Continuous SCK format with continuous selection enabled.

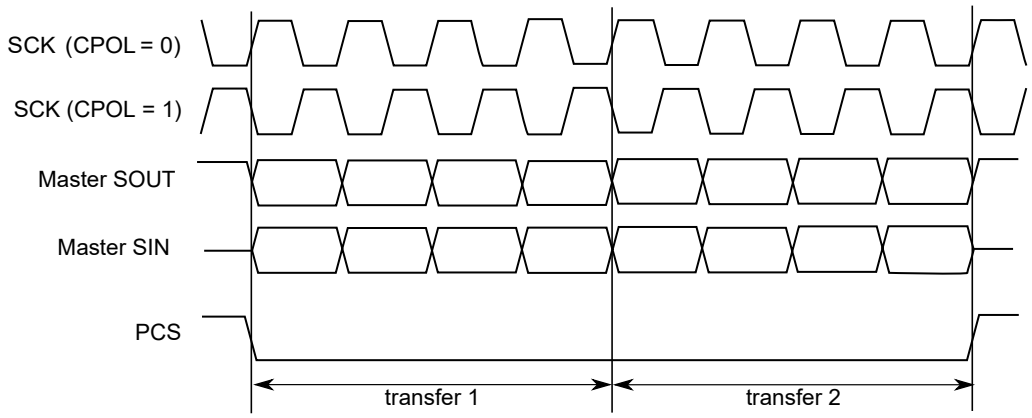


Figure 547. Continuous SCK timing diagram (CONT = 1)

77.4.9 Timed serial bus (TSB)

The DSPI can be programmed in Timed Serial Bus configuration by setting the TSBC bit in the DSI_EXISTSCR0 register. See DSPI DSI Configuration Register 0 (DSI_EXISTSCR0) for details.

TSB configuration provides the Micro Second Channel (MSC) downstream channel support.

The MSC upstream channel is not supported by the DSPI, but can be supported by any available Serial Communication Controller (SCI or UART) in the SoC.

The DSI Continuous Frame Selection Format is not supported by the TSB Mode (DSICR0[DCONT] bit cannot not be asserted).

To work in TSB mode the DSPI must be in master mode and in DSI (DCONF = 0b01) or CSI (DCONF = 0b10) configuration. Both Continuous and Non Continuous Serial Communication Clock (controlled by the DSPI_MCR[CONT_SCKE] bit) are supported in the TSB mode.

The following figure shows the signals used in the TSB interface.

In the TSB configuration the DSPI is able to send from 4 to 66 bits MSC data frames (4 to 64 serialized data bits and up to 2 Data Selection zero bits). The serialized data bits source can be either:

- the DSPI DSI Alternate Serialization Data Register (DSPI_ASDR0/1), written by the host software,
- Parallel Input pin states latched into the DSPI DSI Serialization Data Register (DSPI_SDR0/1).

DSI_EXISTSCR0 TXSS bit or DSPI_SSR0–1 register bits define the source of the data.

The Least Significant Bits of the DSPI_ASDR0 or DSPI_SDR0 registers are selected to be serialized if the data frame is set to less than 32 bits.

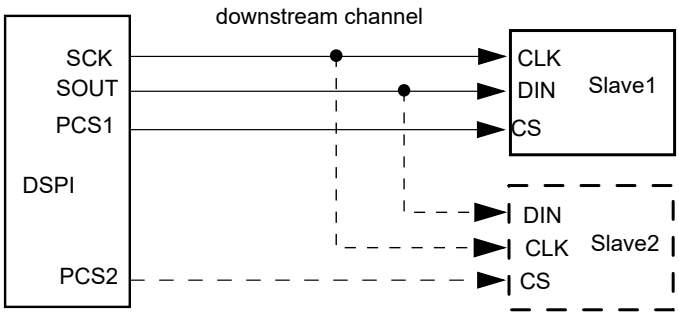


Figure 548. DSPI usage in the TSB Configuration

The PCS signals are driven together with SOUT. The t_{CSC} and t_{ASC} delays are not available. Delay after Transfer (DT) is set in SCK clock periods as a binary number formed by concatenation of the DSPI_CTARn PDT and DT fields plus one, allowing to set DT from 1 to 64 serial clock periods. DT field provides least significant bits and PDT field provides most significant bits of the Delay after Transfer.

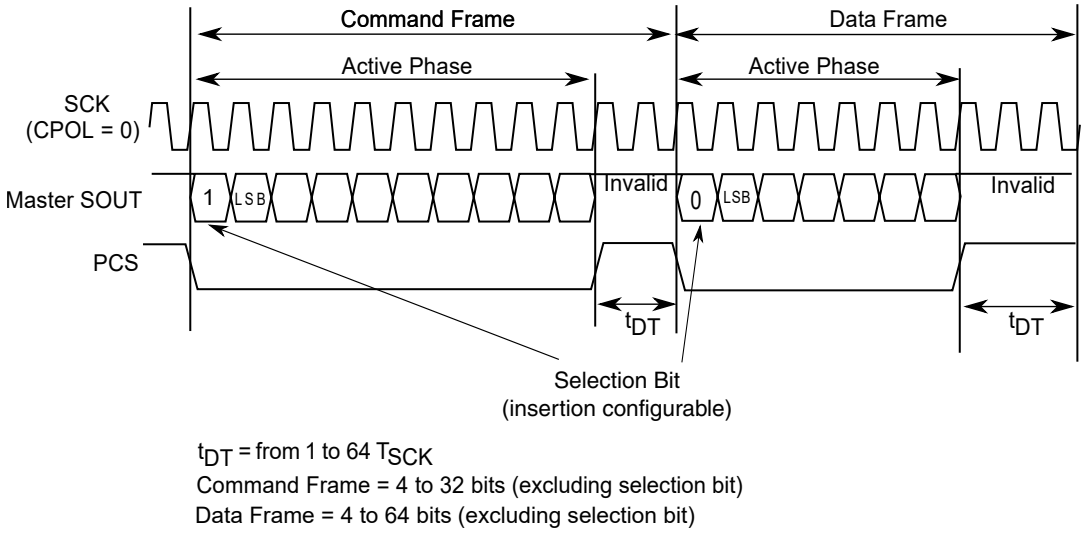


Figure 549. TSB/ITSB Downstream Frames

NOTE

In the above figure, selection bit in the downstream frames may differ in TSB and ITSB modes.

Above figure shows the two types of MSC downstream frames - command frame, and data frame.

The first transmitted bit, called the selection bit, determines the frame type:

- The selection bit "0" indicates a data frame
- The selection bit "1" indicates a command frame

Data frame may contain up to 2 selection bits to support two external slave devices, (so called dual receiver configuration) or no selection bits at all.

The command frame can be written by software, through SPI TX FIFO, using one or two FIFO entries with help of the CONT bit or MCR[XSPI]. The data frame consists of up to 64 bits from the SDR0–1 or ASDR0–1 registers and up to two selection bits (0). Number of data bits in the data frame is defined by the DSCICR1[TSBCNT] field.

The selection bit of the MSC command frames (1) can be implemented by software.

The selection bits in the data frames are enabled by DSI_EXISTSCR1 DSE0 and DSE1 bits. Each DSEn bit set increases the data frame size by one bit.

To comply with MSC specification, set DSPI_CTARn[LSBFE] to transmit least significant bit first.

Regardless the LSBFE bit setting, the Data Frame Selection Bits, if enabled, are always transmitted first, before corresponded data sub frames.

77.4.9.1 MSC dual receiver support with PCS switch over

When in TSB mode it is possible to switch the set of PCS signals that are driven during the first part of the frame to a different set of PCS signals during the second part of the frame. The bit, at which this switch over occurs, is defined by FMSZ field of the DSPI_CTARn register, selected by DSICTAS field of the DSICR0 register. If DSICR1[DSI64E] is enabled, then the bit at which the PCS switch occurs, is defined by the concatenation of {DSICR0[FMSZ4], CTAR[FMSZ]} fields.

Number of the bits, not including the Data Selection Bit, in the first part of the frame is equal to value of the FMSZ field plus one. (This value changes to {FMSZ4,FMSZ} plus one, when DSICR1[DSI64E] is enabled). During this part of the frame the PCS signal levels are controlled by DSI_EXISTSCR0 DPCSn bits, after that by DSI_EXISTSCR1 DPCS1_n bits.

The PCS switch over occurs at driving edge of the SCK clock output.

The second Data Selection Bit is inserted after the PCS switch over if enabled.

Data Frame with PCS switch over is shown in the following figure.

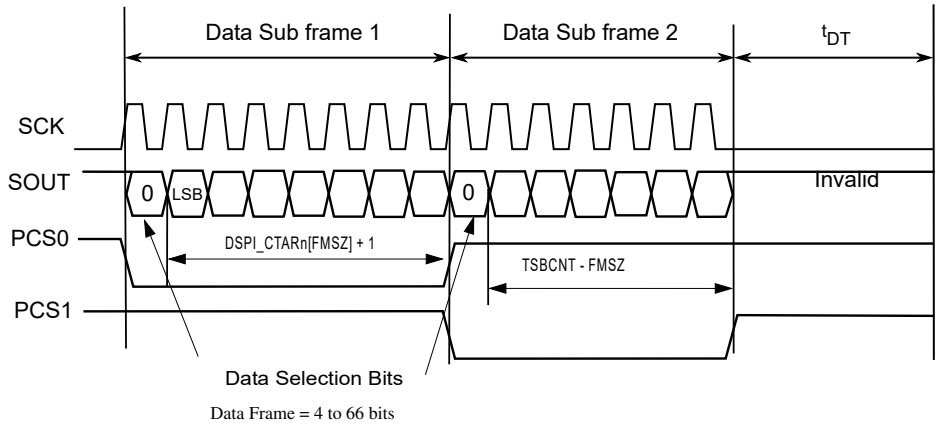


Figure 550. TSB Data Frame Format for MSC Dual Receiver Operation

77.4.10 Interleaved TSB (ITSB) mode

This mode is similar to the TSB mode in some aspects except for the differences mentioned in the table below. The major difference is that the ITSB mode is highly generic in its approach to be compliant with the Downstream operation of the Microsecond Channel Protocol. It includes a triggered time-slot based system with user configurable options for the frames to be transmitted in each time slot. (The time period between any two triggers is known as a time-slot).

The DSPI can be programmed to the ITSB Mode by asserting DSICR0[TSBC], DSICR0[ITSB]. To work in ITSB Mode, the DSPI must be in Master Mode and MCR[DCONF] must be set to CSI mode. (DCONF = 0b10). Both continuous and non-continuous clock serial communication clock (MCR[CONT_SCKE] are supported in this mode.

There are three types of frames which can be transmitted in a time slot i.e. Data Frame, Command Frame and Passive (Idle) frame. Similar to the TSB Mode, SPI frames are used for MSC Command frames, while DSI frames are used for MSC Data frames. A Passive Frame is an Idle frame in which no chip selects are asserted and no data is transmitted. The frame transmission is broadly governed by the following rules:

- Transmission of frames is done on trigger pulses that can be generated internal to the DSPI or externally. This is configured via DSICR0[TRG]. The internal trigger is periodic with a period of 4. Thus there are 4 time-slots which appear periodically in the ITSB mode. The frame rules to be followed during each of the 4 time-slots can be programmed via TS_CONF[TSn] fields.

The length of each time slot can be programmed via TSL[TSx_LEN] fields. The minimum length of a time slot is governed by the following formulae :

— Minimum Length for Time slot X = Frame size of the frame to be transmitted in Time slot X + no. of selection bits, if any + 2 (Inherent time(Delay) changed by baud rate(Fp/n)).

— The above constraint is only true for Data and Command frames. Passive frames do not have a minimum trigger length constraint. The user software shall configure the trigger lengths and trigger source.

- If the previously transmitted frame was a Command (SPI) frame or the TX_FIFO (or CMD FIFO) is empty, the non-passive frame transmitted on a subsequent trigger will not be a command frame.
- If the previously transmitted frame was not a Command (SPI) frame and the TX_FIFO (and CMD FIFO) have sufficient data to allow a SPI frame transmission, the frame transmitted on subsequent trigger can be a Command (SPI) frame.
- A Dual Receiver Frame (DRF) is a single Data (DSI) Frame which is split and transmitted to two different receivers (via occurrence of PCS switchover at the split) - the former part being called DRF1 and the latter part as DRF2 (Dual Receiver Frames 1 & 2). Using TS_CONF[TSn] fields, a time-slot can be programmed to transmit a sole DRF1 or a DRF2 frame. A sole DRF1 frame followed by any other frame is a valid scenario. A DRF2 frame programmed for a time slot is only valid if the immediate previous time-slot was DRF1 - an invalid DRF2 frame, if programmed results in the transmission of a Passive frame (PF).

This mode does not change the way DSI and SPI frame transmissions are done except that ITSB mode interleaves the source (SPI or DSI) with a configurable set of rules based on triggered time-slot system. All features of SPI and DSI mode can be used except for the Continuous Frame Selection format (PUSHR[CONT] and DSICR0[DCONT] bits should not be asserted).

The following table lists the differences between the TSB and ITSB modes:

Table 601. Differences between TSB and ITSB modes

TSB Mode	ITSB Mode
Priority available to frames from SPI. Back to back SPI frames are sent out.	No priority. Messages are interleaved such that there are no back-to-back SPI frames
Selection Bit inserted for DSI frames only. Selection bit for SPI frames is inserted by software.	Selection bit for both DSI and SPI frames inserted automatically. Encoding of selection bit same as TSB mode (0 = DSI; 1 = SPI).
Occasionally triggered transmission (that is trigger is received via hardware trigger input).	Triggered time-slot based transmission (that is frames are transmitted continuously on every trigger).
Gap between frames is configurable. Time between frames is t_{DT} which is configurable from 1 to 64 baud rate clock cycles.	Gap between frames is configurable and can be introduced in any of the two ways - By programming a Passive Frame or by increasing the length of a time-slot. Time t_{DT} is not used in this mode as it can be made part of the trigger period (as passive time).

In both TSB & ITSB mode, separate frame completion interrupts will be available to indicate frame transmission completion from SPI & DSI frames. MSC dual receiver support with PCS switchover is also supported in ITSB mode. See MSC Dual Receiver Support with PCS Switch Over for more details.

The ITSB mode is suitable to implement the Downstream Channel for the MSC Bus because of the above features.

77.4.10.1 Configuring DSPI for ITSB mode

The following steps give the recommended way to initialize the DSPI for the ITSB mode of operation:

- The DSPI should be put in HALT mode (by asserting the MCR[HALT] bit) before programming the registers.
- Set the DSICR0[TSBC] and DSICR0[ITSB] bits. The DSICR0[TRRE] and DSICR0[CID] bits should be cleared. DSICR0[DCONT] and PUSHR[CONT] should not be used in ITSB mode. If DSICR0[ITSB] bit is set without setting DSICR0[TSBC], then the DSPI operates in the Normal Mode depending on MCR[DCONF] bit.

- Configure the Time Slot Length's via TSL register and the frame rules for each time slot via TS_CONF register.
- Based on trigger source requirements, set the values in the DSICR0[TRG] bit.
- Enable frame completion interrupts for either any frame completion (TCF) or separate frame complete (DSITCF and SPITCF) as required by application.
- When remainder configuration of DSPI is complete, clear the MCR[HALT] bit to allow DSPI to start operations.

Once configured and DSPI is brought out of HALT, the ITSB mode shall start sequencing the frames from either DSI or SPI as per the rules mentioned in Interleaved TSB (ITSB) Mode.

77.4.10.2 Variable length time slots

In the Interleaved TSB Mode, the TSL[TSx_LEN] registers are used to configure the time slot length's as required by the application. There are up to 4 time slots named TS0, TS1, TS2 and TS3 respectively, which repeat periodically. To achieve a periodicity less than 4, any time slot length can be programmed as 0 (which eliminates this time slot). The following figures illustrate this concept.

In the figure below, the fields TSL[TSx_LEN] are programmed to be non-zero for x = 0,1,2,3. Hence, the time slots repeat after every 4 trigger pulses as shown.

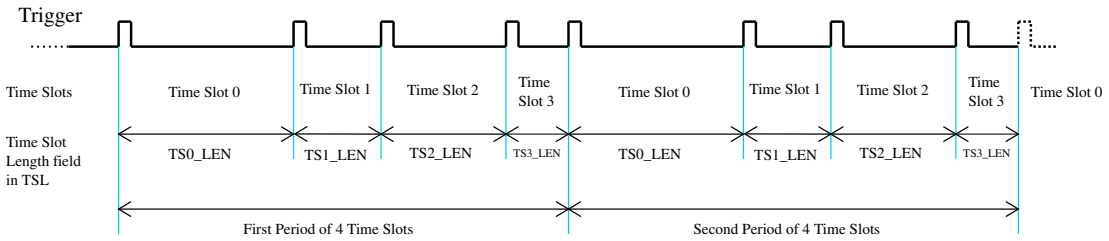


Figure 551. Periodic Time Slots with period = 4

In the figure below, the fields TSL[TSx_LEN] are programmed to be non-zero for x = 0,1,2, while TSL[TS3_LEN] = 0. Hence, the time slots repeat after every 3 trigger pulses as shown.

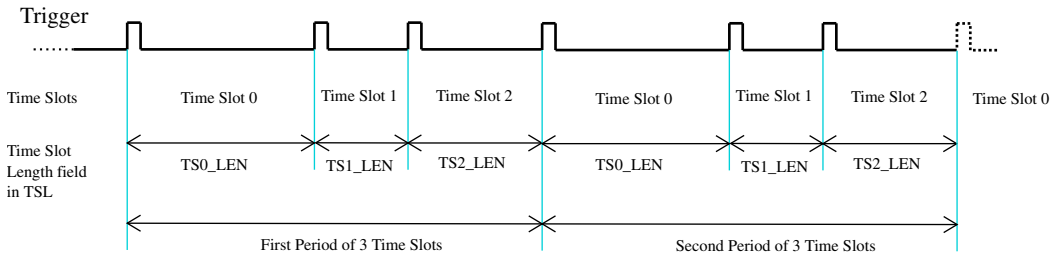


Figure 552. Periodic Time Slots with period = 3

The following figure shows time slots with periodicity of 1. Here the fields TSL[TSx_LEN] are programmed to zero for x = 1,2 and 3 while TSL[TS0_LEN] is non-zero. Hence, the time slots repeat after every trigger as shown.

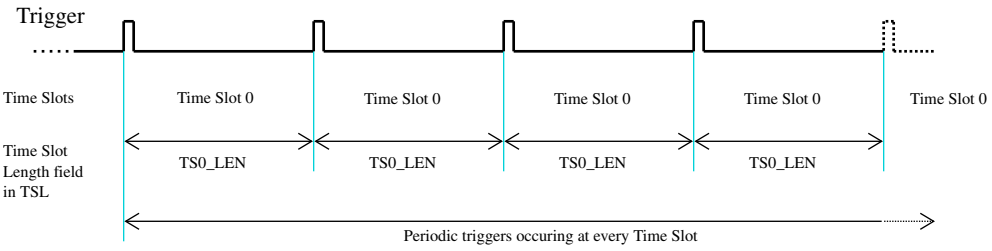


Figure 553. Periodic Time Slots with period = 1

Similarly, any TSL[TSx_LEN] can be made 0 to vary periodicity of time slots, but it is an illegal scenario to have all TSL[TSx_LEN] fields as 0.

NOTE

If external triggering mechanism is enabled (DSICR0[TRG] is set), then it must be ensured that the minimum distance between two trigger pulses is at least 5P, where P is the protocol clock period.

When internal triggering mechanism is enabled (DSICR0[TRG] is zero), the minimum value which can be programmed in the field TSL[TSx_LEN] is given by L = F + 1 + m; where F is the frame size of the frame programmed to be transmitted for the time slot TSx. The variable 'm' equals 1 when maximum baud rate is programmed (i.e. SCK = protocol clock frequency/ 2) and 0 otherwise.

77.4.10.3 Using ITSB mode for MSC downstream channel

MSC Downstream Channel uses three types of frames: command frames, data frames and passive frames. The Downstream operation of these frames require:

- Data frames can be sent back to back.
- Back to back command frames are not a legal scenario.
- Passive frames are used when no activity is desired for any time slot. In a passive frame, chip selects are de-asserted, and no SCK or data is transmitted. For this reason Command Frames cannot be separated by Passive frames as it would still be an illegal scenario.
- In dual MSC ASIC, some bits of the data frame goes to first ASIC and remainder bits to second ASIC. The first part is referred to as DRF1 (Dual Receiver Frame 1) and the second part as DRF2 (Dual Receiver Frame 2).
- A DRF2 programmed for a time slot is only valid if the immediately preceding time slot was DRF1. If DRF2 is valid, it would be transmitted seamlessly after DRF1 without waiting for the trigger pulse for the time slot of DRF2. For that reason, the TSL[TSx_LEN] for DRF1 must be programmed to the minimum possible value. If DRF2 is not valid, a Passive Frame is transmitted instead.

The ITSB mode can help implement the MSC Downstream Channel by allowing the command frames to be sent via the SPI interface and data frames to be sent via the DSI interface. Once the DSPI has been configured to work in ITSB mode the user software can program the DSI and SPI sides to send data and command frames respectively. The programming of frames for transmission via DSI or SPI is same as explained in Combined Serial Interface (CSI) Configuration.

The following figure shows a sample MSC Downstream transmission for the ITSB mode with the following configuration:

- All TSL[LEN] are programmed to be non-zero. Note that the length between triggers are not drawn to scale in the figure. The lengths of all 4 time slots shown are unequal.
- Data and Command selection bits are enabled, i.e. DSICR1[DSE0] and DSICR1[CSE] are set.
- TS_CONF[TS0] = CMD_SRDF
- TS_CONF[TS1] = CMD_SRDF
- TS_CONF[TS2] = CMD_PF
- TS_CONF[TS3] = CMD_SRDF
- PCS0 is used for Data Frames while PCS1 is used for Command Frames. Both chip select's are active low.

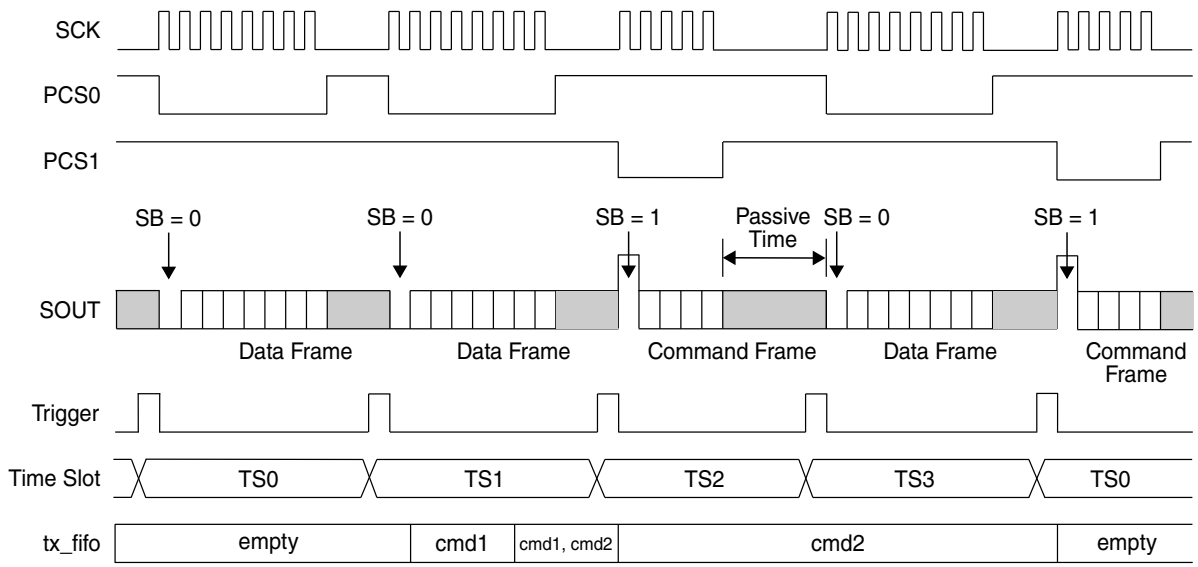


Figure 554. Sample MSC Downstream transmission using ITSB mode

Brief description of operation includes:

- At the first trigger, TS0 is initiated. The frame rule for TS0 is configured as CMD_SRDF (Command if valid, else Single Receiver Data Frame). Since there is no data present in the TXFIFO, a valid command frame is not available to be transmitted. Hence a single receiver data frame is transmitted instead.
- The second trigger initiates TS1. Again a single receiver data frame is transmitted since the frame rule for TS1 is programmed to CMD_SRDF and a command frame is not valid as there is no data present in the TXFIFO when TS1 is initiated.
- During TS1, two frames are pushed into the TX_FIFO.
- At third trigger, TS2 is initiated , the frame rule for which is programmed to CMD_PF (Command if valid. else Passive Frame). A Command frame is transmitted as the TX_FIFO is not empty.
  - Since the frame size of the command frame is less than the trigger length for TS2, no transmission happens till next trigger. This is marked as the “Passive Time”. Such passive time exists in all frames after frame transmission completes and until next trigger pulse is detected.
- For TS3, the frame rule programmed is CMD_SRDF. Since the previous transmission was a command frame, a single receiver data frame is transmitted during TS3.
- The time slot TS0 repeats, and this time a command frame is transmitted during TS0 since the Command Frame is eligible to be transmitted.
- At sixth trigger (not shown), TS1 occurs and the process continues.

The figure below shows another sample MSC Downstream transmission for the ITSB mode with the following configuration:

- All TSL[LEN] are programmed to be non-zero. Note that the length between triggers are not drawn to scale in the figure. The lengths of all 4 time slots shown are unequal.
- Data and Command selection bits are enabled, i.e. DSICR1[DSE0] and DSICR1[CSE] are set.
- TS_CONF[TS0] = CMD_DRF1
- TS_CONF[TS1] = DRF2
- TS_CONF[TS2] = CMD_DRF1
- TS_CONF[TS3] = CMD_DRF2
- PCS0 is used for DRF1 while PCS1 is used for DRF2 or Command Frames. Both chip select's are active low.

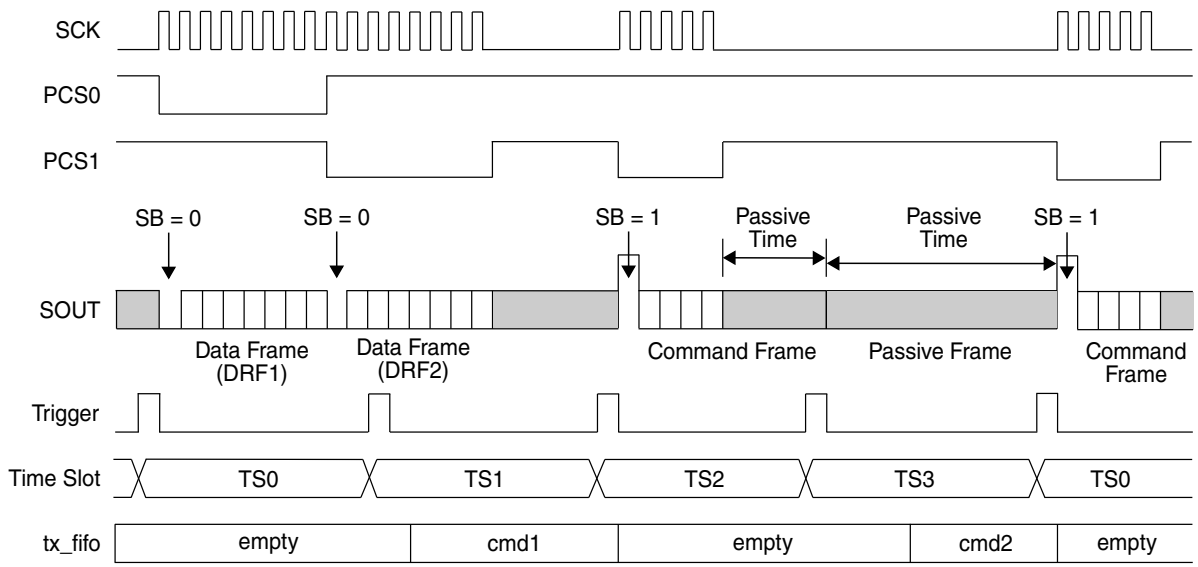


Figure 555. Sample MSC Downstream transmission using ITSB mode

Brief description of operation includes:

- At the first trigger, TS0 is initiated. The frame rule for TS0 is configured as CMD_DRF1 (Command if valid, else Dual Receiver Frame 1). Since there is no data present in the TXFIFO, a valid command frame is not available to be transmitted. Hence DRF1 is selected for transmission. Now it is checked if the next trigger is DRF2 which is true and hence DRF1 and DRF2 are transmitted back-to-back seamlessly with the PCS switch-over occurring in between. Note that this happens independent of the next trigger. If the next trigger were configured to CMD_DRF2 instead, then at the current trigger, the validity of CMD is checked to confirm the presence of DRF2 for next trigger. If presence of DRF2 is confirmed for next trigger, it is transmitted along with DRF1 seamlessly as shown here, otherwise only DRF1 would be transmitted in the current trigger and the CMD frame would be transmitted in the next trigger.
- During TS1, one frame is pushed into the TX_FIFO.
- Since DRF2 is transmitted immediately after DRF1, the occurrence second trigger does not cause any operation. Hence it must be ensured by the user that Trigger Length of TS0 must be programmed to minimum possible value - during which DRF1 can be successfully transmitted. This ensures that trigger for TS1 occurs sometime after the switch-over and not after DRF2 has been transmitted.
- The third trigger initiates TS2, the frame rule for which is configured as CMD_DRF1. A Command frame is transmitted as the data required to transmit a command frame is available (TX_FIFO and CMD_FIFO_DEPTH_PP is not empty) and the previous transmitted frame was not a command frame.
- The fourth trigger initiates TS3, the frame rule for which is configured as CMD_DRF2. Since a CMD frame isn't available and DRF2 is not valid (since DRF1 wasn't transmitted in the previous trigger), a passive frame is transmitted instead.
- The time slot TS0 repeats, and this time a command frame is transmitted during TS0 since the Command Frame is eligible to be transmitted.
- At sixth trigger (not shown), TS1 occurs and the process continues.

NOTE

For a command/data frame to be transmitted on a trigger, they should be available some time before the occurrence of the trigger. A DSI frame must be updated/present "X" time units before the occurrence of the trigger for the time slot in which this data is to be transmitted. This is true for all DSI frames and also implies that when DRF1 and DRF2 are positioned to be transmitted seamlessly, both DRF1 and DRF2 frames must be available 'X' time units before occurrence of trigger pulse for the time slot of DRF1 itself.

Similarly, a command frame must be available "Y" time units before the occurrence of the trigger for the time slot in which this data is to be transmitted.

Here X = 2R + 1P and Y = 1R + 3P; where R = register clock period, P = protocol clock period.

77.4.11 Parity generation and check

The module can generate and check parity in the serial frame. The parity bit replaces the last transmitted bit in the frame. The parity is calculated for all transmitted data bits in frame, not including the last data bit that would be transmitted. The parity generation and control are done on a frame basis. The registers field setting frame size defines the total number of bits in the frame, including the parity bit. Thus, to transmit or receive the same number of data bits with parity check, increase the frame size by one versus the same data size frame without the parity check.

Parity can be selected as odd or even. Parity errors in the received frame set parity error flags in the Status register. The parity error interrupt requests are generated, if enabled. The module can be programmed to stop frame transmission in case of a frame reception with parity error.

77.4.11.1 Parity for SPI frames

When the module is in the master mode the parity generation is controlled by PE and PP bits of the CMD FIFO entries (PUSHR). Setting the PE bit enables parity generation for transmitted DSPI frames and parity check for received frames. The PP bit defines polarity of the parity bit.

When continuous PCS selection is used to transmit DSPI data, two parity generation scenarios are available:

- Generate or check parity for the whole frame
- Generate or check parity for each sub-frame separately

To generate or check parity for the whole frame, set PE bit only in the last command or TX FIFO entry, forming this frame with the PUSHR.

To generate or check parity for each sub-frame, set PE bit in each command or TX FIFO entry, forming this frame.

If the parity error occurs for received DSPI frame, SR[SPEF] is set. If the value of MCR[PES] is 1, the module stops DSPI frames transmission. To resume DSPI operation, clear SR[SPEF] or MCR[PES].

77.4.11.2 Parity for DSI frames

When DSPI is in Master mode, parity generation is controlled by PE and PP bits of the DSI_EXISTSCR0 register similar to the SPI frames. The parity is calculated and checked for each DSI frame. DSI_EXISTSCR0[DCONT] bit has no effect on parity generation. In slave mode the parity is controlled by the PE and PP bits of the CTAR1 register.

If the parity error occurs for received DSI frame, the DSPI_SR[DPEF] bit is set. If DSI_EXISTSCR0[PES] bit is set, the DSPI stops DSI frames transmission. To resume DSI operation clear the DSPI_SR[DPEF] or the DSI_EXISTSCR0[PES] bits.

77.4.12 Clocking

This table describes the clock signals on the boundary of the module:

Table 602. DSPI clocks

Clock	Description
Serial Clock (O)	Supplies a clock signal from the module to DSPI slaves
Serial Clock (I)	Supplies a clock signal to the module from the DSPI master

77.4.13 Interrupts/DMA requests

The module has several conditions that can generate only interrupt requests and three conditions that can generate interrupt or DMA requests. The following table lists these conditions.

Table 603. Interrupt and DMA request conditions

Condition	Flag	Interrupt	DMA
End of Queue (EOQ)	EOQF	Yes	-
TX FIFO Fill	TFFF	Yes	Yes
CMD FIFO Fill	CMDFFF	Yes	Yes
TX FIFO Invalid Write	TFIWF	Yes	-
Transfer Complete	TCF	Yes	-
CMD Transfer Complete	CMDTCF	Yes	-
SPI Transfer Complete	SPITCF	Yes	-
DSI Transfer Complete	DSITCF	Yes	-
RX FIFO Drain	RFDF	Yes	Yes
RX FIFO Overflow	RFOF	Yes	-
SPI Parity Error	SPEF	Yes	-
DSI Parity Error	DPEF	Yes	-
DSI Deserialized Data Match	DDIF	Yes	Yes

Each condition has a corresponding field in the SR and a Request Enable field in the RSER. Certain fields, as shown in the above table, generate interrupt requests or DMA requests depending on the configuration of this register.

The module also provides a global interrupt request line, which is asserted when any of individual interrupt requests lines is asserted.

77.4.13.1 EOQ interrupt request

The EOQ interrupt request indicates that the end of a transmit queue is reached. The module generates the interrupt request when the value of RSER[EOQF_RE] is 1 and the value of the EOQ field in the executing DSPI command is 1.

If the value of MCR[XSPI] is 1 and the value of the EOQ field in the executing SPI command is 1, the module generates the EOQ interrupt request after the last bit of the last data frame in the command cycle is transmitted.

When the value of MCR[XSPI] is 0, the module generates the interrupt request after the last bit of the SPI frame, with the value of EOQ as 1, is transmitted.

77.4.13.2 Transmit FIFO fill interrupt or DMA request

The transmit FIFO fill request indicates that the TX FIFO is not full. This request is generated when the number of entries in the TX FIFO is less than the maximum number of possible entries, and the value of RSER[TFFF_RE] is 1.

RSER[TFFF_DIRS] selects whether a DMA request or an interrupt request is generated.

NOTE

TFFF clears automatically when DMA is used to fill TX FIFO. You must configure the DMA to fill only one FIFO location per transfer.

To clear TFFF when not using DMA, follow these steps for every PUSH performed using CPU to fill TX FIFO:

1. Wait until the value of TFFF is 1.
2. Write data to PUSHR using CPU.
3. Clear TFFF by writing a 1 to its location. If TX FIFO is not full, the flag does not clear.

77.4.13.3 CMD FIFO fill interrupt or DMA request

The CMD FIFO fill request indicates that the CMD FIFO is not full. This request is generated when the number of entries in the CMD FIFO is less than the maximum number of possible entries, and the value of RSER[CMDFFF_RE] is 1. RSER[CMDFFF_DIRS] selects whether a DMA request or an interrupt request is generated.

The request is useful when the value of MCR[XSPI] is 1 because TX FIFO and CMD FIFO can be filled independently. If the value of MCR[XSPI] is 0, the TX FIFO fill interrupt or DMA request suffices to fill both the FIFOs, which must be filled simultaneously.

NOTE

The CMDFFF flag clears automatically when DMA is used to fill CMD FIFO. Configure the DMA to fill only one FIFO location per transfer.

To clear CMDFFF when not using DMA, follow these steps for every PUSH performed using CPU to fill CMD FIFO:

1. Wait until the value of CMDFFF is 1.
2. Write data to PUSHR using CPU.
3. Clear CMDFFF by writing a 1 to its location. If CMD FIFO is not full, this flag does not clear.

77.4.13.4 Transmit FIFO invalid write interrupt request

The transmit FIFO invalid write request is valid only when the value of MCR[XSPI] is 1. This request indicates that data exists in the TX FIFO while the CMD FIFO is empty. Because no command fields are associated with the data present in TX FIFO, this data is considered invalid until a command entry is available. The transmit FIFO invalid write request is generated for this condition when the value of RSER[TFIWF_RE] is 1.

77.4.13.5 Transfer complete interrupt request

The transfer complete request indicates the end of the transfer of a serial frame. This request is generated at the end of each frame transfer when the value of RSER[TCF_RE] is 1.

77.4.13.6 Command transfer complete interrupt request

The command transfer complete request indicates the end of transfer of the last SPI frame in a command cycle. This request is generated when the value of RSER[CMDTCF_RE] is 1.

77.4.13.7 SPI transfer complete interrupt request

The SPI Transfer Complete Request indicates the end of transfer of an DSPI frame in any Transmission Mode which uses DSPI in CSI Mode. The DSPI Transfer Complete Request is generated when SR[SPITCF] flag asserts and SPITCF_RE bit is set in the RSER.

77.4.13.8 DSI transfer complete interrupt request

The DSI Transfer Complete Request indicates the end of transfer of a DSI frame in any Transmission Mode which uses DSPI in CSI Mode. The DSI Transfer Complete Request is generated when SR[DSITCF] flag asserts and DSITCF_RE bit is set in the RSER.

77.4.13.9 Receive FIFO drain interrupt or DMA request

The receive FIFO drain request indicates that the RX FIFO is not empty. This request is generated when the number of entries in the RX FIFO is not 0, and the value of RSER[RFDF_RE] is 1.

RSER[RFDF_DIRS] selects whether a DMA request or an interrupt request is generated. You must configure the DMA to drain only one FIFO location per transfer.

77.4.13.10 Receive FIFO overflow interrupt request

The receive FIFO overflow request indicates that an overflow condition in the RX FIFO has occurred. This request is generated when RX FIFO and the Shift register are full, and a transfer is initiated. The value of RSER[RFOF_RE] must be equal to 1 for the interrupt request to be generated.

Depending on the state of MCR[ROOE], the data from the transfer that generated the overflow is either ignored or shifted to the Shift register. If the value of the ROOE field is 1, the incoming data is shifted in to the Shift register. If the value of the ROOE field is 0, the incoming data is ignored.

77.4.13.11 SPI frame parity error interrupt request

The DSPI Frame Parity Error Flag indicates that a DSPI frame with parity error had been received. The SPEF_RE bit in the RSER must be set for the interrupt request to be generated.

77.4.13.12 DSI frame parity error interrupt request

The DSI Frame Parity Error Flag indicates that a DSI frame with parity error has been received. The DPEF_RE bit in the DSPI_RSER must be set for the interrupt request to be generated.

77.4.13.13 Deserialized data match interrupt or DMA request

The DDIF indicates that a DSI frame matching the data in DPIR0–1, masked with DIMR0–1, had been received.The value of RSER[DDIF_RE] must be 1 for the request to be generated. RSER[DDIF_DIRS] selects whether a DMA request or an interrupt request is generated.

77.4.14 Power saving features

This module supports the following power-saving strategies:

- Module Disable mode: clock gating of non-memory mapped logic

All power-saving features require a logic external to DSPI.

77.4.14.1 Module Disable mode

This is a block-specific mode that the module can enter to save power. The host CPU can initiate the Module Disable mode by writing a 1 to MCR[MDIS]. The hardware can also initiate this mode.

When the value of the MDIS field is 1, the module negates the Clock Enable signal at the next frame boundary. After the Clock Enable signal is negated, it is said to have entered the Module Disable Mode. This also puts the module in the Stopped state. The value of SR[TXRXS] must be 0 to indicate the Stopped state. If implemented, the Clock Enable signal can stop the clock to the non-memory mapped logic. When Clock Enable is negated, the module is in a dormant state, but the memory mapped registers are still accessible. Certain read or write operations have a different effect when the module is in the Module Disable mode. Reading the POPR does not change the state of the RX FIFO. Similarly, writing to the PUSHR does not change the state of the TX FIFO or CMD FIFO. Clearing either of the FIFOs has no effect in the Module Disable mode. Also, changes to MCR[DIS_TXF]

and MCR[DIS_RXF] have no effect in the Module Disable mode. In this mode, all status bits and register flags in the module return the correct values when read, but writing to them has no effect. Also, writing to the TCR during the Module Disable mode has no effect. Interrupt and DMA request signals cannot be cleared in the Module Disable mode.

77.5 Initialization/application information

This section describes how to initialize the module.

77.5.1 How to manage queues

Queues are not a part of this module, but the module includes features to support queue management.

Queues are primarily supported in DSPI configuration, and here are the steps to manage them.

1. When the module executes the last command word from a queue, the EOQ bit in the command word indicates that it is the last entry in the queue.
2. At the end of the transfer, the value of SR[EOQF] is configured as 1.
3. If the value of SR[EOQF] is 1, the field disables serial transmission and reception of data, putting the module in the Stopped state. The value 0 is written to SR[TXRXS] indicating the Stopped state.
4. The DMA can continue to fill TX FIFO until it is full or step 5 occurs.
5. Disable DMA transfers by disabling the DMA enable request for the DMA channel assigned to TX FIFO, CMD FIFO, and RX FIFO. This is done by clearing the corresponding DMA enable request bits in the DMA controller.
6. Ensure that all the received data in RX FIFO has been transferred to the memory receive queue by reading SR[RXCNT] or by checking SR[RFDF] after each read operation of the POPR.
7. Modify the DMA descriptor of TX and RX channels for new queues.
8. Flush TX FIFO and CMD FIFO by writing a 1 to MCR[CLR_TXF] and flushing RX FIFO by writing a 1 to MCR[CLR_RXF].
9. Clear the transfer count either by setting the CTCNT bit in the command word of the first entry in the new queue or via the CPU writing directly to TCR[SPI_TCNT].
10. Enable the DMA channel through the DMA enable request. DMA channels are assigned to modules TX FIFO, CMD FIFO, and RX FIFO. For each module, a separate DMA enable request bit is available.
11. Enable serial transmission and serial reception of data by clearing the EOQF field.

77.5.2 Initializing module in Master mode

After the appropriate mode in MCR[MSTR] is configured, the module is enabled by writing a 0 to MCR[HALT]. The module's slave must be enabled before you enable its master. This ensures that the slave is ready to be communicated with, before the master initializes communication.

77.5.3 Baud rate settings

The following table shows the baud rate that is generated based on the combination of the baud rate prescaler, PBR, and the baud rate scaler, BR, in the CTARs. The values calculated assume a 100 MHz protocol frequency, and the value of the DBR field is 0..

NOTE

The clock frequency provided in this chapter is an example. See the Clocking chapter for details on the frequency used to drive this module in the chip.

Table 604. Baud rate values (bit/s)

		Baud rate divider prescaler values			
		2	3	5	7
Baud rate scaler values	2	25.0M	16.7M	10.0M	7.14M
	4	12.5M	8.33M	5.00M	3.57M
	6	8.33M	5.56M	3.33M	2.38M
	8	6.25M	4.17M	2.50M	1.79M
	16	3.12M	2.08M	1.25M	893k
	32	1.56M	1.04M	625k	446k
	64	781k	521k	312k	223k
	128	391k	260k	156k	112k
	256	195k	130k	78.1k	55.8k
	512	97.7k	65.1k	39.1k	27.9k
	1024	48.8k	32.6k	19.5k	14.0k
	2048	24.4k	16.3k	9.77k	6.98k
	4096	12.2k	8.14k	4.88k	3.49k
	8192	6.10k	4.07k	2.44k	1.74k
	16384	3.05k	2.04k	1.22k	872
	32768	1.53k	1.02k	610	436

77.5.4 Delay settings

The following table shows the values for the Delay after Transfer (t_{DT}) and CS to SCK Delay (T_{CSC}) that can be generated based on the prescaler values and the scaler values set in the CTARs. The values calculated assume a 100 MHz protocol frequency.

NOTE

The clock frequency mentioned in this section is only an example. See the clocking chapter for the frequency used to drive this module in the chip.

This table does not apply for TSB Continuous mode.

Table 605. Delay values

		Delay scaler values (CTAR[PDT])			
		1	3	5	7
Delay scaler values (CTAR[DT])	2	20.0 ns	60.0 ns	100.0 ns	140.0 ns
	4	40.0 ns	120.0 ns	200.0 ns	280.0 ns
	8	80.0 ns	240.0 ns	400.0 ns	560.0 ns
	16	160.0 ns	480.0 ns	800.0 ns	1.1 µs
	32	320.0 ns	960.0 ns	1.6 µs	2.2 µs
	64	640.0 ns	1.9 µs	3.2 µs	4.5 µs
	128	1.3 µs	3.8 µs	6.4 µs	9.0 µs
	256	2.6 µs	7.7 µs	12.8 µs	17.9 µs
	512	5.1 µs	15.4 µs	25.6 µs	35.8 µs
	1024	10.2 µs	30.7 µs	51.2 µs	71.7 µs
	2048	20.5 µs	61.4 µs	102.4 µs	143.4 µs
	4096	41.0 µs	122.9 µs	204.8 µs	286.7 µs
	8192	81.9 µs	245.8 µs	409.6 µs	573.4 µs
	16384	163.8 µs	491.5 µs	819.2 µs	1.1 ms
	32768	327.7 µs	983.0 µs	1.6 ms	2.3 ms
	65536	655.4 µs	2.0 ms	3.3 ms	4.6 ms

77.5.5 Calculation of FIFO pointer addresses

Complete visibility of the FIFO contents is available through the FIFO registers, and valid entries can be identified through a memory-mapped pointer and counter for each FIFO. The pointer to the first-in entry in each FIFO is memory mapped. For the TX FIFO, the first-in pointer is Transmit Next Pointer (TXNXTPTR), and for the CMD FIFO, the first-in pointer is the Command Next Pointer (CMDNXTPTR). For the RX FIFO, the first-in pointer is the Pop Next Pointer (POPNXTPTR). The following figure illustrates the concept of first-in and last-in FIFO entries along with the FIFO counter. The TX FIFO is chosen for illustration, but the concepts carry over. See TX FIFO buffering mechanism, CMD FIFO buffering mechanism, and RX FIFO buffering mechanism for details on the FIFO operation.

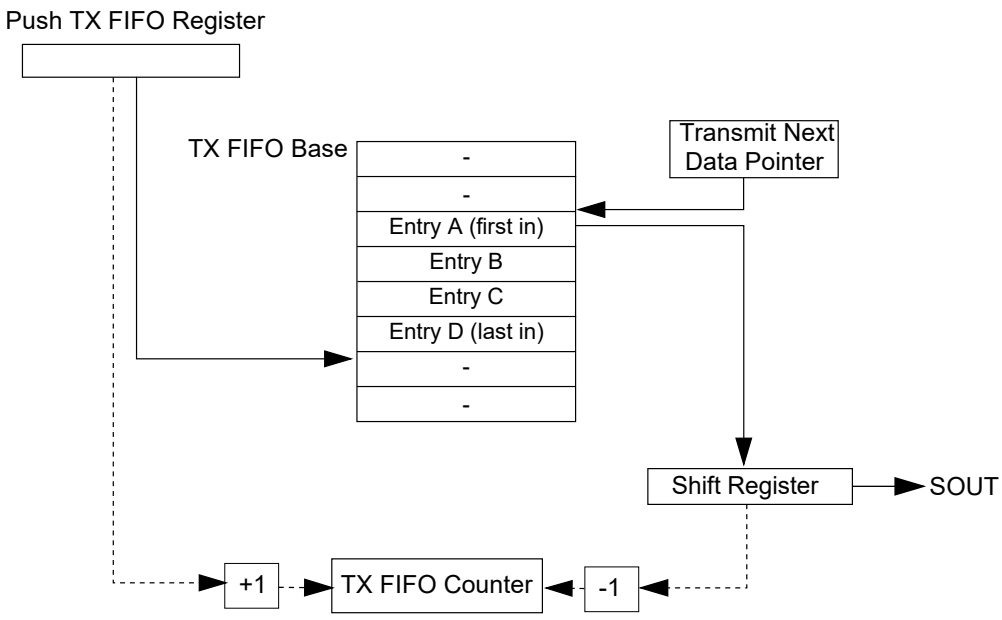


Figure 556. TX FIFO pointers and counter

77.5.5.1 Address calculation for the first-in entry and last-in entry in the TX FIFO

Use the following equation to compute the memory address of the first-in entry in the TX FIFO:

- First-in EntryAddress = TXFIFOBase+[4xTXNXTPTR]

Use the following equation to compute the memory address of the last-in entry in the TX FIFO:

- Last-in EntryAddress = TXFIFOBase+4x[TXCTR+TXNXTPTR - 1]mod[TXFIFOdepth]

Here is an explanation of the different components of these equations:

- TX FIFO base: Base address of TX FIFO
- TXCTR: TX FIFO Counter
- TXNXTPTR: Transmit Next Pointer
- TX FIFO Depth: Transmit FIFO depth, implementation specific

77.5.5.2 Address calculation for the first-in entry and last-in entry in the CMD FIFO

Use the following equation to compute the memory address of the first-in entry in the CMD FIFO:

- First-in EntryAddress = CMDFIFOBase+[4xCMDNXTPTR]

Use the following equation to compute the memory address of the last-in entry in the CMD FIFO:

- Last-in EntryAddress = CMDFIFOBase+4x[CMDCTR+CMDNXTPTR - 1]mod[CMDFIFOdepth]

Here is an explanation of the different components of these equations:

- CMD FIFO Base: Base address of CMD FIFO
- CMDCTR: CMD FIFO Counter
- CMDNXTPTR: Command Next Pointer
- CMD FIFO Depth: Command FIFO depth, implementation specific

77.5.5.3 Address calculation for the first-in entry and last-in entry in the RX FIFO

Use the following equation to compute the memory address of the first-in entry in the RX FIFO:

- First-in EntryAddress = RXFIFOBase+[4xPOPNXTPTR]

Use the following equation to compute the memory address of the last-in entry in the RX FIFO:

- Last-in EntryAddress = RXFIFOBase+4x[RXCTR+POPNXTPTR - 1]mod[RXFIFOdepth]

Here is an explanation of the different components of these equations:

- RX FIFO Base: Base address of RX FIFO
- RXCTR: TX FIFO Counter
- POPNXTPTR: Pop Next Pointer
- RX FIFO Depth: Receive FIFO depth, implementation specific

77.6 DSPI register descriptions

Register accesses to memory addresses that are reserved or undefined result in a transfer error. Any write access to the POPR and RXFR*n* also results in a transfer error. No transfer error will be generated when accessing offset 0x140.

NOTE

While the module is in the running state, do not write to:

- DIMR0, DPIR0, and SSR0
- DIMR1, DPIR1, and SSR1
- CTAREn
- TSL and TS_CONF

77.6.1 DSPI memory map

DSPI_MSC base address: 4050_8000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration Register (MCR)	32	RW	8000_4001h
8h	Transfer Count Register (TCR)	32	RW	0000_0000h
Ch - 20h	Clock and Transfer Attributes Register (In Master Mode) (CTAR0 - CTAR5)	32	RW	7800_0000h
2Ch	Status Register (SR)	32	RW	0201_0000h
30h	DMA/Interrupt Request Select and Enable Register (RSER)	32	RW	0000_0000h
34h	PUSH TX FIFO Register In Master Mode (PUSHR)	32	RW	0000_0000h
38h	POP RX FIFO Register (POPR)	32	R	0000_0000h
3Ch - 78h	Transmit FIFO Registers (TXFR0 - TXFR15)	32	R	0000_0000h
7Ch - B8h	Receive FIFO Registers (RXFR0 - RXFR15)	32	R	0000_0000h
BCh	DSI Configuration Register 0 (DSICR0)	32	RW	0000_0000h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
C0h	DSI Serialization Data Register 0 (SDR0)	32	R	0000_0000h
C4h	DSI Alternate Serialization Data Register 0 (ASDR0)	32	RW	0000_0000h
C8h	DSI Transmit Comparison Register 0 (COMPR0)	32	R	0000_0000h
CCh	DSI Deserialization Data Register 0 (DDR0)	32	R	0000_0000h
D0h	DSI Configuration Register 1 (DSICR1)	32	RW	0000_0000h
D4h	DSI Serialization Source Select Register 0 (SSR0)	32	RW	0000_0000h
E8h	DSI Deserialized Data Interrupt Mask Register 0 (DIMR0)	32	RW	0000_0000h
ECh	DSI Deserialized Data Polarity Interrupt Register 0 (DPIR0)	32	RW	0000_0000h
F0h	DSI Serialization Data Register 1 (SDR1)	32	R	0000_0000h
F4h	DSI Alternate Serialization Data Register 1 (ASDR1)	32	RW	0000_0000h
F8h	DSI Transmit Comparison Register 1 (COMPR1)	32	R	0000_0000h
FCh	DSI Deserialization Data Register 1 (DDR1)	32	R	0000_0000h
100h	DSI Serialization Source Select Register 1 (SSR1)	32	RW	0000_0000h
114h	DSI Deserialized Data Interrupt Mask Register 1 (DIMR1)	32	RW	0000_0000h
118h	DSI Deserialized Data Polarity Interrupt Register 1 (DPIR1)	32	RW	0000_0000h
11Ch - 130h	Clock and Transfer Attributes Register Extended (CTARE0 - CTARE5)	32	RW	0000_0001h
13Ch	Status Register Extended (SREX)	32	R	0000_0000h
150h	Time Slot Length Register (TSL)	32	RW	0000_0000h
154h	Time Slot Configuration Register (TS_CONF)	32	RW	0000_0000h

77.6.2 Module Configuration Register (MCR)

Offset

Register	Offset
MCR	0h

Function

This register includes fields to configure various attributes associated with module operations. The HALT and MDIS fields of this register can be changed any time, but the effect takes place only on the next frame boundary. Also, only these two fields can be changed when the module is in the Running state.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	MSTR	CONT_SC...	DCONF		FRZ	Reserved	Reserved	ROOE	Reserved						PCSIS	
W																
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	MDIS	DIS_TXF	DIS_RXF	0	0	Reserved		0				XSPI	Reserved	PES	HALT
W					CLR_TXF	CLR_RXF										
Reset	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31 MSTR	Master/Slave Mode Select Enables either Master mode (if supported) or Slave mode (if supported) operation 0b - Reserved 1b - Enables Master mode
30 CONT_SCKE	Continuous SCK Enable Enables the SCK to run continuously 0b - Continuous SCK disabled 1b - Continuous SCK enabled
29-28 DCONF	Interface Configuration Selects among the different interface configurations of the module 00b - DSPI 01b - DSI 10b - CSI 11b - Reserved
27 FRZ	Freeze Enables transfers to be stopped on the next frame boundary when the device enters Debug mode. 0b - Do not halt serial transfers in Debug mode. 1b - Halt serial transfers in Debug mode.
26 —	Reserved
25	Reserved

Table continues on the next page...

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Field	Function
—	
24 ROOE	Receive FIFO Overflow Overwrite Enable In case of RX FIFO overflow, configures the module to ignore the incoming serial data or overwrite existing data. If the RX FIFO is full and new data is received, the data from the transfer, generating the overflow, is ignored or shifted to the Shift register. 0b - Incoming data is ignored. 1b - Incoming data is shifted to the Shift register.
23-18 —	Always write the reset value to this field.
17-16 PCSIS	Peripheral Chip Select x Inactive State Determines the inactive state of PCSx. TThe Slave Select input to the module in slave mode is always Active Low. **NOTE** The effect of this bit only takes place when module is enabled. Ensure that this bit is configured correctly before enabling the DSPI interface. 00b - The inactive state of PCSx is low. 01b - The inactive state of PCS0 is high and for rest of PCSx, it is low.
15 —	Reserved
14 MDIS	Module Disable Allows the clock to be stopped to the non-memory mapped logic in the module, effectively putting it in a software-controlled, power-saving state. The reset value of this field is parametrized with a default reset value of 1. 0b - Enables the module clocks 1b - Allows external logic to disable the module clocks
13 DIS_TXF	Disable Transmit FIFO When the TX FIFO is disabled, the transmit part of the module operates as a simplified, double-buffered DSPI. This field can be written to only when the value of the MDIS field is 0. 0b - TX FIFO is enabled. 1b - TX FIFO is disabled.
12 DIS_RXF	Disable Receive FIFO When the RX FIFO is disabled, the receive part of the module operates as a simplified, double-buffered DSPI. This field can only be written to when the MDIS field is cleared.

Table continues on the next page...

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Field	Function
	0b - RX FIFO is enabled. 1b - RX FIFO is disabled.
11 CLR_TXF	Clear TX FIFO Flushes the TX FIFO. Writing a 1 to this field clears the TX FIFO counter. The value of this field is always read as 0. 0b - Do not clear the TX FIFO counter. 1b - Clear the TX FIFO counter.
10 CLR_RXF	Clear RX FIFO Flushes the RX FIFO. Writing a 1 to this field clears the RX counter. The value of this field is always read as 0. 0b - Do not clear the RX FIFO counter. 1b - Clear the RX FIFO counter.
9-8 —	Reserved
7-4 —	Reserved
3 XSPI	Extended SPI Mode Enables the usage of CTARE registers that allow you to send up to 32-bit SPI frames. Command cycling is also enabled, and that allows you to send multiple data frames using a single command frame. If MCR[DIS_TXF] is asserted, you cannot use the Extended SPI mode to transmit SPI frames, which are more than 16 bits in size. 0b - Normal SPI mode. Frame size can be up to 16 bits, and command cycling is unavailable in this mode. 1b - Extended SPI mode. Up to 32-bit SPI frames, along with command cycling, are enabled.
2 —	Reserved
1 PES	Parity Error Stop Controls DSPI operation when a parity error is detected in a received DSPI frame. 0b - DSPI frame transmission continues. 1b - DSPI frame transmission stops.
0 HALT	Halt Starts and stops frame transfers. See Start and Stop of Module transfers for details.

Table continues on the next page...

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Field	Function
	0b - Starts transfers. 1b - Stops transfers.

77.6.3 Transfer Count Register (TCR)

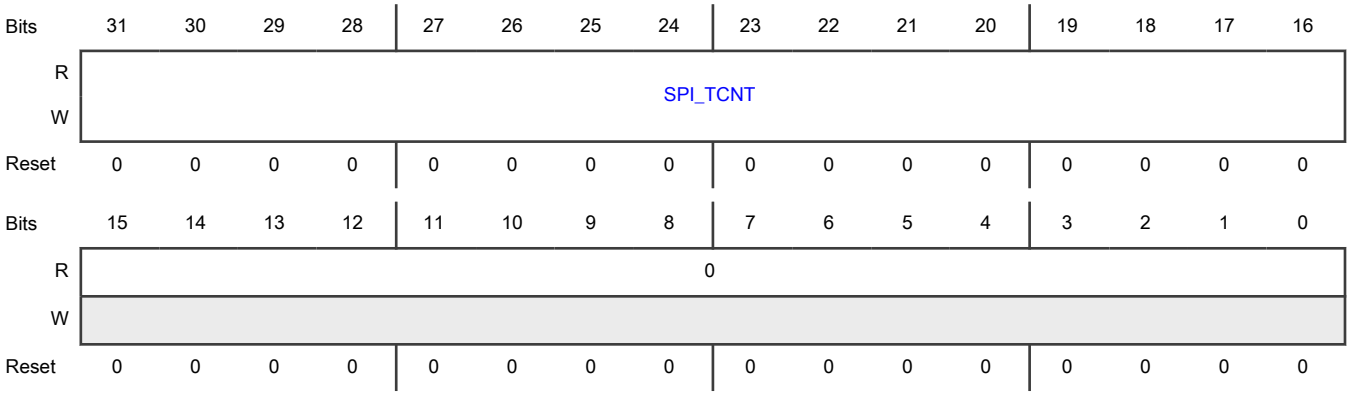
Offset

Register	Offset
TCR	8h

Function

This register includes a counter that indicates the number of DSPI transfers made. The purpose of the transfer counter is to assist with queue management. Do not write to the TCR when the module is in the Running state.

Diagram



Fields

Field	Function
31-16 SPI_TCNT	DSPI Transfer Counter Counts the number of DSPI transfers that the module performs This field increments every time the last bit of a DSPI frame is transmitted, and a value written to this field presets the counter to that value. The field is reset to 0 at the beginning of a frame if the value of PUSHR[CTCNT] is 1. If the counter is not overwritten or cleared, it eventually overflows at value 65535 to 0.
15-0 —	Reserved

77.6.4 Clock and Transfer Attributes Register (In Master Mode) (CTAR0 - CTAR5)

Offset

Register	Offset
CTAR0	Ch
CTAR1	10h
CTAR2	14h
CTAR3	18h
CTAR4	1Ch
CTAR5	20h

Function

CTARs are used to define different transfer attributes. Do not write to the CTARs when the module is in the Running state, except FMSZ and LSBFE in Continuous Selection Format.

In Master mode, the CTARs define combinations of transfer attributes such as frame size, clock phase and polarity, data bit ordering, baud rate, and various delays.

When the module is configured as a DSPI master, the CTAS field in the command portion of the TX FIFO entry selects which of the CTARs is used.

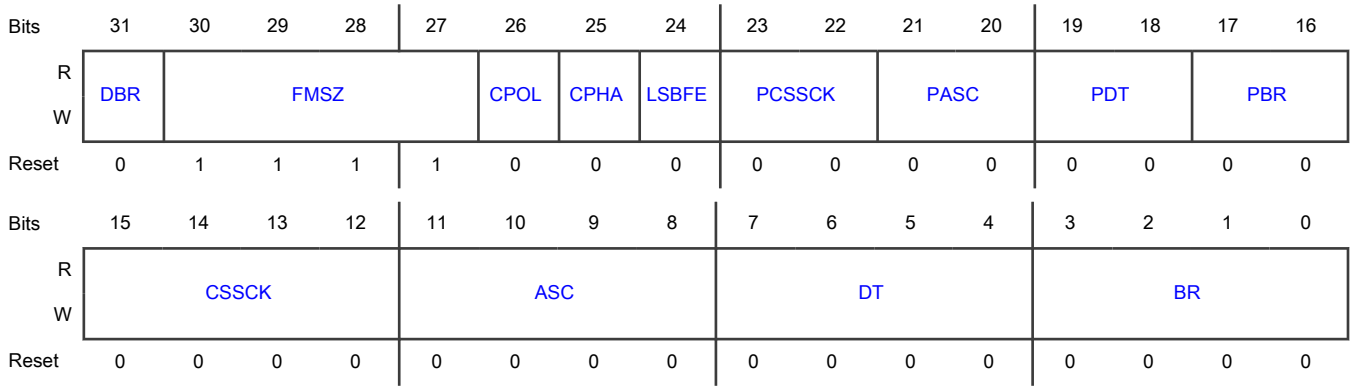
When the module is configured as a DSI master, the DSICTAS field in the DSI Configuration Register 0 (DSICR0), selects which of the CTAR register is used.

In CSI Configuration, the transfer attributes are selected based on whether the current frame is DSPI data or DSI data. DSPI transfers in CSI Configuration follow the protocol described for DSPI Configuration, and DSI transfers in CSI Configuration follow the protocol described for DSI Configuration.CSI Configuration is valid only in conjunction with master mode.

TSB mode sets some limitations on transfer attributes:

- Clock phase is forced to be CPHA = 1 and the CPHA bit setting has no effect.
- PCS lines are driven at the driving edge of the SCK clock together with SOUT, so PCS assertion and negation delays control is unavailable and PCSSCK, PASC, CSSCK and ASC fields have no effect.
- Delay after transfer can be set from 1 to 64 serial clocks with help of PDT and DT fields

Diagram



Fields

Field	Function
31 DBR	Double Baud Rate Doubles the effective baud rate of the Serial Communications Clock (SCK). This field is used only in master mode. It effectively halves the Baud Rate division ratio, supporting faster frequencies, and odd division ratios for the Serial Communications Clock (SCK). If the value of this field is 1, the duty cycle of the SCK depends on the value in the Baud Rate Prescaler and the Clock Phase bit as listed in the following table. See the BR field description for details on how to compute the baud rate.

Table 606. DSPI SCK Duty Cycle

DBR	CPHA	PBR	SCK Duty Cycle
0	any	any	50/50
1	0	00	50/50
1	0	01	33/66
1	0	10	40/60
1	0	11	43/57
1	1	00	50/50
1	1	01	66/33
1	1	10	60/40
1	1	11	57/43

0b - The baud rate is computed normally with a 50/50 duty cycle.

1b - The baud rate is doubled with the duty cycle depending on the Baud Rate Prescaler.

30-27 FMSZ	Frame Size The number of bits transferred per frame is equal to the FMSZ value plus 1. Regardless of the transmission mode, the minimum valid frame size value is 4. When the DSPI operates in TSB mode, the FMSZ field value plus 1 is equal to the data frame bit number, where control of the PCS assertion switches from the DSICR0 to the DSICR1 register. If TSB Mode is operated when DSI is in 64-bit mode, then DSICR0[FMSZ4] also affects the switching of PCS assertion control.
26 CPOL	Clock Polarity Selects the inactive state of the SCK. For successful communication between serial devices, the devices must have identical clock polarities. When the Continuous Selection Format is selected, switching between clock polarities without stopping the module can cause errors in the transfer due to the peripheral device interpreting the switch of clock polarity as a valid clock edge.

NOTE

In case of Continuous SCK mode, when the module goes in low power mode(disabled), inactive state of SCK is not guaranteed.

0b - The inactive state value of SCK is low.

1b - The inactive state value of SCK is high.

Table continues on the next page...

Field	Function
25 CPHA	Clock Phase Selects which edge of SCK causes data to change and which edge causes data to be captured. This field is used in both master and slave mode. For successful communication between serial devices, the devices must have identical clock phase settings. In Continuous SCK mode or TSB mode, the field value is ignored and the transfers are done as if the value of this field is set to 1. 0b - Data is captured on the leading edge of SCK and changed on the following edge. 1b - Data is changed on the leading edge of SCK and captured on the following edge.
24 LSBFE	LSB First Specifies whether the LSB or MSB of the frame is transferred first. When the DSPI operates in TSB configuration, this field should be set to be compliant to the MSC specification. 0b - Data is transferred MSB first. 1b - Data is transferred LSB first.
23-22 PCSSCK	PCS to SCK Delay Prescaler Selects the prescaler value for the delay between assertion of PCS and the first edge of the SCK. See the CSSCK field description for information on how to compute the PCS to SCK Delay. See PCS to SCK Delay (t_{CSC}) for more details. In the TSB mode, the PCSSCK field has no effect. 00b - PCS to SCK Prescaler value is 1. 01b - PCS to SCK Prescaler value is 3. 10b - PCS to SCK Prescaler value is 5. 11b - PCS to SCK Prescaler value is 7.
21-20 PASC	After SCK Delay Prescaler Selects the prescaler value for the delay between the last edge of SCK and the negation of PCS. See the ASC field description for information on how to compute the "After SCK Delay". In the TSB mode, the PASC field has no effect. See After SCK Delay (t_{ASC}) for details. 00b - Delay after Transfer Prescaler value is 1. 01b - Delay after Transfer Prescaler value is 3. 10b - Delay after Transfer Prescaler value is 5. 11b - Delay after Transfer Prescaler value is 7.
19-18 PDT	Delay after Transfer Prescaler Selects the prescaler value for the delay between the negation of the PCS signal at the end of a frame and the assertion of PCS at the beginning of the next frame. The PDT field is only used in master mode. In the TSB mode the PDT field defines two most-significant bits of the "Delay after Transfer". See the DT field description for details on how to compute the "Delay after Transfer". See Delay after Transfer (t_{DT}) for more details. 00b - Delay after Transfer Prescaler value is 1. 01b - Delay after Transfer Prescaler value is 3. 10b - Delay after Transfer Prescaler value is 5. 11b - Delay after Transfer Prescaler value is 7.

Table continues on the next page...

Field	Function
17-16 PBR	Baud Rate Prescaler Selects the prescaler value for the baud rate. This field is used only in master mode. The baud rate is the frequency of the SCK. The protocol clock is divided by the prescaler value before the baud rate selection takes place. See the BR field description for details on how to compute the baud rate. 00b - Baud Rate Prescaler value is 2. 01b - Baud Rate Prescaler value is 3. 10b - Baud Rate Prescaler value is 5. 11b - Baud Rate Prescaler value is 7.
15-12 CSSCK	PCS to SCK Delay Scaler Selects the scaler value for the PCS to SCK delay. This field is used only in Master mode. In the TSB mode, the field has no effect. The PCS to SCK Delay is the delay between the assertion of PCS and the first edge of the SCK. The delay is a multiple of the protocol clock period, and it is computed according to the following equation: $t_{CSC} = (1/f_P) \times PCSSCK \times CSSCK$. The following table lists the delay scaler values. **Table 607. Delay scaler encoding** See PCS to SCK Delay (t_{CSC}) for details.

Field value	Delay scaler value
0000	2
0001	4
0010	8
0011	16
0100	32
0101	64
0110	128
0111	256
1000	512
1001	1024
1010	2048
1011	4096
1100	8192
1101	16384
1110	32768
1111	65536

Table continues on the next page...

Field	Function
11-8 ASC	After SCK Delay Scaler Selects the scaler value for the "After SCK Delay". This field is used only in master mode. The "After SCK Delay" is the delay between the last edge of SCK and the negation of PCS. The delay is a multiple of the protocol clock period, and it is computed according to the following equation: $t_{ASC} = (1/f_P) \times PASC \times ASC$ See Delay Scaler Encoding table in CTARn[CSSCK] field description for scaler values. See After SCK Delay (t_{ASC}) for more details.
7-4 DT	Delay After Transfer Scaler Selects the "Delay after Transfer" Scaler. This field is used only in master mode. The "Delay after Transfer" is the time between the negation of the PCS signal at the end of a frame and the assertion of PCS at the beginning of the next frame. In the Continuous Serial Communications Clock operation, the DT value is fixed to one SCK clock period, The "Delay after Transfer" is a multiple of the protocol clock period, and it is computed according to the following equation: $t_{DT} = (1/f_P) \times PDT \times DT$ See Delay Scaler Encoding table in CTARn[CSSCK] field description for scaler values. In the TSB mode, the "Delay after Transfer" is equal to a number formed by concatenation of the PDT and DT fields plus 1 of the SCK clock periods. See Delay after Transfer (t_{DT}) for more details.
3-0 BR	Baud Rate Scaler Selects the scaler value for the baud rate. This field is used only in master mode. The prescaled protocol clock is divided by the baud rate scaler to generate the frequency of the SCK. The baud rate is computed according to the following equation: SCK baud rate = $(f_P / PBR) \times [(1+DBR)/BR]$ The following table lists the baud rate scaler values.

Table 608. Baud rate scaler

CTARn[BR]	Baud rate scaler value
0000	2
0001	4
0010	6
0011	8
0100	16
0101	32
0110	64
0111	128
1000	256
1001	512
1010	1024

Table continues on the next page...

Field	Function
	Table 608. Baud rate scaler (continued)

CTARn[BR]	Baud rate scaler value
1011	2048
1100	4096
1101	8192
1110	16384
1111	32768

77.6.5 Status Register (SR)

Offset

Register	Offset
SR	2Ch

Function

This register includes status and flag fields, which reflect the status of the module and indicate the occurrence of events that can generate interrupts or DMA requests. The software can clear the fields of this register by writing a 1, and writing a 0 does not effect the fields. The register may not be writeable in the Module Disable mode because of the use of power-saving mechanisms.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TCF	TXRXS	SPITCF	EOQF	0	DSITCF	TFFF	BSYF	CMDTCF	DPEF	SPEF	DDIF	RFOF	TFIWF	RFDF	CMDFFF
W	W1C		W1C	W1C		W1C	W1C		W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXCTR				TXNXTPTR				RXCTR				POPNXTPTR			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 TCF	Transfer Complete Flag Indicates that all bits in a frame are shifted out. This field remains set until it is cleared by writing a 1 to it.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Transfer is incomplete. 1b - Transfer is complete.
30 TXRXS	TX and RX Status Reflects the run status of the module 0b - Transmit and receive operations are disabled when the module is in the Stopped state. 1b - Transmit and receive operations are enabled when the module is in the Running state.
29 SPITCF	DSPI Frame Transfer Complete Flag. This bit functions similar to TCF except that this bit is asserted only on DSPI frame transmission completion in the following modes: • CSI • TSB in CSI • ITSB This flag will not be asserted when the module is used in DSPI or DSI Modes. 0b - DSPI frame transfer is not complete. 1b - DSPI frame transfer is complete.
28 EOQF	End of Queue Flag Indicates that the last entry in a queue has been transmitted when the module is in the Master mode. This field is set when the TX FIFO entry has the EOQ bit set in the command halfword and the end of the transfer is reached. The field remains set until cleared by writing a 1 to it, and when it is set, the TXRXS field is automatically cleared. 0b - EOQ is not set in the executing command. 1b - EOQ is set in the executing DSPI command.
27 —	Reserved
26 DSITCF	DSI Frame Transfer Complete Flag. This bit functions similar to TCF except that this bit is asserted only on DSI frame transmission completion in the following modes: • CSI • TSB in CSI • ITSB This flag will not be asserted when the module is in SPI or DSI mode. 0b - DSI frame transfer is not complete. 1b - DSI frame transfer is complete.

Table continues on the next page...

Table continued from the previous page...

Field	Function
25 TFFF	Transmit FIFO Fill Flag Indicates whether there is an available location to be filled in the FIFO. Either DMA or an interrupt can be used to add another entry to the FIFO. Note that this field is set if at least one location is free in the FIFO. The field can be cleared if the value 1 is written to it or by acknowledgement from the DMA controller to the TX FIFO full request, when the TX FIFO is full. If FIFO is filled manually, and not by DMA, see Transmit FIFO fill interrupt or DMA request. **NOTE** The reset value of this field is 0 when the module is disabled (MCR[MDIS] = 1). 0b - TX FIFO is full. 1b - TX FIFO is not full.
24 BSYF	Busy Flag Indicates that the current command frame is being used for transmitting multiple data frames. The value of this field is valid only when the value of MCR[XSPI] is 1, and the field is not set for the last data frame of a cyclic command transfer or when the value of CTARE[DTCP] is 1. See CMD FIFO buffering mechanism for details. 0b - No cyclic command transfer is in progress. 1b - Cyclic command transfer is in progress. Current data frame is not the last data frame for on-going cyclic command transfer.
23 CMDTCF	Command Transfer Complete Flag Indicates that the last data frame for the current cyclic command has been transmitted. Therefore, this field is set only for the last data frame of a cyclic command transfer or when the value of CTARE[DTCP] is 1. The field remains set until it is cleared by writing a 1 to it. 0b - Data transfer by current command is incomplete. 1b - Data transfer by current command is complete.
22 DPEF	DSI Parity Error Flag Indicates that a DSI frame with parity error had been received. The field remains set until it is cleared by writing a 1 to it. 0b - No parity error. 1b - Parity error has occurred.
21 SPEF	DSPI Parity Error Flag Indicates that a DSPI frame with parity error had been received. The field remains set until it is cleared by writing a 1 to it. 0b - No parity error. 1b - Parity error has occurred.
20	DSI Data Received with Active Fields

Table continues on the next page...

Table continued from the previous page...

Field	Function
DDIF	Indicates that a DSI frame had been received with bits selected by DIMR with active polarity, defined by DPIR. The field remains set until it is cleared by writing a 1 to it. 0b - No DSI data with active bits was received. 1b - DSI data with active bits was received.
19 RFOF	Receive FIFO Overflow Flag Indicates an overflow condition in the RX FIFO. The field is set when the RX FIFO and the Shift register are full and a transfer is initiated. The field remains set until it is cleared by writing a 1 to it. 0b - No RX FIFO overflow occurred. 1b - RX FIFO overflow has occurred.
18 TFIWF	Transmit FIFO Invalid Write Flag Indicates data write on TX FIFO when CMD FIFO is empty. Without a command, the data entries present in TX FIFO are invalid. This field remains set until it is cleared by writing a 1 to it. 0b - No invalid data is present in TX FIFO. 1b - Invalid data is present in TX FIFO because CMD FIFO is empty.
17 RFDF	Receive FIFO Drain Flag Indicates whether there is an available location to be drained from the FIFO. Either DMA or an interrupt can be used to read from the FIFO. Note that this field is set if at least one location can be read from the FIFO. The field can be cleared by writing a 1 to it or by acknowledgement from the DMA controller when the RX FIFO is empty. 0b - RX FIFO is empty. 1b - RX FIFO is not empty.
16 CMDFFF	Command FIFO Fill Flag Indicates whether there is an available location to be filled in the FIFO. Either a DMA request or an interrupt indication can be used to add another entry to the FIFO. Note that this bit is set if at least one location is free in the FIFO. The CMDFFF is cleared by writing a '1' to it or by acknowledgement from the DMA controller to the CMD FIFO full request. **NOTE** The reset value of this field is 0 when the module is disabled (MCR[MDIS] = 1). 0b - CMD FIFO is full. 1b - CMD FIFO is not full.
15-12 TXCTR	TX FIFO Counter Indicates the number of valid entries in the TX FIFO. This field increments every time the PUSHR is written and decrements every time DSPI command is executed and the DSPI data is transferred to the Shift register.
11-8	Transmit Next Pointer

Table continues on the next page...

Table continued from the previous page...

Field	Function
TXNXTPTR	Indicates which TX FIFO entry is transmitted during the next transfer. This field updates every time DSPI data is transferred from the TX FIFO to the Shift register. **NOTE** If TX FIFO is cleared by writing 1 to MCR[CLR_TXF], the value of the TXNXTPTR field does not change immediately to 0. Only when the next transfer starts, the field reflects the latest value, TXNXTPTR = 1.
7-4 RXCTR	RX FIFO Counter Indicates the number of entries in the RX FIFO. This field decrements every time the POPR is read and increments every time data is transferred from the Shift register to the RX FIFO.
3-0 POPNXTPTR	Pop Next Pointer Contains a pointer to the RX FIFO entry to be returned when the POPR is read. This field is updated when the POPR is read.

77.6.6 DMA/Interrupt Request Select and Enable Register (RSER)

Offset

Register	Offset
RSER	30h

Function

This register controls DMA and interrupt requests. Do not write to the register when the module is in the Running state.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TCF_RE	CMDFF_...	SPITCF_...	EOQF_RE	Reserved	DSITCF_...	TFFF_RE	TFFF_DI...	CMDTCF_...	DPEF_RE	SPEF_RE	DDIF_RE	RFOF_RE	TFIWF_RE	RFDF_RE	RFDF_DI...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CMDFF_...	DDIF_DI...	0													
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 TCF_RE	Transmission Complete Request Enable Enables SR[TCF] to generate an interrupt request 0b - TCF interrupt requests are disabled. 1b - TCF interrupt requests are enabled.
30 CMDFFF_RE	Command FIFO Fill Flag Request Enable Enables SR[CMDFFF] to generate a request. The CMDFFF_DIRS field of this register selects between generating an interrupt request or a DMA request. 0b - CMDFFF interrupts or DMA requests are disabled. 1b - CMDFFF interrupts or DMA requests are enabled.
29 SPITCF_RE	DSPI Frame Transmission Complete Request Enable. The SPITCF_RE bit enables SPITCF flag in the SR to generate an interrupt request. 0b - SPITCF interrupt requests are disabled. 1b - SPITCF interrupt requests are enabled.
28 EOQF_RE	Finished Request Enable Enables SR[EOQF] to generate an interrupt request 0b - EOQF interrupt requests are disabled. 1b - EOQF interrupt requests are enabled.
27 —	Reserved
26 DSITCF_RE	DSI Frame Transmission Complete Request Enable. The DSITCF_RE bit enables DSITCF flag in the SR to generate an interrupt request. 0b - DSITCF interrupt requests are disabled. 1b - DSITCF interrupt requests are enabled.
25 TFFF_RE	Transmit FIFO Fill Request Enable Enables SR[TFFF] to generate a request. The TFFF_DIRS field of this register selects between generating an interrupt request or a DMA request. 0b - TFFF interrupts or DMA requests are disabled. 1b - TFFF interrupts or DMA requests are enabled.
24 TFFF_DIRS	Transmit FIFO Fill DMA or Interrupt Request Select Selects between generating a DMA request or an interrupt request. When SR[TFFF] and RSER[TFFF_RE] are set, this field selects between generating an interrupt request or a DMA request. 0b - TFFF flag generates interrupt requests.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - TFFF flag generates DMA requests.
23 CMDTCF_RE	Command Transmission Complete Request Enable Enables SR[CMDTCF] to generate an interrupt request 0b - CMDTCF interrupt requests are disabled. 1b - CMDTCF interrupt requests are enabled.
22 DPEF_RE	DSI Parity Error Request Enable Enables the DPEF flag in the SR to generate an interrupt request. 0b - DPEF interrupt requests are disabled. 1b - DPEF interrupt requests are enabled.
21 SPEF_RE	DSPI Parity Error Request Enable Enables the SPEF flag in the SR to generate an interrupt request. 0b - SPEF interrupt requests are disabled. 1b - SPEF interrupt requests are enabled.
20 DDIF_RE	DSI Data Received (with active bits request enable) Enables SR[DDIF] to generate an interrupt or DMA request. 0b - Disabled 1b - Enabled
19 RFOF_RE	Receive FIFO Overflow Request Enable Enables SR[RFOF] to generate an interrupt request 0b - RFOF interrupt requests are disabled. 1b - RFOF interrupt requests are enabled.
18 TFIWF_RE	Transmit FIFO Invalid Write Request Enable Enables SR[TFIWF] to generate an interrupt request 0b - TFIWF interrupt requests are disabled. 1b - TFIWF interrupt requests are enabled.
17 RFDF_RE	Receive FIFO Drain Request Enable Enables SR[RFDF] to generate a request. The RFDF_DIRS field of this register selects between generating an interrupt request or a DMA request. 0b - RFDF interrupt or DMA requests are disabled. 1b - RFDF interrupt or DMA requests are enabled.
16	Receive FIFO Drain DMA or Interrupt Request Select

Table continues on the next page...

Table continued from the previous page...

Field	Function
RFDF_DIRS	Selects between generating a DMA request or an interrupt request. If SR[RFDF] is set, and the value of the RFDF_RE field in this register is 1, the RFDF_DIRS field selects between generating an interrupt request or a DMA request. 0b - Interrupt request 1b - DMA request
15 CMDFFF_DIRS	Command FIFO Fill DMA or Interrupt Request Select Selects between generating a DMA request or an interrupt request. When SR[CMDFFF] is set, and the value of the CMDFFF_RE field in this register is 1, the CMDFFF_DIRS field selects between generating an interrupt request or a DMA request. 0b - CMDFFF flag generates interrupt requests. 1b - CMDFFF flag generates DMA requests.
14 DDIF_DIRS	DSI Data Received (with active bits, DMA, or interrupt request select) Selects between generating a DMA request or an interrupt request. When SR[DDIF] is set, and the value of the DDIF_RE field in this register is 1, the DDIF_DIRS field selects between generating an interrupt request or a DMA request. 0b - Interrupt request 1b - DMA request
13-0 —	Reserved

77.6.7 PUSH TX FIFO Register In Master Mode (PUSHR)

Offset

Register	Offset
PUSHR	34h

Function

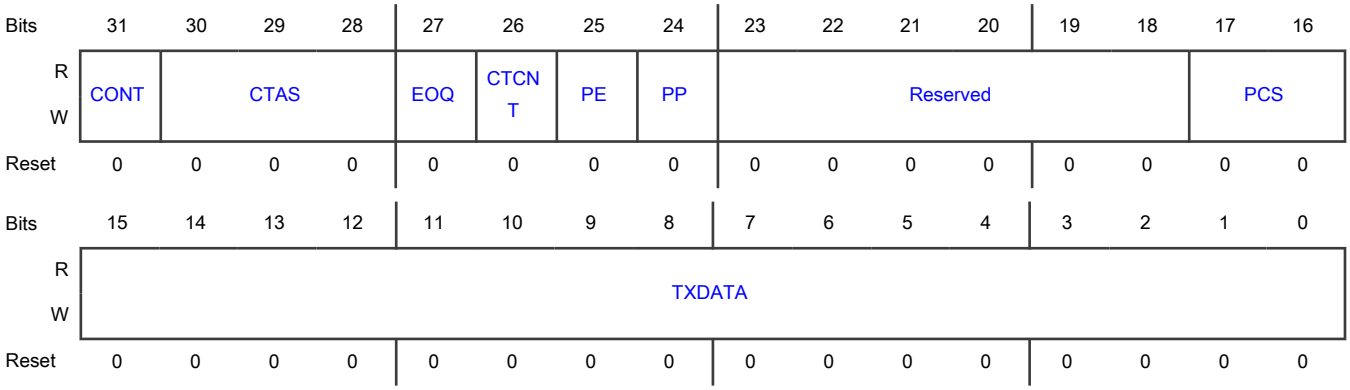
Specifies data to be transferred to the TX FIFO and CMD FIFO. You must write 16 bits of data into the TXDATA field. An 8- or 16-bit write access to the TXDATA field transfers 16 bits of data bus to the TX FIFO. A write access to the command fields transfers the 16 bits of command information to the CMD FIFO. In Master mode, the register transfers 16 bits of data to the TX FIFO and 16 bits of command information to the CMD FIFO.

If Extended SPI Mode is disabled (MCR[XSPI]), the TX FIFO and CMD FIFO must be filled simultaneously. In other words, you must perform write accesses to both the data and command fields for every PUSHR operation. With Extended SPI Mode disabled and both the TX FIFO and CMD FIFO are written to and read from simultaneously, they behave as a single 32 bit FIFO. When Extended SPI mode is enabled (MCR[XSPI]), the TX FIFO and CMD FIFO can be written to independently.

A read access of PUSHR returns the topmost TX FIFO and CMD FIFO entries concatenated.

When the module is disabled, writing to this register does not update the FIFO. Therefore, any reads performed while the module is disabled return the last PUSHR write performed while the module was still enabled.

Diagram



Fields

Field	Function
31 CONT	Continuous Peripheral Chip Select Enable Selects a continuous selection format. The bit is used in DSPI Master mode. The bit enables the selected PCS signals to remain asserted between transfers. 0b - Return PCSn signals to their inactive state between transfers. 1b - Keep PCSn signals asserted between transfers.
30-28 CTAS	Clock and Transfer Attributes Select Selects which CTAR to use in master mode to specify the transfer attributes for the associated DSPI frame. See the chip specific section for details to determine how many CTARs this device has. You should not program a value in this field for a register that is not present. 000b - CTAR0 001b - CTAR1 010b - CTAR2 011b - CTAR3 100b - CTAR4 101b - CTAR5 110b - Reserved 111b - Reserved
27 EOQ	End Of Queue Host software uses this bit to signal to the module that the current DSPI transfer is the last in a queue. At the end of the transfer, the EOQF bit in the SR is set. 0b - The DSPI data is not the last data to transfer. 1b - The DSPI data is the last data to transfer.
26	Clear Transfer Counter

Table continues on the next page...

Table continued from the previous page...

Field	Function
CTCNT	Clears the TCNT field in the TCR register. The TCNT field is cleared before the module starts transmitting the current DSPI frame. 0b - Do not clear the TCR[TCNT] field. 1b - Clear the TCR[TCNT] field.
25 PE	Parity Enable Enables parity bit transmission and parity reception check for the DSPI frame. 0b - No parity bit included/checked. 1b - Parity bit is transmitted instead of the last data bit in the frame; parity is checked for the received frame.
24 PP	Parity Polarity Controls the polarity of the parity bit transmitted and checked. 0b - Even Parity: the number of 1 bits in the transmitted frame is even. The SR[SPEF] bit is set if the number of 1 bits is odd in the received frame. 1b - Odd Parity: the number of 1 bits in the transmitted frame is odd. The SR[SPEF] bit is set if the number of 1 bits is even in the received frame.
23-18 —	Always write the reset value to this field.
17-16 PCS	PCS Select which PCS signals are to be asserted for the transfer. 00b - Negate the PCS[x] signal. 01b - Assert the PCS[x] signal.
15-0 TXDATA	Transmit Data Holds SPI data to be transferred according to the associated DSPI command.

77.6.8 POP RX FIFO Register (POPR)

Offset

Register	Offset
POPR	38h

Function

This register is used to read the RX FIFO. An 8- or 16-bit access to the register has the same effect on the RX FIFO as 32-bit read accesses. A write to this register generates a transfer error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXDATA	Received Data Contains the DSPI data from the RX FIFO entry to which the pop next data pointer points

77.6.9 Transmit FIFO Registers (TXFR0 - TXFR15)

Offset

For a = 0 to 15:

Register	Offset
TXFRa	3Ch + (a × 4h)

Function

These registers provide visibility into the TX FIFO for debugging purposes. Each register is an entry in the TX FIFO. The registers can only be read and not modified. Reading the TXFR*x* registers does not alter the state of the TX FIFO. Also, reading these registers is invalid if the module is operating in the Extended SPI mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXCMD_TXDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXDATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 TXCMD_TXDATA	Transmit Command or Transmit Data In Master mode the TXCMD field contains the command that sets the transfer attributes for the DSPI data.
15-0 TXDATA	Transmit Data Contains the DSPI data to be shifted out

77.6.10 Receive FIFO Registers (RXFR0 - RXFR15)

Offset

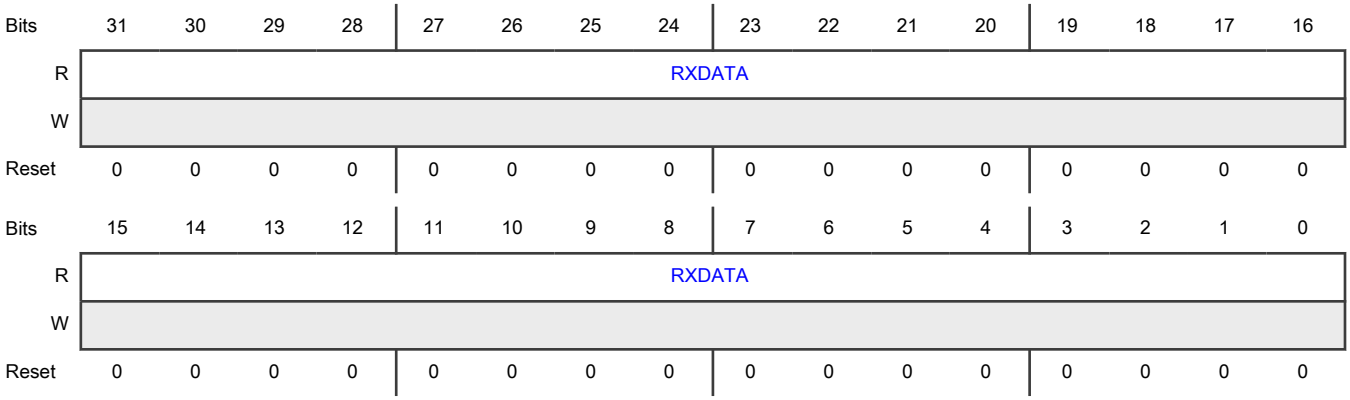
For a = 0 to 15:

Register	Offset
RXFRa	7Ch + (a × 4h)

Function

These read-only registers provide visibility into the RX FIFO for debugging purposes. Each register is an entry in the RX FIFO. Reading the RXFR*x* registers does not alter the state of the RX FIFO. However, the value of MCR[MDIS] must be 0 when RXFR is read.

Diagram



Fields

Field	Function
31-0 RXDATA	Receive Data Contains the received SPI data

77.6.11 DSI Configuration Register 0 (DSICR0)

Offset

Register	Offset
DSICR0	BCh

Function

This register selects various attributes associated with the following configurations:

- DSI
- TSB
- ITSB

NOTE

Do not write to this register while the module is in the Running state.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved	FMSZ4	Reserved						FMSZ5	TRG	ITSB	TSBC	TXSS	TPOL	TRRE	CID
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DCONT	DSICTAS			DMS	PES	PE	PP	DPCSx							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 FMSZ4	MSB of Frame Size in Master Mode If 1 is the value of this field, 16 is added to the frame size, as defined by CTAR*n*[FMSZ]. The DSICTAS field of this register selects the CTAR*n* register.
29-24 —	Reserved
23 FMSZ5	MSB of Frame Size in Master Mode (when DSI is used in 64-bit mode)

Table continues on the next page...

Table continued from the previous page...

Field	Function
	If 1 is the value of this field, 32 is added to the frame size, as defined by the concatenation of {DSICR0[FMSZ[4]], CTARn[FMSZ]} fields. The DSICTAS field in this register selects the CTAR*n* register. Hence, the final concatenated frame size is {DSICR0[FMSZ[5]], DSICR0[FMSZ[4]] , CTARn[FMSZ]}. This field is only valid when the value of DSICR1[DSI64E] is 1.
22 TRG	Trigger Source for Interleaved TSB mode. This bit decides the source for trigger. 0b - Internal Trigger - Trigger is generated internal to IP. 1b - External Trigger - Trigger is generated external to IP at chip level.
21 ITSB	Interleaved TSB mode. This bit enables the Interleaved TSB mode of operation. When enabled, there is no priority among frames from the SPI/DSI. DSI frames are always sent when either the previous transmission was a DSPI frame or if the TX_FIFO is empty. Frames are transmitted on every trigger whose source is selected by the TRG bit setting. The ITSB mode requires the DSICR0[TSBC] bit to be set and should be written only when MCR[HALT] bit is asserted. If ITSB bit is set without setting DSICR0[TSBC], then the module operates in the Normal Mode depending on MCR[DCONF] bit. See Interleaved TSB (ITSB) Mode for more details. 0b - Interleaved mode is disabled. 1b - Interleaved mode is enabled.
20 TSBC	Timed Serial Bus Configuration. Enables the Timed Serial Bus interface configuration and allows t_{DT} to be programmable. 0b - Timed Serial Bus Configuration disabled. 1b - Timed Serial Bus Configuration enabled.
19 TXSS	Transmit Data Source Select Selects the source of data to be serialized. The source can be either data from the host software, written to the ASDR0/1, or parallel input pin states latched into the SDR0/1. 0b - Source of serialized data is the SDR. 1b - Source of serialized data is the ASDR.
18 TPOL	Trigger Polarity Selects the active edge of the hardware trigger input signal, initiating DSI frames transfer 0b - Falling edge initiates a transfer. 1b - Rising edge initiates a transfer.
17 TRRE	Trigger Reception Enable Enables the module to initiate a DSI frames transfer with an hardware trigger signal. 0b - Trigger signal reception is disabled. 1b - Trigger signal reception is enabled.

Table continues on the next page...

Table continued from the previous page...

Field	Function
16 CID	Change In Data Transfer Enable Enables a change in serialization data to initiate a DSI frames transfer in DSI and CSI configurations. If the value of this field is 1, DSI frames are initiated when the current DSI data differs from the previous DSI data shifted out.
15 DCONT	DSI Continuous Peripheral Chip Select Enable Enables the PCS signals to remain asserted between transfers. This field affects PCS signals only in the DSI Master mode. When the TSBC bit is set, DCONT has no effect. 0b - Return PCS signals to their inactive state after the transfer is complete. 1b - Keep PCS signals asserted after the transfer is complete.
14-12 DSICTAS	DSI Clock and Transfer Attributes Select Selects the CTAR register to provide transfer attributes for DSI frames. This field is used in the DSI Master mode. In the DSI Slave mode, CTAR1 is always selected.
11 DMS	Data Match Stop If the value of this field is 1, it stops DSI frame transmissions when SR[DDIF] is set. 0b - DDIF flag does not have an effect on DSI frame transmissions. 1b - DDIF flag stops DSI frame transmissions.
10 PES	Parity Error Stop If set, stops DSI operation if the parity error happened in the received DSI frame. 0b - Parity error does not stop DSI frame transmissions. 1b - Parity error stops all DSI frame transmissions.
9 PE	Parity Enable Enables parity bit transmission and parity reception check for the DSI frames. 0b - No parity bit included/checked. 1b - Parity bit is transmitted instead of the last data bit in the frame; parity is checked for the received frame.
8 PP	Parity Polarity Controls the polarity of the parity bit transmitted and checked. 0b - Even Parity: the number of 1 bits in the transmitted frame is even. The SR[DPEF] bit is set if in the received frame number of 1 bits is odd. 1b - Odd Parity: the number of 1 bits in the transmitted frame is odd. The SR[DPEF] bit is set if in the received frame number of 1 bits is even.
7-0 DPCSx	DSI Peripheral Chip Select 0–7 Selects which of the PCS signals to assert during a DSI master mode transfer

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0000_0000b - Negate PCS[x] 0000_0001b - Assert PCS[x]

77.6.12 DSI Serialization Data Register 0 (SDR0)

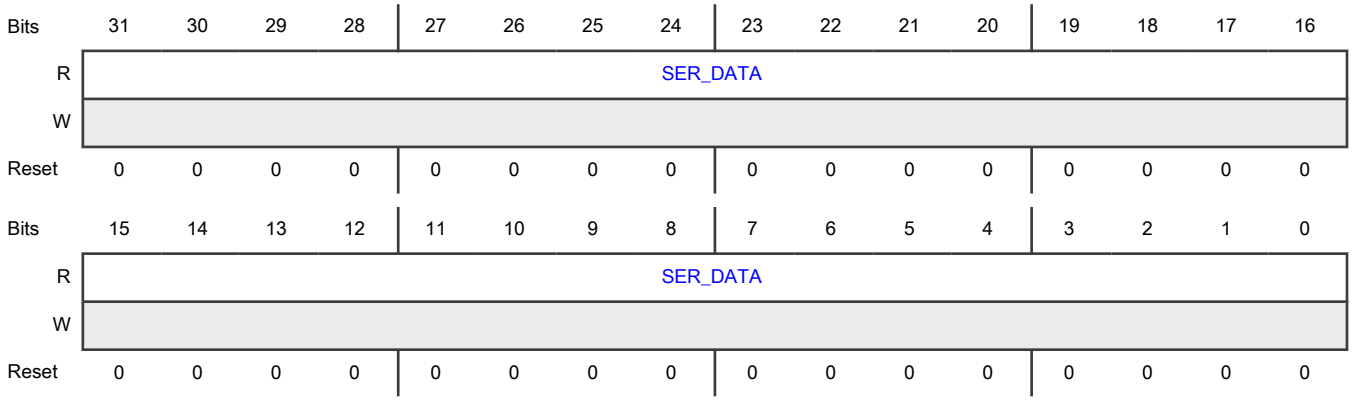
Offset

Register	Offset
SDR0	C0h

Function

This register includes the states of the 32 LSB parallel input signals. These states are latched into the SDR0, which is a read-only register, on the rising edge of every bus clock. If the value of DSICR0[TXSS] is 0, the data in the SDR0 is used as the source for DSI frames. If the value of DSICR1[DSI64E] is 1, the concatenation of {SDR1, SDR0} provides the 64-bit serialization data value.

Diagram



Fields

Field	Function
31-0 SER_DATA	Serialized Data Contains the signal states of the 32 LSB parallel input signals

77.6.13 DSI Alternate Serialization Data Register 0 (ASDR0)

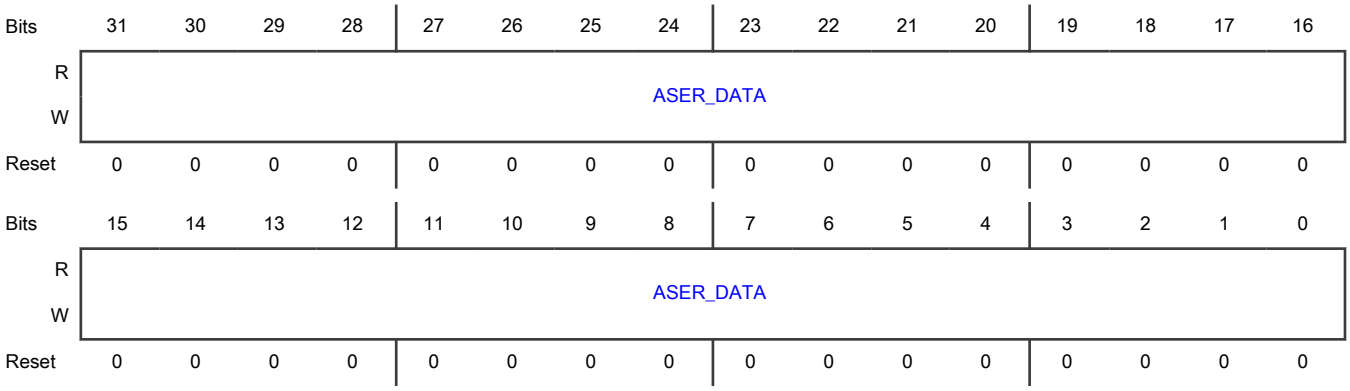
Offset

Register	Offset
ASDR0	C4h

Function

The host software uses this register to write 32 LSB of the data to be serialized. If the value of DSICR0[TXSS] is 0, the data in the ASDR0 is the source for DSI frames. Writes to the ASDR0 take effect on the next frame boundary. If the value of DSICR1[DSI64E] is 1, the concatenation of {ASDR1, ASDR0} provides the 64-bit alternate serialization data value.

Diagram



Fields

Field	Function
31-0 ASER_DATA	Alternate Serialized Data Holds the alternate 32 LSB of the data to be serialized

77.6.14 DSI Transmit Comparison Register 0 (COMPR0)

Offset

Register	Offset
COMPR0	C8h

Function

This register holds a copy of 32 LSB of the last transmitted DSI data, which is transferred to the COMPR0 as it is loaded into the TX Shift register. If the value of DSICR1[DSI64E] is 1, the concatenation of {COMPR1, COMPR0} provides the 64-bit transmit comparison value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	COMP_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	COMP_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 COMP_DATA	Compare Data Holds 32 LSB of the last serialized DSI data

77.6.15 DSI Deserialization Data Register 0 (DDR0)

Offset

Register	Offset
DDR0	CCh

Function

This register holds the 32 LSB signal states for the parallel output signals. The host software can read data from incoming DSI frames. If the value of DSICR1[DSI64E] is 1, the concatenation of {DDR1, DDR0} provides the 64-bit deserialized data value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DESER_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DESER_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DESER_DATA	Deserialized Data Holds 32 LSB of deserialized data that is presented as signal states to the parallel output signals

77.6.16 DSI Configuration Register 1 (DSICR1)

Offset

Register	Offset
DSICR1	D0h

Function

This register selects various attributes associated with the following configurations:

- DSI
- TSB
- ITSB

NOTE

You must not write to the DSICR1 when the module is in the Running state.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		TSBCNT						0			Reserved	CSE	DSI64E	DSE1	DSE0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved								DPCS1_x							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-24	Timed Serial Bus Operation Count

Table continues on the next page...

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Field	Function
TSBCNT	When TSB is enabled (DSICR0[TSBC]), TSBCNT defines the length of the data frame. When DSI 64-bit mode is enabled (DSI64E), the length value can vary from 3 to 63 (000011b to 111111b); otherwise, it can vary from 3 to 31 (000011b to 011111b). The length value specifies the number of data bits to be shifted out during a transfer in TSB mode. The number of data bits in the data frame is one more than the value in the TSBCNT field.
23-21 —	Reserved
20 —	Reserved
19 CSE	Command Select Enable When the DSICR0[ITSB] and DSICR0[TSBC] is set, the CSE bit controls insertion of command selection bit (Logic 1) in the beginning of the DSPI (command) frame. 0b - No selection bit is inserted in the beginning of the command frame. 1b - Command selection bit is inserted at the beginning of the command frame. Total number of bits in the command frame is increased by 1.
18 DSI64E	DSI 64-bit Mode Enable Enables DSI 64-bit mode, which allows the serialization and deserialization of data frames up to 64 bits in size. The following extended registers are valid only when this mode is enabled: SDR1, ASDR1, COMPR1, DDR1, SSR1, DIMR1, DPIR1. 0b - DSI 64-bit mode disabled. DSI mode operates according to the default 32-bit configuration. 1b - DSI 64-bit mode enabled. DSI mode operates according to the 64-bit configuration.
17 DSE1	Data Select Enable 1 When the TBSC bit is set, the DSE1 bit controls insertion of the zero bit (Data Select) in the middle of the data frame. The insertion bit position is defined by the FMSZ field of CTARn register, selected by the DSICR0[DSICTAS] field. If DSI 64-bit mode is enabled (DSICR1[DSI64]), then the insertion bit position is defined by the concatenation of {DSICR0[FMSZ4], CTAR[FMSZ]}. The TSBCNT field value must be greater than the position of insertion for proper operation of DSE1. 0b - No Zero bit is inserted in the middle of the data frame. 1b - Zero bit is inserted at the middle of the data frame. Total number of bits in the data frame is increased by 1.
16 DSE0	Data Select Enable 0 When the TBSC bit is set, the DSE0 bit controls insertion of the zero bit (Data Select) in the beginning of the DSI frame. 0b - No Zero bit is inserted in the beginning of the frame. 1b - Zero bit is inserted at the beginning of the data frame. Total number of bits in the data frame is increased by 1.

Table continues on the next page...

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Field	Function
15-8 —	Reserved
7-0 DPCS1_x	DSI Peripheral Chip Select 0–7 Specifies the PCSs to assert for the second part of the DSI frame when operating in TSB or ITSB configuration with dual receiver. DPCS1 selects the PCS signals to assert during the second part of the DSI frame. DPCS1 controls the assertions of PCS signals only in TSB and ITSB mode. 0000_0000b - Negate PCS[x]. 0000_0001b - Assert PCS[x].

77.6.17 DSI Serialization Source Select Register 0 (SSR0)

Offset

Register	Offset
SSR0	D4h

Function

This register is used to create a combined frame for transmission that contains fields from ASDR0 and SDR0. Each field in the SSR0 selects a corresponding field to be serialized. If the value of DSICR0[TXSS] is 1, SSR0 has no effect. If the value of DSICR1[DSI64E] is 1, the concatenation of {SSR1, SSR0} provides the 64-bit serialization source select value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	SS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SS															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0	Source Select

Table continues on the next page...

Field	Function
SS	Selects the serialization source for the 32 LSB of the DSI frame. Each bit of this field selects data for a corresponding bit in the transmitted frame. 0000_0000_0000_0000_0000_0000_0000_0000b - The bit in the transmitted frame is derived from the parallel input pin. 0000_0000_0000_0000_0000_0000_0000_0001b - The bit in the transmitted frame is derived from the ASDR0.

77.6.18 DSI Deserialized Data Interrupt Mask Register 0 (DIMR0)

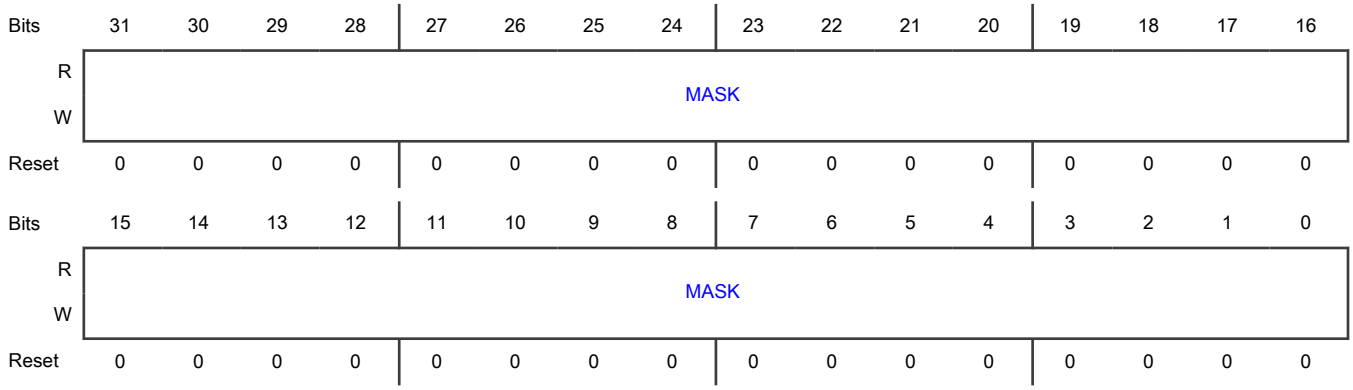
Offset

Register	Offset
DIMR0	E8h

Function

This register selects bits from the 32 LSB of the received DSI frame to be checked to generate the Deserialized Data Interrupt (DDI). If the value of DSICR1[DSI64E] is 1, the concatenation of {DIMR1, DIMR0} provides the 64-bit deserialized data interrupt mask value.

Diagram



Fields

Field	Function
31-0 MASK	Mask Defines which bits in the 32 LSB of received deserialized data should be checked to produce the DDI 0000_0000_0000_0000_0000_0000_0000_0000b - The bit in the received DSI frame does not produce a DDI interrupt. 0000_0000_0000_0000_0000_0000_0000_0001b - The bit in the received DSI frame can produce a DDI interrupt if the data bit matches the configured polarity.

77.6.19 DSI Deserialized Data Polarity Interrupt Register 0 (DPIR0)

Offset

Register	Offset
DPIR0	ECh

Function

This register defines which data bit value from the 32 LSB of received DSI frame generates the DDI. If the value of DSICR1[DSI64E] is 1, the concatenation of {DPIR1, DPIR0} provides the 64-bit deserialized data polarity interrupt value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	DP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	DP															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DP	Data Polarity Defines which value from the 32 LSB of the received deserialized data configures SR[DDIF] 0000_0000_0000_0000_0000_0000_0000_0000b - SR[DDIF] is configured if the received bit is 0. 0000_0000_0000_0000_0000_0000_0000_0001b - SR[DDIF] is configured if the received bit is 1.

77.6.20 DSI Serialization Data Register 1 (SDR1)

Offset

Register	Offset
SDR1	F0h

Function

This register contains the states of the 32 MSB signal states of the 64 parallel input signals. The states of these parallel input signals are latched into the SDR1 on the rising edge of every bus clock. If the value if DSICR0[TXSS] is 0, the data in the SDR1 and SDR0 is used as the source of the DSI frames. The concatenation of {SDR1, SDR0} provides the 64-bit data to be serialized. This register is valid only when the value of DSICR1[DSI64E] is 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	SER_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	SER_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 SER_DATA	Serialized Data Contains the 32 MSB signal states of the 64 parallel input signals

77.6.21 DSI Alternate Serialization Data Register 1 (ASDR1)

Offset

Register	Offset
ASDR1	F4h

Function

The host software uses this register to write the 32 MSB of the 64-bit data to be serialized. When the value of DSICR0[TXSS] is 1, the data in the ASDR1 and ASDR0 is the source of the DSI frames. Writes to the ASDR1 take effect on the next frame boundary. The concatenation of {ASDR1, ASDR0} provides the 64-bit alternate serialization data. This register is valid only when the value of DSICR1[DSI64E] is 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ASER_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ASER_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 ASER_DATA	Alternate Serialized Data Holds the 32 MSB of the 64-bit alternate data to be serialized

77.6.22 DSI Transmit Comparison Register 1 (COMPR1)

Offset

Register	Offset
COMPR1	F8h

Function

This register holds a copy of the 32 MSB of the last transmitted 64-bit DSI data. The upper 32 bits of the 64-bit DSI data is transferred to this register as it is loaded into the TX Shift register. The concatenation of {COMPR1, COMPR0} provides the 64-bit transmit comparison data. This register is valid only when the value of DSICR1[DSI64E] is 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	COMP_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	COMP_DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 COMP_DATA	Compare Data Holds the 32 MSB of the last serialized 64-bit DSI data

77.6.23 DSI Deserialization Data Register 1 (DDR1)

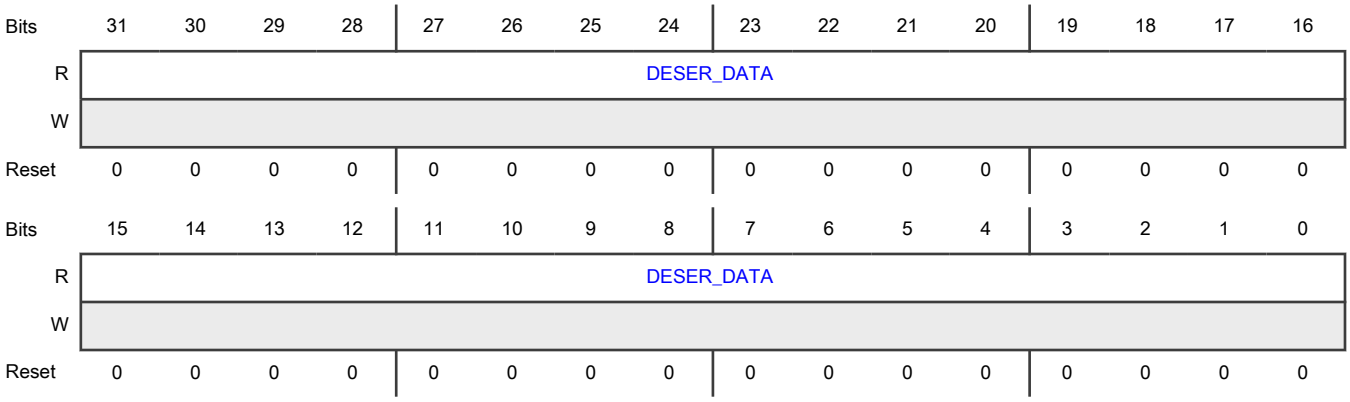
Offset

Register	Offset
DDR1	FCh

Function

This register holds the 32 MSB signal states for the 64 parallel output signals. The host software can read data from the incoming DSI frames. The concatenation of {DDR1, DDR0} provides the 64-bit deserialized data. The register is valid only when the value of DSICR1[DSI64E] is 1.

Diagram



Fields

Field	Function
31-0 DESER_DATA	Deserialized Data Holds 32 MSB of the deserialized data that is presented as signal states to the 64 parallel output signals

77.6.24 DSI Serialization Source Select Register 1 (SSR1)

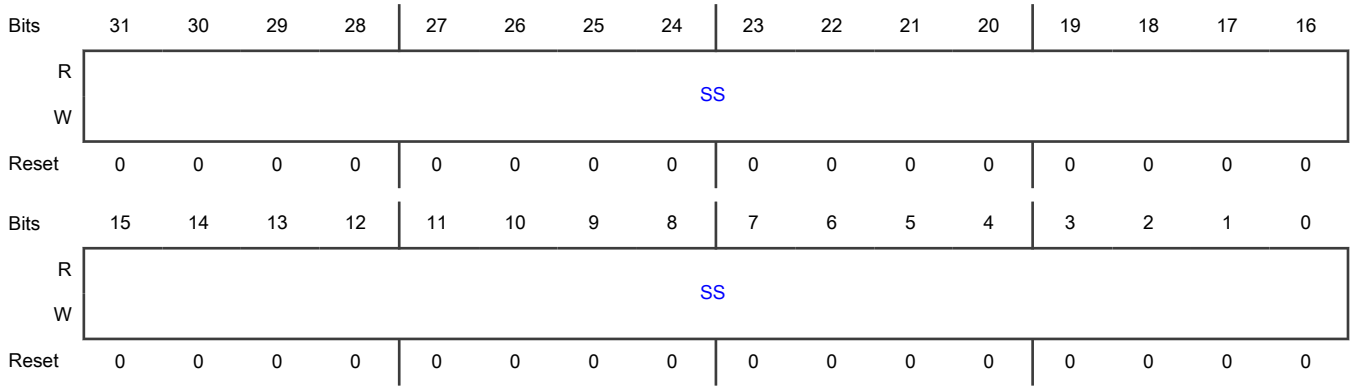
Offset

Register	Offset
SSR1	100h

Function

This register is used to create a combined frame for transmission that contains fields from ASDR1 and SDR1. Each field in the SSR1 selects a corresponding field to be serialized. If the value of DSICR0[TXSS] is 1, the SSR1 has no effect. The concatenation of {SSR1, SSR0} provides the 64-bit serialization source select value. The register is valid only when the value of DSICR1[DSI64E] is 1.

Diagram



Fields

Field	Function
31-0 SS	Source Select Selects the serialization source for the 32 MSB of the 64-bit DSI frame. Each bit of this field selects data for a corresponding bit in the transmitted frame. 0000_0000_0000_0000_0000_0000_0000_0000b - The bit in the transmitted frame is derived from the parallel input pin. 0000_0000_0000_0000_0000_0000_0000_0001b - The bit in the transmitted frame is derived from the ASDR0/1 registers.

77.6.25 DSI Deserialized Data Interrupt Mask Register 1 (DIMR1)

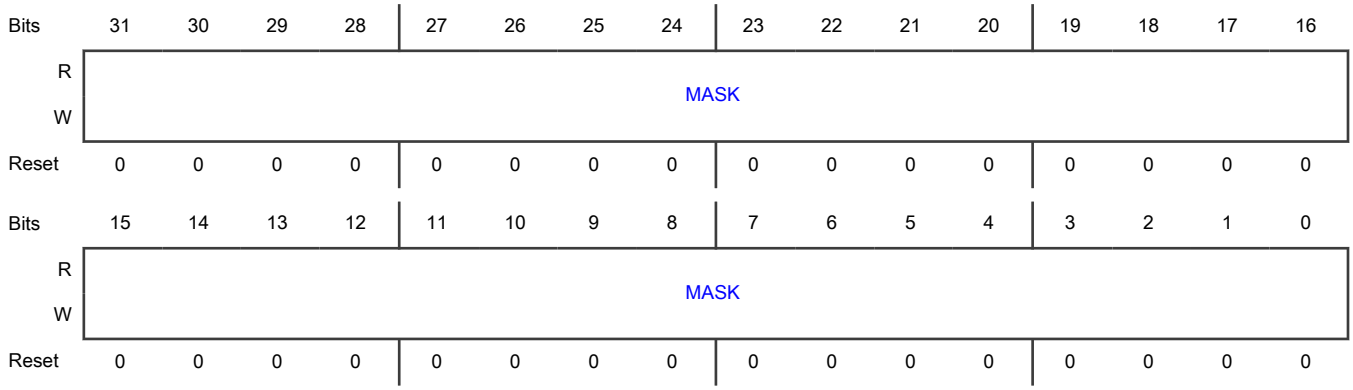
Offset

Register	Offset
DIMR1	114h

Function

This register selects bits from the 32 MSB of the received 64-bit DSI frame to be checked to generate the DDI. The concatenation of {DIMR1, DIMR0} provides the 64-bit deserialized data interrupt mask value. The register is valid only when the value of DSICR1[DSI64E] is 1.

Diagram



Fields

Field	Function
31-0 MASK	Mask Defines which of the 32 MSB in the received 64-bit deserialization data should be checked to produce the DDI 0000_0000_0000_0000_0000_0000_0000_0000b - The bit in the received DSI frame does not produce a DDI. 0000_0000_0000_0000_0000_0000_0000_0001b - The bit in the received DSI frame can produce a DDI if the data bit matches the configured polarity.

77.6.26 DSI Deserialized Data Polarity Interrupt Register 1 (DPIR1)

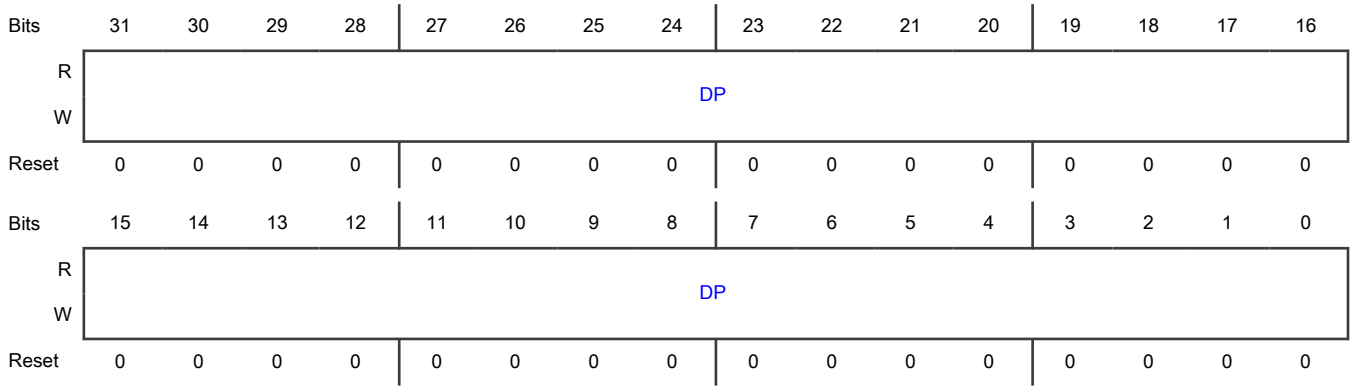
Offset

Register	Offset
DPIR1	118h

Function

This register defines which of the 32 MSB value in the received 64-bit DSI frame generates the DDI. The concatenation of {DPIR1, DPIR0} provides the 64-bit deserialized data polarity value. The register is valid only when the value of DSICR1[DSI64E] is 1.

Diagram



Fields

Field	Function
31-0 DP	Data Polarity Defines which of the 32 MSB of the received 64-bit deserialized data configures SR[DDIF] 0000_0000_0000_0000_0000_0000_0000_0000b - SR[DDIF] is configured if the received bit is 0. 0000_0000_0000_0000_0000_0000_0000_0001b - SR[DDIF] is configured if the received bit is 1.

77.6.27 Clock and Transfer Attributes Register Extended (CTARE0 - CTARE5)

Offset

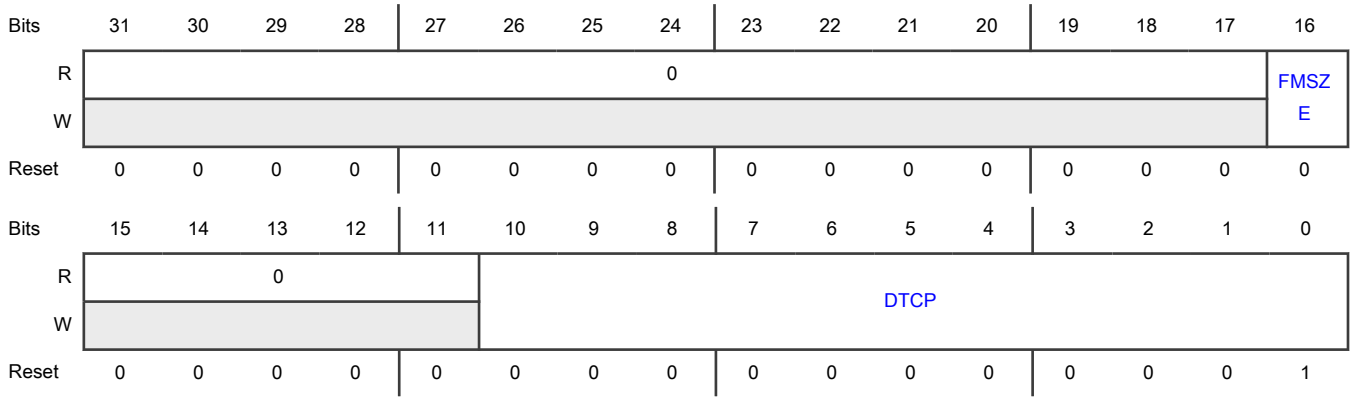
Register	Offset
CTARE0	11Ch
CTARE1	120h
CTARE2	124h
CTARE3	128h
CTARE4	12Ch
CTARE5	130h

Function

These registers are used to define the extended transfer attributes for DSPI frames. The registers are valid only when the value of MCR[XSPI] is 1.

When the module is configured as a DSPI master, the CTAS field in CMD FIFO entry selects which of the CTARE registers is used.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 FMSZE	Frame Size Extended This field is valid only when the value of MCR[XSPI] is 1. The field, concatenated with CTAR[FMSZ], defines the frame size of the DSPI frames to be transmitted. The effective frame size is the concatenation of {CTARE[FMSZE], CTAR[FMSZ]} plus 1. 0b - Default mode. Up to 16-bit DSPI frames can be transferred. 1b - Up to 32-bit DSPI frames can be transferred. Each frame transfer is a result of two simultaneous TX FIFO pop operations.
15-11 —	Reserved
10-0 DTCP	Data Transfer Count Preload This field is valid only when the value of MCR[XSPI] is 1. The field defines the number of data frames, the size of which is defined by CTARE[FMSZE] and CTAR[FMSZ], to be transmitted using the command frame that selected this register. The value 0 is reserved and should not be written to this field, and the default value of the field is 1.

77.6.28 Status Register Extended (SREX)

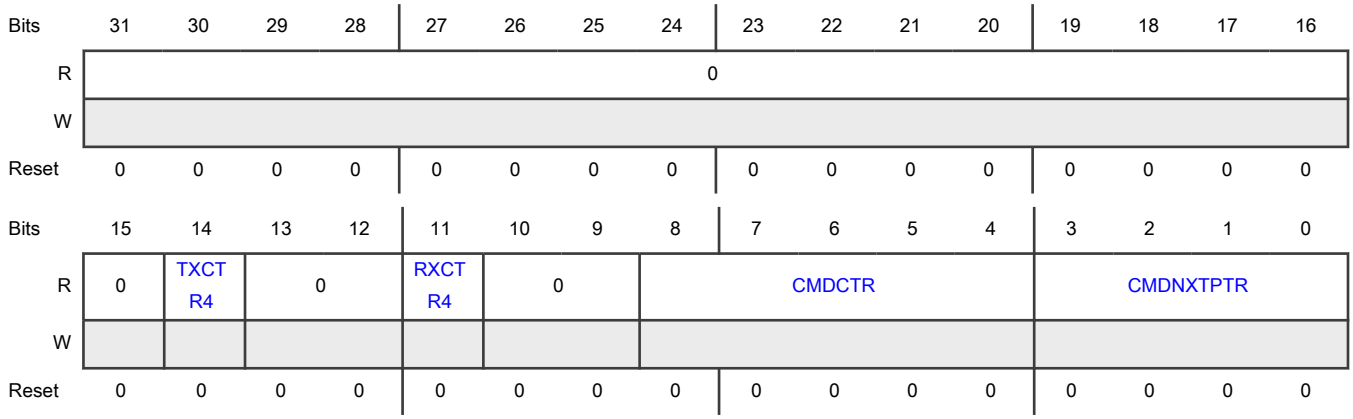
Offset

Register	Offset
SREX	13Ch

Function

The register contains status fields, which indicate the status of the module and the occurrence of events. The register is not writeable.

Diagram



Fields

Field	Function
31-15 —	Reserved
14 TXCTR4	TX FIFO Counter[4] This bit is an extension of SR[TXCTR]. The concatenated field {TXCTR4, TXCTR} indicates the number of valid entries in the TX FIFO. This field is incremented every time the PUSHR is written. And this field is decremented every time an DSPI command is executed and the DSPI data is transferred to the Shift register.
13-12 —	Reserved
11 RXCTR4	RX FIFO Counter[4] This bit is an extension of SR[RXCTR]. The concatenated field {RXCTR4, RXCTR} indicates the number of entries in the RX FIFO. This field is decremented every time the POPR is read. And this field is incremented every time data is transferred from the Shift register to the RX FIFO.
10-9 —	Reserved
8-4 CMDCTR	CMD FIFO Counter Indicates the number of entries in the CMD FIFO. This field increments every time the command part of the PUSHR is written, and decrements every time the DSPI command is executed (all data frames are transmitted because of current command frame).
3-0 CMDNXTPTR	Command Next Pointer Indicates which CMD FIFO entry is used during the next transfer. This field updates every time DSPI data is transmitted because of current command frame.

77.6.29 Time Slot Length Register (TSL)

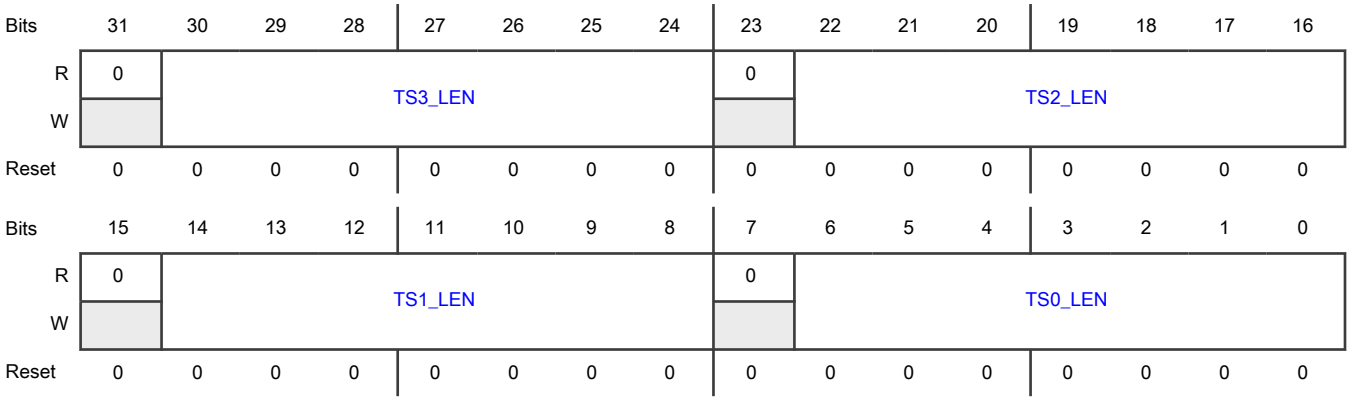
Offset

Register	Offset
TSL	150h

Function

The TSL register is only valid when DSICR0[ITSB] is enabled and internal triggering mechanism is used. It provides the length of every time slot in terms of baud cycles.

Diagram



Fields

Field	Function
31 —	Reserved
30-24 TS3_LEN	Time Slot 3 Length This field provides the length of TS3 in terms of baud cycles. It must be ensured that the programmed value is greater than or equal to the length of the frame to be transmitted during TS3. Time Slot3 Length = TS3_LEN+1.This time slot shall be skipped if programmed to 0.
23 —	Reserved
22-16 TS2_LEN	Time Slot 2 Length This field provides the length of TS2 in terms of baud cycles. It must be ensured that the programmed value is greater than or equal to the length of the frame to be transmitted during TS2. Time Slot 2 Length = TS2_LEN+1.This time slot shall be skipped if programmed to 0.
15 —	Reserved

Table continues on the next page...

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Field	Function
14-8 TS1_LEN	Time Slot 1 Length This field provides the length of TS1 in terms of baud cycles. It must be ensured that the programmed value is greater than or equal to the length of the frame to be transmitted during TS1. Time Slot 1 Length = TS1_LEN+1.This time slot shall be skipped if programmed to 0.
7 —	Reserved
6-0 TS0_LEN	Time Slot 0 Length This field provides the length of TS0 in terms of baud cycles. It must be ensured that the programmed value is greater than or equal to the length of the frame to be transmitted during TS0. Time Slot 0 Length = TS0_LEN+1.This time slot shall be skipped if programmed to 0.

77.6.30 Time Slot Configuration Register (TS_CONF)

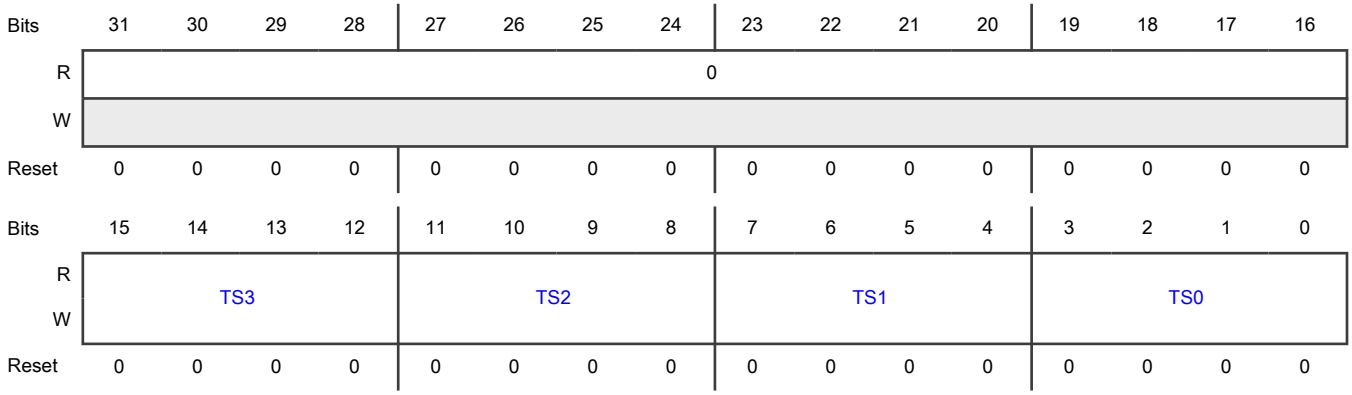
Offset

Register	Offset
TS_CONF	154h

Function

This register provides the basic configuration options available for the triggered implementation of MSC protocol. This register is only valid when DSICR0[ITSB] is enabled. Some configurations in this register check for the validity of command frame. The following conditions must be true for a command frame to be valid : a) The previous transmitted frame should not be a command frame. b) Data required to transmit the command frame should be available.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-12 TS3	Time Slot 3 This field is used to program the frame rule to be followed during Time Slot 3. This field is only valid when DSICR0[ITSB] mode is enabled. 0000b - PF - Passive Frame 0001b - SRDF - Single Receiver Data Frame 0010b - DRF1 - First part of Dual Receiver Frame 0011b - DRF2 - Second part of Dual Receiver Frame 0100b - CMD_PF - Command Frame if valid, else Passive Frame 0101b - CMD_SRDF - Command Frame if valid, else Single Receiver Data Frame 0110b - CMD_DRF1 - Command Frame if valid, else first half of Dual Receiver Data Frame 0111b - CMD_DRF2 - Command Frame if valid, else second half of Dual Receiver Data Frame 1xxxb - Reserved
11-8 TS2	Time Slot 2 This field is used to program the frame rule to be followed during Time Slot 2. This field is only valid when DSICR0[ITSB] mode is enabled. 0000b - PF - Passive Frame 0001b - SRDF - Single Receiver Data Frame 0010b - DRF1 - First part of Dual Receiver Frame 0011b - DRF2 - Second part of Dual Receiver Frame 0100b - CMD_PF - Command Frame if valid, else Passive Frame 0101b - CMD_SRDF - Command Frame if valid, else Single Receiver Data Frame 0110b - CMD_DRF1 - Command Frame if valid, else first half of Dual Receiver Data Frame 0111b - CMD_DRF2 - Command Frame if valid, else second half of Dual Receiver Data Frame 1xxxb - Reserved
7-4 TS1	Time Slot 1 This field is used to program the frame rule to be followed during Time Slot 1. This field is only valid when DSICR0[ITSB] mode is enabled. 0000b - PF - Passive Frame 0001b - SRDF - Single Receiver Data Frame 0010b - DRF1 - First part of Dual Receiver Frame 0011b - DRF2 - Second part of Dual Receiver Frame

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Field	Function
	0100b - CMD_PF - Command Frame if valid, else Passive Frame 0101b - CMD_SRDF - Command Frame if valid, else Single Receiver Data Frame 0110b - CMD_DRF1 - Command Frame if valid, else first half of Dual Receiver Data Frame 0111b - CMD_DRF2 - Command Frame if valid, else second half of Dual Receiver Data Frame 1xxxb - Reserved
3-0 TS0	Time Slot 0 This field is used to program the frame rule to be followed during Time Slot 0. This field is only valid when DSICR0[ITSB] mode is enabled. 0000b - PF - Passive Frame 0001b - SRDF - Single Receiver Data Frame 0010b - DRF1 - First part of Dual Receiver Frame 0011b - DRF2 - Second part of Dual Receiver Frame 0100b - CMD_PF - Command Frame if valid, else Passive Frame 0101b - CMD_SRDF - Command Frame if valid, else Single Receiver Data Frame 0110b - CMD_DRF1 - Command Frame if valid, else first half of Dual Receiver Data Frame 0111b - CMD_DRF2 - Command Frame if valid, else second half of Dual Receiver Data Frame 1xxxb - Reserved

77.7 Glossary

Table 609. Glossary

Term	Definition
Asserted	A signal that is asserted is in its active state. An active low signal changes from logic level one to logic level zero when asserted, and an active high signal changes from logic level zero to logic level one.
Clear	To clear a bit or bits means to establish logic level zero on the bit or bits.
FIFO entry	FIFO entries and FIFO registers are used interchangeably.
Logic level one	The voltage that corresponds to Boolean true (1) state.
Logic level zero	The voltage that corresponds to Boolean false (0) state.
Negated	A signal that is negated is in its inactive state. An active low signal changes from logic level zero to logic level one when negated, and an active high signal changes from logic level one to logic level zero.
Set	To set a bit or bits means to establish logic level one on the bit or bits.
SPI/DSPI slave	Peripheral device which operates under the control of SPI master device.

Table continues on the next page...

Table 609. Glossary (continued)

Term	Definition
SS/SS_b	SS is slave select. Signal from the SPI master to the SPI slave indicating which SPI slave device the master want to communicate with.

Chapter 78
Ethernet Media Access Controller (EMAC)

78.1 Chip-specific EMAC information

78.1.1 EMAC instance and configuration

This chip supports up to 1 instance of EMAC IP.

NOTE

DWC_EQOS refer to the Synopsys Ethernet MAC IP.

NOTE

The description for some EMAC registers include references to configurations of the Synopsis Ethernet MAC IP. Refer to MAC_HW_Feature registers for the specific features available in this chip.

NOTE

EMAC operates only in Clock options A and B, since the module clock becomes lower than the protocol clock (RMII/MII clocks) in other modes.

NOTE

QuadSPI cannot be used along with Ethernet in 176LQFP-EP.

Following key features are supported:

- This chip supports only MII/RMII interfaces
- 4 bit MII interface operating at 2.5/25/50Mhz, MII can run at 10/100/200 Mbps.
- 2 bit RMII interface operating at 50Mhz, RMII can run at 10/100Mbps
- 4 bit MII-Lite interface operating at 2.5/25Mhz
- 4 PPS are supported using DMA trigger
- 200Mbps data rate is supported on Ethernet MII interface
- MTL Receive FIFO size 8192bytes
- MTL Transmit FIFO size 8192bytes

NOTE

The DMA referred within EMAC chapter refers to the internal EMAC DMA engine and not the device AXBS master DMA.

NOTE

Register access beyond 8k address space is not supported and will generate a transfer error.

NOTE

Always use store and forward mode if possible. In cut through mode, if multiple masters are active then there is chance (even in round robin arbitration mode) that EMAC DMA may starve for data resulting in insufficient data in TX FIFO leading to Tx underflow. To avoid this, increase MTL_TxQ0_Operation_Mode[TTC] value as needed.

The table below provides the information on the specific configuration utilized for the S32K396.

Table 610. Specific configuration information

Application Interface		
	Application interface configuration	EQOS-AHB
	Data width	32
	Endian mode	Little Endian
	Address width	32
	CSR interface	APB3 interface
General feature		
	Mode of operation	10/100
	Enable double VLAN processing	Yes
	Enable Que/channel based VLAN tag insertion on Tx	Yes
	Enable SA and VLAN insertion on Tx	Enabled by default
Buffer management		
	MTL Receive FIFO size in bytes	8192
	MTL Receive FIFO size in bytes	8192
	Enable debug memory access	Yes
	Use single port memory	Yes
PHY interface		
	Supported interfaces	MII, RMII
	Enabled signal phy interface	No
	Enable MDIO interface	Yes
Filtering		
	Enable Additional 1-31 MAC address registers	2
	Enable Address Filter Hash Table	Yes
	Hash Table Size	64
	Enable VLAN Hash table based filtering	Yes
	Extended Rx VLAN Filter Enable	Yes
	Number of VLAN tag Filters	4
	Enable Layer3 and Layer4 Packet Filter	Yes
	Number of layer3 and Layer 4 packet filters	4
	Enable Flexible Programmable Receive Parser	Yes

Table continues on the next page...

Table 610. Specific configuration information (continued)

	Maximum Packet Header Size for Parsing	128
	Maximum Entries of Parser Look up table	64
	Packet duplication support	Yes
IEEE 1588 timestamp		
	Enable IEEE 1588 Time stamp support	Enabled by default
	IEEE 1588 System Time Support	Both option
	Add IEEE 1588 Higher word register	Yes
	Enable IEEE 1588 sub nanoseconds time stamp support	Yes
	Add IEEE 1588 Auxiliary snapshot	No
	Enable Flexible Pulse Per Seconds Output	Yes
	Number of pulse per Second outputs	4
	Enable PTP Timestamp offload feature	No
	Enable One Step timestamp for PTP over UDP/IP feature	No
	Enable One Step timestamp feature	Yes
Multiple queue support		
	Number of transmit Queue	2
	Number of receive Queue	2
	Enable data center Bridging	No
	Enable Audio Video Bridging	Yes
	Enable support for AV in Tx queue 1	No
	Number of DMA Channel on the receive side	2
Time sensitive networking		
	Enable Enhancement to Schedule traffic(EST)	Yes
	Width of Time Interval Field in the Gate Control List	24
	Depth of Gate Control List	256
	Enable Frame Pre-emption support	Yes
Time based scheduling		
	Enable time based Scheduling	Yes
TCP/IP offloading features		

Table continues on the next page...

Table 610. Specific configuration information (continued)

	Enable receive TCP/IP Checksum Check	Enabled by default
	Enable transmit TCP/IP Checksum offload	Enabled by default
	Enable support for Tx COE in Tx queue 0	Yes
	Enable support for Tx COE in Tx queue 1	No
	Enable TCP Segmentation offloading for TCP/IP	No
	Enable Split Header Feature	No
	Enable IPv4 ARP offload	No
RMON counters		
	Enable MAC Management Counters(MMC)	Yes
	Enable the MAC Management Counters for Receiver TCP/IP Checksum offload	No
Automotive safety feature		
	Enable all automotive safety feature	Yes

78.2 Overview

This section and all its sub-sections are Synopsys Proprietary. Used with permission.

EMAC:

- Supports the 10/100 Mbps application in compliance with IEEE802.3-2015 specifications
- Can support advanced applications such as time-sensitive networking and AVB
- Supports a MAC core that has prominent features such as a flexible receive parser, media clock recovery and generation, and safety

78.2.1 Features

EMAC supports these features in addition to the default feature defined in the IEEE802.3 specification:

- MII (10/100 Mbps), RMII (10/100 Mbps)
- Time-aware shaper (IEEE802.1bv), time synchronization (IEEE802.1AS-rev), and frame preemption (IEEE802.1Qbu) for time-sensitive networking
- Media clock recovery and generation for AVB
- AMBA 2.0 for AHB master and APB3 interface
- RMII specification version 1.2 from RMII consortium
- Separate interface for transmit, receive, and control paths
- Two-buffer ring
- Broadcast and multicast packet duplication
- Full-duplex flow control operations (IEEE 802.3x pause packet and priority flow control)
- Network statistics with MAC management (RMON) counters
- Flexibility to control the pulse per second (PPS) output signal

- MDIO clause 22 and clause 45 interface for configuration and management of the PHY device
- Preamble and SFD insertion and deletion

NOTE

Only byte-aligned preamble is supported.

- Automatic CRC and pad generation/stripping option
- Option to disable CRC checking
- Programmable insert packet gap
- Source address insertion or replacement
- VLAN insertion, replacement, and deletion in transmitted packets with per-packet or static-global control, insertion, replacement, and deletion of up to two VLAN tags, insertion, replacement, and deletion of queue or channel-based VLAN tags
- IEEE802.1Q VLAN tag detection and an option to delete the tags in the receive packets
- Programmable safety watchdog timeout limits
- Flexible address filtering modes that allow:
  - Up to two additional 48-bit perfect DA filters with masks for each byte
  - Up to two 48-bit SA comparison checks with masks for each byte
  - 64-bit hash filter for multicast and unicast DA addresses
  - Option to pass all multi-cast addressed packets
  - Promiscuous mode to pass all packets without any filtering for network monitoring
  - Passing of all incoming packets (according to filter) with a status report
- Additional packet filtering that is based on:
  - Virtual local area network (VLAN) tag—perfect match and hash-based filtering, which is based on either outer or inner VLAN tag, is possible
  - Layer 3 and layer 4—TCP or UDP over IPv4 or IPv6
  - Extended VLAN tag—filtering based on four filter selections

NOTE

The DCB feature discussed in the following section(s) is not supported.

78.2.2 Block diagram

This figure shows the EMAC block diagram. EMAC has four main blocks to perform all the functions.

- The AHB interface is connected to all DMA channels.
- The DMA arbiter helps in the arbitration of all paths (transmit and receive) in DMA channels.
- Each channel has a separate set of control and status registers (CSRs) for managing the transmit and receive functions, descriptor handling, and interrupt handling.

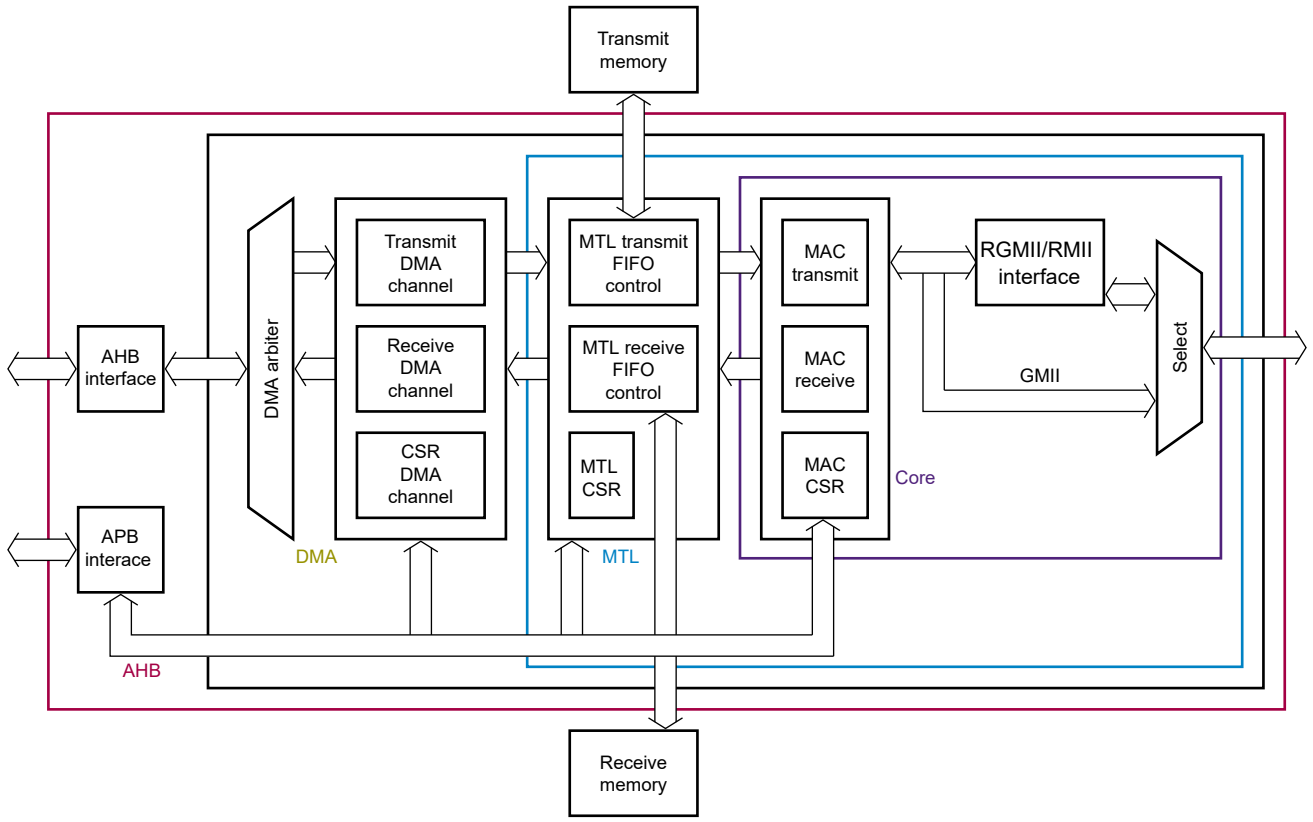


Figure 557. System-level block diagram

78.3 Architecture

This section and all its sub-sections are Synopsys Proprietary. Used with permission.

The section describes EMAC interfaces, protocols, and functionality. These are its main blocks:

- AHB master and APB3 slave interface
- DMA controller
- MTL
- MAC
- Interrupts

78.3.1 AHB master and CSR slave (APB3) interface

The 32-bit APB3 slave interface:

- Provides access to DMA, MTL, and MAC control and status registers (CSRs)
- Supports the 32-bit write and read transfers to these CSRs
- Supports single- and all-burst transfers, and an OKAY response

The DMA block uses the AHB master interface to interact with the external world. The AHB master interface:

- Controls data transfer
- Is AMBA 2.0-compliant with no restrictions
- Supports 32-bit data transfer

- Supports single and INCR transfers
- Supports burst-length modes such as Fixed, Unspecified, and Mixed

78.3.2 DMA inclusions

DMA controller:

- Includes independent transmit (Tx) and receive (Rx) engines, and a CSR space. The transmit engine transfers data from the system memory to the MTL interface, whereas the receive engine transfers data from the MTL interface to the system memory.
- Is designed for packet-oriented data transfers such as packets in Ethernet.
- Communicates with the host through CSR, descriptor lists, and data buffers.

DMA descriptors

DMA supports up to two transmit and two receive descriptor lists (or DMA channels). The base address of each list is written to the respective transmit and receive descriptor list address registers. A descriptor list is forward linked and the next descriptor is always considered at a fixed offset to the current one, and DMA_CH0_Control[DSL] controls the offset. The number of descriptors in the list is programmed using the respective DMA Channel 0 Tx Descriptor Ring Length (DMA_CH0_TxDesc_Ring_Length) and DMA Channel 0 Rx Descriptor Ring Length (DMA_CH0_RxDesc_Ring_Length) registers. After the DMA processes the last descriptor in the list, it automatically jumps to the descriptor in the list address register to create a descriptor ring.

EMAC supports the ring structure for DMA descriptors. For more information, see Descriptors .

The DMA engine uses descriptors to efficiently move data from source to destination with minimal host intervention, and the DMA controller can be programmed to interrupt the host in certain situations. These situations may include packet transmit and receive transfer completion and other normal or error conditions.

The descriptor lists reside in the physical memory address space of the application. Each descriptor can point to a maximum of two buffers in the system memory, enabling two buffers to be used and physically addressed rather than contiguous buffers in the memory.

Data buffers

A data buffer resides in the application physical memory space and consists of an entire packet or part of a packet but cannot exceed a single packet. Buffers contain only data. The buffer status is maintained in the descriptor. Data chaining refers to packets that span multiple data buffers. However, a single descriptor cannot span multiple packets. The DMA skips to the data buffer of the next packet when an EOP is detected.

The next few sections discuss DMA controller.

78.3.2.1 DMA controller bus burst access

DMA engines attempt to transfer data in a burst of the maximum size programmed using DMA_CH0_Tx_Control[TxPBL] and DMA_CH0_Rx_Control[RxPBL] of the respective DMAs, which always access the receive and transmit descriptors in the maximum possible (limited by PBL or 16 * 8/bus width) burst length for 16 bytes to be read. The burst transfers that the DMA initiates can be split into multiple burst transfers according to the AHB requirements and settings specified in DMA System Bus Mode (DMA_SysBus_Mode).

The transmit DMA initiates a data transfer only when sufficient space is available in the MTL transmit queue to accommodate either of these:

- Bytes corresponding to the configured burst (PBL * bus_width/8)
- Remaining bytes in the transmit buffer without EOP
- Number of bytes till EOP

The receive DMA initiates a data transfer in these conditions:

- Sufficient data is available in the MTL receive queue to accommodate the configured burst
- EOP (when it is less than the configured burst length) is detected in the receive queue

DMA indicates the start address and the number of transfers required to the AHB master interface. When the interface is configured for fixed-length burst, it transfers data by using the best combination of the INCR4, INCR8, or INCR16 and SINGLE transactions. If EOP is reached before the fixed burst ends on the AHB interface, DMA performs dummy transfers to complete the fixed burst. Otherwise, DMA_SysBus_Mode[FB] becomes 0. The DMA transfers the data using undefined length (INCR) and SINGLE transactions.

When the AHB interface is configured for address-aligned beats, both DMA engines ensure that the first-burst transfer that AHB initiates is less than or equal to the size of the configured PBL value, and the subsequent beats start at an address aligned to this value. The DMA can only align the address for beats up to size 16 (for PBL > 16) for the AHB interface because it does not support more than INCR16.

78.3.2.2 DMA application data buffer alignment

The transmit and receive data buffers do not have any restrictions on start address alignment. For example, in systems with 32-bit memory, the start address for buffers can be aligned to any of the four bytes. However, the DMA always initiates write transfers with an address aligned to the bus width and dummy data (old data) in the invalid byte lanes. The process of write transfer typically happens during the beginning or end of an Ethernet packet transfer. The software driver must discard the dummy bytes based on the start address of the buffer and size of the packet.

Table 611. Data buffer alignment examples

Examples	
Buffer read	If the transmit buffer address is FF2h (for a 32-bit data bus) and 15 bytes need to be transferred, the DMA reads five full words from address FF0h. However, when DMA transfers data to the MTL transmit queue, the extra bytes (the first two bytes) are dropped or ignored. Similarly, the last 3 bytes of the last transfer are also ignored. The DMA always ensures that it transfers a full 32-bit data to the MTL transmit queue, unless it is the end of the packet.
Buffer write	If the receive buffer address is FF2h (for a 64-bit data bus) and 16 bytes of a received packet need to be transferred, the DMA writes 3 full words from address FF0h. However, the first 2 bytes of the first transfer and the last 6 bytes of the third transfer have dummy data. The DMA considers the offset address only if it is the first receive buffer of the packet. It ignores the offset address and performs full-word writes for the middle and last receive buffers of the packet.

78.3.2.3 DMA buffer size calculations

DMA does not update the size fields in the transmit and receive descriptors. It updates only the status fields (RDES and TDES) of the descriptors. The driver performs the size calculations.

The transmit DMA transfers the exact number of bytes (as the buffer size field of TDES2 indicates) to MAC. If a descriptor is marked as first (TDES3[FD] = 1), the DMA marks the first transfer from the buffer as SOP, and if the descriptor is marked as last (TDES3[LD]), the DMA marks the last transfer from that data buffer as EOP to the MTL.

The receive DMA transfers data to a buffer until the buffer is full or MTL sends the end of packet. When TDES3[FD] = 1, the amount of valid data in a buffer is accurately indicated by the buffer size fields in DMA Channel Rx Control (DMA_CH0_Rx_Control) minus the data buffer pointer offset. The offset is 0 when the data buffer pointer is aligned to the data bus width. If a descriptor is marked as last, the buffer may not be full (as indicated by DMA_CH0_Rx_Control[RBSZ_13_y] and DMA_CH0_Rx_Control[RBSZ_x_0]). To compute the amount of valid data in this final buffer, the driver must read the packet length (PL fields of RDES3[14:0]) and subtract the sum of the buffer sizes of the preceding buffers in this packet. The receive DMA always transfers the start of the next packet with a new descriptor.

78.3.2.4 DMA arbiter

The arbiter inside the DMA module performs the arbitration between the transmit and receive channel accesses to the AHB master interface. These two types of arbitrations are supported:

- Round-robin: If DMA_Mode[DA] = 0 and both transmit and receive DMAs simultaneously request access, the arbiter allocates the data bus in ratio sets defined in DMA_Mode[PR].
- Fixed-priority: If DMA_Mode[DA] = 1, receive DMA is always prioritized over transmit DMA for data access by default. If DMA_Mode[TXPR] = 1, transmit DMA is prioritized over receive DMA as explained in Table 628.

78.3.3 MTL

MTL provides the FIFO memory interface to buffer and regulate the packets between system memory and MAC. It also enables data to be transferred between the system clock and MAC clock domains. The MTL layer has two data paths: transmit path and receive path. MTL communicates with the host through ATI on the transmit path and through ARI on the receive path.

78.3.3.1 Transmit path

The internal DMA:

- Handles all transactions for the transmit path through ATI.
- Pushes the Ethernet packet reads from system memory to the corresponding queue.

The Ethernet packet, then, pops out and is transferred to MAC when the queue reaches its threshold (Threshold mode) or if the complete packet is in the queue (Store-and-Forward mode). When EOP is transferred, the status of the transmission is taken from MAC and transferred back to the internal DMA.

78.3.3.1.1 Transmit control word

This control information related to packet transmission is provided as part of the control word through the ATI interface:

- Packet length (if DCB is enabled with WFQ scheduling algorithm)
- CRC pad control
- Source address insertion control
- VLAN insertion and replacement control and VLAN tag for outer and inner VLAN tags
- TCP/IP checksum insertion control
- One-step timestamping control correction
- Transmit timestamp enable

78.3.3.1.2 Transmit operation

These two modes of operation trigger data read towards MAC:

- Threshold (or cut-through) mode: This is the default mode. In this mode, as soon as the number of bytes in the queue crosses the configured threshold level (or when the end of packet is written before the threshold is crossed), the data is ready to be popped out and forwarded to MAC. The threshold level is configured by using MTL_TxQ0_Operation_Mode[TTC].
- Store-and-Forward mode: In this mode, MTL pops the packet out to MAC only when one or more of the following conditions are true:
  - A complete packet is stored in the queue.
  - The transmit FIFO becomes almost full.
  - The ATI watermark becomes low.

  The watermark becomes low when the requested queue is not spacious enough to accommodate the requested burst length on ATI. Therefore, MTL, when operating in Store-and-Forward mode, allows packet transmission even if the packet length is bigger than the transmit queue size.

You can flush the complete content of the transmit queue by writing 1 to MTL_TxQ0_Operation_Mode[FTQ] or MTL_TxQ1_Operation_Mode[FTQ], depending on the queue. Doing so initializes the queue pointers to the default state. The FTQ

field returns to 0 by itself. If you write 1 to the FTQ field during a packet transfer from MTL to MAC, MTL stops further transfers because MTL considers the queue to be empty. Therefore, an underflow event occurs at the MAC transmitter.

78.3.3.1.3 Initialization flow

After reset, MTL is ready to manage the data flow between DMA and MAC.

- With single-transmit queue configurations, there are no initialization requirements for enabling MTL.
- With multiple-transmit queue configurations, initialize the queue size for each of the queues by programming MTL_TxQ0_Operation_Mode[TQS] corresponding to a transmit queue. Also, initialize the MAC block. Internal DMA controllers must be individually enabled through their respective CSRs.

78.3.3.2 Receive path

MAC sends packets to the MTL receive module and pushes them into the receive queue. MTL indicates the status (fill level) of the queue to the application or DMA when it crosses the configured receive threshold (MTL_RxQ0_Operation_Mode[RTC]), or when the MTL receive module receives the complete packet in Store-and-Forward mode. MTL also indicates the fill level of the queue so that DMA can initiate preconfigured burst transfers to the AHB interface.

78.3.3.2.1 Receive operation

During a receive operation, MTL is MAC's slave. This is the general sequence of events:

1. When MAC receives a packet, it indicates the availability of receive data.
2. MAC indicates the SOP and EOP delimiters.
3. MTL accepts the data and pushes it into the corresponding receive queue.
4. When MAC transfers EOP to the MTL receive module, MAC also drives the status word that MTL pushes into the corresponding receive queue.
5. MTL takes the data out of the queue and sends it to DMA depending on these modes:
   - Threshold mode
   - Store-and-Forward mode

   The sections that follow discuss these modes.

78.3.3.2.1.1 Threshold mode

In Threshold (default) mode, MTL reads the data and indicates its availability to the application or DMA when one of these occurs:

- Data bytes equal to the threshold amount are written to the receive queue (to MTL_RxQ0_Operation_Mode[RTC] and MTL_RxQ1_Operation_Mode[RTC]).
- A full packet of data is received into the queue.

78.3.3.2.1.2 Store-and-Forward mode

In this mode (when MTL_RxQ0_Operation_Mode[RSF] = 1), the initial receive queue locations are reserved for the status words before writing the SOP. A packet is read out only after it is completely written into the receive queue. In this mode, all error packets are dropped (if configured through MTL_RxQ0_Operation_Mode[FEP]) in such a way that only valid packets are read and forwarded to the application.

78.3.3.2.2 Multi-packet receive operation

In Threshold mode, the packet status is available immediately after the packet data. In Store-and-Forward mode, the packet data is available after the packet status. MTL is capable of storing any number of packets in the queue as long as it is not full.

If MAC receives a packet when the corresponding receive queue is full, MTL ignores that packet and overflow pulse generates on the corresponding receive queue. In addition, MTL increments the overflow counter in MTL Rx Queue Missed Packet Overflow Count (MTL_RxQ0_Missed_Packet_Overflow_Cnt) for the corresponding queue.

78.3.3.2.3 Error handling in receive operation

MTL performs these actions if the MTL receive queue is full before it receives the EOP data from MAC:

1. Declares an overflow
2. Drops the whole packet (including the status word)
3. Increments the overflow counter in DMA (MTL Rx Queue Missed Packet Overflow Count (MTL_RxQ0_Missed_Packet_Overflow_Cnt))

This is true even if MTL_RxQ0_Operation_Mode[FEP] is 1.

If the start address of such a packet is already transferred to the read controller, the rest of the packet is dropped and a dummy EOP is written to the queue along with the status word with overflow status. The status indicates a partial packet because of overflow. In such packets, the Packet Length field is invalid. If the MTL receive queue is configured to operate in the Store-and-Forward mode and the length of the received packet is more than the queue size, overflow occurs and all such packets are dropped.

The MTL receive control logic can filter errors and undersized packets, if enabled by using MTL_RxQ0_Operation_Mode[FEP] and MTL_RxQ0_Operation_Mode[FUP]. If the start address of one such packet is already transferred to the receive queue read controller, the packet is not filtered. The start address of the packet is transferred to the read controller after the packet crosses the receive threshold defined using MTL_RxQ0_Operation_Mode[RTC].

If the MTL receive queue is configured to operate in Store-and-Forward mode, all error packets can be filtered and dropped. For the application or DMA to flush the error packet being read from the queue, it must assert the flush signal. MTL then stops transferring data to the application (DMA). It internally reads the rest of the packet and drops it. MTL then starts transferring the next packet, if it's available.

78.3.4 MAC

MAC can support the MII and RMII PHY interface and it consists of:

- MTI
- MRI
- MCI

78.3.4.1 MAC transmission

The MAC transmission process is as follows:

1. The transmission initiates when MTL pushes in data with the SOP signal asserted.
2. After the SOP signal is detected, MAC accepts the data and begins transmitting to RMII or MII.
3. After the EOP signal is transferred to MAC, it performs one of these steps:
   - Completes normal packet transmission and sends the transmission status to MTL
   - Sends retry requests if a normal collision (in Half-Duplex mode) occurs during transmission, and until one of the following is true:
     - Packet is successfully transmitted.
     - Maximum retry requests have expired. When this happens, MAC aborts the packet transmission with "excessive collision transmit" status. MAC accepts and drops all further data until it receives the next SOP. The MTL block must retransmit the same packet from SOP on observing a retry request (in the status) from MAC.
   - If any one of the following happens, MAC aborts the packet transmission:

- No carrier (Half-Duplex mode)
- Loss of carrier (Half-Duplex mode)
- Excessive deferral (Half-Duplex mode)
- Late collisions (Half-Duplex mode)
- Jabber
- MAC accepts and drops all further data until it receives the next SOP

4. MAC issues an underflow status if MTL is not able to provide data continuously during transmission. Until the next SOP is received, MAC accepts and drops all further data.
5. During the normal transfer of a packet from MTL, if MAC receives an SOP without getting an EOP for the previous packet, it ignores the SOP and considers the new packet as a continuation of the previous packet.

78.3.4.2 MAC reception

The receive operation initiates as follows:

1. MAC detects a state-of-frame data on RMII or MII.
2. MAC strips the preamble and SFD before processing an Ethernet packet.
3. The MAC AFM:
   - Checks the header fields (SA and DA) of an incoming packet for filtering
   - Verifies the CRC contained in the packet's FCS field
4. MAC's AFM checks the header fields (SA and DA) of an incoming packet for filtering.
5. FCS verifies the CRC of the received packet.
6. MAC stores the received packet in a shallow buffer until address filtering is performed.
7. AFM drops the packet if it fails the address filter.

78.3.5 Interrupts

EMAC supports interrupt coalescing, which reduces the number of interrupts generated by the module and reduces the CPU load. MAC Interrupt Status (MAC_Interrupt_Status) captures various interrupt events. If the interrupt enable field of an interrupt is 1, the corresponding interrupt generates based on the event status in the Status registers. The Interrupt mode (INTM) field decides whether the interrupt signal is a level signal or pulse signal. See the following table and interrupt map file attached to this document for details.

Table 612. Interrupt request

Interrupt request	Interrupt Enable / Mask Register	Interrupt Flag Register
Common interrupt	MAC Interrupt Enable (MAC_Interrupt_Enable)	MAC Interrupt Status (MAC_Interrupt_Status)
	MMC Receive Interrupt Mask (MMC_Rx_Interrupt_Mask)	MMC Receive Interrupt (MMC_Rx_Interrupt)
	MMC Transmit Interrupt Mask (MMC_Tx_Interrupt_Mask)	MMC Transmit Interrupt (MMC_Tx_Interrupt)
	MMC FPE Transmit Interrupt Mask (MMC_FPE_Tx_Interrupt_Mask)	MMC Transmit FPE Fragment Counter Interrupt Status (MMC_FPE_Tx_Interrupt)

Table continues on the next page...

Table 612. Interrupt request (continued)

Interrupt request	Interrupt Enable / Mask Register	Interrupt Flag Register
	MMC FPE Receive Interrupt Mask (MMC_FPE_Rx_Interrupt_Mask)	MMC Receive Packet Assembly Error Counter Interrupt Status (MMC_FPE_Rx_Interrupt)
	MTL Debug Control (MTL_DBG_CTL)	MTL Debug Status (MTL_DBG_STS)
	MTL EST Interrupt Enable (MTL_EST_Intr_Enable)	MTL EST Status (MTL_EST_Status)
	MTL Rx Parser Interrupt Control Status (MTL_RXP_Interrupt_Control_Status)	MTL Rx Parser Interrupt Control Status (MTL_RXP_Interrupt_Control_Status)
	MTL Queue 0 Interrupt Control Status (MTL_Q0_Interrupt_Control_Status)	MTL Queue 0 Interrupt Control Status (MTL_Q0_Interrupt_Control_Status)
	MTL Queue 1 Interrupt Control Status (MTL_Q1_Interrupt_Control_Status)	MTL Queue 1 Interrupt Control Status (MTL_Q1_Interrupt_Control_Status)
	DMA Channel 0 Interrupt Enable (DMA_CH0_Interrupt_Enable)(transfer complete interrupts only)	DMA_CH0_Interrupt_Status
	DMA Channel 1 Interrupt Enable (DMA_CH1_Interrupt_Enable)(transfer complete interrupts only)	DMA_CH1_Interrupt_Status
		DMA Interrupt Status (DMA_Interrupt_Status) (First level status. Indicates major block event source: DMA channel, MTL or MAC)
		MTL Interrupt Status (MTL_Interrupt_Status) (Status summary for MTL block interrupts: Rx Parser, EST, FIFO Debug, Queue 1/Queue 0)
Tx interrupt 0/1	DMA Channel Tx Control (DMA_CH0_Tx_Control)	DMA Channel 0 Status (DMA_CH0_Status)
	DMA Channel 0 Interrupt Enable (DMA_CH0_Interrupt_Enable)	
	DMA Channel 1 Tx Control (DMA_CH1_Tx_Control)	DMA Channel 1 Status (DMA_CH1_Status)
	DMA Channel 1 Interrupt Enable (DMA_CH1_Interrupt_Enable)	
Rx interrupt 0/1	DMA Channel Rx Control (DMA_CH0_Rx_Control)	DMA Channel 0 Status (DMA_CH0_Status)
	DMA Channel 0 Interrupt Enable (DMA_CH0_Interrupt_Enable)	
	DMA Channel 1 Rx Control (DMA_CH1_Rx_Control)	DMA Channel 1 Status (DMA_CH1_Status)
	DMA Channel 1 Interrupt Enable (DMA_CH1_Interrupt_Enable)	

Table continues on the next page...

Table 612. Interrupt request (continued)

Interrupt request	Interrupt Enable / Mask Register	Interrupt Flag Register
Safety interrupt	MTL ECC Interrupt Enable (MTL_ECC_Interrupt_Enable)	MTL ECC Interrupt Status (MTL_ECC_Interrupt_Status)
		MTL Safety Interrupt Status (MTL_Safety_Interrupt_Status)
	MTL DPP Control (MTL_DPP_Control)	MAC DPP FSM Interrupt Status (MAC_DPP_FSM_Interrupt_Status)
	MAC FSM Control (MAC_FSM_Control)	

These are the interrupt output signals that are synchronous to the CSR clock.

- Sbd_intr_o – common interrupt
- Sbd_perch_tx_intr_o[max_dma_ch] – interrupt per transmit channel
- Sbd_perch_rx_intr_o [max_dma_ch] – interrupt per receive channel

NOTE

max_dma_ch = number of transmit/receive queues, which is 2

The sbd_intr_o common interrupt is a level signal. When it is asserted, a corresponding interrupt event source can be found in DMA Interrupt Status (DMA_Interrupt_Status), which is a read-only register that contains the event source fields corresponding to each DMA channel (transmit and receive queue pair), MAC transaction layer, and MAC blocks. You must then read the following registers and look for the fields that are 1:

- MAC Interrupt Status (MAC_Interrupt_Status)
- MTL Interrupt Status (MTL_Interrupt_Status)
- DMA Channel 0 Status (DMA_CH0_Status)

The sbd_intr_o interrupt deasserts only when all the enabled interrupt events are clear in their respective status registers, and correspondingly, all the fields in DMA Interrupt Status (DMA_Interrupt_Status) are 0. DMA Channel 0 Status (DMA_CH0_Status) captures all the interrupt events of that transmit DMA and receive DMA channel pair.

DMA Channel 0 Interrupt Enable (DMA_CH0_Interrupt_Enable) contains the corresponding enable fields for each of the interrupt events. These are the two groups of interrupts in the DMA channel:

- Normal—DMA_CH0_Status[NIS] indicates this interrupt, which is used for events that occur during the normal transfer of packets (TI, RI, TBU).
- Abnormal—DMA_CH0_Status[AIS] indicates this interrupt, which is used for error events.

Interrupts are not queued. If the same interrupt event occurs again before the driver responds to the previous one, no additional interrupts generate.

The common sbd_intr_o output signal asserts for the transfer complete interrupts only when the corresponding interrupts are enabled in DMA Channel 0 Interrupt Enable (DMA_CH0_Interrupt_Enable).

EMAC also supports these per-channel transfer-complete interrupt signals:

- sbd_perch_tx_intr_o[max_dma_ch] (transmit per channel interrupts)
- sbd_perch_rx_intr_o[max_dma_ch] (receive per channel interrupts)

The behavior of the RI/TI/sbd_perch_tx_intr_o[]/sbd_perch_rx_intr_o[] changes depends on the configuration specified in DMA_Mode[INTM]. This table explains the transfer complete interrupt behavior.

Table 613. Transfer complete interrupt behavior

Interrupt mode	Behavior of sbd_perch_tx_intr_o[] and sbd_perch_rx_intr_o[]	Behavior of the TI/RI interrupts and sbd_intr_o
INTM = 1	In this mode, these signals indicate the values of the corresponding DMA_CH0_Status[RI] and DMA_CH0_Status[TI] fields when DMA_CH0_Status[RI] and DMA_CH0_Status[TI] are 1, respectively. Therefore, they are level signals that you clear by writing 1 to these fields. The signals do not assert when DMA_CH0_Status[RI] or DMA_CH0_Status[TI] is 0.	DMA_CH0_Status[RI] and DMA_CH0_Status[TI] are configured as explained. For any RI/TI events: • The sbd_intr_o signal does not assert. • DMA_CH0_Status[NIS] remains 0.
INTM = 2	In this mode, RI/TI are queued and indicate the values of the corresponding DMA_CH0_Status[RI] and DMA_CH0_Status[TI] fields when any of these fields is 1. RI and TI are level signals that you clear by writing 1 to these fields. However, the fields become 1 again if another TI/RI event is detected before DMA_CH0_Status[RI] and DMA_CH0_Status[TI] become 1 for the previous event.	DMA_CH0_Status[RI] and DMA_CH0_Status[TI] become 1 whenever the transfer complete event is detected and are reset whenever the software driver changes them to 0 by writing 1. However, if another transfer complete event is detected before the software changes it to 0 (services it), EMAC automatically writes 1 to these fields again. The generation of the sbd_intr_o signal; however, is not based on DMA_CH0_Status[RI] or DMA_CH0_Status[TI].

78.4 External signals

This section and all its sub-sections are Synopsys Proprietary. Used with permission.

78.4.1 Module signals

This table provides port/signal names and their descriptions. See the IOMUX file attached to this document for details.

Table 614. Module signals

Port name (clock/signal)	I/O	Description
MII_RMII_TXCLK (Clock)	I	MII: The external PHY provides this transmission clock, which operates at a frequency of 25 MHz in 100 Mbps mode and at 2.5 MHz in 10 Mbps mode. All transmission signals that MAC generates are synchronous to this clock, which is required for all PHY interfaces.

Table continues on the next page...

Table 614. Module signals (continued)

Port name (clock/signal)	I/O	Description
		RMII: The RMII interface uses this 50 MHz clock. If you select RMII mode, MII_RX_CLK (25 MHz or 2.5 MHz) must be derived from the RMII reference clock.
MII_RX_CLK (Clock)	I	The external PHY provides this receive clock for the MII and RMII interfaces. The clock operates at a frequency of 25 MHz in 100 Mbps mode and at 2.5 MHz in 10 Mbps mode. All MII receive signals that MAC receives are synchronous to MII_RX_CLK. The clock's input is required for all PHY interfaces.
EMAC_PPS[3:0] (Signals)	I/O	This group of signals is used as pulse per second in Output mode and as media clock generation trigger in Input mode. The signals trigger input to DUT to capture presentation time. Based on the presentation control value of MAC PPS Control (MAC_PPS_Control), the signals can be defined as pulse or level signals.
MII_RMII_TX_EN (Signal)	O	MAC drives this signal, which performs multiple functions depending on the selected PHY interface as described in this list: • MII: When high, indicates that valid data is being transmitted to the PHY_TXD_O bus. MII_RMII_TX_EN is synchronous to MII_RMII_TX_CLK. • RMII: When high, indicates that valid data is being transmitted to the PHY_TXD_O bus. MII_RMII_TX_EN is synchronous to MII_RMII_RX_CLK.
MII_RMII_TXD[3:0] (Signals)	O	This is a group of transmit data signals driven by MAC. These signals perform multiple functions depending on the selected PHY interface as described in this list: • MII: Bits[3:0] provide the MII transmit data nibble. The data is valid only when the MII_RMII_TX_EN signal is high. MII_RMII_TXD[3:0] is synchronous to MII_MII_TX_CLK.

Table continues on the next page...

Table 614. Module signals (continued)

Port name (clock/signal)	I/O	Description
		• RMII: Bits[1:0] provide the RMII transmit data. The data is valid only when the MII_RMII_TX_EN signal is high. MII_RMII_TXD[3:0] is synchronous to MII_RMII_TX_CLK.
MII_CRS (Signal)	I	This signal is valid only in MII mode. The PHY drives this signal high when the transmit or receive medium is not idle, and drives the signal low when both these mediums are idle. The signal is not synchronous to any clock.
MII_COL (Signal)	I	This signal is valid only in MII mode. The PHY drives this signal high when a collision is detected on the medium. The signal is not synchronous to any clock.
MII_RMII_RX_DV (Signal)	I	The PHY drives this signal. It performs multiple functions depending on the selected PHY interface as described in this list: • MII: Indicates that the data on the MII_RXD bus is valid. It remains high continuously from the first recovered byte or nibble of the packet through the final recovered byte or nibble of the packet. MII_RMII_RX_DV is synchronous to MII_RX_CLK. • RMII: Contains the CRS and data valid information of the receive interface. MII_RMII_RX_DV is synchronous to MII_RMII_TX_CLK.
MII_RMII_RX_ER (Signal)	I	The PHY drives this signal. It performs multiple functions depending on the selected PHY interface as described in this list: • MII: Indicates an error or carrier extension in the received packet of the MII_RXD[3:0] bus. MII_RMII_RX_ER is synchronous to MII_RX_CLK. • RMII: Is not used.
MII_RMII_RXD[3:0] (Signals)	I	This is a group of data signals received from the PHY. These signals perform multiple functions depending on the

Table continues on the next page...

Table 614. Module signals (continued)

Port name (clock/signal)	I/O	Description
		selected PHY interface as described in this list: • MII: Bits [3:0] provide the MII receive data nibble. The data is valid only when the MII_RMII_RX_DV signals are high. MII_RMII_RXD[3:0] is synchronous to MII_RX_CLK. • RMII: Bits [1:0] provide the RMII receive data. The data is valid only when the MII_RMII_RX_DV signal is high. MII_RMII_RXD[3:0] is synchronous to MII_RMII_TX_CLK.
MII_RMII_MDC	O	MAC provides timing reference for MII_RMII_MDIO or MII through this periodic clock. The application clock generates this clock through a clock divider that MAC_MDIO_Address[CR] controls.
MII_RMII_MDIO (Signal)	I/O	MDIO uses this signal to transfer control and data information to PHY.

78.5 Using PHY interfaces

This section is Synopsys Proprietary. Used with permission.

This module support the following modes:

- RMII 10/100 Mbps interface
- MII 10/100 Mbps interface

Phy_intf_sel input signal decides which mode is selected. Samples the Phy_intf_sel signal at reset. See External signals for more information. MAC_Configuration[PS] and MAC_Configuration[FES] selects the mode's speed.

The module supports the IEEE802.3-2015 specification for MII and RMII specification version 1.2 from RMII consortium.

NOTE

RMII reference clock (50 MHz) can be fed to IP from an external source or internally from PLL on SoC.

The module supports the access of the phy registers through SMA. It is a two wire Station management interface (MIM):

1. MDC
2. MDIO

According to IEEE 802.3 specification, maximum operating frequency of MDC is 2.5 Mhz which system clock derives using a divider. MAC_MDIO_Address[CR] programs to generate different MDC clock frequency.

SMA supports MDIO clause 45 and clause 22 frame structure per the IEEE802.3 specification. Writing 1 to MAC_MDIO_Address[C45E] enables the clause 45 frame structure.

The MII interface reduces the accuracy of the 1588 timestamp if it is overclocked to run at 200 Mbps. This happens because the MAC logic uses the MII interface speed,to adjust or compensate for the timestamps taken at MII, as compared to the time generated in the PTP clock domain as specified in MAC_Configuration[FES].

78.6 VLAN and double VLAN insertion, deletion, replacement and tagging

This section and all its sub-sections are Synopsys proprietary. These are used with permission.

The following sections describe the VLAN and double VLAN features.

78.6.1 Double VLAN processing

In the double VLAN tagging processing, the module supports the processing of two VLAN tags. The two VLAN tags are:

1. Inner VLAN tag (C-VLAN)
2. Outer VLAN tag (S-VLAN)

If there is only one tag in a packet then it is considered as an outer tag.

The module uses MAC_VLAN_Incl and MAC_Inner_VLAN_Incl and MAC_VLAN_Tag registers to support the following functions in a double VLAN processing feature.

- Insertion, replacement, or deletion of up to two VLAN tags in the transmit path.
- Packet filtering and stripping on the basis of any one of the two VLAN tags in the receive path. Stripping and providing up to two VLAN tags in the receive path as a part of the receive status.

78.6.1.1 Transmit path

Table 615. Double VLAN processing features in transmit path

Feature	Description
Support for C-VLAN and S-VLAN tag types	The inner or outer VLAN tag can be of C-VLAN and S-VLAN type. MAC_VLAN_Incl[CSVL] and MAC_Inner_VLAN_Incl[CSVL] specifies the VLAN type. The module supports the processing of any sequence of outer and inner VLAN tags. **NOTE** The module does not support the C-VLAN and S-VLAN sequence. MAC does not examine whether the packet, which the application provides has a valid sequence of the VLAN tag types or the insertion or replacement operation results in an invalid sequence of VLAN tag type. Therefore, the application must provide a correct sequence of VLAN tag types and program the MAC in such a way that it results in correct sequence of VLAN tag types in the transmitted packet. The application must ensure the following: • The inner tag should not be S-VLAN when outer C-VLAN Tag insertion is enabled. • The outer tag should not be C-VLAN when inner S-VLAN Tag insertion is enabled. • The inner tag should not be S-VLAN when C-VLAN replaces the outer tag. • The outer tag should not be C-VLAN when S-VLAN replaces the inner tag.
VLAN tag deletion	MAC_VLAN_Incl[VLC] or MAC_Inner_VLAN_Incl[VLC] respectively enables the VLAN tag deletion for an outer or inner tag. When you enable the VLAN deletion, MAC deletes the tag present at the corresponding position. When a packet has only one tag, it is considered as the outer tag. If you enable the inner tag deletion and if there is only one tag in the packet, then the MAC does not delete the tag.
VLAN tag insertion or replacement	MAC_VLAN_Incl[VLC] or MAC_Inner_VLAN_Incl[VLC] respectively enables the VLAN tag insertion or replacement for an outer or inner tag. When you enable the VLAN tag insertion or replacement, the MAC_VLAN_Incl[VLTI] or MAC_Inner_VLAN_Incl[VLTI] determines whether the VLAN tag must be fetched from the register or from the control word.

78.6.1.2 Receive path

Table 616. Double VLAN processing in receive path

Feature	Description
Outer or inner VLAN tag-based filtering	Mac can filter packets through the ERIVLT bit on the basis of the outer or inner VLAN tag.
C-VLAN or S-VLAN tag-based filtering	Mac can filter packets through the ERSVLM bit on the basis of the C-VLAN or S-VLAN type.
Outer and inner VLAN tag stripping	Mac can strip the outer and inner VLAN tags from received frame on the basis of the EVLS and EIVLS bits.
16-bit outer and inner VLAN tag and type in Rx status	Mac can provide the 16-bit outer and inner VLAN tag and type in the Rx status on the basis of the EVLRXS and EIVLRXS bits, respectively.
Disabling or skipping checking of outer VLAN tag type	Mac can disable or skip checking of an outer VLAN tag type to match C-VLAN or S-VLAN on the basis of the DOVLTC bit.

78.6.1.3 Source address and VLAN insertion, replacement, or deletion

This module supports the SA, and VLAN insertion, replacement and deletion feature. The SA and VLAN fields are Tx packet-related control information that interfaces provide as part of the control word. IP supports the feature to insert or replace the source address on the basis of the information in the MAC address registers, and it also supports the feature to insert, replace, or delete the VLAN fields (VLAN type and VLAN tag) on the basis of the setting of the MAC_VLAN_Incl[VLTI]. SA insertion or replacement feature is enabled for all the transmit packets or selective packets. Similarly, VLAN insertion, replacement, or deletion feature is enabled for all the Tx packets or selective packets.

78.6.1.4 Programming source address insertion or replacement

You can use the SA insertion or replacement feature to instruct MAC to perform the following actions for Tx packets:

- Insert the content of the MAC address registers in the SA field
- Replace the content of the SA field with the content of the MAC address registers

When SA insertion is enabled, the application must ensure that the packets sent to MAC do not have the SA field. The MAC does not check whether the SA field is present in the transmit packet and it inserts the content of MAC address registers in the SA field. Similarly, when the SA replacement is enabled, the application must ensure that the SA field is present in the packets sent to the MAC.

MAC replaces the six bytes following the DA field in the transmit packet with the content of the MAC address registers.

- Configure MAC_Configuration[SARC] to enable the SA insertion or replacement for all Tx packets.
- Enable the SA insertion for selective packet by configuring the SA insertion control field (bits [25:23] of TDES3) in the first transmit descriptor of the packet. When you write 1 to bit 25 of TDES3, the SA insertion control field indicates insertion or replacement by MAC Address1 registers. When bit 25 of TDES3 resets, it indicates insertion or replacement by MAC Address 0 registers.

If you do not enable the MAC Address1 registers, then the MAC Address0 registers are used for insertion or replacement irrespective of the value of the most-significant bit of the SA insertion control field.

78.6.1.5 Programming VLAN insertion, replacement, or deletion

You can use the VLAN insertion, replacement, or deletion feature to instruct MAC to perform the following actions for the Tx packets:

- Delete the VLAN type and VLAN tag fields.
- Insert or replace the VLAN type and VLAN tag fields.

Insertion or replacement is done on the basis of the setting of the MAC_VLAN_Incl[VLTI] as described in theTable 617:

Table 617. VLAN insertion or replacement based on VLTI bit

Condition	Description
VLTI bit=1	MAC inserts or replaces the following: • VLAN type field (C-VLAN or S-VLAN as indicated by the MAC_VLAN_Incl[CSVL]) • VLAN tag field depending on the content of the VT field of transmit context descriptor of the packet
VLTI bit resets	MAC inserts or replaces the following: • VLAN type field (C-VLAN or S-VLAN as indicated by the MAC_VLAN_Incl[CSVL]) • VLAN tag field with the MAC_VLAN_Incl[VLT]

When the VLAN replacement or deletion is enabled, MAC checks whether the VLAN type field (0x8100 or 0x88a8) is present after the DA and SA fields in the transmit packet. The replace or delete operation does not occur if the VLAN type field is not detected in two bytes following the DA and SA fields. However, when the VLAN insertion is enabled, MAC does not check the presence of VLAN type field in the transmit packet and just inserts the VLAN type and VLAN tag fields.

Configuring MAC_VLAN_Incl[VLC] and MAC_VLAN_Incl[VLP] enables the VLAN insertion, replacement, or deletion feature for all Tx packets.

Configuring the VTIR field of TDES2 normal descriptor enables the VLAN insertion, replacement, or deletion for selective packets.

In addition, the VLP (VLAN Priority control) field must reset in MAC_VLAN_Incl (for outer VLAN) and MAC_Inner_VLAN_Incl register (in inner VLAN) for MAC to take the control inputs from the host, depending on the configuration.

78.7 Packet Filtering

This section and all its sub-sections are Synopsys proprietary. Used with permission.

MAC receiver contains various packet filtering scheme. Figure 558 shows the filtering sequence in their precedence order of received packet.

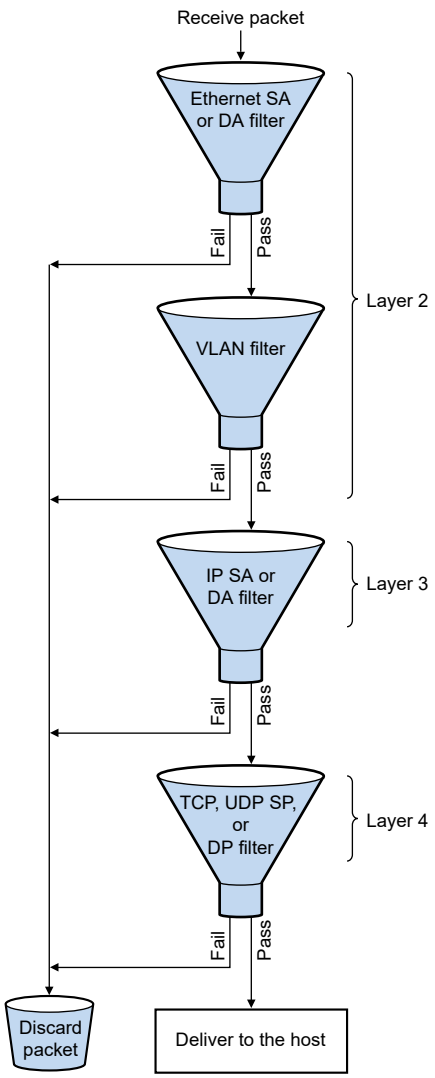


Figure 558. Packet filtering sequence

If you do not enable any of the layer filters, then that filter is bypassed and the subsequent filter is applied. Discard the packet that fails any of the filters. However, you can forward the discarded packet to the host on the basis of the register control.

78.7.1 Source address or destination address filtering

The address filtering module of MAC checks the SA and DA fields of each incoming packet. Programming of different types of address filtering is described in the sections that follows.

78.7.1.1 Unicast destination address filtering

MAC supports up to three MAC addresses for unicast perfect filtering. If perfect filtering is selected (MAC_Packet_Filter[HUC] resets), MAC compares all 48 bits of received unicast address with the programmed MAC address for any match. Default MacAddr0 is always enabled. MAC selects the MacAddr1 to MacAddr2 addresses with an individual enable field. Each byte of MacAddr1 to MacAddr2 can be masked when you compare them with corresponding received DA byte by writing 1 to the corresponding Mask byte control field in the register. This enables group address filtering for the DA.

In hash filtering mode (when you write 1 to HUC bit), MAC performs imperfect filtering by using a 64-bit hash table for unicast addresses . For hash filtering, MAC uses the upper 6 bits CRC of the received destination address to index the content of the hash table. A value of 00000 selects bit 0 of selected register, and a value of 11111 selects bit 63 of hash table register. If the value of

the corresponding bit (indicated by the 6-bit CRC) is 1, the unicast packet is considered to have passed the hash filter, otherwise, the packet is considered to have failed the hash filter.

78.7.1.2 Multicast destination address filtering

Enable MAC_Packet_Filter[PM] to pass all the multicast packets or disable to do multicast addresses filtering on the basis of MAC_Packet_Filter[HMC]. Compare the multicast address with the configured MAC destination address registers (1–2), also supports the group address filtering.

In Hash filtering mode, MAC performs imperfect filtering using a 64-bit hash table. MAC uses the upper 6-bits CRC of received multicast address to index the content of the hash table. A value of 000000 selects bit 0 of selected register and a value of 111111 selects bit 63 of the hash table register. The multicast packet is considered to have passed the hash filter if the value of the corresponding bit is equal to 1. Otherwise, the packet is considered to have failed the hash filter.

78.7.1.3 Hash or perfect address filtering

Configure MAC_Packet_Filter[HPF] to enable or disable the destination address filtering either by hash filter or perfect filter. Also configure MAC_Packet_Filter[HUC] and MAC_Packet_Filter[HMC] to select the hash filtering or perfect filtering for unicast or multicast packet.

78.7.1.4 Broadcast address filtering

MAC does not filter any broadcast packets by default. You must write 1 to MAC_Packet_Filter[DBF] to reject the broadcast packets.

78.7.1.5 Unicast source address filtering

MAC by default compares the source address field with the value configured in the source address registers. Configure bit 30 of MAC address register [1-2] to use it for source address instead of destination address comparison. MAC also supports group filtering with SA. You can filter a group of addresses by masking one or more bytes of the address. MAC drop the packets that fail the SA filter if you write 1 to MAC_Packet_Filter[SAF] field. Otherwise, the result of the SA filter is given as a status bit in the receive status word. When you write 1 to the SAF field, the SA filter and DA filter results ends to decide whether you can forward the packets. This means that the packet is dropped if either filter fails. The packet is forwarded to the application only if the packet passes both filters in-order.

78.7.1.6 Inverse filtering

For DA and SA filtering, you can invert the filter-match result at the final output by writing 1 to the DAIF and SAIF fields of MAC_Packet_Filter register. The DAIF field is applicable for both the unicast and multicast DA packets. The unicast or multicast destination address filter result is inverted in this mode. Similarly, writing 1 to the SAIF field reverses the result of unicast SA filter.

Table 618 and Table 619 summarize the DA and SA filtering on the basis of the type of packets received.

Table 618. Destination address filtering

Packet type	PR	HPF	HUC	DAIF	HMC	PM	DBF	DA filter operation
Broadcast	1	X	X	X	X	X	X	Pass
	0	X	X	X	X	X	0	Pass
	0	X	X	X	X	X	1	Fail
Unicast	1	X	X	X	X	X	X	All packets pass
	0	X	0	0	X	X	X	Pass on perfect or group filter match

Table continues on the next page...

Table 618. Destination address filtering (continued)

	0	X	0	1	X	X	X	Fail on perfect or group filter match
	0	0	1	0	X	X	X	Pass on hash filter match
	0	0	1	1	X	X	X	Fail on hash filter match
	0	1	1	0	X	X	X	Pass on hash or perfect or group filter match
	0	1	1	1	X	X	X	Fail on hash or perfect or group filter match
Multicast	1	X	X	X	X	X	X	Pass all packets
	X	X	X	X	X	1	X	Pass all packets
	0	X	X	0	0	0	X	Pass on perfect or group filter match and drop pause packets if PCF = 0x
	0	0	X	0	1	0	X	Pass on hash filter match and drop pause packets if PCF = 0x
	0	1	X	0	1	0	X	Pass on hash or perfect or group filter match and drop pause packets if PCF = 0x
	0	X	X	1	0	0	X	Fail on perfect or group filter match and drop pause packets if PCF = 0x
	0	0	X	1	1	0	X	Fail on hash filter match and drop pause packets if PCF = 0x
	0	1	X	1	1	0	X	Fail on hash or perfect/group filter match and drop pause packets if PCF = 0x

Table 619. Source address filtering

Packet type	PR	SAIF	SAF	SA filter operation
Unicast	1	X	X	Pass all packets.
	0	0	0	Pass status on perfect or group filter match but do not drop packets that fail
	0	1	0	Fail status on perfect or group filter match but do not drop packet
	0	0	1	Pass status on perfect or group filter match and drop packets that fail
	0	1	1	Fail status on perfect or group filter match and drop packets that fail

NOTE

When you write 1 to the MAC_Packet_Filter[RA] field, all packets are forwarded to the system along with the correct result of the address filtering in the Rx Status.

78.7.2 VLAN filtering

VLAN tag filter can be done either by perfect match or hash table. Depending upon the configuration, MAC can compare either lower 12 bits or all 16 bits of received VLAN tag for perfect match. MAC forward the VLAN tagged packet with match status when it drop all the packets which do not match.

MAC uses 16-bit VLAN hash table for group address filtering on the basis of the VLAN tag. If MAC enables the hash filtering then the most significant 4-bit of CRC-32 of VLAN tag are used to index the content of the MAC_VLAN_Hash_Table. A value of 1 in the VLAN hash table register, corresponding to the index indicates that the VLAN tag of the packet has matched and the packet should be forwarded. A value of 0 indicates that VLAN-tagged packet should be dropped.

MAC supports the inverse matching for VLAN packets. In the Inverse matching mode, the packet must be dropped when the VLAN tag of a packet matches the perfect or hash filter. If MAC enables the VLAN perfect and VLAN hash match, then a packet is considered as matched if either the VLAN hash or the VLAN perfect filter matches. When inverse match is set, MAC forwards a packet only when both the perfect and hash filters indicate mismatch.

Table 620 specifies the different possibilities for VLAN matching and the final VLAN match status. When you write 1 to MAC_Packet_Filter[RA] all packets are received and it indicates the VLAN match status in the VF field of RDES2 normal descriptor (write-back format). When the RA field is not set and when you write 1 to MAC_Packet_Filter[VTFE] the packet drops if the final VLAN match status fails

When VLAN VID programs to 0 in the VL field of MAC_VLAN_Tag register, consider that all the VLAN-tagged packets are perfectly matched but the status of the VLAN hash match depends on the VTHM and VTIM fields in MAC_VLAN_Tag register.

Table 620. VLAN match status

VID	VLAN perfect filter match result	VTHM bit	VLAN hash filter match result	VTIM bit	Final VLAN match status
VID = 0	Pass	0	X	X	Pass
	Pass	1	X	0	Pass
	Pass	1	Fail	1	Pass
	Pass	1	Pass	1	Fail
VID1= 0	Pass	X	X	0	Pass
	Fail	0	X	0	Fail
	Fail	1	Fail	0	Fail
	Fail	1	Pass	0	Pass
	Fail	0	X	1	Pass
	Pass	X	X	1	Fail
	Fail	1	Pass	1	Fail
	Fail	1	Fail	1	Pass

In Table 620, X represents any value.

78.7.3 VLAN filter fail packets queue

When you enable VLAN filtering, route the VLAN filter fail packets to a programmable queue (VFFQ) when the value of MAC_Packet_Filter[RA] = 1 or MAC_Packet_Filter[VTFE] = 0 and write 1 to MAC_RxQ_Ctrl4[VFFQE] for the queue.

Route the packets that passes the VLAN filtering to Rx queues on the basis of the VLAN tag priority field by configuring the PSRQ field in the corresponding MAC_RxQ_Ctrl2 and MAC_RxQ_Ctrl3 registers. Discard the packets that fail the VLAN filter if RA=0 or VTFE=1. However, when RA=1 or VTFE=0, forward the VLAN filter fail packets to the application. In such case, when you write 1 to the VLAN filter fail queue enable (VFFQE) field, the VLAN filter fail packets forward to the Rx queue number programmed in the VFFQ field. If the value of VFFQE=0, the VLAN priority mapping determines the Rx queue number per the PSRQ fields.

Table 621 shows the Rx queue routing table for unicast tagged packets, with DA or SA filter enabled.

Table 621. Rx queue routing table for unicast tagged packets

RA	VFTE	SA or DA filter result	VLAN filter result	VFFQE	Queue routing
X	X	Pass	Pass	X	PSRQ
0	0	Pass	Fail	0	PSRQ
0	0	Pass	Fail	1	VFFQ
0	X	Fail	X	X	Dropped
0	1	Pass	Fail	X	Dropped
1	X	Fail	X	0	UFFQ*/PSRQ
1	X	Fail	X	1	UFFQ*/VFFQ
1	X	Pass	Fail	0	PSRQ
1	X	Pass	Fail	1	VFFQ

X : Don't care condition * : When UFFQE is enabled else PSRQ.

78.7.4 Extended receive VLAN filtering and routing

When the extended Rx VLAN filtering and routing is enabled then both the perfect filtering and hash filtering can be enabled. The overall VLAN filter result is based on the perfect filter result and hash filter result (if enabled). Filter result is passed to application as part of the status bit. Extended routing will take place only if VLAN filter has passed. Routing is only based on perfect filter result. Each perfect filter has a DMA channel enable and DMA channel number filed which must be programmed for routing.

See the extended VLAN based DMA selection in Dynamic (per packet) mapping for more information about routing.

78.7.4.1 Comparison mode

Application has these comparison option for each VLAN tag filter:

- Programs MAC to compare the inner or outer VLAN tag either with 12 bits or 16 bits programmed VID.
- Selects whether the VID comparison is for SVLAN or CVLAN type frames, if type check is enabled for a filter.

78.7.4.2 Filtering

Perfect filtering is done on the basis of the MAC_VLAN_Tag_Filter registers. MAC compares the relevant VLAN tag ID and gives a result for each VLAN tag filter.

The results for each VLAN tag filter are:

- Pass- If any one of the VLAN tag filters gives a match.
- Fail- If the frame mismatches all the filters.

This behavior is applicable only when the inverse filtering is not enabled in MAC_VLAN_Tag_Ctrl.

If inverse filtering is enabled and the frame mis-matches all the relevant filters then it is considered to have passed the VLAN filter. If the frame matches any one of the relevant filters then it is considered to have failed. The frame is bypassed to the application if none of the enabled filters can perform a comparison or if none of the filters are enabled.

The overall filter result and the programming on MAC_Packet_Filter[VTFE] and MAC_Packet_Filter[RA] determines if the frame will drop or it is forwarded to the application. If the value of RA = 1 or VTFE = 0, then the frame is always forwarded whether the filter result is a pass or fail, . If the value of RA = 0 and VTFE = 1, only then, if the VLAN tag filter result is a pass the MAC forwards the frame. If the frame is forwarded to the application, then the relevant filter result is indicated through the status bits.

78.7.4.3 Filter status

The extended receive VLAN filtering and routing feature provides two status fields to show the comparison result of the VLAN tags.

By default, MAC indicates the VLAN filter status through one bit in the status VF field in RDES2. When you enable the extended RX VLAN filtering and routing, two status fields will show the comparison result of the VLAN tags. The outer VLAN tag filter pass and inner VLAN tag filter pass bits are defined in the following positions. The status indicated through these fields depends on the programming as described below.

In RDES2:

- Bit 15 – Outer VLAN tag filter status
- Bit 14 – Inner VLAN tag filter status

In ARI status: MAC filter status:

- Bit 15 – Outer VLAN tag filter status
- Bit 14 – Inner VLAN tag filter status

In MRI status:

- Bit 47 – Outer VLAN tag filter status
- Bit 46 – Inner VLAN tag filter status

Outer VLAN tag filter status (OTS)

- In perfect filtering, without enabling inverse filtering, if you write 1 to this field, it indicates that the frame's outer VLAN tag has matched one of the VLAN tag filters.
- If this field resets, it indicates that the frame's outer VLAN tag has either failed the relevant outer VLAN tag filters or bypassed them.
- This field resets if none of the filters are enabled for outer VLAN tag comparison.
- If inverse filtering is enabled and if you write 1 to this field, then the frame's VLAN tag has passed all the relevant VLAN tag filters. If it is resets, then it has failed at least one filter or bypassed all the filters programmed for outer VLAN tag comparison.
- This bit is valid for both single and double VLAN tagged frames.

Inner VLAN tag filter status (ITS)

- In perfect Filtering, without enabling inverse filtering, if you write 1 to this field, it indicates that the frame's inner VLAN tag has matched one of the VLAN tag filters.
- If this field resets, it indicates that the frame's inner VLAN tag has either failed the relevant inner VLAN tag filters or bypassed them.
- This field resets if none of the filters are enabled for inner VLAN tag comparison.
- If Inverse Filtering is enabled and if you write 1 to this field, then the frame's VLAN tag has passed all the relevant VLAN tag filters. If it resets, then it has failed at least one filter or bypassed all the filters programmed for inner VLAN tag comparison.

- This bit is valid for only double VLAN tagged frames, when double VLAN processing is enabled.

The application must observe the status fields and the program to determine if the frame has passed or failed the VLAN filter.

Table 622 and Table 623 describes the possible filter combinations and the corresponding filter results and they also explain the scenarios when the double VLAN processing and the hash VLAN filter are enabled in the design.

Legend for the table OTS and ITS Bit Values with at least 1 perfect filter enabled

- VTIM: VLAN tag inverse match enable – bit 17 in VLAN_Tag_Ctrl register.
- HFO: Hash filter enabled for outer VLAN tag comparison - bit 25 and bit 27 in VLAN_Tag_Ctrl register.
- HFI: Hash filter enabled for inner VLAN tag comparison – bit 25 and bit 27 in VLAN_Tag_Ctrl register.
- PFO – Perfect filter comparison enabled for outer VLAN tag - Any of the MAC_VLAN_Tag_Filter registers is enabled (write 1 to bit 16) and programmed for outer VLAN tag comparison (write 0 to bit 20).
- PFI – Perfect filter comparison enabled for Inner VLAN Tag - Any of the MAC_VLAN_Tag_Filter registers is enabled (write 1 to bit 16) and programmed for inner VLAN tag comparison (write 1 to bit 20).
- OTS – Outer VLAN tag filter status
- ITS – Inner VLAN tag filter status

Table 622 shows the possible values of status bits (OTS and ITS) when at least one perfect filter is enabled.

Table 622. OTS and ITS bit values with at least 1 perfect filter enabled

VTIM	HFO	HFI	PFO	PFI	OTS	ITS
0	0	0	0	1	0	1/0
0	0	0	1	0	1/0	0
0	0	0	1	1	1/0	1/0
0	1	0	1	1	1/0	1/0
0	1	0	1	0	1/0	0
0	1	0	0	1	1/0	1/0
0	0	1	1	1	1/0	1/0
0	0	1	1	0	1/0	1/0
0	0	1	0	1	0	1/0
1	0	0	0	1	0	1/0
1	0	0	1	0	1/0	0
1	0	0	1	1	1/0	1/0
1	1	0	1	1	1/0	1/0
1	1	0	1	0	1/0	0
1	1	0	0	1	1/0	1/0

Table continues on the next page...

Table 622. OTS and ITS bit values with at least 1 perfect filter enabled (continued)

VTIM	HFO	HFI	PFO	PFI	OTS	ITS
1	0	1	1	1	1/0	1/0
1	0	1	1	0	1/0	1/0
1	0	1	0	1	0	1/0

Table 623 shows the possible values of status bits (OTS and ITS) when no perfect filters are enabled except the VLAN hash filter is enabled.

Table 623. OTS and ITS bit values with only VLAN hash filter enabled

VTIM	HFO	HFI	OTS	ITS
0	0	0	0	0
0	1	0	1/0	0
0	0	1	1/0	1/0
1	0	0	1/0	0
1	1	0	1/0	0
1	0	1	1/0	1/0

With no perfect filters enabled, any VLAN packet is considered to have bypassed the perfect filter. If Hash Filter is enabled for one of the Tags, then the respective Status bit depends on the Filter's result. The Status bits are set to 0 if VLAN Hash Filter is also not enabled.

If the value of ITS/OTS is shown as 1/0; then it indicates that the final result is dependent on the enabled relevant filter's result.

Example 1: The second row of OTS and ITS bit values with only VLAN hash filter enabled indicates that at least one Perfect Filter is enabled for Outer VLAN tag comparison and none of the filters are enabled for Inner VLAN tag comparison. Inverse VLAN Filtering is not enabled. The bit OTS is given as 1/0. If the received frame passes at least one of the enabled Outer VLAN Tag filters then the bit is set to 1. If the frame doesn't pass any of the enabled Outer VLAN Tag filters, then the bit is set to 0.

Example 2: The last row of table "OTS and ITS bit values with only VLAN hash filter enabled" indicates that the inverse filtering is enabled, hash filter and at least one perfect filter is enabled for Inner VLAN Tag comparison, then if the received frame's Inner VLAN tag mismatches with both the Hash Filter and all the enabled Perfect filters, then the frame will have the ITS bit set to 1 else it is set to 0. OTS will be set to 0 as no comparison is performed.

78.7.4.4 Stripping

Each VLAN tags has individual control over stripping. The programming options of always strip, never strip, strip on pass and strip on fail are available. Inner or outer VLAN tag stripping is based on the pass or fail results of the individual tag. If all the relevant filters bypasses a tag, stripping is not applicable for the tag.

- If strip on pass is enabled for the outer VLAN tag, then the stripping occurs only if the outer VLAN tag has passed the relevant filters. The outer VLAN tag filter result field will be 1.
- If strip on fail is enabled for the outer VLAN tag, then the stripping occurs only if the outer VLAN tag has failed relevant filters. The outer VLAN tag filter result field will reset.
- If the outer VLAN tag of the received frame is bypassed by the entire filter (no comparison has been made), then the tag is not stripped, though the status bit is 0.

- As multiple filters are enabled, it is possible that the received VLAN frame could have matched any one or more of the filters. The VLAN Tag's value is not always deterministic from the filter status bits.

If an application strips the VLAN tag on the basis of the filter result, it might lose the VID. You can use it, if stripping is enabled for any of the tags, place the tag in the status. For this the software or application will enable the respective VLAN tag in status bit - 24 or 31 in the MAC VLAN tag control register.

See section Programming guidelines for extended VLAN filtering and routing on receive for more information.

78.7.5 Layer 3 and layer 4 filtering

IP supports the layer 3 based packet filtering which is an IP source or destination address filtering in the IPv4 or IPv6 packets, and layer 4 based packet filtering which is a source or destination port number filtering in TCP or UDP. When you enable layer 3 and layer 4 packet filtering then packets are filtered in the following manner.

- Matched packets: MAC forward the packets that match all enabled fields to the application along with the status. It gives the matched field status only if MAC_Configuration[IPC] = 1 and if one of the following conditions is true:
  - All enabled layer 3 and layer 4 fields match
  - At least one enabled field matches and other fields are bypassed or disabled

When you enable multiple layer 3 and layer 4 filters, any filter match is considered as a match. If more than one filter matches, MAC provides the status of the lowest filter where filter 0 is the lowest filter and filter 3 is the highest filter.

- Unmatched packets: MAC drop the packets that do not match any enabled fields. You can use the inverse match feature to block or drop a packet with specific TCP or UDP over IP fields and forward all other packets.
- Non-TCP or UDP IP packets: By default, all the non-TCP or UDP IP packets bypasses the layer 3 and layer 4 filters. You can optionally program MAC to drop all the non-TCP or UDP packets over IP packets.
- IP has a control register MAC_L3_L4_Control to control the layer L3 and L4 packet filtering along with address registers to program the layer L3 and L4 fields to be matched.

78.7.6 Flexible receive parser

When you enable this function, all incoming packets are parsed per the programmable instruction stored in memory. It perform these functions:

- Packet filter (Accept or reject)
- DMA channel selection

Flexible receive parser block operates over the first 128 bytes data of receive packet on the basis of 64 bytes of instruction on each packet. Figure 559 shows the functional block diagram of flexible receive parser.

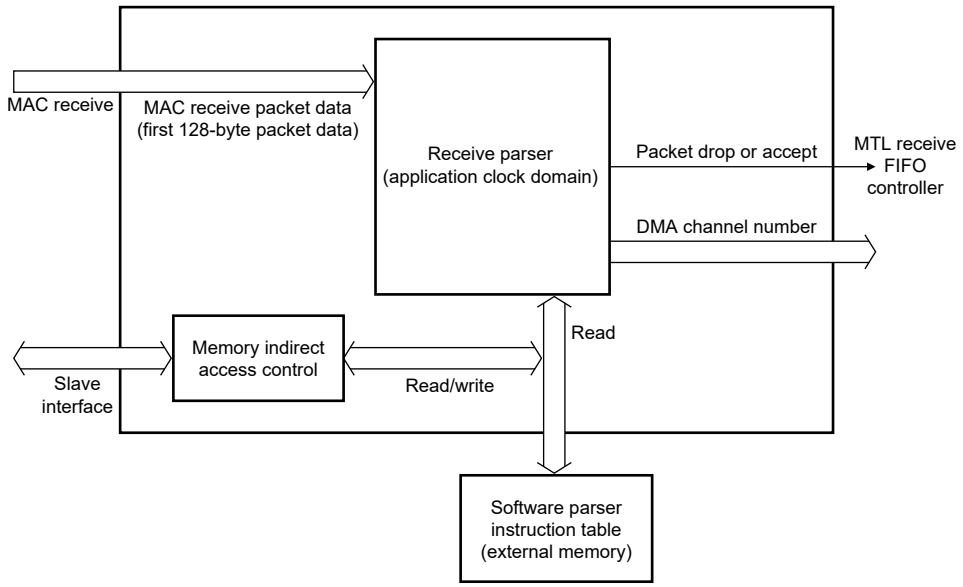


Figure 559. Functional block diagram of flexible receive parser

78.7.6.1 Instruction table format of the flexible receive parser

You must build the 96-bit wide instruction before enabling the receive parser feature and program each instruction as an entry in the instruction memory.

Table 624 shows the format of each entry in the instruction table .

Table 624. Rx parser instruction entry format

Field	Field Name	Description
31:0	MATCH_DATA	This is a 4-byte data. You can use it to compare with incoming packet data which starts at the frame offset as defined in [79:72] of the entry. The comparison is done only on those bits whose corresponding mask bits are 1 (MATCH_EN bits of [63:32]). See the notes (below this table) on the byte order relative to Ethernet arrival data and endianness which the QoS IP supports on the slave interface. The programming of this instruction table must adhere to the same.
62:32	MATCH_EN	When the MATCH_EN = 1, you can use the corresponding packet data bit for comparing. Otherwise, corresponding data bit is don’t care.
64	AF	Accept frame
65	RF	Reject frame
66	IM	Inverse match
67	NC	Next instruction control
71:68	Reserved	-

Table continues on the next page...

Table 624. Rx parser instruction entry format (continued)

Field	Field Name	Description
79:72	Frame offset	[77:72] indicates the frame offset in terms of 4 bytes. (Here [79:78] always 0) Compare the frame offset in the packet data for Match. This is in terms of 4 bytes. The value of actual frame offset in bytes are 0 01 42 8… ..63 252 The max value programmed in this instruction table is 128 B. The 'Actual frame offset' must not cross this limit.
87:80	OK index	If (NIC==0) the memory index you can use next when ENTRY_MATCH==1 and neither AF or RF = 1. If (NIC==1) the memory index you can use next when ENTRY_MATCH==0
95:88	DMA Ch No	Indicates the DMA channel number (1-bit for each). You can use this when ENTRY_MATCH ==1 and AF = 1 (Accept frame). The following bits give the encoding: bit[0]- DMA channel number o, bit[1]- DMA channel number , 1bit[2]- DMA channel number 2… bit[7]- DMA channel number 7. **NOTE** You can encode the DMA channel number using bit wise as QoS IP support multicasting or broadcast across DMA channels. See section 3.3.12 for more information and proper usage.
128:96	Reserved	0 (This field is only for software view and reserved for future enhancements. The memory width remains as 96-bits).

The parser begins parsing from the 0th entry, for each received packet. The subsequent parsing entry location (next entry or OK_INDEX[]) depends on the current entry parser result. Flexible receive parser flow chart shows the detailed flow.

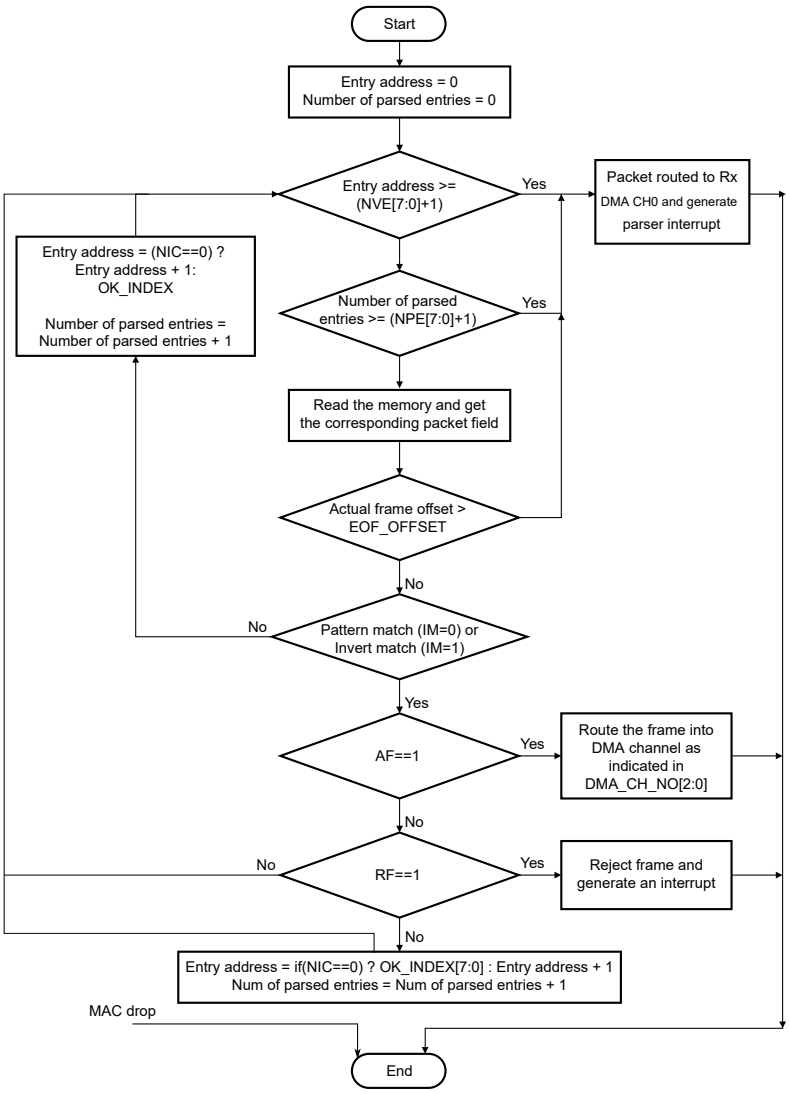


Figure 560. Flexible receive parser flow chart

The EOF_OFFSET shown in the figure is the least among the following:

- Actual packet size
- 128 Byte when frame pre-emption feature is not enabled or configured
- 128 Byte when frame pre-emption feature is enabled and packet is pre-emptive
- 64 Byte when frame pre-emption feature is enabled and packet is express packet

78.7.6.2 Number of valid entries (NVE)

NVE indicates the number of valid entries in the instruction table. The default value is 64. You can change this value by writing into MTL_RXP_Control_Status[NVE].

When parsing, an error is flagged in MTL_RXP_Interrupt_Control_Status[NVEOVIS], if the entry address is greater than MTL_RXP_Control_Status[NVE] + 1. IP generates an interrupt status (MTL_Interrupt_Status[MTLPIS]).

78.7.6.3 Number of parsable entries (NPE)

NPE indicates the number of entries that you can parse on an incoming packet. The default value is 64. Write into MTL_RXP_Control_Status[NPE] to change this value.

When parsing, an error is flagged in MTL_RXP_Interrupt_Control_Status[NPEOVIS], if the number of parsed of parsed entries is more than MTL_RXP_Control_Status[NPE] + 1. IP generates an interrupt status (MTL_Interrupt_Status[MTLPIS]).

NVE[] indicates the number of valid entries in the receive parser memory which you have built and NPE[] indicates the worstcase parsable entries considering the various possible paths that the parser can take. (NVE[] >= NPE[]).

78.7.6.4 Frame offset

It indicates the frame offset, in terms of 4 bytes which you use when comparing against the current table entry.

In an entry, an error is flagged in MTL_RXP_Interrupt_Control_Status[FOOVIS] in any of the following cases:

When frame offset is more than:

- Packet size
- 128B if pre-emption is disabled
- 128B if pre-emption is enabled and packet is pre-empitble
- 64B if pre-emption is enabled and packet is an express packet

IP generates an interrupt status (MTL_Interrupt_Status[MTLPIS]).

NOTE

If the frame ends after the (frame_offset *4) bytes but before ((frame_offset *4)+4) bytes, the receive parser declares a frame offset error if you enable comparison (via MASK bits) for the non-received bytes; from (frame_offset *4) to ((frame_offset *4)+4).

78.7.6.5 Frame reject

You can drop the frame in cases, where an entry matches (considering the inverse match, IM bit in the instruction table) and frame accept bit is not 1, and frame reject bit (RF) = 1.

When a frame drops because RF = 1, IP generates an interrupt status (MTL_Interrupt_Status[MTLPIS]).

78.7.6.6 Out of order processing

The Rx parser flow can be out of order. The decision tree is not based on the order in which packet arrives. This implies that the next entry and next frame offset (OK_INDEX[] and FRAME_OFFSET[]) can be less than the current entry address and current frame offset.

78.7.6.7 DMA channel selection

When you enables the receive parser (MTL_Operation_Mode[FRPE] = 1) it overrides the MAC DMA selection criteria.

When you disables the receive parser (MTL_Operation_Mode[FRPE] = 0) the MAC/MTL determines the DMA channel number.

78.7.6.8 Receive queue selection

The existing MAC functionality determines the receive queue, irrespective of whether the receive parser is enabled or disabled. This is because the receive parser is mainly designed to select the DMA channel and the MAC decides the receive queuing to enable the proper functioning of the pause or PFC feature.

NOTE

When there are multiple queues and multiple DMA Channels are enabled, a particular DMA channel might receive out of order packets because queue selection is based on MAC criteria (VLAN Priority and other criteria) and Rx DMA channel selection is based on receive parser.

78.7.6.9 MAC packet filtering/drop/error handling

Packet filtering is done on the basis of the received packet fields. You must disable the packet filtering features inside the MAC when the receive parser is enabled. Follow these steps to disable the packet filtering features inside the MAC :

1. Write 1 to the Promiscuous mode (MAC_Packet_Filter[PR]).
2. Write 1 to all other fields in MAC_Packet_Filter to its default values.

When MAC decides to drop the packet due to the receive MAC dependent error such as:

- GMII error
- Receive watchdog error
- CRC error
- Giant frame error

the packet drops irrespective of the receive parser decision.

78.7.6.10 Pad strip or CRC strip handling

Software controls the pad strip and CRC strip and it is applicable to all the received packets. Also,software must build the receive parser instructions accordingly, when you enable these features.

NOTE

Enable pad and CRC stripping in real use case.

78.7.6.11 VLAN strip handling

MAC supports stripping the outer VLAN as well as inner VLAN. When you program MAC to strip the VLAN, the receive parser considers those VLAN tags to be part of the incoming packet.

78.7.6.12 Multicast and broadcast support

IP supports multicast and broadcast packet and the packet route to the highest queue number.

When you enables the receive parser, the DMA channel numbers (DMA CH NO, Bits [95:88]) in the instruction table, decide the packet routing.

When you disables the receive parser, DCS (DMA Channel Select) field of the MAC_AddressX_High register determines the packet routing. See the Broadcast/multicast packet duplication.

NOTE

You can select multiple DMA channels for the packet routing because the DCS/DMA CH NO field is per the DMA channel control.

78.7.6.13 Pre-emption support

IP supports the frame preemption feature when the flexible receive parser feature is enabled. It has the following limitations:

- Number of bytes would be 64, so that the receive parser can operate on an express traffic
- Number of bytes would be 128, so that receive parser can operate on a pre-emptive traffic.

78.7.6.14 Software access to the flexible receive parser memory

Software can read and write into the receive parser memory. It uses the following registers via indirect addressing.

- MTL_RXP_Indirect_Acc_Control_Status
- MTL_RXP_Indirect_Acc_Data

For more details, see EMAC register descriptions.

78.7.6.15 Statistical counters

IP supports these statistics counters for flexible receive parser.

1. MTL_RXP_Drop_Cnt
2. DMA_RXP_Error_Cnt

DMA_CH(#i)_Rxp_Accept_cnt (i=0; i<2)

For more details, see EMAC register descriptions.

78.7.6.16 Changing the instruction table by software

Software can update the instruction table in the memory in the following ways:

- Disables the MAC receiver and receive parser by writing 0 to MAC_Configuration[RE] and MTL_Operation_Mode[FRPE]. It waits for receive parser to become inactive (RXPIA, MTL_RXP_Control_Status register bit[31]).
- (Optional) Programs in the entry address 0 to unconditionally (all MATCH_EN bit 0) skip to OK_INDEX[] (to certain location in the memory), where you can program it to reject or accept all the packets.

78.7.6.17 Receive cut-through functionality

In the Cut-Through mode, the receive controller transfer the received packets to DMA just after it receives the cut-through threshold amount of packet data (RTC field in the MTL_RxQx_Operation_Mode register).

However due to Rx parser's result worst case arrival time can be more than the programmed cut-through threshold. So, the receive controller delays the packet transfer to DMA accordingly, and the cut-through functionality is re-defined as follows:

The receive controller transfers packet to DMA after at least RTC number of bytes have been received and receive parser results are available.

78.7.6.18 Receive packet drop indication

In most cases, the packet drops internally in the receive queue. However, back-to-back packets can arrive for the same queue and the first packet's receive parser result is not available when the second packet arrives. In such cases, the packet cannot be flushed internally and forwarded to DMA or the application interface and indicates the status accordingly. See RDES2, bit 16(RXPD) in Receive normal descriptor (write-back format) for more information.

78.7.6.19 Runt packet handling

The receive parser can performs the operation with 64B minimum size packet. If the runt packet is received (MAC must indicate it), the receive parser assumes that it is dropped in the MAC, this is because, the back-to-back runt packets (< 64B) cannot be handled in the receive parser.

78.7.6.20 Uncorrectable ECC error handling

The packet does not drops when the parser detects an uncorrectable ECC error while parsing the parser memory. The packet is sent to the application with an error indication. The RXPI (RX parser incomplete) sets in the packet status along with error summary (ES) bit.

See the Receive normal descriptor (write-back format) for more information.

78.8 IEEE 1588 timestamp support

This section and all its sub-sections are Synopsys proprietary. Used with permission.

IP supports the IEEE 1588 precision time protocol (PTP). It is also able to do precise time stamping and captures incoming and outgoing frame because of the PTP protocol implementation in the IP. It supports all the clock types defined in IEEE 1588-2008. The typical frequency of PTP timestamp clock is 125 MHz.

IP supports these features:

- Provides an option to take snapshot of all packets or only PTP type packets
- Provides an option to take snapshot of only event messages
- Identifies the PTP message type, version, and PTP payload in packets sent directly over Ethernet and sends the status
- Provides an option to measure sub-second time in digital or binary format

78.8.1 Delay request-response mechanism

The system or network is classified into the master and slave nodes for distributing the timing and clock information. Figure 561 shows the process that PTP uses for synchronizing a slave node to a master node by exchanging PTP messages.

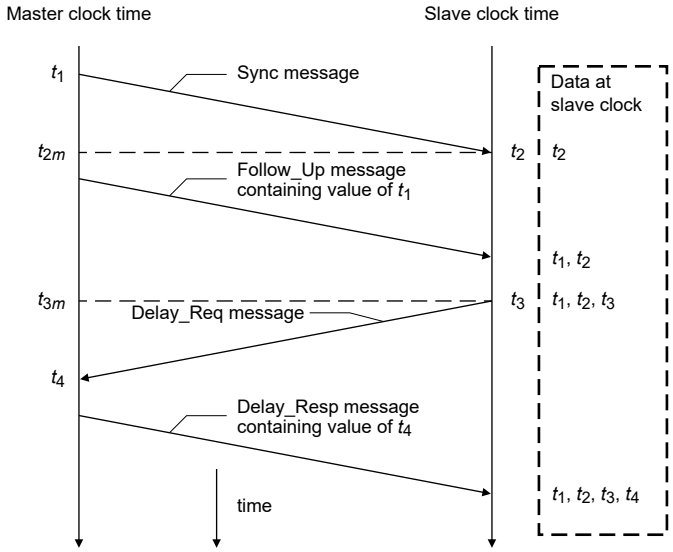


Figure 561. Networked time synchronization

As shown in the figure, PTP uses this process:

1. The master broadcast the PTP sync messages to all its nodes. The sync message contains the reference time information of the master. This message leaves the system of the master at t1. You must capture this time for Ethernet ports at GMII or MII.
2. The slave receives the sync message and it also captures the exact time, t2, using its timing reference.
3. The master sends a Follow_Up message to the slave, which contains t1 information for later use.
4. The slave sends a Delay_Req message to the master and note the exact time, t3, at which this packet leaves the GMII or MII interface.
5. The master receives the message, capturing the exact time t4, at which the message enters its system.
6. The master sends the t4 information to the slave in the Delay_Resp message.
7. The slave use the four values of t1, t2, t3, and t4 to synchronize its local timing reference to the master's timing reference.

Most of the PTP implementation is done in the software above the Ethernet layer. However, the hardware captures the exact time when specific PTP packets enter into or leave the Ethernet port at the MII interface. This timing information must be captured and returned to the software for proper implementation of PTP with high accuracy.

78.8.2 Peer-to-peer PTP transparent clock (P2P TC) message support

The IEEE 1588-2008 supports the peer-to-peer PTP (Pdelay) message in addition to the sync, delay request, follow-up, and delay response messages. Figure 562 shows the method to calculate the propagation delay in clocks supporting the peer-to-peer path correction.

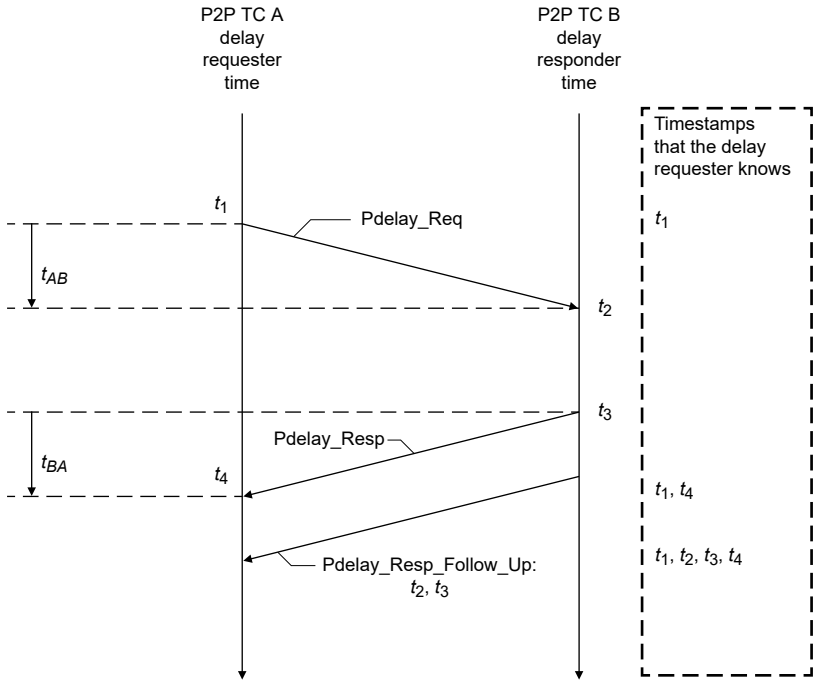


Figure 562. Propagation delay calculation in clocks supporting peer-to-peer path correction

As shown in the above figure, the propagation delay is calculated in the following way:

1. Port 1 issues a Pdelay_Req message and generates a timestamp (t1) for the Pdelay_Req message.
2. Port 2 receives a Pdelay_Req message and generates a timestamp (t2) for this message.
3. Port 2 returns a Pdelay_Resp message and generates a timestamp (t3) for this message. Port 2 returns the Pdelay_Resp message as quickly as possible after the receipt of the Pdelay_Req message, to minimize the errors because of any frequency offset between the two ports. Port 2 returns any one of the following:
   - Difference between the timestamps t2 and t3 in the Pdelay_Resp message
   - Difference between the timestamps t2 and t3 in the Pdelay_Resp_Follow_Up message
   - Timestamps t2 and t3 in the Pdelay_Resp and Pdelay_Resp_Follow_Up messages, respectively
4. Port 1 generates a timestamp (t4) after receiving the Pdelay_Resp message.
5. Port 1 uses all the four timestamps t1, t2, t3, and t4 to compute the mean link delay.

78.8.3 Timestamp correction

According to the IEEE 1588 specification, you must capture a timestamp when the PTP message timestamp point (leading edge of the first bit of the octet immediately following the start frame delimiter octet) crosses the boundary between the node and the network. As MAC takes the timestamp at an internal point far from the actual boundary of the node and network, you must correct or update the captured timestamp for the ingress or egress path latency (including the delay in the PHY layers). Further correction

is done for the inaccuracies or errors introduced because the clock (MII Tx, Rx clock) is different at the capture point as compared to the PTP clock (CLK_PTP_REF_I) that generates the time. The resultant CDC (Clock domain crossing) circuits add an error depending on the clock period of the MII and PTP clocks.

78.8.3.1 Ingress correction

The timestamp captured at the internal snapshot point In the receive side is delayed (later in time) as compared to the time at which the packet's SFD bit is received at the port's boundary. Therefore, the ingress latency and the errors in CDC sampling reduces the captured timestamp. You must determine or calculate the correction value and write into the MAC_Timestamp_Ingress_Corr_* registers.

The correction value consists of these three components:

1. External latency in the PHY layer between boundary point and the input of the core.

   If the PHY is compliant with the IEEE 802.3 Clause 45 MMD registers, it has a register which indicates the maximum and minimum ingress latency. You can read these registers and determines the average ingress latency in the PHY. Alternatively (if the PHY does not support these registers), you must determine the ingress latency from its datasheet or timing characteristics.

2. Internal latency from the core's input to the internal capture point.

   You can read the internal ingress latency from MAC_Timestamp_Ingress_Latency. This is a read-only register and provides the latency in scaled nanoseconds format as defined in IEEE 1588 Clause 5.3.2. The latency differs on the basis of the active PHY interface (MII, RMII, so on) and the operating speed. Therefore, you must read this register after any speed change in MAC, to determine the current internal latency.

3. CDC synchronization

   The CDC synchronization error is almost equal to twice the clock-period of the PTP clock (clk_pt-p_ref_i).

You must add the values that these three components determine and must write into the TSIC and TSICSNS fields of the MAC_Timestamp_Ingress_Corr_* registers.

NOTE

The value written into the register must be negative (two's complement as explained below), because it is subtracted from the captured timestamp. The MAC receiver adds the value in this register to the captured timestamp and then gives the resultant value as the timestamp of the received packet.

When MAC_Timestamp_Control[TSCTRLSSR] is 1, it indicates that the nanoseconds field of the captured timestamp is in decimal format with a granularity of 1ns. So the Bit31 of TSIC must be 1 (for negative value) and bits[30:0] must write with "10^9 - total ingress_correction_value[nanosecond part]" represented in binary. For example, if the required correction value is -5 ns, then the value is 0xBB9A_C9FB.

When MAC_Timestamp_Control[TSCTRLSSR] becomes 0, it indicates that the nanoseconds field of the captured timestamp is in binary format with a granularity of ~0.466ns. Therefore, bits[30:0] must write with "2^31 - total ingress_correction_value" represented in binary with bit[31] = 1.

78.8.3.2 Egress correction

The timestamp captured at the internal snapshot point in the transmit side is earlier (advanced in time) as compared to the time at which the packet's SFD bit is output at the port's boundary. Therefore, the egress latency and the errors in CDC sampling must compensate the captured timestamp. You must determine or calculate this correction value and write into the MAC_Timestamp_Egress_Corr_* registers.

The correction value consists of these three components:

1. External latency in the PHY layer between the core output and the port and the network boundary

   If the PHY is compliant with the IEEE 802.3 Clause 45 MMD registers, it has a register which indicates the maximum and minimum egress latency. You can read these registers and determine the average egress latency in the PHY. Alternatively (if the PHY does not support these registers), you must determine the egress latency from its datasheet or timing characteristics.

2. Internal latency from the internal capture point and the core output of the c

   You can read this internal egress latency from MAC_Timestamp_Egress_Latency. This is a read-only register and gives the latency in scaled nanoseconds format as defined in IEEE 1588 Clause 5.3.2. The latency differs on the basis of the active PHY interface (MII, RMII, so on) and the operating speed. Therefore, you must read this register after any speed change in MAC to determine the current internal latency.

3. CDC synchronization error

   The CDC synchronization error value for one-step timestamping = (1 * period of CLK_PTP_REF_I + 4 * period of CLK_TX_I). Otherwise (Two-step timestamping mode), the value = -(2 * period of CLK_PTP_REF_I).

78.8.3.3 Frequency range of reference timing clock

The timestamp information is transferred across asynchronous clock domains that is from the MAC clock domain to the application/system clock domain. Therefore, a minimum delay is required between the two consecutive timestamp captures. This delay is 4 clock cycles of MII and 3 clock cycles of PTP clocks. If the delay between the two captured timestamp is less than this delay, MAC does not take a timestamp snapshot for the second packet.

78.8.3.4 PTP processing and control

Table 625 shows the common message header for the PTP messages. This format is defined in the IEEE 1588-2008.

Table 625. Message format defined in IEEE 1588-2008

Bits								Octet	Offset
7	6	5	4	3	2	1	0		
transportSpecific				messageType				1	0
Reserved				versionPTP				1	1
messageLength								2	2
domainNumber								1	4
Reserved								1	5
flagField								2	6
correctionField								8	8
Reserved								4	16
sourcePortIdentity								10	20
sequenceId								2	30
controlField (*)								1	32
logMessageInterval								1	33

(*) – control Field is used in version 1. In version 2 message type field is used for detecting different message types.

There are some fields in the Ethernet payload that detects the PTP packet type and controls the snapshot to be taken. These fields are specified in Table 626 for PTP packets over Ethernet.

Following table provides the information about the fields that match to control the snapshots for the PTP packets sent over Ethernet for IEEE 1588 version 1 and version 2. The octet positions are offset by 4 for the tagged packets. This is based on the IEEE 1588-2008, Annex D, and the message format.

Table 626. Ethernet PTP packet fields required for control And status

Field matched	Octet position	Matched value	Description
MAC destination multicast address[1]	0–5	01-1B-19-00-00-00 01-80-C2-00-00-0E	All PTP messages can use any of the following multicast addresses[2]: • 01-1B-19-00-00-00 • 01-80-C2-00-00-0E[3]
MAC packet type	12, 13	0x88F7	PTP Ethernet packet
PTP control field (IEEE 1588 version 1)	46	0x00, 0x01, 0x02, 0x03, or 0x04	• 0x00: SYNC • 0x01: Delay_Req • 0x02: Follow_Up • 0x03: Delay_Resp • 0x04: Management
PTP message type field (IEEE 1588 version 2)	14 (nibble)	0x0, 0x1, 0x2, 0x3, 0x8, 0x9, 0xB, 0xC, or 0xD	• 0x0: SYNC • 0x1: Delay_Req • 0x2: Pdelay_Req • 0x3: Pdelay_Resp • 0x8: Follow_Up • 0x9: Delay_Resp • 0xA: Pdelay_Resp_Follow_Up • 0xB: Announce • 0xC: Signaling • 0xD: Management
PTP version	15 (nibble)	0x1 or 0x2	• 0x1: Supports PTP version 1 • 0x2: Supports PTP version 2

1. The unicast address match of destination addresses (DA), which is programmed in MAC address 0 to 31, is used if MAC_Timestamp_Control[TSENMACADDR] = 1.
2. IEEE 1588-2008, Annex F
3. MAC does not consider the PTP version 1 messages with peer delay multicast address (01-80-C2-00-00-0E) as valid PTP messages.

78.8.4 Transmit path functions

MAC captures a timestamp when the start packet delimiter (SFD) of a packet is sent on the MII interface. You can control the packets, for which the timestamps are captured on a per-packet basis and mark each transmit packet to indicate whether to capture a timestamp for it. MAC does not process the transmitted packets to identify the PTP packets. You can use the control bits in the transmit descriptor to specify the packets. MAC returns the timestamp to the software inside the corresponding transmit descriptor and therefore connects the timestamp automatically to the specific PTP packet. You must write the 64-bit timestamp information to TDES0 and TDES1 fields. The TDES0 field holds the 32 least significant bits of the timestamp.

78.8.5 Receive path functions

You can program MAC to capture the timestamp of all packets received on the MII interface or to process the packets to identify the valid PTP messages.

You can use these options of MAC_Timestamp_Control to control the snapshot of the time sent to the application:

- Enable snapshot for all packets
- Enable snapshot for IEEE 1588 version 1 or version 2 timestamp
- Enable snapshot for PTP packets transmitted directly over Ethernet
- Enable timestamp snapshot for the received packet for IPv4 or IPv6
- Enable timestamp snapshot only for EVENT messages (SYNC, DELAY_REQ, PDELAY_REQ, or PDELAY_RESP)
- Enable the node to be a master or slave and select the snapshot type

Table 627. Timestamp snapshot dependency on register bits

SNAPTYPSEL	TSMSTRENA	TSEVNTENA	PTP messages
00	x	0	SYNC, Follow_Up, Delay_Req, Delay_Resp
00	0	1	SYNC
00	1	1	Delay_Req
01	x	0	SYNC, Follow_Up, Delay_Req, Delay_Resp, Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up
01	0	1	SYNC, Pdelay_Req, Pdelay_Resp
01	1	1	Delay_Req, Pdelay_Req, Pdelay_Resp
10	x	x	SYNC, Delay_Req
11	x	x	Pdelay_Req, Pdelay_Resp

DMA returns the timestamp to the software inside the corresponding receive descriptor. The extended status, contains the timestamp message status and the IPC status. You must write the extended status in the normal descriptor RDES1 and the snapshot of the timestamp in RDES0 and RDES1 fields of context descriptor. The RDES0 field holds the 32 least significant bits of the timestamp.

See the System time correction for programming guidelines for IEEE 1588 timestamping (System time correction).

78.8.6 IEEE 1588 system time source

IP supports both the external and internal time source for reference timestamping.

- External time source uses the 64-bit external time reference and clock as an input in IP. The clock input synchronizes the external timing reference into the MAC clock domain. Upper 32-bit indicates the time in seconds and the lower 32-bit indicates the time in nanoseconds.
- Internal time source uses the only clock input to generate timing reference internally for snapshot and capture timestamps. Internal time reference has two fields.
  - UInteger48 seconds field: The seconds field is the integer portion of the timestamp in seconds units. It is 48-bit wide.

    For example, 2.000000001 seconds are represented as seconds field = 0x0000_0000_0002.

— UInteger32 nanoseconds field The nanoseconds field is the fractional portion of the timestamp in nanoseconds units.

For example, 2.000000001 seconds are represented as nanoseconds field = 0x0000_0001. The nanoseconds field supports the following two modes:

- Digital rollover mode: In this mode, the maximum value in the nanoseconds field is 0x3B9A_C9FF, that is, (10e9-1) nanoseconds.
- Binary rollover mode: In this mode, the nanoseconds field rolls over and increments the seconds field after 0x7FFF_FFFF value . Accuracy is ~0.466 ns per bit.

There is a system time register module, it is used when you use an internal time reference. The 80-bit time is maintained in this module and updated using the input reference clock (CLK_PTP_REF_I). This time is the source for taking snapshots (timestamps) of Ethernet packets which is transmitted or received at the MII interface.

Initialize or correct the system time counter using the coarse correction method. In this method, write the initial value or the offset value to the timestamp update register. For initialization, write the system time counter with the value in the timestamp update register. For system time correction, the offset value is added to or subtracted from the system time.

In the fine correction method, correct the frequency offset and/or frequency drift of a slave clock (CLK_PTP_REF_I) with respect to the master clock (as defined in IEEE 1588-2002) over a period of time instead of in one clock, as in coarse correction. This maintains linear time and does not introduce drastic changes (or a large jitter) in the reference time between the PTP sync message intervals.

See Initialization guidelines for system time generation for programming guidelines for IEEE 1588 timestamping (For internal timestamp source configuration).

78.8.7 IEEE 1588 higher word register

You can invoke the higher word register if system time source is internal. MAC timestamp is 64-bit wide. The values of the upper 16-bits of the seconds field are read from the CSR register.

78.8.8 Flexible pulse-per-second output

IP supports the flexibility of programming the start or stop time, generates pulse width and interval on pulse-per-second output. It also support four such output signals. By default, IP is in fixed pulse-per-second output mode with interval of 1 second.

Initially you must program the start time in target time registers "MAC_PPSx_Target_Time_Seconds and MAC_PPSx_Target_Time_Nanoseconds" for all desired or enabled pps output. If you re-programs start or stop time then you must do it after the synchronization of earlier programmed value. Bit 31 of MAC_PPS#_Target_Time_Nanoseconds register indicates that the synchronization is complete. If the application programs a start or stop time that has already elapsed, MAC sets an error status bit which indicates the programming error. If enabled, MAC also sets the target time reached interrupt event. The application can cancel the start or stop request only if the corresponding start or stop time has not elapsed. If the time has elapsed, the cancel command has no effect.

Program the PPS width and interval in terms of granularity of system time, that is, the number of units of sub-second increment value.

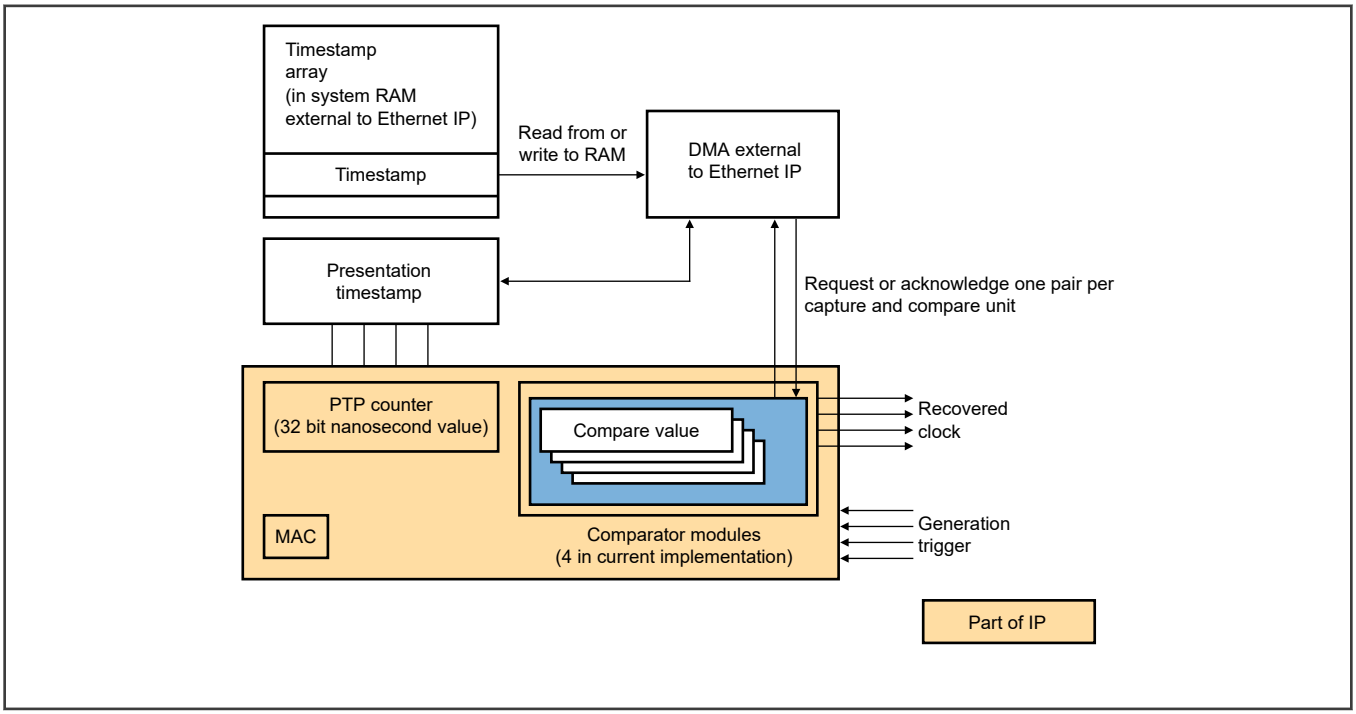
See Programming guidelines for flexible pulse-per-second output for more information.

78.8.9 Media clock generation and recovery

Media clock recovery and generation requires a dedicated hardware and software to complete the operation. IP generates a reference clock with the help of a dedicated hardware which multiplies to get the desired media clock. Software extracts the presentation time from the incoming PTP 1722 frames and program these values into CSR registers so that IP can read them for media clock recovery.

Figure 563 shows that the timestamp array and the DMA module are external to IP. IP supports a 32-bit presentation time counter in nanoseconds that completes at the full 32-bit value to match with 1722 presentation time format and an handshake mechanism with an external application (such as DMA) to program the presentation time into CSR register.

Figure 563. Media clock generation and recovery block diagram



78.8.9.1 Presentation time counter

Presentation time counter provides an another perspective of the PTP system time (1588 timer). For a given PTP system time (PTP[63:32] represents time in seconds Comparator modules and PTP[31:0] represents time in nanoseconds), there exists a corresponding presentation time (32-bit value in nanosecond). The presentation time computed is referred to as current presentation time (CPT).

CPT derives from 64-bit PTP system time. PTPNS[63:0] = (PTP[63:32] * 32'd1,000,000,000) + PTP[31:0] where, PTPNS is the PTP system time converted into a 64-bit nanosecond value.

Current presentation time[31:0] = PTPNS[31:0]

Media clock recovery is possible when the system time is internally generated in IP and compute the CPT in the same way as the internal PTP system time generation. The increment cycle of CPT and system time are same because the values of both the timers are in nanoseconds and they are synchronous. The timer updates at the same instance, but the updated value could be different. You must compute a separate 32-bit update value in nanoseconds for the CPT update. CPT sampled at different edges of a triggering input generates media clock timestamps that are inserted in 1722 based AVBTP packets, to recover the clock at the destination.

78.8.9.2 Comparator modules

Figure 563 shows that the module supports four comparator modules to handle multiple media clocks that it may require. When MAC_Timestamp_Control[PTGE] is 1, it indicates that the comparator modules handshake with the application to program the timestamps into the MAC_PPS(#i)_Target_Time_Seconds register.

Write 1 to presentation time control fields of the particular instance for recovery mode.

The timestamps received from the application are referred as target presentation time (TPT).

When MCGREN#i field of MAC_PPS_Control is 1, it indicates that the IP operates in MCGR mode. The comparator module sends up to two requests to the application for TPT write, when MAC_Timestamp_Control[PTGE] and the presentation time control bits of the particular instance are 1 for MCGR mode. Subsequent requests are generated each time a presentation time match occurs. CPT transitions from a value less than TPT, to a value greater than or equal to CPT. The first request asserts when a specific comparator instance sets to MCGR mode with a non-zero presentation time control and an additional request is made when the comparator receives the first data. This allows the application to write the next TPT value when IP processes the previous TPT value for a match.

TPT read from the MAC_PPS(#i)_Target_Time_Second is considered as a future time. A toggle or pulse is generated in the next cycle when a match is detected. Also,the mcgr_dma_req_o#i request for that comparator asserts (to obtain next TPT) until the corresponding application acknowledgment is set, when a match is detected.

The presentation control fields (PPSCMD#i field of MAC_PPS_Control) determine the shape of the generated waveform. You can program these fields to either toggle or generate a high/low pulse for one PTP clock cycle, when matched.

Media clock recovery: A match occurs, when the free-running CPT value matches the received TPT value. An output signal, EMAC_TMR signal as shown in the IO mux sheet asserts (toggle, low pulse, or high pulse) on the basis of the programmed presentation control value.

Media clock generation: On the basis of the presentation control value programmed in MAC_PPS_Control, the particular comparator captures the presentation time and programs it into MAC_PPS(#i)_Target_Time_Second register. The captured timestamp is read when a request is raised to the application. No new timestamps are captured, until the read operation is complete acknowledgment is received from the application.

78.8.9.3 Media clock generation and recovery flow

Figure 564 shows the media clock generation and recovery flow. Write 1 to MAC_Timestamp_Control[PTGE] for CPT generation and write 1 to MAC_PPS_Control MCGREN#i field to enable the corresponding instance in the MCGR mode, for both media clock generation and recovery.

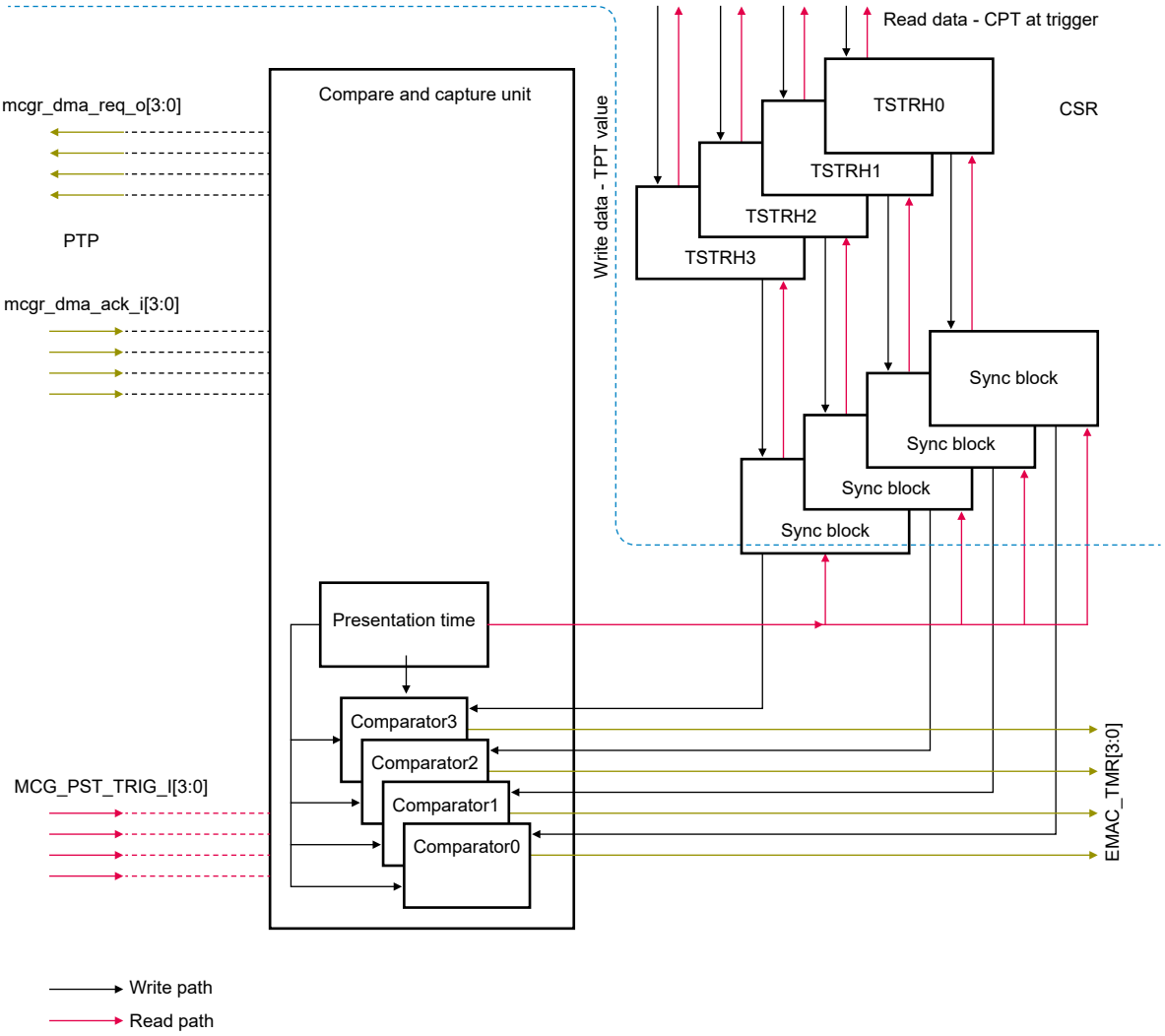


Figure 564. Media clock generation and recovery flow

NOTE

1. The consecutive triggers to sample the presentation time must assert after a few PTP clock cycles so as to allow synchronization delays. (There is no such issue when the input trigger maximum frequency is 8 KHz and the PTP clock runs at least at 1MHz)
2. In the Media Clock Recovery mode, the DMA acknowledgment is both posted as well as non-posted.

See Programming guidelines for media clock generation and recovery for more information.

78.8.10 One step timestamp

IP supports the one step timestamp feature. Writing 1 to bit 20 (OSTC) in the control word, enables the one step timestamp feature for a packet.

See the Programming guidelines for IEEE 1588 timestamping for more information.

78.8.11 IEEE 1588 sub nanoseconds timestamp

IP supports the ingress and egress correction accuracy in sub nanoseconds. It is programmed in MAC_Timestamp_Ingress_Corr_Subnanosec[TSICSNS] and MAC_Timestamp_Egress_Corr_Subnanosec[TSECSNS],

respectively. In this case, the correction has an unit of nanosecond, multiplied by 2^8. You must program the least significant 8 bits of the value in the sub-nanoseconds register.

For example, if the required egress correction is 3.6 nS and MAC_Timestamp_Control[TSCTRLSSR] is 1, then MAC_Timestamp_Egress_Corr_Nanosecond[TSEC] must be 0x3 and MAC_Timestamp_Egress_Corr_Subnanosec[TSECSNS] must be 0x99 (0.6 * 256). Similarly, if the required ingress correction is -3.6 nS and MAC_Timestamp_Control[TSCTRLSSR] is 1, then MAC_Timestamp_Ingress_Corr_Nanosecond[TSIC] must be 0xBB9A_C9FC and MAC_Timestamp_Ingress_Corr_Subnanosec[TSICSNS] must be 0x66 (fractional part of (10^9 - 3.6) * 256).

78.9 Multiple channels and queues support

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IP support two queues and channel on Tx and Rx paths. Figure 565 shows the architecture of IP with two queues and channel.

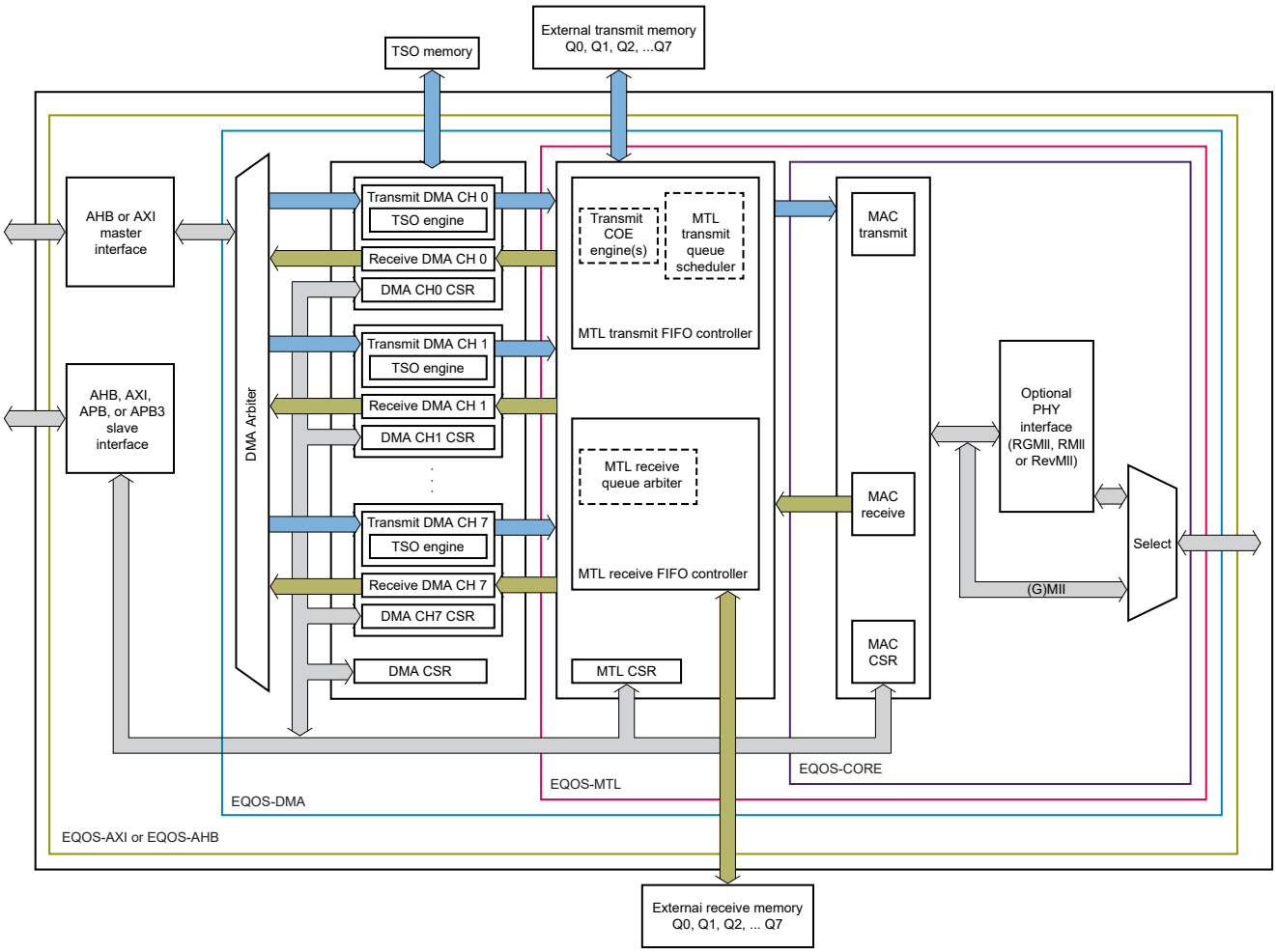

Figure 565. Module with multiple channels and queues block diagram

The above block diagram, support only two queues.

IP DMA arbiter support two types of arbitration scheme, fixed priority and weighted round-robin. The DMA arbiter performs the arbitration between the Tx and Rx paths of DMA channels to access descriptors and data buffers. DMA_Mode[DA] specifies the arbitration scheme (fixed or weighted round-robin) between the channel Tx and Rx DMA.

DMA_Mode[TXPR] sets the priority between the corresponding Tx DMA and Rx DMA. Writing 1 to DMA_Mode[PR] specifies the weighted priority between the Tx DMA and Rx DMA in round robin arbitration scheme.

Table 628 provides an information about the priority scheme between Tx DMA and Rx DMA.

Table 628. Priority scheme for Tx DMA and Rx DMA

Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Priority schemes
x	x	x	0	1	Rx always has priority over Tx
0	0	0	0	0	Tx and Rx have equal priority. Rx gets the access first on simultaneous requests
0	0	1	0	0	Rx has priority over Tx in ratio 2:1
0	1	0	0	0	Rx has priority over Tx in ratio 3:1
0	1	1	0	0	Rx has priority over Tx in ratio 4:1
1	0	0	0	0	Rx has priority over Tx in ratio 5:1
1	0	1	0	0	Rx has priority over Tx in ratio 6:1
1	1	0	0	0	Rx has priority over Tx in ratio 7:1
1	1	1	0	0	Rx has priority over Tx in ratio 8:1
x	x	x	1	1	Tx always has priority over Rx
0	0	0	1	0	Tx and Rx have equal priority. Tx gets the access first on simultaneous requests
0	0	1	1	0	Tx has priority over Rx in ratio 2:1
0	1	0	1	0	Tx has priority over Rx in ratio 3:1
0	1	1	1	0	Tx has priority over Rx in ratio 4:1
1	0	0	1	0	Tx has priority over Rx in ratio 5:1
1	0	1	1	0	Tx has priority over Rx in ratio 6:1
1	1	0	1	0	Tx has priority over Rx in ratio 7:1
1	1	1	1	0	Tx has priority over Rx in ratio 8:1

78.9.1 Multiple queues and channels support in the transmit path

IP support two transmit queues and two channels.

Fixed priority scheme is the default priority scheme for the DMA channels and channel with highest priority always wins the arbitration when it requests for the bus. Channel 0 is always of lowest priority and channel 1 is always of highest priority.

In weighted strict priority (WSP), the weight corresponds to the number of burst transfers given to a channel in one arbitration cycle. Reallocate the unused burst transfers of one or more channels on the basis of the priority. The channel with highest priority receives the unused burst transfer time before it is allocated to a channel with the next highest priority. You can process the next lower priority, when a channel uses the allocated burst transfers. After processing the allocated bandwidth of all the channels that have packets to transmit, allocate any unused burst transfer time to the channel of the highest priority (if required), and then next highest priority (if required), and so on.

In weighted round robin (WRR) priority scheme, program the weight through TCW field of DMA_CH#_Tx_Control register. IN WRR scheme, service all channels in round-robin order according to the weights settings. Table 629 shows that the TCW field of DMA_CH#_Tx_Control register provides the weight for each transmit channel.

Table 629. Weight for DMA channels

TCW Field	Transmit Channel Weight
000	1
001	2
010	3
011	4
100	5
101	6
110	7
111	8

The configured weights correspond to the number of burst transfers given to a channel in one arbitration cycle. The unused or excess burst transfers are distributed equally to all channels.

See Programming guidelines for multi-channel multi-queuing for more information.

78.9.2 Multiple queues and channels support in the receive path

IP support two receive channels and two queues.

In the receive direction, the MTL Rx controller selects the Rx DMA for which it transfers or reads the data from the receive FIFO memory. This scheduling is based on the programming done in the respective MTL_RxQ[x]_Control register.

Each Rx DMA indicates when it is ready to transfer data and the size of the burst-length (number of beats) that it will transfer. The scheduler checks whether sufficient data (of requested burst length) is available to transfer to these DMAs and then selects the receive DMA that is serviced using the programmed priorities.

See Programming guidelines for multi-channel multi-queuing for more information.

78.9.3 Rx queue to DMA mapping

You can program MTL_RxQ_DMA_Map0 (for queues 0 and 1) to route the packets in the MTL receive queues to any one of the multiple DMA channels.

The following types of receive queue to DMA mapping is possible through programming.

78.9.3.1 Static mapping

In this mode, you can connect all the packets of the receive queue to a specific DMA channel. For example, all the packets from the receive queue 0 program MTL_RxQ_DMA_Map0[Q0MDMACH] (bit[3:0]) and MTL_RxQ_DMA_Map0[Q0DDMACH] (bit[7] = 0) to route to a DMA channel.

Similarly, packets from other receive queues program register fields corresponding to each queue to route to any DMA channel.

78.9.3.2 Dynamic (per packet) mapping

In this mode, the destination DMA channel of a packet read from a Rx queue is not constant but it is decided independently for each packet. For example, if you write 1 to MTL_RxQ_DMA_Map0[Q1DDMACH], it indicates that the static mapping disables for receive queue 1 and ignores the value in MTL_RxQ_DMA_Map0[Q1MDMACH]. The MAC receiver decides the destination DMA channel for each packet, depending on the following in decreasing order of priority:

1. **L3-L4 filter based DMA selection**: The TCP/UDP and IP header fields of the received packet are matched against the corresponding values programmed and enabled for comparison in the MAC_L3_L4_Address_Control register. If the match is successful, the DMA channel number programmed in the DMCHN field of the MAC_L3_L4_Address_Control register is selected as the destination DMA channel number, if DMCHEN field of the same register is 1. If none of the L3-L4 registers give a comparison match, then the module proceeds to the next step below.
2. **Extended VLAN based DMA selection**: Extended routing is applicable only if the VLAN filter has passed. Routing is done only on the basis of the perfect filter result. Each perfect filter has a DMA channel enable and a DMA channel number field which you can program. Routing is applicable for a filter, only if the DMA channel enable field is 1. The frame routes to the smallest matching filter's DMA channel, if it is enabled. If the filter's DMA channel number is not enabled, the frame route to channel 0. For example, if a frame's VLAN tag matches filters 7, 3, and 1, then the MAC checks if DMA channel number of filter 1 is enabled through programming. If yes, the frame route to the programmed value; otherwise it route to DMA. When the inverse filter is enabled; is routed to the least mismatched filter's DMA channel number provided it is enabled. If the DMA Channel enable bit is not set, then the frame routes on the basis of the DA based addressing or to channel 0.

   If hash filter is also enabled, it is determines the filter result only. Routing will still depends on the enabled perfect filters. Routing based on the VLAN filter will not occur if none of the perfect filters are enabled or if all of them are bypassed. The frame will route via DA based addressing or to channel 0. If all the perfect filters fails and the hash filter has passed, then the VLAN filter result is a pass but routing will be based on DA based addressing or to channel 0. Similar behavior is seen when you enables inverse filtering as well.
3. **Ethernet DA-based DMA selection**: The DA address of the received packet is compared against the programmed DA values in MAC address registers. If the address matches any of the programmed values, the corresponding DCS field (when enabled) determines the destination DMA channel number.

If none of the above operations make a successful match or decision, then the packet routes to the DMA channel 0 by default.

78.9.3.2.1 Broadcast/multicast packet duplication

This feature provides a mechanism to send the received broadcast or multicast packets to multiple DMA channels.

MAC_Address0_High[DCS] and other optional MAC_Address(#i)_High (i=1 to 2) registers determines the DMA channel number to which the received packet (that matches the MAC address present in that register) must route.

DMA channel routing mechanisms such as extended VLAN, or L3-L4 based routing does not support the packet duplication.

The packet duplication feature is supported only on the highest MTL queue configured. Therefore, you must program MAC_RxQ_Ctrl1[MCBCQ] to the highest RxQ present in the configuration for the packet duplication for broadcast or multicast packets.

78.9.4 Selection of tag priorities assigned to receive queues

Program the PSRQ field in the corresponding MAC_RxQ_Ctrl2 to assign the VLAN tag priorities to receive queues. The bit corresponding to the VLAN tag priority can be set in the PSRQ field for assigning that priority to the receive queue. For example, if you want to assign VLAN tag priority of 3 to receive queue 0, write 1 to bit [3] in PSRQ field of MAC_RxQ_Ctrl2. The VLAN tag priority assigned to particular receive queue must be unique, that is, you cannot assign more than one receive queue to the same VLAN tag priority. However, more than one VLAN tag priorities can be assigned to same receive queue.

The settings in the PSRQ field is used for VLAN tagged receive packet routing to receive queues as well as for PFC based transit flow control. The received VLAN tagged receive packet route to receive queue that has the VLAN tag priority match. In PFC based transit flow control, PSRQ field corresponding to a particular receive queue enables VLAN tag priorities in the PFC packet transmitted when corresponding receive queue reach the threshold level.

78.9.5 Receive side routing from MAC to queues

IP supports receive side routing from MAC to queues. MAC route the receive packets to the receive queues on the basis of the these packet types in that order

- Unicast/Multicast destination address packets that fail the destination address filter
- Multicast/Broadcast destination address packets that pass the destination address filter
- VLAN tag priority field in VLAN tagged AV data packets
- AV control packets
- VLAN tagged IEEE 1588 PTP over Ethernet packets
- Untagged IEEE1588 PTP over Ethernet packets
- VLAN tag priority field in VLAN tagged packets
- Untagged packets

You can route the outer C-VLAN tagged AV data receive packets on the basis of the priorities assigned to receive queues through PSRQ field in the corresponding MAC_RxQ_Ctrl2 and MAC_RxQ_Ctrl3 and the corresponding receive queue is enabled for AV through RXQ#EN field in MAC_RxQ_Ctrl0. These packets may be single VLAN tagged with C-VLAN type or double VLAN tagged with outer VLAN tag of C-VLAN type when double VLAN feature enables (MAC_VLAN_Tag_Ctrl[EDVLP] = 1) with an inner C-VLAN tagged or inner S-VLAN tagged when SVLAN processing is enabled (MAC_VLAN_Tag_Ctrl[ESVL] = 1). This type of Rx packet routing is available when you select the AV feature and multiple receive queues in the configuration.

You can route the AV control receive packets on the basis of the receive queue number specified in MAC_RxQ_Ctrl1[AVCPQ] and the corresponding receive queue is enabled for AV through RXQ#EN field in MAC_RxQ_Ctrl0. These packets may be single VLAN tagged with C-VLAN type or double VLAN tagged with outer VLAN tag of C-VLAN type when double VLAN feature is enabled (MAC_VLAN_Tag_Ctrl[EDVLP] = 1) with inner C-VLAN tagged or inner S-VLAN tagged when SVLAN processing is enabled (MAC_VLAN_Tag_Ctrl[ESVL] = 1). This type of receive packet routing is available when you select the AV feature and multiple receive queues in the configuration.

You can route the VLAN tagged receive packets on the basis of the priorities assigned to receive queues through PSRQ field in corresponding MAC_RxQ_Ctrl2 and MAC_RxQ_Ctrl3 and RXQ#EN field in MAC_RxQ_Ctrl0 enables the corresponding receive queue for DCB/generic. This type of receive packet routing is available when you select the multiple receive queues in the configuration.

You can route the untagged IEEE 1588 PTP over Ethernet receive packets on the basis of the receive queue number specified in MAC_RxQ_Ctrl1[PTPQ] and the corresponding receive queue is enabled through RXQ#EN field in MAC_RxQ_Ctrl0. Also, you can route the VLAN tagged IEEE 1588 PTP over Ethernet receive packets on the basis of the priorities assigned to receive queues through PSRQ field in corresponding MAC_RxQ_Ctrl2 and MAC_RxQ_Ctrl3 or the receive queue number specified in the MAC_RxQ_Ctrl1[PTPQ] and RXQ#EN field in MAC_RxQ_Ctrl0 register enables the corresponding Rx queue. Programming MAC_RxQ_Ctrl1[TPQC] determines this. This type of receive packet routing is available when IEEE 1588 timestamp feature supports and the multiple receive queues are selected in the configuration. The VLAN tagged IEEE 1588 PTP over Ethernet receive packets are detected only when you disables 802.1AS mode (MAC_Timestamp_Control[AV8021ASMEN] = 0), otherwise this type of receive packets are routed as generic VLAN tagged Rx packets.

You can route the multicast or broadcast destination address receive packets that passes the destination address filter on the basis of the receive queue number specified in MAC_RxQ_Ctrl1[MCBCQ]the MCBCQ field of MAC_RxQ_Ctrl1 register when enabled through MAC_RxQ_Ctrl1[MCBCQEN] and the corresponding receive queue is enabled through RXQ#EN field in MAC_RxQ_Ctrl0. This type of Rx packet routing is available when you select the multiple receive queues in the configuration.

You can route the untagged receive packets on the basis of the receive queue number specified in MAC_RxQ_Ctrl1[UPQ] and RXQ#EN field in MAC_RxQ_Ctrl0 enables the corresponding receive queue. This type of receive packet routing is available when you select the multiple receive queues in the configuration.

The unicast destination address receive packets that fail the destination address filter can be routed based on the receive queue number specified in MAC_RxQ_Ctrl4[UFFQ] when enabled through MAC_RxQ_Ctrl4[UFFQE]UFFQE, MAC_Packet_Filter[RA] = 1 and the corresponding receive queue is enabled through RXQ#EN field in MAC_RxQ_Ctrl0. This type of receive packet routing is available when you select the multiple receive queues in the configuration.

You can route the multicast destination address receive packets that fails the destination address filter on the basis of the receive queue number specified in MAC_RxQ_Ctrl4[MFFQ] when MAC_RxQ_Ctrl4[MFFQE] enables it. MAC_Packet_Filter[RA] = 1 and RXQ#EN field in MAC_RxQ_Ctrl0 enables the corresponding receive queue. This type of receive packet routing is available when you select the multiple receive queues in the configuration.

The receive packet will route through the receive queue 0, if it is not classified in any of the defined packet type for routing.

78.9.6 Receive side arbitration between DMA and MTL

IP controller supports receive side arbitration between DMA and MTL.

After the current packet processing completes, the DMA channel controller fetches the next descriptor and after the descriptor fetching completes, the DMA channel controller evaluates the amount of data to transfer to the Rx buffer on the basis of the programmed PBL and receive buffer length. Accordingly, it requests the MTL to transfer the data.

After servicing the current request, the MTL receive queue arbitration scheme selects receive queue on the basis of the arbitration scheme (MTL_Operation_Mode[RAA]) and the weights programmed in queue <n> receive control register. The arbitration is done among queues for which DMA is ready to service. After the receive queue is selected, PBL amount of data is read out from that queue and route to the receive DMA channel on the basis of the receive channel selection criteria.

The arbitration occur after every PBL data transfer completes and descriptors are ready for processing from at least one DMA channel.

78.9.7 Transit side arbitration between DMA and MTL

IP supports transit side arbitration between DMA and MTL. Transit DMA channels and transit queues are always mapped directly because the number of transit DMA channels are always equal to the number of transit queues in MTL. For instance, each transit DMA pushes data into its respective transit queue assigned to it.

The data inside each transit queue is stored in packets. Therefore, if two DMAs are allowed to transfer data into the same queue, when a transit DMA starts a packet transfer, the other DMA cannot transfer data unless the previous packet is completely pushed-in. This means that the second DMA remains idle until the first packet is transferred. Hence, each DMA is always connected directly to its corresponding transit queue.

78.9.8 Audio video bridging

IP supports the audio video bridging in 100 Mbps mode only, which allows the transmission of time sensitive traffic over network. IP implements these protocol for supporting the AVB feature:

- IEEE 802.1Qbv-2015 (Enhancements to scheduling traffic)
- IEEE 802.3br (Interspersing traffic)
- IEEE 802.1Qbu (Frame preemption)

The queue 0 transmit path supports the strict priority algorithm, and it is used for best-effort traffic when transmit paths of additional queues use the credit-based shaper algorithm to support traffic management. For a queue, the credit-based shaper algorithm determines that a queue is available for transmission if these conditions are true:

- The queue contains one or more packets.
- The credit for the queue is positive per the algorithm
- AV traffic is received on all queues. IP can also receive untagged PTP packets in addition to AV traffic on any queue.

78.9.9 Queue modes

Transit and receive queues both handles the AV traffic.

Queueing is based on WRR (Weighted round robin) or WSP (Weighted strict priority) algorithm for generic traffic. It is based on CBS (Credit Base Shaper) and SP (Strict Priority) algorithm for AV traffic.

The receive queue is configured for generic or AV based routing, which depends on the RXQ#EN field of corresponding queue. Queueing is done on the basis of the VLAN tag priority. The VLAN tag priority must match the PSRQ field of MAC_RxQ_Ctrl2. The receive packets can route to a particular DMA channel on the basis of the DCS field of perfectly-matched MAC address register.

By default, the untagged packets in a generic traffic route to the receive queue specified in MAC_RxQ_Ctrl1[UPQ]. Queue 0 is the default value of MAC_RxQ_Ctrl1[UPQ]. You can override the default value with any other value, for the MAC_RxQ_Ctrl1[UPQ].

The AV control packets (tagged or untagged) route on the basis of MAC_RxQ_Ctrl1[AVCPQ]. The PTP over Ethernet packets route on the basis of MAC_RxQ_Ctrl1[PTPQ].

78.9.10 Queue priorities

You can program the priority of an receive queue in the corresponding field of MAC_RxQ_Ctrl2. Also, you must program the AV queue (high priority) as an higher priority than the best-effort queue (low priority).

78.9.11 Enhancements to scheduled traffic (EST)

The IEEE 802.1Qbv-2015 defines the schedule for each queues on every egress port which makes the implementation aware of traffic arrival schedule. This information blocks the lower priority traffic from transmission in this time window or slot. This ensures that the sender forward the scheduled traffic to receiver through all the network nodes with a deterministic delay.

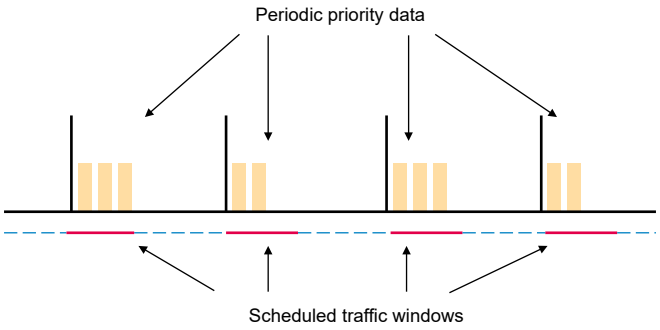

Figure 566. Time aware shaper implementation for traffic scheduling

An important requirement to achieve a low latency is to ensure that there are no interfering frames during the scheduled windows that are reserved for high priority traffic. The use of scheduled traffic imposes limitations when a transmission starts.

As shown in Figure 567 , if an interfering frame begins transmission just before the reserved time period starts, it can extend transmission into the reserved window, and potentially interfere with higher priority traffic. Therefore, a guard band whose size is equal to the largest possible interfering frame is required before the window starts.

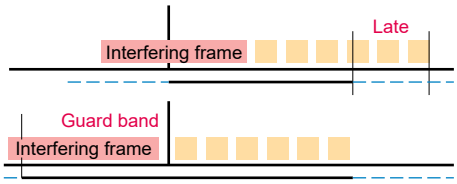

Figure 567. Implementing a guard band to avoid delays due to interfering frames

A larger guard band equates to a less efficient use of network bandwidth. However, this issue is addressed with the implementation of IEEE802.1Qbu (frame preemption). Frame preemption breaks the interfering frame into smaller fragments. Therefore, the guard band must be as large as the largest possible interfering fragment instead of the largest possible interfering frame.

During the guard band, only the frames that can complete the transmission of the entire frame before the next gate close event are permitted. This ensures that the high priority traffic can always start at the beginning of the window reserved for it.

78.9.11.1 Frequently used terms in EST

These are some of the frequently used terms in the EST support and their definitions.

- Gate control list: The list in the hardware memory that hold the gate controls and the associated time intervals.
- Gate controls: For a given schedule (row in gate control list) there is a gate open (O) and gate close (C) state associated with each TC. The set of O or C values, whose width is same as configured TCs is called the gate controls. Example: CCOCOOCO means TC7=C, TC6=C, TC5=O and so on.
- Time interval: Time interval (in nanoseconds) is a 16, 20, or 24-bit configurable field in the gate control list that indicates the time for which the associated gate controls are valid.
- Base time register: Each gate control list is associated with a 64-bit base time register that holds the start time (in PTP format) for the list.

78.9.11.2 Updates to the transmit scheduling to support EST

To support EST, these updates are required to transmit scheduling:

- Implementation of gate control list (GCL)
- Enforcing gate controls in the scheduler
- Utilizing gate open (O) duty cycle in the computation of idleSlope (CBS)

78.9.11.2.1 Implementation of gate control list (GCL)

Figure 568 shows how the gate control list governs the gate close(C) and open(O) events on the basis of the schedule provided for each event. GCL has two parts:

- Time interval: Defines the time in nanoseconds for which the gate controls are valid and must apply before reading the next gate controls from the list. The configurable width of 16, 20 or 24-bit represents a maximum of 64us, 1ms, or 16ms schedule interval respectively. It supports left shift of the time interval up to 7 bits to be able to apply a multiplication factor from 1 to 128ns (in steps of 2(power)n). The maximum value (post shifting) of this field must be 999,999,999 ns.
- Gate control: Defines the open (O) represented by logic 1 or close (C) represented by logic 0 state for the gate of each TC.

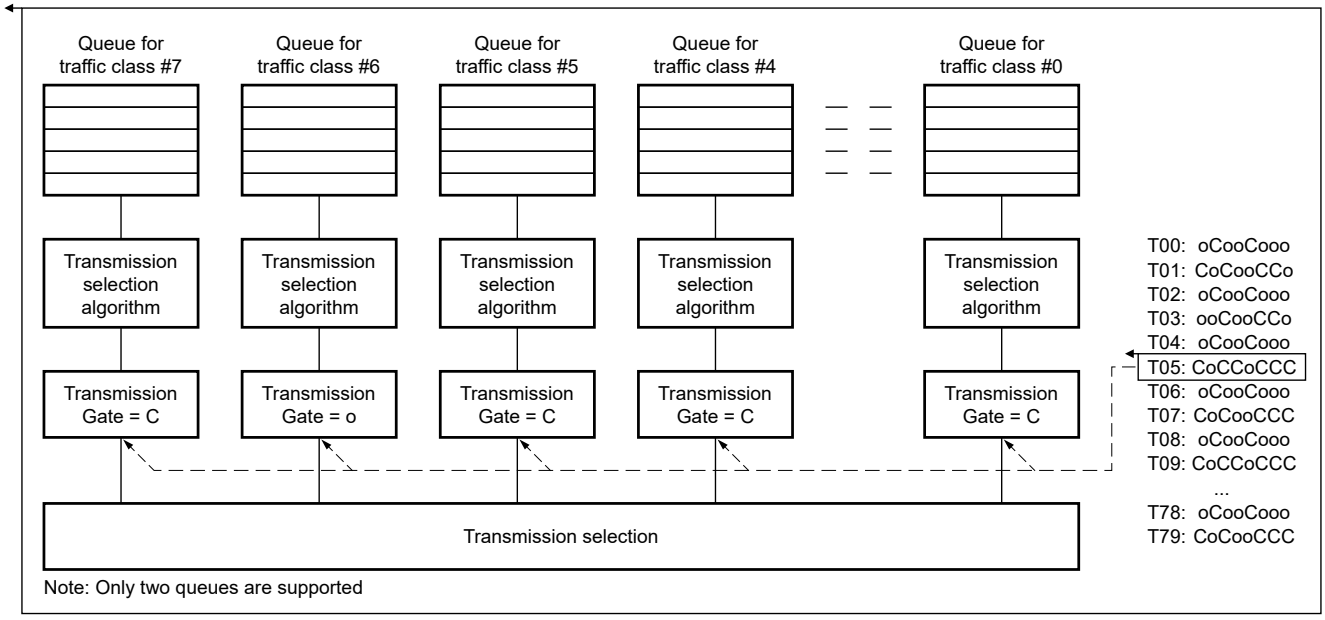

Figure 568. Block diagram from IEEE 802.1 Qbv specification - GCL governing gate close and open events

The implementation of GCL consists of these two gate control lists:

- HWOL - Hardware owned list which is a list for hardware access.
- SWOL - Software owned list which is a list for software access.

The access to these lists is mutually exclusive. Hardware sets the ownership to the list in MTL_EST_Status[SWOL]. Table 630 provides the implementation details of GCL.

Table 630. External memory used for holding the two gate-control lists

Gate control (up to 8 bits)	Time interval (ns) 16, 20, or 24 bits	
OOCCCCCC	T0	HWOL or SWOL
OOOOCCCC	T1	
CCCCOOCC	T2	
CCCCCCOO	T3	
I	I	
I	I	
OCOCOCOO		
OOOOCCCC	T last	
OOOOCCCC	T0	SWOL or HWOL
OOOOCCCC	T1	
OOCCCCCC	T2	
OOOOCCCC	T3	
I	I	
I	I	
OCOCCCCC		
OOCCCCCC	T last	

78.9.11.2.2 Registers related to gate control list

The following are the set of four registers (one for each GCL) related to GCL. These registers are implemented through Indirect addressing using MTL_EST_GCL_Control and MTL_EST_GCL_Data registers.

1. 64-bit Base time register (BTR)
2. 40-bit Cycle time register (CTR)
3. m-bit Time extension register (TER)
4. n-bit [Gate control] List length register (LLR) (n depends of the configured GCL depth)

78.9.11.2.2.1 Base time register (BTR)

This is a 64-bit register that specifies the start time to execute the GCL. The format of the BTR is same as the PTP format (upper 32-bits holds time in seconds and lower 32 bits hold time in nanoseconds). After the execution of a given list starts, the implementation can update the value in BTR to indicate the next list execution start time.

78.9.11.2.2.2 Cycle time register (CTR)

This is a 40-bit register that specifies the time at which the execution of the GCL must repeat. This register consists of an 8-bit value in seconds, and a 32-bit value in nanoseconds (similar to the PTP time format with truncated seconds register). For a given GCL, the start time is "Base Time" + N * "Cycle Time" where N is an integer value that represents the iteration number starting with 0 for first iteration. If the GCL execution takes longer than the cycle time, then the list is truncated at the cycle time and the subsequent loop begins at cycle time.

78.9.11.2.2.3 Time extension register (TER)

This is a m-bit (where m = Configured time interval width + 7) register that specifies the amount of time (in nano seconds) the current GCL can extend before switching to the new GCL. This helps to avoid the execution of the small fragments of the current list before switching to a new list.

78.9.11.2.2.4 List length register (LLR)

This is an n-bit register (when n is 7, 8, 9, 10, or 11 for a GCL configured depth of 64, 128, 256, 512, or 1024 respectively) that specifies the integer value of the length of the GCL (that is the number of valid rows in each GCL). The processing of the GCL stops after the number of rows read equals to the LLR value.

78.9.11.2.3 Transmission gating implementation

A bridge or an end station can enhance to allow transmission from each TC that is yet to be scheduled relative to a known timescale. To achieve this, a transmission gate is associated with each TC; the state of the transmission gate determines if you can select the queued frames for transmission.

For a TC, the transmission gate can be in one of these two states:

1. Open: Select queued frames for transmission, in accordance with the definition of the transmission selection algorithm associated with the TC.
2. Closed: Does not select queued frames for transmission.

A frame on a traffic class queue is not available for transmission if the transmission gate is in the closed state or if there is insufficient time available to transmit the entirety of that frame before the next gate-close event associated with that queue.

The implementation has visibility to the current schedule of gate controls and the immediate next schedule of the gate controls. So the maximum Gate Open period does not exceed the sum of the two Time Intervals. This is because, a frame is selected for transmission only if the gate is currently Open and the duration of gate open interval is greater than the time taken to transfer the entire frame.

The implementation must know the frame size before the transmission, so that you can avoid the transmission overruns and only the frames that can complete are scheduled at all times.

The implementation adequately compensates for the implementation delays in the data transfer from the buffer to the line by offsetting the current time with all the relevant delays (provided by MTL_EST_Control[CTOV]). This ensures that the schedule provided is always accurately implemented at the line.

You must ensure that the GCL slot interval is always greater than the expected packet size and overhead (scheduler delay, inter frame gap (IFG), and preamble, all combined).

78.9.11.3 Idle slope computation updates

When EST is enabled, credit accumulates only when the gate is open therefore, the effective data rate of the idleSlope must increase to reflect the duty cycle for the transmission gate associated with the queue.

The idleSlope is computed on the basis of the gate open time and oper cycle time values. Program the idleSlope registers (implemented one per CBS enabled TC) based on the following equation. The existing MTL register has sufficient field width to accommodate the new values for idleSlope.

idleSlope = (operIdleSlope(N) * OperCycle/GateOpenTime)

78.9.11.3.1 Operational details of GCL

Write 1 to MTL_EST_Control[SSWL], so that the hardware can access the programmed gate control list. The first set of gate controls are applied when the current time is equal to the value in the base time register (BTR) and is held until the programmed "time interval" value.

One additional gate control event is always read ahead from the list, to avoid the transmission overruns. This enables the GCL to determine the next gate close events (if any) for the open TCs.

The scheduling is done on the basis of the gate open state and time interval of only the current and subsequent schedule. An internal accumulator adds the time intervals when gate controls are applied. BTR + Accumulator specifies the time at which the next set of gate controls are applied.

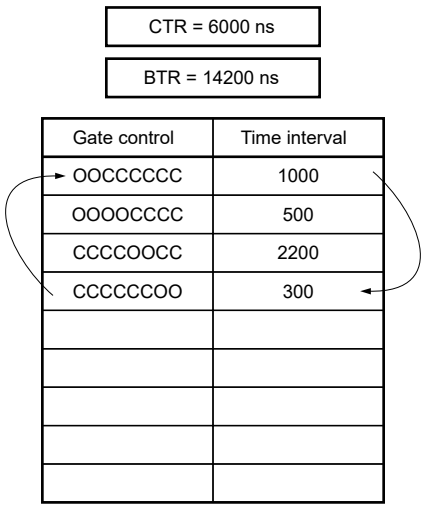

Figure 569. GCL and associated registers - basetime and cycletime

GCL is read progressively from the first row adhering to the schedule. The read operations continue until the list length (from LLR register) is reached and the execution of the list restarts at BTR + CTR time. At this point the value in CTR increments BTR to mark the beginning of a new cycle. In the absence of any gate controls, all the gates are in open state, during the execution of the list.

In cases where the execution time of the list is greater than the cycletime, the list is truncated and the next iteration starts when the current time equals BTR + CTR.

Table 631. GCL and associated registers - BTR and CTR

Current time	Gate control applied	Accumulator value	BTR (with updates)
14200	OOCCCCCC	1000	14200
15200	OOOOCCCC	1500	14200
15700	CCCCOOCC	3700	14200
17900	CCCCCCOO	4000	14200

Table continues on the next page...

Table 631. GCL and associated registers - BTR and CTR (continued)

Current time	Gate control applied	Accumulator value	BTR (with updates)
18200	OOOOOOOO	0	20200
20200	OOCCCCCC	1000	20200
21200	OOOOCCCC	1500	20200

Table 631 describes an example in which the execution starts at 14200 and the first set of gate controls "OOCCCCCC" are applied immediately. The time interval is 1000 ns, so the next set of gate controls are applied at 14200 (BTR) + 1000 (Accumulator) = 15200 ns . The above table shows that there are no gate controls available after the execution of the last gate control and before the next iteration of the loop. The gates are deemed in open state during that time period as depicted at 18200 current time.

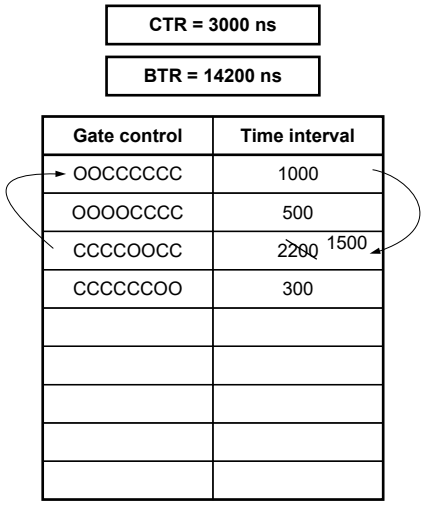

Figure 570. GCL and associated registers - BaseTime and CycleTime list execution time > CycleTime

Table 632 indicates that the list execution takes longer than the allocated CycleTime, so the list is truncated and the list starts from the BTR+CTR.

Table 632. GCL and associated registers - BTR and CTR, execution time > Cycle Time

Current Time	Gate Control Applied	Accumulator Value	BTR (with updates)
14200	OOCCCCCC	1000	14200
15200	OOOOCCCC	1500	14200
15700	CCCCOOCC	3700	14200
17200	OOCCCCCC	1000	17200
18200	OOOOCCCC	1500	17200
18700	CCCCOOCC	3700	17200

When you apply the third set of gate controls, BTR + CycleTime (17200) < BTR + Accumulator (17900), so the list is truncated and execution switches to a new iteration at 17200.

78.9.11.3.2 Installing a new GCL

The switch to the new GCL can happen in one of the following ways when a new software programmed GCL is available and executed at the new BTR value:

- New base time aligned with current schedule
- New base time unaligned with current schedule

78.9.11.3.2.1 New base time aligned with current schedule

If the choice of cycle time for the new gating cycle is unchanged from the cycle time for the current gating cycle, and if the BTR chosen for the new gating cycle (new BTR) is an integer multiple of the current cycle time (+ current BTR), then the new gating cycle exactly lines up with the old gating cycle, that is, the cycle start times for the new gating cycle is same as they would have been for the old configuration. This could be considered to be the ideal case and allows the new gating cycle to be installed and executed with no timing issues. The implementation completes the execution of an iteration of the current list and switches to the new list at the beginning of the BaseTime listed in the new list.

If (New base time > = Current time)

ConfigChangeTime = New BaseTime

Else If (New base time < Current time)

1. Set the BTRError

2. ConfigChangeTime = (New BaseTime + N* New CycleTime)

where N is the smallest integer for which the relation ConfigChangeTime >= CurrentTime and (N =< 8) is true.

When N > 8 the hardware cannot auto recover and the loop count value in BTRError reporting is set to 1111 requires the software to reprogram the new base time.

Figure 571 illustrates the installation of the new GCL along with the timelines.

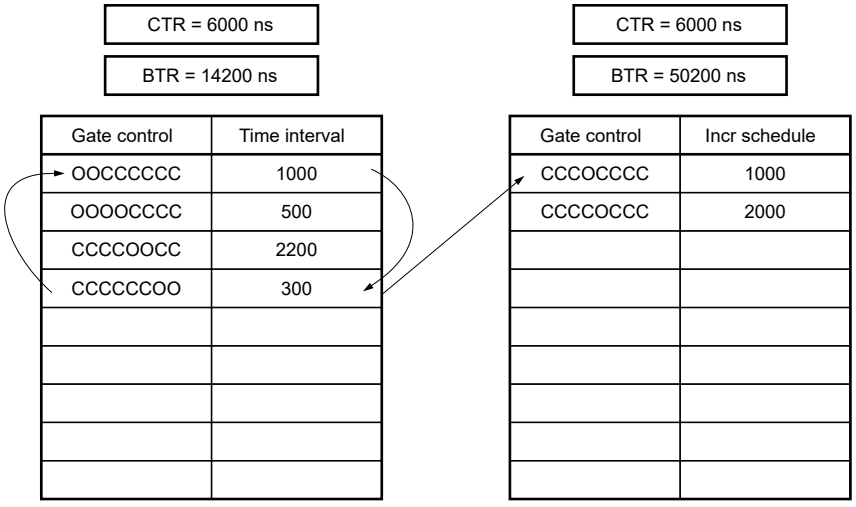

Figure 571. Switching to a new configuration that is aligned with the existing configuration

In the above example, after the sixth iteration of the first GCL, the BTR values of the old and new GCL are equal. At that point the new GCL is processed as a natural extension to the existing GCL.

Table 633. GCL and associated registers - BTR and CTR

Current time	Gate control applied	Accumulator value	BTR (with updates)
44200	OOCCCCCC	1000	44200
45200	OOOOCCCC	1500	44200
45700	CCCCOOCC	3700	44200
47900	CCCCCCOO	4000	44200
48200	OOOOOOOO	0	50200
50200	CCCOCCCC	1000	50200
51200	CCCCOCCC	3000	50200
53200	OOOOOOOO	0	56200

78.9.11.3.2.2 New base time unaligned with current schedule

If the new cycletime differs from the current cycletime or new basetime in the future and is not an integer multiple of current cycletime, then the old and new cycles do not line up. When new basetime is reached (when the new configuration is installed and starts to execute), the last old cycle is normally truncated to start the first new cycle. This could be undesirable if it results in a very short last old cycle; arguably it would be better to simply extend the penultimate old cycle by that small amount, rather than starting a very short cycle. The Cycle Time Extension Register (related to the current config list) allows this extension of the last old cycle to be done in a defined way; if the last complete old cycle ends normally in less than current Cycle Time Extension (TER) ns before the new base time, then the last complete cycle before new BaseTime is reached is extended so that it ends at new BaseTime.

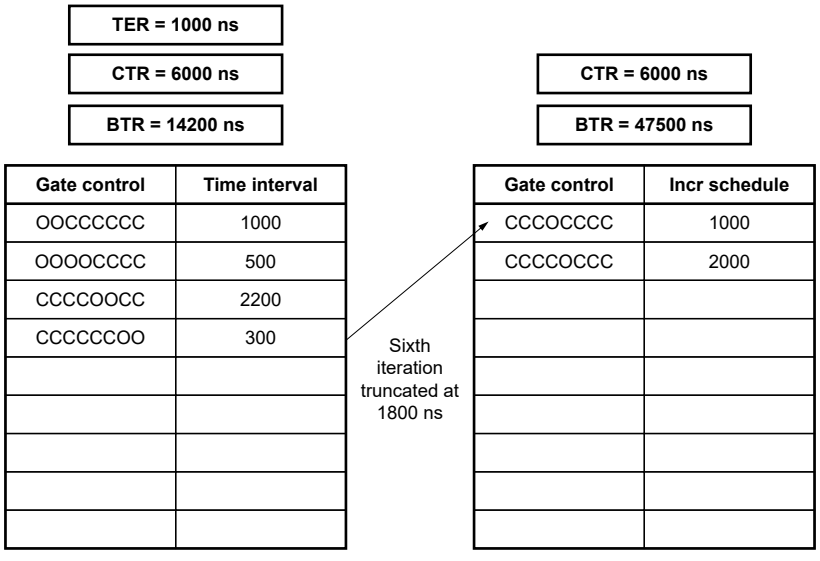

Figure 572. Switching to new list truncating the current list

At the end of the fifth iteration the Current time + Cycle time extension (TER) < New BTR so the sixth iteration of current configuration is started. During the sixth iteration of the current list when the new BTR value is smaller than the next schedule in the current list, it switches to the new list.

Table 634. Extending to new list by truncating the current list

Current time	Gate control applied	Accumulator value	BTR (with updates)
44200	OOCCCCCC	1000	44200
45200	OOOOCCCC	1500	44200
45700	CCCCOOCC	3700	44200
47500	CCCOCCCC	4000	44200
48500	CCCCOCCC	0	50200
50500	OOOOOOOO	1000	50200

Below is an example where the current config list is extended instead of starting a new iteration as the extension time of 800 ns is less than the allowed cycle extension time (TER) of 1000 ns.

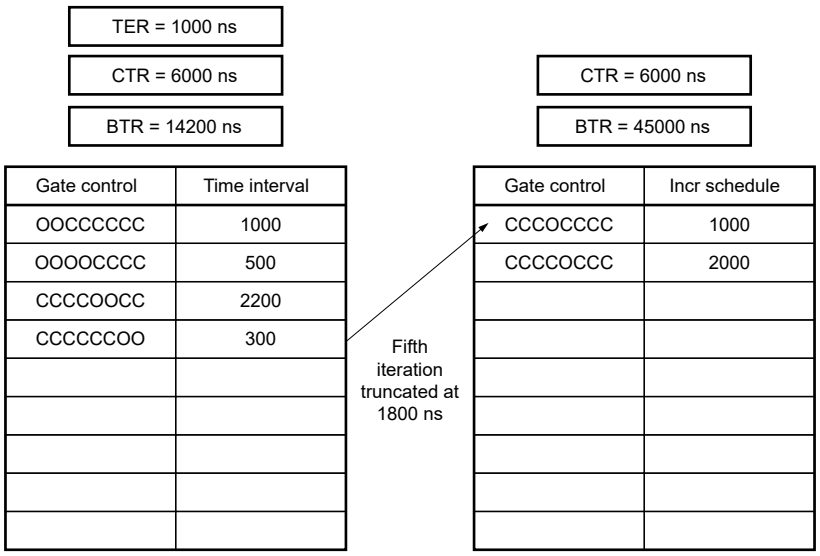

Figure 573. Switching to new list by extending the current list

Table 635. Switching to new list by extending the current list

Current time	Gate control applied	Accumulator value	BTR (with updates)
38200	OOCCCCCC	1000	38200
39200	OOOOCCCC	1500	38200
39700	CCCCOOCC	3700	38200
41900	CCCCCCOO	4000	38200
42200	OOOOOOOO	0	44200

Table continues on the next page...

Table 635. Switching to new list by extending the current list (continued)

Current time	Gate control applied	Accumulator value	BTR (with updates)
45000	CCCOCCCC	1000	45000
46000	CCCCOCCC	3000	45000
48000	OOOOOOOO	0	51000

78.9.11.4 Impact of Transmit Scheduling Algorithms on EST

When EST is used in isolation, the Gate Control List manages the final open/close state of the Queues along with the checks carried out by the Transmission Selection Algorithm in MTL. As the Gate Controls operate on a predefined repetitive schedule, it is recommended to use Strict Priority or Credit Based Shaper (CBS) scheduling algorithms.

Other algorithms such as the Weighted Round Robin (WRR), Deficit Weighted Round Robin (DWRR) and Weighted Fair Queuing (WFQ) implement masking of the queues based on the current winning queue. The algorithm is applied only among the group of queues that open simultaneously. To ensure Queues whose gates are "Open" get priority, these algorithms are modified to treat "gate open" queues and "gate closed" queues as separate groups giving priority to gate open queues.

For example, consider 4 queues (Q3, Q2, Q1, Q0) with weights 4:3:2:1; Q3 and Q2 are in Open state in slot one slot, while Q1 and Q0 are in Open state in another slot. In this case, the scheduler works as follows:

1. In the first slot, the Q3 and Q2 are serviced in the ratio of 4:3 for the duration the slot is open.
2. In the second slot, the queues Q1 and Q0 are serviced in the ratio of 2:1.
3. Fresh arbitration is started every time a slot is opened.

In other words, the traffic does not get distributed in the intended ratio of 4:3:2:1; but as two groups with different ratios and only for the duration of the slot when the gates are open continuously

NOTE

See Programming guidelines for EST

78.9.12 Frame preemption (FPE)

Frame preemption breaks the interfering frame into smaller fragments. Therefore, the guard band needs to be only as large as the largest possible interfering fragment instead of the largest possible interfering frame. During the guard band, only the frames that can complete the transmission of the entire frame before the next gate close event are permitted. This ensures that the high priority traffic can always start at the beginning of the window reserved for it.

Preemption allows one or more higher priority (express) frames to interrupt the transmission of a lower priority (preemptable) frame; the preemptable frame transmission is resumed and completed after the express frame transmission is complete. To support frame preemption, the following two abstractions of the MAC are used:

- A preemptable MAC, called pMAC, which carries the preemptable traffic.
- An express MAC, called eMAC, which carries the express traffic.

In the implementation, only parts of the MAC that holds the state during preemption is replicated and represented as pMAC and eMAC. The MAC uses the following two ways to puts on hold, the transmission of the preemtable traffic, in the presence of express traffic:

- The MTL scheduler interrupts the preemptable traffic that is currently being transmitted. When the preemption capability is active, the MAC interrupts the transmission and reception of preemptable frames. A preempted fragment can be followed by zero or more express frames, before the continuation fragments. The preemptable frame can be fragmented any number of times, however, the minimum final and non-final fragment length criterion must be is met. However, interleaving of more than 1 preemptable packet is not permitted. This implies that if a preemptable packet is fragmented by an express

packet, another preemptable packet cannot be transferred until all the remaining fragments of the first preempted packet are transferred.

- The MTL scheduler prevents starting the transmission of preemptable traffic. When the preemption capability is inactive, the pMAC entity is disabled and only express traffic is transmitted or received. Frame preemption feature can be enabled by setting EFPE field of the MAC_FPE_CTRL_STS register.

If you are unable to schedule fragmented packets after a certain number of attempts because of some reason, there is a possibility that the remaining fragmented packets are dropped. For this, software can program MTL_EST_Control[LCSE] to increase number of iterations or MTL_EST_Control[DFBS] to disable dropping of packet.

NOTE

EST and FPE cannot be used at the same time.

78.9.12.1 GCL Modification to Support FPE

In the EST-only configuration, the GCL entry has up to 24 bits of Time Interval and up to 8 high order bits representing the Gate Open/Close state requirements as shown in the following figure.

Gate control (up to 8 bits)	Time interval (ns) 16, 20 or 24 bits
OOCCCCCC	T0
OOOOCCCC	T1
CCCCOOCC	T2
CCCCCCOO	T3
|	|
|	|
OCOCOCOO	T126
OOOOCCCC	T127

Figure 574. Gate Control List When FPE is Disabled

EST only supports SetGate operation, which implies that the gates are set to either open or close at a given time interval. However, when both Frame Preemption (FPE) and EST are enabled, the GCL also supports Set-and-Hold-MAC and Set-and-Release-MAC operations, in addition to the SetGate operation. To enable the support of hold and release operations, the format of the GCL is slightly changed while configuring and enabling the FPE. The first Queue (Q0) is always programmed to carry preemption traffic and therefore it is always Open. The bit corresponding to Q0 is renamed as Release/Hold MAC control. The TX Queues whose packets are preemptable are indicated by setting the PEC field of the MTL_FPE_CTRL_STS register. The GCL bit of the corresponding Queue are ignored and considered as always "Open". So, even if the software writes a "0" ("C"), it is ignored for such queues.

Gate control (up to 7 bits)	Release or hold indication	Time interval (ns) 16, 20 or 24 bits
CCCOOOO	0	T0
CCCCOOO	0	T1
OCCCOOO	1	T2
COCCOOO	1	T3
CCOCOOO	1	T4
CCCOOOO	0	T5
CCCCOOO	0	T6

Figure 575. Gate Control List When FPE is Enabled

When the Release/Hold bit transitions from a '0' to '1', a Set-and-Hold-MAC operation is performed. This marks the cease of the preemptable traffic. This is achieved by sending a Hold request to MTL "ha" ns in advance (where ha is the time interval mentioned in the Hold Advance (HADV) field of the MTL_FPE_Advance register). When the Release/Hold bit transitions from a '1' to '0' a Set-and-Release-MAC operation is performed. This marks the resuming of the preemptable traffic. This is achieved by sending a Release request to MTL "ra" ns in advance (where ra is the time interval mentioned in the Release Advance (RADV) field of the MTL_FPE_Advance register). The preemptable traffic is blocked for the time duration the Release/Hold bit is set to a '1' in the Gate Control List.

78.9.12.2 Impact of Preemption on CBS

In Credit Base Shaper(CBS), the definition of "Transmit" is as follows:

- TRUE for the duration of frame transmission from the queue.
- FALSE when frame transmission from the queue is complete.
- When CBS algorithm is used along with frame preemption, the value of "Transmit" is TRUE only while the frame is being transmitted by the MAC. If the frame transmission is delayed or interrupted (for instance, a preemptable frame transmission is interrupted to allow the transmission of an express frame from a different queue, or the start of express frame is delayed because a preemptable frame is being transmitted) the value of "Transmit" is FALSE until transmission of the frame commences or is resumed.

Also, the value of "Transmit" is FALSE during the transmission of any overhead that is a consequence of frame preemption. For example, additional frame overhead (mCRC, Fragment Count) that is added to the preemptable frame.

At any given time, if there are no frames in the queue, and the value of Transmit is FALSE, and credit is positive value, the credit value is set to zero if here is no preemptable frame from the queue for which transmission is in progress but has been interrupted.

78.9.12.3 mPacket Format

When the preemption capability is active, MAC sends mPackets to the PHY. An mPacket can be one of the following:

1. A express packet
2. A preemptable packet
3. An initial fragment of a preemptable packet
4. A continuation fragment of a preemptable packet

Start mPacket Delimiter (SMD)

The value of the SMD indicates whether the mPacket contains an express packet, the start of a preemptable packet (initial fragment or complete packet), or any of continuation fragments of a preemptable packet. Following table shows the valid SMD values.

Table 636. Possible SMD Values of mPacket

mPacket Type	Notation	Frame Count	Value
verify packet	SMD-V	-	0x07
respond packet	SMD-R	-	0x19
express packet	SMD-E	-	0xD5
preemptable packet start	SMD-S0	0	0xE6
	SMD-S1	1	0x4C
	SMD-S2	2	0x7F
	SMD-S3	3	0xB3
continuation fragment	SMD-C0	0	0x61
	SMD-C1	1	0x52
	SMD-C2	2	0x9E
	SMD-C3	3	0x2A

frag_count

A frag_count is a modulo-4 counter that increments for each continuation fragment of the preemptable packet. The frag_count protects against mPacket reassembly errors by enabling detection of the loss of up to 3 packet fragments.

The frag_count field is present only in mPackets with SMD-C notation (continuation fragment). The frag_count is zero in the first continuation fragment of each preemptable packet.

Table 637. Possible frag_count Values

frag_count	Value
0	0xE6
1	0x4C
2	0x7F
3	0xB3

mData

The contents of the packet from the MAC, starting with the first byte after the SFD to the last byte before the FCS are sent in the mData fields of one or more mPackets for that frame. The minimum size of the mData field is 60 bytes.

CRC The CRC field contains a cyclic redundancy check (CRC) and has an indication of the final mPacket of a frame. In the final mPacket of a frame, the CRC field contains the last 4 octets of the MAC frame (the FCS field).

For other mPackets, the CRC field contains an mCRC value. The mCRC is calculated on the octets of the packet from the first octet of the frame (the octet following the SFD of preemption frames) to the last octet of the packet transmitted in that mPacket by performing an XOR of the calculated 32 bit CRC value of the fragment and a value of 0x0000FFFF.

Summary of Packet Formats

- Express Packet: 7bytes of PREAMBLE, SMD-E, Data, and CRC
- Complete Preemptable Packet: 7 bytes of PREAMBLE, <Current Preemptable packet SMD>, Data, CRC
- Initial Fragment (non-final) of Preemptable Packet: 7 bytes of PREAMBLE, <Current Preemptable packet SMD>, Data, mCRC
- Continuation fragments (non-final) of Preemptable packet: 6 bytes of PREAMBLE, <Current Preemptable continuation fragment SMD>, <Current Preemptable continuation fragment FC>, Data, mCRC
- Final fragment of Preemptable packet: 6 bytes of PREAMBLE, <Current Preemptable continuation fragment SMD>, <Current Preemptable continuation fragment FC>, Data, CRC

Table 638. Current and Previous SMD Values

Previous Preemptable packet SMD	Current Preemptable packet SMD
SMD-S0	SMD-S1
SMD-S1	SMD-S2
SMD-S2	SMD-S3
SMD-S3	SMD-S0

Table 639. Current and Previous SMD Values

Previous Preemptable fragment SMD	Previous Preemptable fragment FC	Current Preemptable continuation fragment SMD	Current Preemptable continuation fragment FC
SMD-S0	NA	SMD-C0	FC0
SMD-S1	NA	SMD-C1	FC0
SMD-S2	NA	SMD-C2	FC0
SMD-S3	NA	SMD-C3	FC0
SMD-C0	FC0	SMD-C0	FC1
SMD-C0	FC1	SMD-C0	FC2
SMD-C0	FC2	SMD-C0	FC3
SMD-C0	FC3	SMD-C0	FC0
SMD-C1	FC0	SMD-C1	FC1
SMD-C1	FC1	SMD-C1	FC2
SMD-C1	FC2	SMD-C1	FC3
SMD-C1	FC3	SMD-C1	FC0
SMD-C2	FC0	SMD-C2	FC1

Table continues on the next page...

Table 639. Current and Previous SMD Values (continued)

Previous Preemptable fragment SMD	Previous Preemptable fragment FC	Current Preemptable continuation fragment SMD	Current Preemptable continuation fragment FC
SMD-C2	FC1	SMD-C2	FC2
SMD-C2	FC2	SMD-C2	FC3
SMD-C2	FC3	SMD-C2	FC0
SMD-C3	FC0	SMD-C3	FC1
SMD-C3	FC1	SMD-C3	FC2
SMD-C3	FC2	SMD-C3	FC3
SMD-C3	FC3	SMD-C3	FC0

78.9.12.4 Transmit Preemption

When FPE is enabled (setting EFPE=1 in MAC_FPE_CTRL_STS register), the MTL preempts a preemptable frame, when a "hold" request is asserted (EST/Qbv configured and enabled) express frames are available for transmission, that is, frame is present in MTL FIFO and is qualified for arbitration, after ensuring that the minimum mPacket mData field size is met. Therefore, preemption occurs only if at least 60 bytes of the preemptable frame have been transmitted and at least 64 bytes (including the frame CRC) remain to be transmitted.

The earliest starting position of preemption is controlled by the AFSZ field of the MTL_ FPE_CTRL_STS Register. Preemption does not occur until at least 64 * (1+ AFSZ) - 4 bytes of the preemptable frame have been sent.

When preemption occurs, all the preemptable queues are blocked and only the express queues are allowed to arbitrate (if more than one express queue has traffic) and transmit.

Continuation fragment of the preempted frame is the first frame to be transmitted after "release" request is asserted (EST/Qbv configured and enabled) and all the express traffic transmission completes.

NOTE

All the PTP packets should be transmitted as express packets

MTL communicates the following frame-type information to the MAC using a 2-bit preemption control signal on the MTI interface qualified by SoF and EoF.

- Express Frame
- Preemption Frame (Full or Fragment)
- Continuation Fragment (non-Final or Final)

Table 640. Preemption Control Values on MTI Interface for Various Frame Types

Qualifier	Preemption Control Value	Frame Type
SoF	00	Start Express
SoF	01	Start Preemption

Table continues on the next page...

Table 640. Preemption Control Values on MTI Interface for Various Frame Types (continued)

Qualifier	Preemption Control Value	Frame Type
SoF	10	Continuation Fragment
SoF	11	Reserved
EoF	00	End of Frame
EoF	01	End of Fragment

MTL should wait for the previous fragment status to be received before resuming the continuation fragments of a preempted frame. Fragment status is described in detail in the Tx Fragment Status section.

78.9.12.4.1 MAC Tx Preemption

MAC supports preemption by implementing the functionality needed to generate the mPackets as described in “mPacket Format”.

Based on the Preemption Control value received on the MTI interface (qualified with SoF and EoF), MAC determines the frame type (shown in the above table 'Preemption Control Values on MTI Interface for Various Frame Types') and generates mPackets accordingly.

When the preemption capability is active, MAC replaces the SFD of a preemption packet with an SMD-S value. A 2-bit rolling frame count is encoded in the SMD-S value.

The SMD-E value is the same as the SFD value so the SFD of an express packet does not need to be replaced.

78.9.12.4.1.1 Tx Fragment Status

MAC sends Tx fragment status to indicate successful transmission of fragmented mPackets.

In case of a transmission error (underflow, jabber, and so on) the frame status is sent (and not a fragment status) with an error indication along with all other relevant status fields. In case of receiving an error status for a transmitted fragment, the MTL drops the remaining fragments and does not send any more continuation fragments.

78.9.12.5 Receive Preemption

78.9.12.5.1 MAC Receive Preemption

When FPE is enabled, the MAC Receiver passes the incoming packets and differentiates between Express packets and preemptable packets. An SMD containing an SMD-E indicates express packet, and SMD containing an SMD-S indicates the first mPacket of a preemptable packet.

If an mPacket containing an SMD-S is received when MAC has not completed receiving the previous preempted packet, MAC sets a CRC Error status for the previously received partial packet.

When an SMD-S is detected, MAC records the frame count indicated by the SMD and then begins sending data on the MRI interface.

The MAC checks the last four bytes of the mPacket . If the last four bytes of the mPacket do not match CRC, that indicates the end of the packet with or without a CRC error as per the CRC check result. If the last four octets of the mPacket match, that indicates that the packet was preempted.

An SMD containing an SMD-C indicates an mPacket that continues the data for a preempted packet. Upon receiving an SMD value of SMD-C, MAC checks the following:

1. A preempted packet is in progress
2. The frame count indicated by the SMD matches the frame count of the packet in progress
3. The frag_count value indicates the next fragment count.

If any of the above check fails, the mPacket is discarded and MAC sets a CRC Error status for the partially received packet.

If all the checks pass, the next fragment count is incremented modulo 4.

When a packet is preempted, the MAC saves the state of the partially received packet (filter check status, timestamp, length fields etc.) and will be able to process any received Express packets before the continuation fragment is received.

The MAC Receiver sends a "dummy status" for all the mPacket fragments successfully received and sends the Rx status with the final fragment. If an error is detected during any of the fragments the Rx status is sent and the fragment is marked as final fragment. All subsequent continuation fragments received for this packet are dropped in the MAC.

The MAC communicates the following frame type information to the MTL using a 2-bit preemption control signal.

1. Express Frame
2. Preemption Frame (Full or Fragment)
3. Continuation Fragment (non-Final or Final)

Table 641. Preemption Control Values on MRI Interface for Various Frame Types

Qualifier	Preemption Control Value	Frame Type
SoF	00	Start Express
SoF	01	Start Preemption
SoF	10	Continuation Fragment
SoF	11	Reserved
EoF	00	End of Frame
EoF	01	End of Fragment

78.9.12.5.1.1 Data Alignment

When a received frame cannot be fragmented on any byte boundary, MAC retains the unaligned bytes of data in the previous fragment and resends them with the next fragment as shown in the following figure.

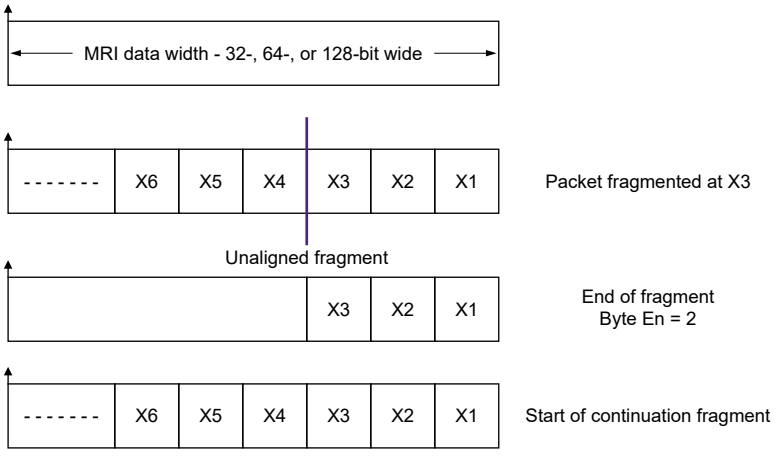

Figure 576. Data Alignment Feature of MAC

78.9.12.5.1.2 MTL Receive Preemption

The MTL Rx must have at least 2 Rx queues to support FPE function as the preemptable packets and the express packets must be routed to separate Rx queues. The destination Rx queue of a received packet is controlled by MAC_RxQ_Ctrl[n] registers. Program these registers such that Preemptable traffic and express traffic are not routed to the same Rx queue. As the queue mapping for tagged packets is based on VLAN user-priority field, this implies that priority of preemptable and express packets are mutually exclusive. In other words, packets of a certain priority (traffic class) are either express or preemptable but cannot be both.

For the preemptable frames, in addition to the PSRQ (Priority Selected in Rx queue) based queue routing, a programmable "Frame Preemption Residue Queue" (FPRQ) is supported to route all other Preemption Packets received (Untagged, SA/ DA or VLAN Filter Fails forwarded due to RA being set or VTFE being reset).

Table 642. Preemption Control Values on MRI Interface for Various Frame Types

Preemption Packet Type	Queue Routing
AV Tagged Packets passing the SA/DA and VLAN filters	PSRQ*
DCB/Generic Tagged Packets passing the SA/DA and VLAN filters	PSRQ**
Tagged Packets failing the SA/DA and VLAN filters without setting the Receive All (RA = 0) or setting VTFE = 1	Dropped
All other packets OR when RA = 1	FPRQ

78.9.12.5.1.3 MTL Receive Arbitration

On the ARI Interface, data is fetched from the MTL Rx FIFO based on the arbitration selected in the MTL_Operation_Mode register. Frame based arbitration can be used only when all the MTL Preemption Queues are operating in Store and Forward mode, else there will be loss of bandwidth on the ARI interface because all the fragments of a preemptable packet is not available. Therefore, any express packets received between the fragments are blocked until all the fragments are received and transferred; this defeats the purpose of express traffic.

When operating in either Threshold (cut through) or Store and forward modes of operation, PBL based arbitration is recommended over Frame based arbitration. In case of PBL based arbitration, the watermark check is always performed and the arbitration/ transfer of data in terms of chunks of "PBL" size of data which is almost similar to the concepts of "fragments". Therefore the express queue packets get blocked for less time as well as the ARI interface transfers the data without loss of efficiency.

78.9.12.6 Verify and Respond mPackets

When FPE function is present, the MAC can receive and detect the Verify and Respond mPackets, even when FPE is not enabled by software. When MAC detects valid Verify/Respond mPackets, it notifies the software by setting the RVER and RRSP fields of MAC_FPE_CTRL_STS register respectively. Optionally an interrupt can be generated. As such packets have empty (all-zero) data payload, they are dropped inside the MAC and not forwarded to the MRI.

Software can set the SVER and SRSP fields of MAC_FPE_CTRL_STS register to request MAC to transmit Verify and Respond mPackets respectively. Upon successful transmission of these frames, MAC clears the SVER/SRSP bits and sets the TVER & TRSP fields of MAC_FPE_CTRL_STS register. Optionally an interrupt can be generated when these events occur.

Software must ensure that frame preemption verify and response packet are not triggered at the same time. Trigger either of the packets and then wait for its completion before triggering another packet.

78.9.12.7 Frame Preemption and MMC Counter and Interrupt Registers

The following MMC counters and associated Interrupt registers are instantiated/present in the MAC when Frame Preemption feature is enabled.

Table 643. MMC Counters and Associated Interrupt Registers

Frame Assembly Error Counter	Description	Associated MMC Counter
Frame Assembly Error Counter	A 32-bit counter that provides the number of MAC frames with reassembly errors on the Receiver, due to mismatch in the Fragment Count value.	MMC_Rx_Packet_Assembly_Err_Cntr
Frame SMD Error Counter	A 32-bit counter that provides the number of received MAC frames rejected due to arriving with an SMD-C when there was no preceding preempted frame.	MMC_Rx_Packet_SMD_Err_Cntr
Frame Assembly OK Counter	A 32-bit counter that provides the number of MAC frames that were successfully reassembled.	MMC_Rx_Packet_Assembly_Ok_Cntr
MAC Rx Fragment Counter	A 32-bit counter that provides the number of additional mPackets received due to preemption.	MMC_Rx_FPE_Fragment_Cntr
MAC Tx Fragment Counter	A 32-bit counter that provides the number of additional mPackets transmitted due to preemption.	MMC_Tx_FPE_Fragment_Cntr
Hold Request Counter	A 32-bit counter that maintains the count of number of times a hold request is given to MAC.	MMC_Tx_Hold_Req_Cntr

78.9.12.7.1 Additional Registers Associated With MMC Interrupts

Following are the additional registers associated with MMC interrupts for the MMC error counters:

- MMC_FPE_Tx_Interrupt
- MMC_FPE_Tx_Interrupt_Mask
- MMC_Rx_Interrupt
- MMC_FPE_Rx_Interrupt_Mask

78.9.13 Time-Based Scheduling

Time-based scheduling feature is suitable for traffic whose periodicity and rate are predictable. To improve the quality-of-service of such traffic,

- The transmit DMA fetches the packet from the host memory for transmission at designated time. This helps the software to setup the Transmit descriptors in advance even before packet is ready/available. It reduces the overhead on the software and avoids constant monitoring of the time and preparing descriptors just in time when the packet is targeted to be transmitted.
- The MAC transmits the packet only at the designated/pre-determined time even if the packets are fetched in advance. This helps in maintaining a constant transmission rate that can be consumed by the receiver station; therefore avoiding congestion and excessive buffering in the network.

The time-based scheduling feature supports fetching and launching an Ethernet packet at (or after) a pre-determined time. The time-based scheduling is supported only in the following modes/configurations:

- Full duplex mode
- Link speed is 100Mbps or higher

The following figure shows the time-based scheduling flow.

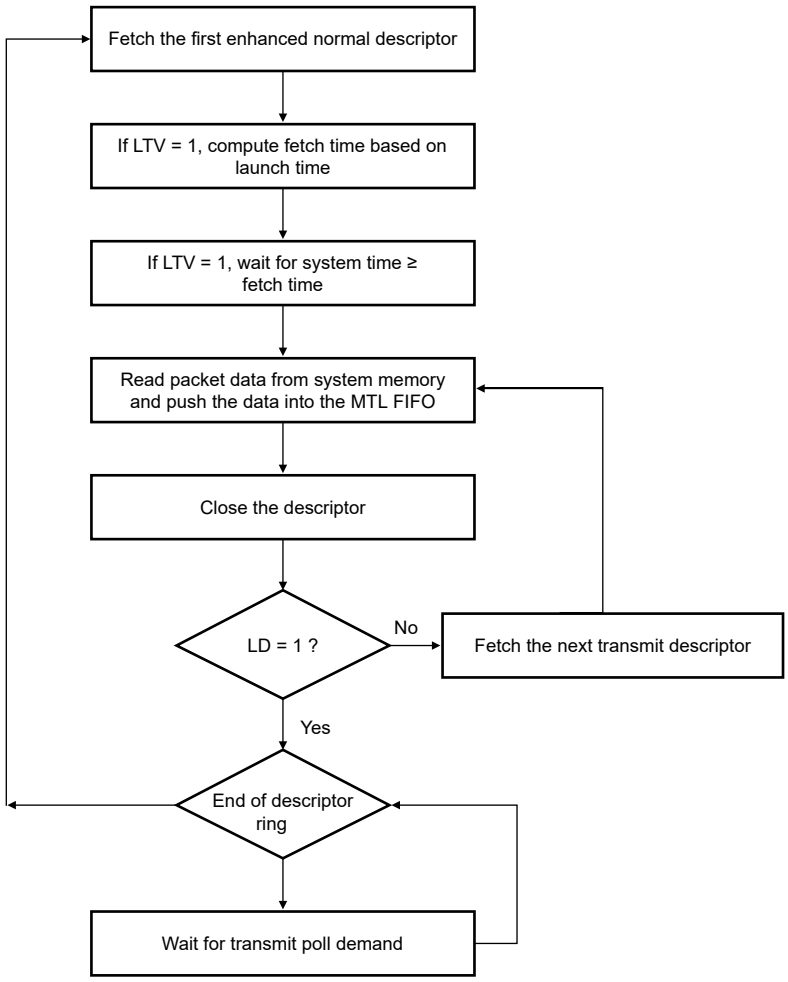

Figure 577. Time-Based Scheduling Flow

Following are the definitions specific to the time-based scheduling feature:

78.9.13.1 Launch time

The time beyond which MTL can schedule the packet for transmission. The launch time resets after the transmission of one frame. These are the two formats of the launch time.

Normal or absolute format:

In this format, the launch time is interpreted in the normal or absolute format if the ESTM bit of the MTL_TBS_CTRL register is set to 0.

The launch time is a 32-bit value, where most-significant 8-bits represent the time in seconds and the rest 24-bits represent the time in 256 ns. The launch time is compared against the IEEE 1588 based system or PTP time (bits[39:8]) and rolls over after 256 seconds.

The maximum value of the lower 32-bits of system time is 999,999,999 decimal (0x3B9AC9FF) and it wraps to 0 when reaching this value (representing a full second). Therefore, the maximum value of the lower 24-bits of the launch time (after multiplying by 256) must be 0x3B9AC9.

As the maximum value of launch time is 256 seconds,

- Launch time is greater than current system time when its value is between system time[39:8] and System time[39:8] + 128 sec.

- Launch time is less than current system time when its value is between System Time[39:8] + 128sec and System Time[39:8] + 256 sec, because this is a modulo 256 computation.

EST or offset format

In this format, the launch time is a offset value relative to the time which the BTR of the GCL list provided in the GCL slot number (GSN) indicates. The value in the BTR is always updated to the start time of the current loop of the GCL.

For each packet, the GSN value and the launch time value are specified in the enhanced transmit descriptor in the DMA configurations, or as control word in the MTL configurations.

The launch time offset is a 32-bit value; the upper 8-bits represent the time in seconds and the rest 24 bits represent the time in 256 ns, which is added to the BTR value corresponding to GCL slot number. The value of the launch time offset must be smaller than the value of the cycle time (specified in the CTR register that is implemented when EST is enabled). If the CTR is greater than or equal to 1s, the maximum value of the lower-24 bits of launch time offset must be 999,999,999 decimal (0x3B9AC9FF).

In this format, the launch time is a 64-bit value, which is interpreted as, Launch time = Launch GSN BTR[63:0] + (Launch time offset[31:0] << 8), which is compared with the system time [63:0].

GSN BTR is the Base Time value at which the Launch GSN loop started execution.

GCL slot number (GSN) A modulo 16 count of the GCL loop count is implemented and it is known as GSN. The count is incremented for every new GCL loop. Installation of new GCL list does not impact the count. Read MTL_EST_Status[CGSN] to obtain the current GCL slot number.

The maximum value of GSN is 15. Therefore the GSN values between MTL_EST_Status[CGSN] and MTL_EST_Status[CGSN]+8 represent current or future slots and all other GSN values are interpreted as elapsed slots or past slots. So, for the correct interpretation of time, GSN value must be between MTL_EST_Status[CGSN] and MTL_EST_Status[CGSN]+8.

78.9.13.2 Launch expiry time

Normal or Absolute Mode

In this mode, when MTL_TBS_CTRL[LEOV] = 1, MTL_TBS_CTRL[LEOS] determines the maximum amount of time a frame is eligible for launch, starting from the time the frame becomes eligible for launch.

The launch expiry offset is a 24-bit value defined in 256 ns units, with a maximum possible value of 999,999,999 ns (0x3B9AC9FF).

Launch expiry time = (Launch time[39:8] + LEOS[32:8]) * 256 ns

The packet with a specific launch time is considered as eligible for transmission when the launch time is less than the system time and (if MTL_TBS_CTRL[LEOV] = 1) the system time is less than the launch expiry time.

When the system time is greater than the launch expiry time, the frame is categorized as expired and it drops from the MTL FIFO.

NOTE

- For correct interpretation and meaningful operation, the fetch, launch, and launch expiry time must never set to a value larger than the Current system time + 128 sec; such a value is interpreted as time that has already elapsed.
- In Full Duplex mode, the frames dropped from the MTL FIFO have error summary (Bit 15) and excessive deferral (bit 3) of TxStatus set.

EST/Offset Mode

In EST mode, when MTL_TBS_CTRL[LEOV] = 1, MTL_TBS_CTRL[LEGOS] and MTL_TBS_CTRL[LEOS] determines the maximum amount of time a frame remains eligible for launch, starting from the time the frame becomes eligible for launch.

Launch Expiry Offset = (LEGOS: LEOS)

LEGOS holds the GSN offset (multiples of CTR time) and LEOS holds maximum value of CTR (sub CTR values) in ns.

Launch expiry offset is a 24-bit value defined in the units of 256 ns, with a maximum possible value of the smaller of 999,999,999 ns or CTR-1 ns.

The Launch expiry GSN is computed as follows:

Launch expiry GSN = (Launch GSN + LEGOS + CCMA) where, CCMA is the CTR carry due to modulo addition. This value is 1 if ((Launch time offset + LEOS) << 8) is equal to or greater than CTR.

When CCMA = 1, Launch expiry offset = (Launch time offset+ LEOS) - CTR

When CCMA = 0,

Launch expiry offset = (Launch time offset + LEOS).

Launch expiry time = Launch expiry GSN BTR [63:0] + Launch expiry time offset.

When MTL_TBS_CTRL[LEOV] is not 1, the launch expiry time is not checked.

When MTL_TBS_CTRL[LEOV] = 1, and

- the system time is greater than the launch expiry time, the frame drops from MTL FIFO. Then the frame is considered as expired.
- the launch time is smaller than the system time and the launch expiry time is greater than the system time, then the frame is considered eligible for launch.

NOTE

- Max value of MTL_TBS_CTRL[LEGOS] is 7. This indicates that when MTL_TBS_CTRL[LEOV] = 1, the frame has a maximum life time of <8 GCL loop iterations after it becomes eligible for launch.
- The slot number of the first GCL list that executes each time after EST is enabled, is zero.

78.9.13.3 Fetch time

This accounts for all possible delays in the DMA fetch operation and ensures that the frame is present in the MTL FIFO before the launch time.

If DMA_TBS_CTRL[FTOV] is 1, it indicates the fetch time for each packet. If DMA_TBS_CTRL[FTOV] is not 1, it indicates that the fetch time offset is not valid and DMA fetches packets without any time constraints.

Normal/Absolute mode

In this mode fetch time is derived or calculated by reducing the time specified in DMA_TBS_CTRL[FTOS] from the given launch time.

In Normal mode, the fetch launch time is computed as:

Fetch Time[39:8] = (Launch Time[39:8] - FTOS[31:8])

The fetch time is 32-bits and is compared against the system time[39:8] to determine whether it is eligible for fetching the frame:

- The fetch time is defined as greater than system time if the fetch time is in the range of system time[39:8]" and system time[39:8] + 128 sec. The frame is considered as not-eligible for fetch.
- The fetch time is defined as smaller than the system time if the fetch time is in the range of system time[39:8] + 128 sec and system time[39:8] + 256 sec. The frame is considered as eligible for fetch.

This is a modulo 256 computation.

EST/Offset mode

In this mode, the fetch GSN offset (DMA_TBS_CTRL[FGOS]) provides the slot number offset to deduct from the launch GSN. In this case the FTOS value must be smaller than 999,999,999 ns or CTR-1 ns.

If (Launch time offset >= FTOS):

Fetch time offset = ((Launch time offset - FTOS) * 256ns)

CBFS(CTR borrow for fetch subtraction) = 0

If (Launch time offset < FTOS) Fetch time offset = CTR + ((Launch time offset - FTOS) * 256ns)

CBFS (CTR borrow for fetch subtraction) = 1

The fetch GSN is computed as follows:

Fetch GSN = Launch GSN - FGOS - CBFS

Fetch time = Fetch GSN BTR[63:0] + Fetch time offset

The frame is eligible for DMA fetch when the fetch time is smaller than the system time.

DMA operations sequence

This is the sequence of operation when FTOV = 1:

1. Fetch the first enhanced normal descriptor (FD = 1).
2. Compute the fetch time on the basis of the launch time and wait for the system time to be greater than fetch time, if LTV = 1 and fetch is enabled.
3. Read the frame (data) from the host memory and transfer to MTL FIFO.
4. Close the normal descriptor.
5. Fetch the next normal descriptor (if the previous descriptor was not the last).
6. Repeat steps 4 to 6, until the last descriptor of the frame (LD = 1).

After the last descriptor of a frame, program the next enhanced normal descriptor with a new launch time and with LTV = 1. Otherwise, process the subsequent frames without any time restrictions.

See Programming the launch time in time-based scheduling for more information.

78.10 TCP/IP Offloading Features

This section and all other sections, along with respective sub-sections are Synopsys Proprietary. Used with permission.

78.10.1 Transmit Checksum Offload Engine

The MAC has a Checksum Offload Engine (COE) to support checksum calculation and insertion in the Transmit path, using which, the software can offload the task of checksum insertion to the hardware. In the transmit path MAC calculates the checksum and inserts it in the Tx packet. This feature helps in reducing the load on the software and can improve the overall throughput of the system. This feature is supported for only Q0 queue.

The checksum offload engine module supports two types of checksum calculation and insertion. The checksum engine can be controlled for each packet by setting the CIC bits (TDES3 Bits[17:16]).

Note: The checksum for TCP, UDP, or ICMP is calculated over a complete packet, and then inserted into its corresponding header field. Because of this requirement, when this function is enabled, the Tx FIFO automatically operates in the store-and-forward mode even if IP is configured for Threshold (cut-through) mode.

78.10.1.1 IP Header Checksum Engine

In IPv4 datagrams, the integrity of the header fields is indicated by the 16-bit Header Checksum field (the eleventh and twelfth bytes of the IPv4 datagram). The COE detects an IPv4 datagram when the Type field of Ethernet packet has the value 0x0800 and the Version field of IP datagram has the value 0x4. The checksum field of the input packet is ignored during calculation and replaced with the calculated value.

NOTE

IPv6 headers do not have a checksum field. Therefore, the COE does not modify the IPv6 header fields.

The result of this IP header checksum calculation is indicated by the IP Header Error status bit in the Transmit status (Bit 0 in Table 19-12 on page 1330). This status bit is set whenever the values of the Ethernet Type field and the Version field of IP header are not consistent, or when the Ethernet packet does not have enough data, as indicated by the IP header Length field. In other words, this bit is set when an IP header error is asserted under the following circumstances:

- For IPv4 datagrams:
  - The received Ethernet type is 0x0800, but the Version field of IP header is not equal to 0x4.
  - The IPv4 Header Length field indicates a value less than 0x5 (20 bytes).
  - The total packet length is less than the value given in the IPv4 Header Length field.
- For IPv6 datagrams:
  - The Ethernet type is 0x86dd but the IP header Version field is not equal to 0x6.
  - The packet ends before the IPv6 header (40 bytes) or extension header (as given in the corresponding Header Length field in an extension header) is completely received.

78.10.1.2 TCP/UDP/ICMP Checksum Engine

The TCP/UDP/ICMP Checksum Engine processes the IPv4 or IPv6 header (including extension headers) and determines whether the encapsulated payload is TCP, UDP, or ICMP. The checksum is calculated for the TCP, UDP, or ICMP payload and inserted into its corresponding field in the header. The Tx COE can work in the following two modes:

- The TCP, UDP, or ICMPv6 pseudo-header is not included in the checksum calculation and is assumed to be present in the Checksum field of the input packet. This engine includes the Checksum field in the checksum calculation, and then replaces the Checksum field with the final calculated checksum.
- The engine ignores the Checksum field, includes the TCP, UDP, or ICMPv6 pseudo-header data into the checksum calculation, and overwrites the checksum field with the final calculated value.

NOTE

For ICMP-over-IPv4 packets, the Checksum field in the ICMP packet must always be 16'h0000 in both modes, because pseudo-headers are not defined for such packets. If it does not equal 16'h0000, an incorrect checksum may be inserted into the packet.

The result of this operation is indicated by the Payload Checksum Error status bit in the Transmit Status vector (Bit 12 in Table 19-3 on page 1324). This engine sets the Payload Checksum Error status bit when it detects that the packet has been forwarded to the MAC Transmitter engine in the store-and-forward mode without the end of packet (EOP) being written to the FIFO, or when the packet ends before the number of bytes indicated by the Payload Length field in the IP Header is received. When the packet is longer than the indicated payload length, the COE ignores them as stuff bytes, and no error is reported. When this engine detects the first type of error, it does not modify the TCP, UDP, or ICMP header. For the second error type, it still inserts the calculated checksum into the corresponding header field. Following table describes the functions supported by Transmit Checksum Offload engine based on the packet type. When the MAC does not insert the checksum, it is indicated as "No" in the table.

NOTE

You should not enable checksum insertion for IPv4 or IPv6 packets that are greater than the frame size constraint specified in Description of Transmit Checksum Offload Engine because it may result in incorrect checksum insertion or unexpected behavior.

Table 644. Transmit Checksum Offload Engine Functions for Different Packet Types

Packet Type	Hardware IP headerchecksum insertion	Hardware TCP/ UDPchecksum insertion
Non-IPv4 or IPv6 packet	No	No
IPv4 packet is greater than 1,522 bytes (2,000 bytes when IEEE 802.3ad Support for 2K Packets is enabled in MAC) but less than or equal to the frame size constraint specified in Transmit Checksum Offload Engine.	Yes	Yes

Table continues on the next page...

Table 644. Transmit Checksum Offload Engine Functions for Different Packet Types (continued)

Packet Type	Hardware IP headerchecksum insertion	Hardware TCP/ UDPchecksum insertion
IPv6 packet is greater than 1,522 bytes (2,000 bytes when IEEE 802.3ad Support for 2K Packets is enabled in MAC) but less than or equal to the frame size constraint specified in Transmit Checksum Offload Engine.	Not Applicable	Yes
IPv4 with TCP, UDP, or ICMP	Yes	Yes
IPv4 packet has IP options (IP header is longer than 20 bytes)	Yes	Yes
Packet is an IPv4 fragment	Yes	No
IPv6 packet with the following next header fields in main or extension headers: • Hop-by-hop options (in IPv6 main header) • Hop-by-hop options (in IPv6 extension header) • Destinations options • Routing (with segment left 0) • Routing (with segment left > 0) • TCP, UDP, or ICMP • Authentication • Any other next header field in main or extension headers	• Not Applicable • Not Applicable • Not Applicable • Not Applicable • Not Applicable • Not Applicable • Not Applicable • Not Applicable	• Yes • No • Yes • No • No • Yes • No • No
IPv4 packet has TCP header with Options fields	Yes	Yes
IPv4 Tunnels: • IPv4 packet in an IPv4 tunnel • IPv6 packet in an IPv4 tunnel	• Yes (IPv4 tunnel header) • Yes (IPv4 tunnel header)	• No • No
IPv6 Tunnels: • IPv4 packet in an IPv6 tunnel • IPv6 packet in an IPv6 tunnel	• Not applicable • Not applicable	• No • No
IPv4 packet has 802.3ac tag (with C-VLAN Tag or S-VLAN Tag when enabled).	Yes	Yes
IPv6 packet has 802.3ac tag (with C-VLAN Tag or S-VLAN Tag when enabled).	Not applicable	Yes
IPv4 frames with security features (such as encapsulated security payload)	Yes	No
IPv6 frames with security features (such as encapsulated security payload)	Not applicable	No

78.10.2 Receive Checksum Offload Engine

IP provides the Checksum Offload Engine that is used to detect any error in an IPv4 or IPv6 packet in the receive path. The MAC verifies the checksum field of the received packet with the internally calculated checksum and provides the status.

The Receive Checksum Offload engine is used to detect errors in IP packets by calculating the header checksum and further matching it with the received header checksum. This engine also identifies a TCP, UDP, or ICMP payload in received IP packets and calculates the checksum of such payloads appropriately.

Here, both IPv4 and IPv6 packet in the received Ethernet packets are detected and processed for data integrity. The MAC receiver identifies IPv4 or IPv6 packets by checking for value 0x0800 or 0x86DD, respectively, in the Type field of the received Ethernet packet. This identification is applicable to single VLAN-tagged packets. It is also applicable to double VLAN-tagged packets when the Enable Double VLAN Processing option is selected and the EDVLP bit of the MAC_VLAN_Tag register is set.

The Rx COE calculates the IPv4 header checksums and checks that they match the received IPv4 header checksums. The result of this operation (pass or fail) is given to the RFC module for insertion into the receive status word. The IP Header Error bit is set for any mismatch between the indicated payload type (Ethernet Type field) and the IP header version, or when the received packet does not have enough bytes, as indicated by the Length field of the IPv4 header (or when fewer than 20 bytes are available in an IPv4 or IPv6 header).

This engine also identifies a TCP, UDP, or ICMP payload in the received IP datagrams (IPv4 or IPv6) and calculates the checksum of such payloads properly, as defined in the TCP, UDP, or ICMP specifications. This engine includes the TCP, UDP, or ICMPv6 pseudo-header bytes for checksum calculation and checks whether the received checksum field matches the calculated value. The result of this operation is given as a Payload Checksum Error bit in the receive status word. This status bit is also set if the length of the TCP, UDP, or ICMP payload does not match the expected payload length given in the IP header.

Following table describes the functions supported by the Rx COE based on the packet type. When the payload of an IP packet is not processed (indicated as "No" in the table), the information (whether the checksum engine is bypassed or not) is given in the receive status.

NOTE

The MAC does not append any payload checksum bytes to the received Ethernet packets.

Table 645. Receive Checksum Offload Engine Functions for Different Packet Types

Packet type	Hardware IP header checksum checking	Hardware TCP/UDP/ICMP checksum checking
Non-IPv4 or IPv6	No	No
IPv4 packet is greater than 1,522 bytes (2,000 bytes when IEEE 802.3ad Support for 2K Packets is enabled in the MAC)	Yes	Yes
IPv6 packet is greater than 1,522 bytes (2,000 bytes when IEEE 802.3ad Support for 2K Packets is enabled in the MAC)	Not Applicable	Yes
IPv4 with TCP, UDP, or ICMP	Yes	Yes
IPv4 header's protocol field contains a protocol other than TCP, UDP, or ICMP	Yes	No

Table continues on the next page...

Table 645. Receive Checksum Offload Engine Functions for Different Packet Types (continued)

Packet type	Hardware IP header checksum checking	Hardware TCP/UDP/ICMP checksum checking
IPv4 packet has IP options (IP header is longer than 20 bytes)	Yes	Yes
Packet is an IPv4 fragment	Yes	No
IPv6 packet with the following next header fields in main or extension headers: • Hop-by-hop options (in IPv6 main header) • Hop-by-hop options (in IPv6 extension header) • Destinations options • Routing (with segment left 0) • Routing (with segment left > 0) • TCP, UDP, or ICMP • Any other next header field in main or extension headers	• Not Applicable • Not Applicable • Not Applicable • Not Applicable • Not Applicable • Not Applicable • Not Applicable	• Yes • No • Yes • Yes • No • Yes • No
IPv4 packet has TCP header with Options fields	Yes	Yes
IPv4 Tunnels: • IPv4 packet in an IPv4 tunnel • IPv6 packet in an IPv4 tunnel	• Yes (IPv4 tunnel header) • Yes (IPv4 tunnel header)	• No • No
IPv4 Tunnels: • IPv4 packet in an IPv6 tunnel • IPv6 packet in an IPv6 tunnel	• Not Applicable • Not Applicable	• No • No
IPv4 packet has 802.3ac tag (with C-VLAN Tag or S-VLAN Tag when enabled)	Yes	Yes
IPv6 packet has 802.3ac tag (with C-VLAN Tag or S-VLAN Tag when enabled)	Not Applicable	Yes
IPv4 frames with security features (such as encapsulated security payload)	Yes	No

Table continues on the next page...

Table 645. Receive Checksum Offload Engine Functions for Different Packet Types (continued)

Packet type	Hardware IP header checksum checking	Hardware TCP/UDP/ICMP checksum checking
IPv6 frames with security features (such as encapsulated security payload)	Not Applicable	No

Set the IPC bit of the MAC_Configuration register for enabling Receive Checksum offload.

78.11 MAC Management Counters

This section is Synopsys Proprietary. Used with permission.

IP supports storing the statistics about the received and transmitted packets in registers that are accessible through the application/software. The MMC module maintains a set of registers for gathering statistics on the received and transmitted packets. The MMC counters are free running.

For MMC register details, see registers "MMC_Control" to "MMC_Rx_FPE_Fragment_Cntr" in EMAC register descriptions.

78.12 Flow Control

This section and its sub-sections are Synopsys Proprietary. Used with permission.

78.12.1 Transmit Flow Control

The Transmit Flow Control involves transmitting Pause packets in full-duplex mode and backpressure in half-duplex mode to control the flow of packets from the remote end.

78.12.1.1 Flow control in Full duplex mode

IP supports the IEEE802.3x Pause Packets.

Pause packet structure is shown in the following table.

Table 646. Pause Packet Fields

Field	Description
DA	Contains the special multicast address
SA	Contains the MAC address 0
Type	Contains 8808
MAC Control opcode	Contains 0001 for IEEE 802.3x Pause Control packets; 0101 for PFC packets
PT	Contains Pause time specified in the PT field of the MAC_Q#_Tx_Flow_Ctrl register

78.12.1.2 Pause Packet Control

When the FCB bit is set, the MAC generates and transmits a single Pause packet. If the FCB bit is set again after the Pause packet transmission is complete, the MAC sends another Pause packet irrespective of whether the pause time is complete or not. To extend the pause or terminate the pause prior to the time specified in the previously-transmitted Pause packet, the application should program the Pause Time register with appropriate value and then again set the FCB bit.

78.12.1.3 Flow Control in Half-Duplex Mode

In half-duplex mode, the MAC uses the deferral mechanism for the flow control (backpressure). When the application requests to stop receiving packets, the MAC sends a JAM pattern of 32 bytes when it senses a packet reception, provided the transmit flow control is enabled. This results in a collision and the remote station backs off. If the application requests a packet to be transmitted, it is scheduled and transmitted even when the backpressure is activated. If the backpressure is kept activated for a long time (and more than 16 consecutive collision events occur), the remote stations abort the transmission because of excessive collisions.

Following table describes the flow control in the Tx path for Queue 0 based on the setting of the following bits:

- EHFC bit of MTL_RxQ0_Operation_Mode register
- TFE bit of MAC_Q0_Tx_Flow_Ctrl register
- DM bit of MAC_Configuration register

Flow control is similar for all queues.

Table 647. Tx MAC Flow Control

EHFC	TFE	DM	Description
x	0	x	The MAC transmitter does not perform the flow control or backpressure operation.
0	1	0	The MAC transmitter performs back-pressure when Bit 0 of MAC_Q0_Tx_Flow_Ctrl register is set or the sideband signal sbd_flowctrl_i is 1.
1	1	0	The MAC transmitter performs back-pressure when Bit 0 of MAC_Q0_Tx_Flow_Ctrl register is set or the sideband signal sbd_flowctrl_i is 1. In addition, the MAC Tx performs back-pressure when Rx Queue level crosses the threshold set by Bits[10:8] of MTL_RxQ0_Operation_Mode register.
0	1	1	The MAC transmitter sends the Pause packet when Bit 0 of MAC_Q0_Tx_Flow_Ctrl register is set or the sideband signal sbd_flowctrl_i is 1.
1	1	1	The MAC transmitter sends the Pause packet when Bit 0 of MAC_Q0_Tx_Flow_Ctrl register is set or the sideband signal sbd_flowctrl_i is 1. In addition, the MAC Tx sends a Pause packet when Rx Queue level crosses the threshold set by Bits[10:8] of MTL_RxQ0_Operation_Mode register.

78.12.1.4 Enabling Transmit Flow Control

To independently enable Transmit Flow Control for each Tx queue, set the TFE bit in the MAC_Q#_Tx_Flow_Ctrl register.

78.12.2 Receive Flow Control

In the Receive path, the Flow Control is functional only in the full-duplex mode. If any Pause packet is received in the half-duplex mode, the packet is considered as a normal control packet.

NOTE

Receive pause packets should have a frame size of 64 bytes.

The Receive Flow Control is implemented by the MAC based on the bit value of the respective register, and the destination address and different fields of the received packet.

Following table describes the flow control in the Rx path based on the setting of the following bits:

- RFE bit of MAC_Rx_Flow_Ctrl register
- DM bit of MAC_Configuration register

Table 648. Rx MAC Flow Control

RFE	DM	Description
0	x	The MAC receiver does not detect the received Pause packets.
1	0	The MAC receiver does not detect the received Pause packets but recognizes such packets as Control packets.
1	1	The MAC receiver detects or processes the Pause packets and responds to such packets by stopping the MAC transmitter.

78.12.2.1 Enabling Receive Flow Control

To enable Pause Flow Control, set the RFE bit in the MAC_Rx_Flow_Ctrl register.

78.13 Loopback Mode

This section is Synopsys Proprietary. Used with permission.

The MAC supports Loopback of transmitted packets to its receiver.

The following are some guidelines for using the loopback mode:

- Enable loopback only with the full-duplex mode. In half-duplex mode, the carrier sense signal (crs) or collision (col) signal inputs get sampled which may result into issues such as packet dropping.
- If the loopback mode is enabled without connecting a PHY chip (for example, in FPGA setup), you should externally generate the Tx and Rx clocks and provide these clocks to the MAC.
- Do not loop back big packets. Big packets (>1522 bytes) may get corrupted in the loopback FIFO.

To enable this feature, program the LM bit of the MAC_Configuration register.

You can enable loopback for all PHY interfaces. The data is always looped back through internal asynchronous FIFO on to the internal Receive MII or GMII interface, irrespective of which PHY interface is selected. The loopback data is also passed through the corresponding transmit PHY interface block, on to the Ethernet line.

78.14 Automotive Safety Features

This section and all its sub-sections are Synopsys Proprietary. Used with permission.

IP supports the automotive safety feature.

78.14.1 Error Correction Code (ECC) Protection for Memories

The Error Correction Code (ECC) block can correct single-bit error and detect double-bit error.

At the write interface, ECC checkbits are generated by computing ECC on the contents of the data bus and respective address is appended with the data that is written to the memory.

At the read interface, ECC checkbits are recomputed on the content of the read data and the respective address is compared with the received checkbits in the memory.

Following figure shows the block diagram of ECC protection for memories

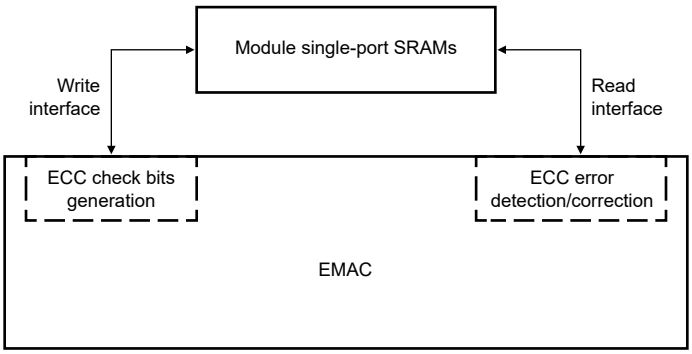

Figure 578. Block Diagram of ECC Protection for Memories

78.14.1.1 Handling the Address Mismatch

The ECC is calculated over the sum of memory data and memory location address. However only data is written in the memory along with the ECC(address is excluded).

On the read interface, the ECC is checked over the sum of memory DATA, memory ECC, and Internally generated address. When an ECC correctable error is detected over the range of the address bit position, it is treated as an uncorrectable error. This is because data might have been read from a different location.

78.14.1.2 Diagnostic Support for the Error Management

Following statistics are provided for monitoring the error behavior on each of the memory blocks.

- Error status provided to management
  - A separate status for correctable, uncorrectable, and address mismatch is specified in the MTL_ECC_Interrupt_Status register.
  - Memory locations at which correctable and uncorrectable errors are detected is specified in the MTL_ECC_Err_Addr_Status register. In addition, a control bit (MEEAO field of MTL_ECC_Control register) decides, whether the first errored memory address is reported or the latest errored memory address is reported.
  - MTL_ECC_Err_Cntr_Status register has separate counters to count the number of correctable and uncorrectable errors
- Interrupts provided to management
  - Separate interrupts are generated for correctable and uncorrectable errors.
  - sbd_sfty_ue_intr_o interrupt is generated when uncorrectable errors are detected and these errors cannot be masked.
  - sbd_sfty_ce_intr_o interrupt is generated when correctable errors are detected. The module sets the respective interrupt enable bits (in the DMA/MTL_ECC_Interrupt_enable register).
  - To find the root cause of the error, read the DMA/MTL_Safety_Interrupt_Status and DMA/MTL_ECC_Interrupt_Status registers.
  - To clear the interrupt, write 1 in the respective interrupt status bit in DMA/MTL_ECC_Interrupt_Status registers.

NOTE

- The status/counters/interrupts are generated per memory.
- MTL Tx and Rx memory is logically divided into multiple queues. But, ECC diagnostics (status/counter/interrupts) are common to all queues.

78.14.1.3 ECC Error Injection Capabilities

IP supports error injection capabilities for each memory as a static configuration. The position where the errors are injected in the data word is random. For each memory, 3 control bits are provided to inject errors. The 3 bits are:

- A single bit to enable error injection
- Two bits to indicate the type of error to be injected ❑ 00: 1 bit error
  - 01: 2 bit error
  - 10: 3 bit error
  - 11: 1 bit error in address field

The control bit descriptions for

- MTL Tx/Rx and DMA TSO memory are specified in the MTL_DBG_CTL register, for and for R.
- MTL EST memory are specified in the MTL_EST_GCL_Control register
- Rx parser memory are specified in the MTL_RXP_Indirect_Acc_Control_Status register

NOTE

While using debug mode for ECC error injection:

- There should be no traffic in the module
- When multiple CSR writes are required for writing single data word into the memory, the application should ensure that all the CSR writes corresponding to one memory write maintains the same value for the error injection control word.
- See Programming guidelines for ECC protection for memories

78.14.2 Finite State Machine(FSM) Parity and Timeout Protection

The FSM protection feature supports FSM parity and time out protection.

78.14.2.1 FSM State Parity Protection

Odd parity is implemented on all the FSM state register bits. Parity is monitored for every clock, after the reset is de-asserted. When a bit flips due to transient errors or permanent faults, the erroneous FSM is set to its default state and an uncorrectable error is indicated.

When the FSM state parity protection is enabled, by setting PRTYEN field of MAC_FSM_Control Register, the FSM state error is indicated by setting the FSMPES field of the MAC_DPP_FSM_Interrupt_Status register. Also, the Safety Interrupt (sbd_sfty_ue_intr_o) is asserted when an FSM Error is detected.

Error Injection mode is also supported for FSM parity error check. Program the Error Injection enable for the respective clock domain denoted by [23:16] bits of MAC_FSM_Control Register.

78.14.2.2 FSM Timeout Protection

The FSM Timeout feature provides a mechanism to ensure that all FSMs in the module can complete a transaction and return to a known completion state (IDLE or any other state that indicates completion of a transaction/transfer) within the programmed timeout value.

Program the TMR field of MAC_FSM_ACT_Timer register with a value that indicates the number of CSR cycles required to generate a 1 microsecond tic. This microsecond tic is internally used to generate the programmed timeout duration. Two timeout tics (normal mode timeout and large mode timeouts) are generated to provide flexibility to choose one per clock domain, by using the bits [31:24] of MAC_FSM_Control Register. Supported values for Timeout duration are 1us, 1.024ms, 16.384ms, 65.5536ms, 262.144ms, 1048.576ms (~1sec), 4194.304ms (~4s), 8.388s, 16.777s, and 33.554s which is based on the programmable bits NTMRMD, LTMRMD fields of MAC_FSM_ACT_Timer register. Interface timeouts are based on the normal mode tic generation; only the FSM timeouts depend on either normal or large tick selection.

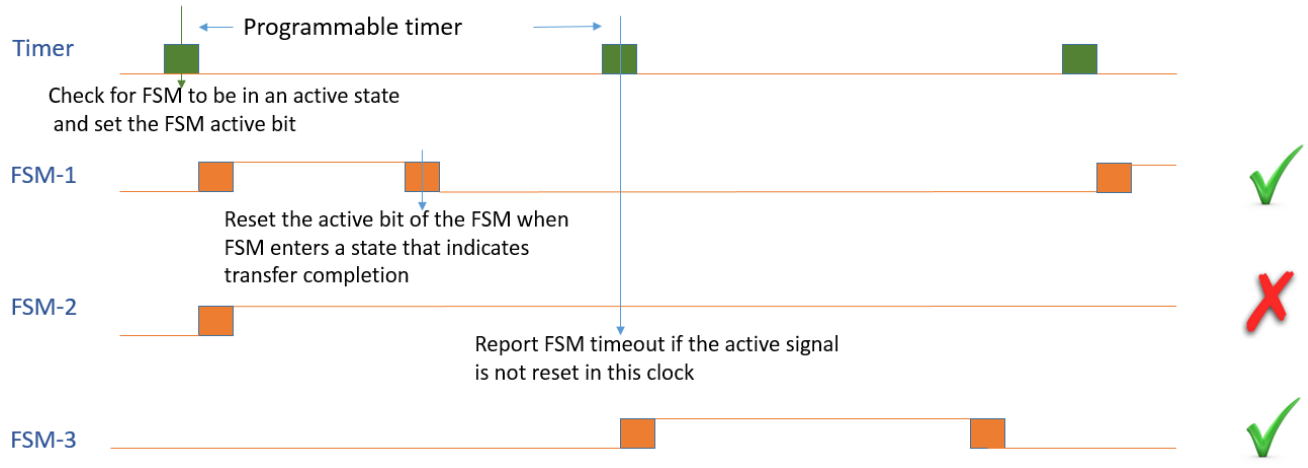

Figure 579. FSM Timeout Timing Diagram

In the above figure, the timer ticks are generated based on the programmable timeout value. The timer ticks are synchronized and made available in all the clock domains that have the FSMs.

At every timer tick, all the FSMs are monitored for being in active state (non-IDLE state, which indicates the FSM is actively processing transactions or hand-shakes) and an FSM active flag bit is set. The active flag bit is implemented for every FSM that is monitored for timeout. When the FSM reaches an IDLE or transaction completion state, the active flag bit of that FSM is reset. At the subsequent timer tick, all the FSMs' active flag bits are monitored and any flag that is set indicates a timeout for that FSM. This process of setting the flag and checking at subsequent timer tick is repeated at every tick.

Timeout Error Injection per clock domain is enabled by programming [15:8] fields of MAC_FSM_Control register. When Timeout error injection enable is set for a clock domain, the FSMs in that clock domain automatically timeout and generate an interrupt even without traffic. As error injection is a debug mode, TMR value need not indicate 1us, but can be programmed to a smaller value at which debug mode ticks are needed. FSM Timeout and Parity Error Injection modes can be used for testing at key-on/key-off.

The FSM timeout status is specified in the [15:8] field of MAC_DPP_FSM_Interrupt_Status register as per the respective clock domains. One FSM timeout status bit is made available per clock domain. The safety interrupt (sbd_sfty_ue_intr_o) is asserted when the timeout error is set for any of the clock domains. IP does not attempt to recover from a FSM timeout condition and relies on the application to take the corrective action (resetting IP).

78.14.2.3 Enabling FSM Parity and Timeout Protection

FSM timeout feature is enabled by setting the TMOUTEN field of MAC_FSM_Control register.

NOTE

See Programming guidelines for FSM parity and timeout

78.14.3 Application/CSR Interface Timeout Protection

This feature provides timeout protection to the application/CSR Interface. All the interfaces which has the handshake mechanism monitored for potential hangs due to the external agent (Master/Slave/Interconnect/Application client) not responding to the requests/transfers initiated by the QoS. After the request is initiated the response arrival interval is monitored. If the response does not arrive within a programmed time (TMR field of MAC_FSM_ACT_Timer) the timeout is triggered, using similar trigger generation as explained in the Section FSM protection.

The timeout is triggered when IP initiates SEQ, NON-SEQ and BUSY transfers on HTRANS[1:0]; and HREADY is not asserted by Slave within the programmed time.

The Timeout status for the AHB master interface is set in the MSTTES field of the MAC_DPP_FSM_Interrupt_Status register. The Safety interrupt (sbd_sfty_ue_intr_o) is asserted when application timeout status is set.

The hardware does not attempt to recover from Application/CSR Interface hangs and relies on software to take appropriate corrective action.

NOTE

- Protection is not needed for APB3 Slave interfaces because potential hangs can be only when IP does not respond to the requests. In such cases the IP internal protection logic (FSM timeout) detects such defects.
- Based on the time at which the transfer is initiated relative to the timer ticks, the timeout period could be any value between the programmed timeout and 2x times the programmed timeout.
- When an uncorrectable safety interrupt is issued and the read of the Interrupt status register returns all zeros, it implies that the CSR read is not functional. As soft reset of IP is not possible without the CSR access, and therefore, a hard reset of IP is recommended.
- See Programming guidelines for FSM parity and timeout .

78.15 Descriptors

This section and all its sub-sections are Synopsys Proprietary. Used with permission.

78.15.1 Overview

The DMA in the Ethernet subsystem transfers data based on a linked list of descriptors. The application creates the descriptors in the system memory. The module supports the following two types of descriptors:

- Normal Descriptor: Normal descriptors are used for packet data and to provide control information applicable to the packets to be transmitted.
- Context Descriptor: Context descriptors are used to provide control information applicable to the packet to be transmitted.

Each normal descriptor contains two buffers and two address pointers. These buffers enable the adapter port to be compatible with various types of memory management schemes.

NOTE

There is no limit for the number of descriptors that can be used for a single packet.

78.15.2 Descriptor Structure

The module supports the ring structure for DMA descriptor as shown in the following figure.

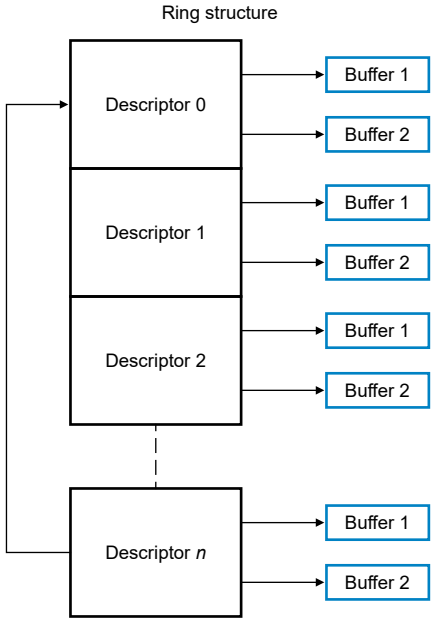

Figure 580. Descriptor Ring Structure

In Ring structure, descriptors are separated by the Word, DWord, or LWord number programmed in the DSL field of the DMA_CH#_Control register. The application needs to program the total ring length, that is, the total number of descriptors in ring span in the following registers of a DMA channel:

- Transmit Descriptor Ring Length Register (DMA_CH#_TxDesc_Ring_Length)
- Receive Descriptor Ring Length Register (DMA_CH#_RxDesc_Ring_Length)

The Descriptor Tail Pointer Register contains the pointer to the descriptor address (N). The base address and the current descriptor pointer decide the address of the current descriptor that the DMA can process. The descriptors up to one location less than the one indicated by the descriptor tail pointer (N – 1) are owned by the DMA. The DMA continues to process the descriptors until the following condition occurs:

Current Descriptor Pointer == Descriptor Tail Pointer;

The DMA goes into the Suspend mode when this condition occurs. The application must perform a write to the Descriptor Tail pointer register and update the tail pointer so that the following condition is true:

Current Descriptor Pointer < Descriptor Tail Pointer;

The DMA automatically wraps around the base address when the end of ring is reached, as shown in the following figure.

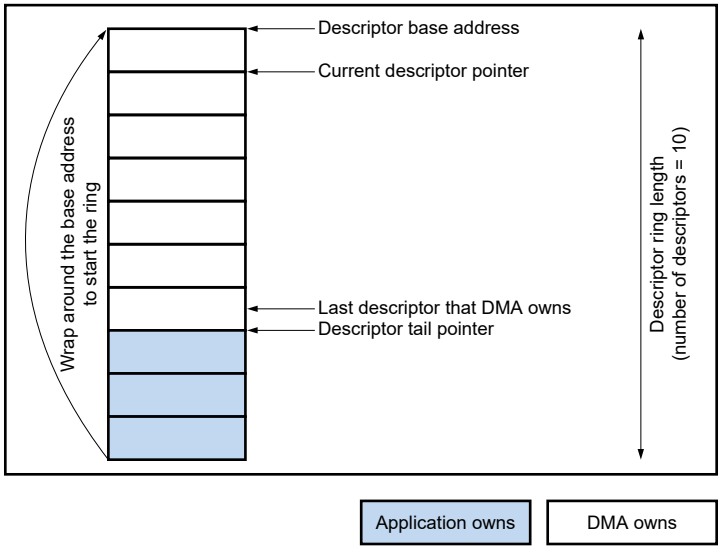

Figure 581. DMA Descriptor Ring

For descriptors owned by the application, the OWN bit of DES3 is reset to 0. For descriptors owned by the DMA, the OWN bit is set to 1. If the application has only one descriptor in the beginning, the application sets the last descriptor address (tail pointer) to Descriptor Base Address + 1. The DMA processes the first descriptor and then waits for the application to advance the tail pointer.

78.15.3 Transmit Descriptor

The DMA in the module requires at least one descriptor for a transmit packet. In addition to two buffers, two byte-count buffers, and two address pointers, the transmit descriptor has control fields which can be used to control the MAC operation on per-transmit packet basis. The Transmit Normal descriptor has two formats: Read format and Write-Back format

NOTE

TSO Split header is not supported.

Software must not write same tail pointer addresses when DMA is in Suspended state before setting new descriptor(s) for further processing.

78.15.3.1 Transmit Normal Descriptor (Read Format)

Following figure shows the Read Format for a Transmit normal descriptor. Table: 'TDES0 Normal Descriptor (Read Format)' through Table: 'TDES3 Normal Descriptor (Read Format)' describe the read format for the Transmit Normal Descriptors: TDES0, TDES1, TDES2, and TDES3.

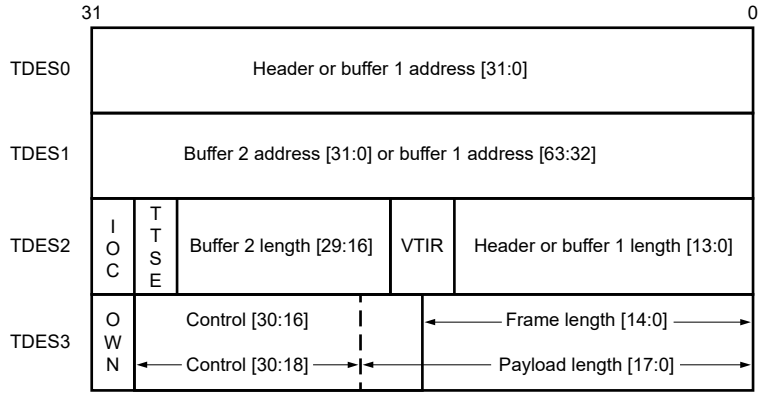

Figure 582. Transmit Descriptor Read Format

78.15.3.1.1 TDES0 Normal Descriptor (Read Format)

Table 649. TDES0 Normal Descriptor (Read Format)

Bit	Name	Description
31:0	BUF1AP	Buffer 1 Address Pointer or TSO Header Address Pointer These bits indicate the physical address of Buffer 1. These bits indicate the TSO Header Address pointer when the following bits are set: • TSE bit of TDES3 • FD bit of TDES3

78.15.3.1.2 TDES1 Normal Descriptor (Read Format)

Table 650. TDES1 Normal Descriptor (Read Format)

Bit	Name	Description
31:0	BUF2AP	Buffer 2 or Buffer 1 Address Pointer This bit indicates the physical address of Buffer 2 when a descriptor ring structure is used. There is no limitation for the buffer address alignment. In 40- or 48-bit addressing mode, these bits indicate the most-significant 8- or 16- bits of the Buffer 1 Address Pointer.

78.15.3.1.3 TDES2 Normal Descriptor (Read Format)

Table 651. TDES2 Normal Descriptor (Read Format)

31	30	29-16	15:14	13:0
IOC	TTSE/ TMWD	B2L	VTIR	HL or B1L

Table 652. TDES2 Normal Descriptor (Read Format)

Bits	Name	Description
31	IOC	Interrupt on Completion This bit controls the setting of TI and ETI status bits in the DMA_CH#_Status register. When ETIC = 1 and TDES2[LD] = 0, this bit sets the ETI bit. When TDES3[LD] = 1, this bit sets the TI status bit.
30	TTSE/ TMWD	Transmit Timestamp Enable or External TSO Memory Write Enable This bit enables the IEEE1588 time stamping for Transmit packet referenced by the descriptor, if TSE bit is not set. If TSE bit is set and external TSO memory is enabled, setting this bit disables external TSO memory writing for this packet.
29:16	B2L	Buffer 2 Length The driver sets this field. When set, this field indicates Buffer 2 length.
15:14	VTIR	VLAN Tag Insertion or Replacement These bits request the MAC to perform VLAN tagging or untagging before transmitting the packets. The application must set the CRC Pad Control bits appropriately when VLAN Tag Insertion, Replacement, or Deletion is enabled for the packet. The following list describes the values of these bits: • 2'b00: Do not add a VLAN tag. • 2'b01: Remove the VLAN tag from the packets before transmission. This option should be used only with the VLAN packets. • 2'b10: Insert a VLAN tag with the tag value programmed in the MAC_VLAN_Incl register or context descriptor. • 2'b11: Replace the VLAN tag in packets with the tag value programmed in the MAC_VLAN_Incl register or context descriptor. This option should be used only with the VLAN packets. These bits are valid when the Enable SA and VLAN Insertion on Tx option is selected while configuring the core.
13:0	HL or B1L	Header Length or Buffer 1 Length For Header length only bits [9:0] are taken. The size 13:0 is applicable only when interpreting buffer 1 length. If the TCP Segmentation Offload feature is enabled through the TSE bit of TDES3, this field is equal to the header length. When the TSE bit is set in TDES3, the header length includes the length in bytes from Ethernet Source address till the end of the TCP header. The maximum header length supported for TSO feature is 1023 bytes. The maximum header length supported for TSO feature is 1023 bytes. If the TCP Segmentation Offload feature is not enabled, this field is equal to Buffer 1 length.

78.15.3.1.4 TDES3 Normal Descriptor (Read Format)

Table 653. TDES2 Normal Descriptor (Read Format)

31	30	29	28	27:26	25:23	22:19	18	17:16	15	14:0
OWN	CTXT	FD	LD	CPC	SAIC	SLOTNUM or THL	TSE	CIC/TPL	TPL	FL/TPL

Table 654. TDES3 Normal Descriptor (Read Format)

Bits	Name	Description
31	OWN	Own Bit When this bit is set, it indicates that the DMA owns the descriptor. When this bit is reset, it indicates that the application owns the descriptor. The DMA clears this bit after it completes the transfer of data given in the associated buffer(s).
30	CTXT	Context Type This bit should be set to 1'b0 for normal descriptor.
29	FD	First Descriptor When this bit is set, it indicates that the buffer contains the first segment of a packet.
28	LD	Last Descriptor When this bit is set, it indicates that the buffer contains the last segment of the packet. When this bit is set, the B1L or B2L field should have a non-zero value.
27:26	CPC	CRC Pad Control This field controls the CRC and Pad Insertion for Tx packet. This field is valid only when the first descriptor bit (TDES3[29]) is set. The following list describes the values of Bits[27:26]: • 2'b00: CRC and Pad Insertion The MAC appends the cyclic redundancy check (CRC) at the end of the transmitted packet of length greater than or equal to 60 bytes. The MAC automatically appends padding and CRC to a packet with length less than 60 bytes. • 2'b01: CRC Insertion (Disable Pad Insertion) The MAC appends the CRC at the end of the transmitted packet but it does not append padding. The application should ensure that the padding bytes are present in the packet being transferred from the Transmit Buffer, that is, the packet being transferred from the Transmit Buffer is of length greater than or equal to 60 bytes. • 2'b10: Disable CRC Insertion The MAC does not append the CRC at the end of the transmitted packet. The application should ensure that the padding and CRC bytes are present in the packet being transferred from the Transmit Buffer. • 2'b11: CRC Replacement The MAC replaces the last four bytes of the transmitted packet with recalculated CRC bytes. The application should ensure that the padding and CRC bytes are present in the packet being transferred from the Transmit Buffer. This field is valid only for the first descriptor. Note: When the TSE bit is set, the MAC ignores this field because the CRC and pad insertion is always done for segmentation.
25:23	SAIC	SA Insertion Control These bits request the MAC to add or replace the Source Address field in the Ethernet packet with the value given in the MAC Address 0 register. The application must set the CRC Pad Control bits appropriately when SA Insertion Control is enabled for the packet.

Table continues on the next page...

Table 654. TDES3 Normal Descriptor (Read Format) (continued)

Bits	Name	Description
		Bit 25 specifies the MAC Address Register (1 or 0) value that is used for Source Address insertion or replacement. The following list describes the values of Bits[24:23]: • 2'b00: Do not include the source address • 2'b01: Include or insert the source address. For reliable transmission, the application must provide frames without source addresses. • 2'b10: Replace the source address. For reliable transmission, the application must provide frames with source addresses. • 2'b11: Reserved These bits are valid in the EQOS-DMA, EQOS-AXI, and EQOS-AHB configurations when the Enable SA and VLAN Insertion on Tx option is selected while configuring the core and when the First Segment control bit (TDES3 [29]) is set. This field is valid only for the first descriptor.
22:19	SLOTNUM or THL	SLOTNUM: Slot Number Control Bits in AV Mode These bits indicate the slot interval in which the data should be fetched from the corresponding buffers addressed by TDES0 or TDES1. When the Transmit descriptor is fetched, the DMA compares the slot number value in this field with the slot interval maintained in the RSN field DMA_CH#_Slot_Function_Control_Status. It fetches the data from the buffers only if a value matches. These bits are valid only for the AV channels. THL: TCP/UDP Header Length If the TSE bit is set, this field contains the length of the TCP/UDP header. The minimum value of this field must be 5 for TCP header. The value must be equal to 2 for UDP header. This field is valid only for the first descriptor.
18	TSE	TSO Split header is not supported. The value of this bit is always zero.
17:16	CIC/TPL	Checksum Insertion Control or TCP Payload Length These bits control the checksum calculation and insertion. The following list describes the bit encoding: • 2'b00: Checksum Insertion Disabled. • 2'b01: Only IP header checksum calculation and insertion are enabled. • 2'b10: IP header checksum and payload checksum calculation and insertion are enabled, but pseudo-header checksum is not calculated in hardware. • 2'b11: IP Header checksum and payload checksum calculation and insertion are enabled, and pseudo-header checksum is calculated in hardware. This field is valid when the Enable Transmit TCP/IP Checksum Offload option is selected and the TSE bit is reset. When the TSE bit is set, this field contains the upper bits [17:16] of the TCP Payload (or IP Payload for UDP fragmentation). This allows the TCP/UDP packet length field to be spanned across TDES3[17:0] to provide 256 KB packet length support.

Table continues on the next page...

Table 654. TDES3 Normal Descriptor (Read Format) (continued)

Bits	Name	Description
		This field is valid only for the first descriptor.
15	TPL	Reserved or TCP Payload Length When the TSE bit is reset, this bit is reserved. When the TSE bit is set, this is Bit 15 of the TCP payload length [17:0]. This field is valid only when the Enable TCP Segmentation Offloading for TCP/IP Packets option is selected while configuring the core.
14:0	FL/TPL	Frame Length or TCP Payload Length This field is equal to the length of the packet to be transmitted in bytes. When the TSE bit is not set, this field is equal to the total length of the packet to be transmitted: Ethernet Header Length + TCP /IP Header Length – Preamble Length – SFD Length + Ethernet Payload Length When the TSE bit is set, this field is equal to the lower 15 bits of the TCP payload length in case of segmentation and IP payload in case of UDP fragmentation. In case of segmentation, this length does not include Ethernet header or TCP/UDP/IP header length. In case of fragmentation, this length does not include Ethernet header and IP header. When DWRR/WFQ algorithm is NOT enabled, value written into this field is not used when TSE = 0.

78.15.3.1.5 Transmit normal descriptor (write-back format)

The transmit descriptor write-back format includes timestamp low, timestamp high, OWN, and Status bits.

The write-back format is applicable only for the last descriptor of the corresponding packet. Write 1 to the LD bit (TDES3[28]) in the descriptor where DMA writes back the status and timestamp information for the corresponding transmit packet.

Figure 583 shows the transmit descriptor write-back format.

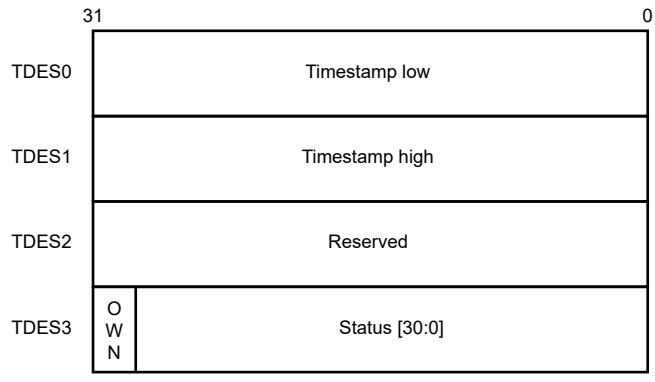

Figure 583. Transmit descriptor write-back format

TDES0 normal descriptor (write-back format)

Table 655 shows that this format is only applicable to the last descriptor of a packet.

Table 655. TDES0 normal descriptor (write-back format)TDES0 normal descriptor (write-back format)

Bit	Name	Description
31:0	TTSL	Transmit Packet Timestamp Low DMA updates this field with least significant 32 bits of the timestamp captured for the corresponding transmit packet. DMA writes the timestamp only if TTSE bit of TDES2 is 1 in the first descriptor of the packet. This field has the timestamp only if you write 1 to the Last Segment bit (LS) in the descriptor and the Timestamp status (TTSS) bit.

TDES1 normal descriptor (write-back format)

Table 656 shows that this format is only applicable to the last descriptor of a packet.

Table 656. TDES1 normal descriptor (write-back format)

Bit	Name	Description
31:0	TTSH	Transmit Packet Timestamp High DMA updates this field with the most significant 32 bits of the timestamp captured for a corresponding transmit packet. DMA writes the timestamp only if the TTSE bit of TDES2 is 1 in the first descriptor of the packet. This field has the timestamp only if you write 1 to the Last Segment bit (LS) in the descriptor and Timestamp status (TTSS) bit.

TDES2 Normal Descriptor (Write-Back Format)

This format is applicable only to the last descriptor of a packet.

Table 657. TDES2 normal descriptor (write-back format)

Bit	Description
31:0	Reserved

TDES3 Normal Descriptor (Write-Back Format)

This format is applicable only to the last descriptor of a packet.

Table 658. TDES3 normal descriptor (write-back format)

31	30	29	28	27:18	17	16	15	14	13	12	11	10	9	8	7:4	3	2	1	0
OWN	CTXT	FD	LD	Rsvd	TTSS	EUE	ES	JT	FF	PCE	LoC	NC	LC	EC	CC	ED	UF	DB	IHE

Table 659. TDES3 normal descriptor (write-back format)

Bit	Name	Description
31	OWN	Own Bit When this field is 1, it indicates that the module DMA owns the descriptor. DMA write 0 to this field when it completes the packet transmission. After the write-back is complete, this field is set to 'b0.
30	CTXT	Context Type

Table continues on the next page...

Table 659. TDES3 normal descriptor (write-back format) (continued)

Bit	Name	Description
		This field must be set to 'b0 for normal descriptor.
29	FD	First Descriptor This field indicates that the buffer contains the first segment of a packet.
28	LD	Last Descriptor This field is set to 'b1 for last descriptor of a packet. DMA writes the status fields only in the last descriptor of the packet.
27:24	Rsvd	Reserved
23	DE	Descriptor Error When this field is 1, it indicates that the descriptor content is incorrect. DMA writes 1 to this field during write-back when the descriptor is closed. Descriptor errors can be: • Incorrect sequence from the context descriptor. For example, a location after the first descriptor for a packet. • All 1s • CTXT is 1 along with LD or FD bits as 1. **NOTE** When a descriptor error occurs due to all ones or CTXT, LD, and FD bits are 1, the transmit DMA closes the transmit descriptor with DE and LD bits set to 1. When you write 1 to IOC bit in TDES2 of corresponding first descriptor, the transmit DMA write 1 to TI bit in the DMA_CH#_Status register **NOTE** Based on CTXT, LD, and FD bits of the transmit descriptor, the subsequent descriptor might consider as the first descriptor (even if FD bit is not 1) and partial packet is sent.
22:18	Rsvd	Reserved
17	TTSS	Tx Timestamp Status This field indicates that a timestamp has been captured for the corresponding transmit packet. When this field is 1, it indicates that TDES0 and TDES1 have timestamp values that were captured for the transmit packet. This field is valid only when the Last Segment control bit (TDES3 [28]) in a descriptor is 1. This field is valid only when IEEE1588 timestamping feature is enabled; otherwise, it is reserved.
16	EUE	ECC Uncorrectable Error Status Indicates the ECC uncorrectable error in the TSO memory. **NOTE** An uncorrectable error in the transmit FIFO memory is reported with (Bit 13) FF = 1. This is because the module flushes all such packets.

Table continues on the next page...

Table 659. TDES3 normal descriptor (write-back format) (continued)

Bit	Name	Description
15	ES	Error Summary This field indicates the logical OR of the following bits: • TDES3[0]: IP header error • TDES3[14]: Jabber timeout • TDES3[13]: Packet flush • TDES3[12]: Payload checksum error • TDES3[11]: Loss of carrier • TDES3[10]: No carrier • TDES3[9]: Late collision • TDES3[8]: Excessive collision • TDES3[3]: Excessive deferral • TDES3[2]: Underflow error This field is 1 when EUE (bit 16) = 1.
14	JT	Jabber Timeout This field indicates that the MAC transmitter experiences a jabber time-out. This field is 1 only when MAC_Configuration[JD] is not 1.
13	FF	Packet Flushed This field indicates that DMA or MTL flushes the packet because the CPU gives a software flush command.
12	PCE	Payload Checksum Error This field indicates that the checksum offload engine had a failure and does not insert any checksum into the encapsulated TCP, UDP, or ICMP payload. This failure can either because of insufficient bytes, as the payload length field of the IP header indicates or the MTL starting to forward the packet to the MAC transmitter in Store-and-forward mode without calculating the checksum. This second error condition only occurs when the transmit FIFO depth is less than the length of the Ethernet packet that is transmitted to avoid deadlock. The MTL starts forwarding the packet when the FIFO is full, even in the Store-and-forward mode. This error can also occur when you detects a bus error during packet transfer. When the full checksum offload engine is not enabled, this bit is reserved.
11	LoC	Loss of Carrier This field indicates that a loss of carrier occurred during packet transmission (that is, the gmii_crs_i signal was inactive for one or more transmit clock periods during packet transmission). This field is valid only for the packets transmitted without collision and when MAC operates in the Half-duplex mode.
10	NC	No Carrier This field indicates that the carrier sense signal from the PHY was not asserted during transmission.

Table continues on the next page...

Table 659. TDES3 normal descriptor (write-back format) (continued)

Bit	Name	Description
9	LC	Late Collision This bit indicates that packet transmission was aborted because a collision occurred after the collision window (64 byte times including Preamble in MII mode and 512 byte times including Preamble and Carrier Extension in GMII mode). This bit is not valid if Underflow Error is set.
8	EC	Excessive Collision This field indicates that the transmission was aborted after 16 successive collisions when you transmits the current packet. If MAC_Configuration[DR] = 1, this field is 1 after first collision and abort the packet transmission.
7:4	CC	Collision Count This 4-bit counter value indicates the number of collisions occurred before transmitting the packet. The count is not valid when the EC bit = 1.
3	ED	Excessive Deferral This field indicates that the transmission ends because of an excessive deferral of over 24,288 bit times (155,680 bits times in 1000 Mbit/s mode or Jumbo packet enabled mode) if MAC_Configuration[DC] = 1. When TBS is enabled in Full duplex mode and this field is 1, it indicates that the frame drops after the expiry time is reached.
2	UF	Underflow Error This field indicates that MAC aborts the packet because the data arrived late from the system memory. The underflow error can occur because of either of the following conditions: • DMA encounters an empty transmit buffer when it transmits the packet • The application filled the MTL Tx FIFO slower than the MAC transmit rate The transmission process enters the Suspended state and sets the underflow bit corresponding to a queue in MTL_Interrupt_Status.
1	DB	Deferred Bit This field indicates that MAC defers before transmitting because of presence of carrier. This field is valid only in the Half-Duplex mode.
0	IHE	IP Header Error When IP Header Error is 1, this field indicates that the checksum offload engine detects an IP header error. This field is valid only when transit checksum offload is enabled. Otherwise, it is reserved. If COE detects an IP header error, it inserts an IPv4 header checksum if the Ethernet type field indicates an IPv4 payload. In Full-Duplex mode, when EST/Qbv is enabled and this field is 1, it indicates the frame drop status due to the frame size error or schedule error.

78.15.3.2 Transmit context descriptor

The transmit context descriptor can provide any time before a packet descriptor. The context is valid for the current packet and subsequent packets. The context descriptor provide the timestamps for one-step timestamp correction and VLAN tag ID for VLAN insertion feature. Write back is done on a context descriptor only to write 0 to OWN bit.

NOTE

DMA internally store the VLAN tag IDs and MSS values which the application provides in a context descriptor with their corresponding valid bits set. DMA always passes the last valid VLAN tag to the MTL, when the outer or inner VLAN tag is provided with the valid bit set. The application cannot invalidate the valid VLAN tag which DMA stores. The VLAN tag is inserted or replaced based on the control inputs provided for the packet.

The inner VLAN tag control input is used only for the next packet that immediately follows the context descriptor. The application must provide a context descriptor before the normal descriptor of each packet for which DMA must use the inner VLAN tag control input.

Figure 584 shows the transmit context descriptor format.

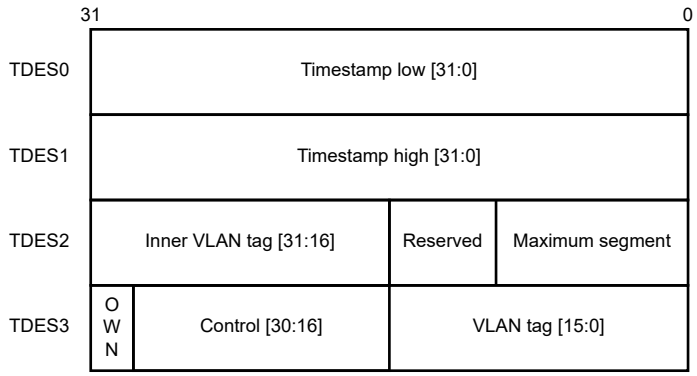

Figure 584. Transmit context descriptor format

78.15.3.2.1 TDES0 context descriptor

Table 660 describes the TDES0 context descriptor format.

Table 660. TDES0 context descriptor

Bit	Name	Description
31:0	TTSL	Transmit Packet Timestamp Low For one-step correction, the driver can provide the lower 32 bits of timestamp in this descriptor word. DMA uses this value as the low word for doing one-step timestamp correction. This field is valid only if the OSTC and TCMSSV bits of TDES3 context descriptor are 1.

78.15.3.2.2 TDES1 context descriptor

Table 661 describes the TDES1 context descriptor format.

Table 661. TDES1 context descriptor

Bit	Name	Description
31:0	TTSH	Transmit Packet Timestamp High For one-step correction, the driver can provide the upper 32 bits of timestamp in this descriptor. DMA uses this value as the high word for doing one-step timestamp correction. This field is valid only if the OSTC and TCMSSV bits of TDES3 context descriptor are 1.

78.15.3.2.3 TDES2 context descriptor

Table 662 shows the TDES2 context descriptor format.

Table 662. TDES2 context descriptor

Bit	Name	Description
31:16	IVT	Inner VLAN Tag When the IVLTV bit of TDES3 context descriptor is 1 and the TCMSSV and OSTC bits of TDES3 context descriptor becomes 0, it indicates that the TDES2[31:16] contains the inner VLAN tag to insert in the subsequent transmit packets.
15:14	Rsvd	Reserved
13:0	MSS	TSO split header is not supported. The value of this bit is always zero.

78.15.3.2.4 TDES3 context descriptor

Table 663. TDES3 context descriptor

31	30	29:28	27	26	25:24	23	22:18	17	16	15:0
OWN	CTXT	Rsvd	OSTC	TCMSSV	Rsvd	CDE	Rsvd	IVLTV	VLTV	VT

Table 664 shows the TDES3 context descriptor format.

Table 664. TDES3 context descriptor

Bit	Name	Description
31	OWN	Own Bit When this field is 1, it indicates that the module DMA owns the descriptor. When this field becomes 0, it indicates that the application owns the descriptor. DMA writes 0 to this field immediately after the read.
30	CTXT	Context Type This field must set to 1'b1 for context descriptor.
29:28	Rsvd	Reserved
27	OSTC	One-Step Timestamp Correction Enable When this field is 1, it indicates that DMA performs a one-step timestamp correction with reference to the timestamp values provided in TDES0 and TDES1.
26	TCMSSV	One-Step Timestamp Correction Input or MSS Valid When this field and the OSTC field are 1, it indicates that the timestamp correction input provided in TDES0 and TDES1 is valid. When the OSTC field becomes 0 and this field and the TSE bit of TDES3 are 1 in subsequent normal descriptor, it indicates that the MSS input in TDES2 is valid.
25:24	Rsvd	Reserved

Table continues on the next page...

Table 664. TDES3 context descriptor (continued)

Bit	Name	Description
23	DE	Descriptor Error When this field is 1, it indicates that the descriptor content is incorrect. DMA writes 1 to this field during write-back when it closes the context descriptor. Descriptor errors can be: • Incorrect sequence from the context descriptor. For example, a location before the first descriptor for a packet. • All ones. • CD, LD, and FD bits = 1. **NOTE** When a descriptor error occurs due to all ones or CTXT, LD, and FD bits are 1, the transmit DMA closes the transmit descriptor with DE and LD bits are 1. When you write 1 to IOC bit in TDES2 of corresponding first descriptor, the transmit DMA writes 1 to TI bit in the DMA_CH#_Status register **NOTE** On the basis of CTXT, LD, and FD bits of the transmit descriptor, the subsequent descriptor might considered as the first descriptor (even if FD bit is not 1) and partial packet is sent. **NOTE** This error is categorized as an abnormal event. Recovery from this event is possible by issuing a software reset only. DMA stopping, reconfiguring, and restarting recovery mechanism is not supported.
22:20	Rsvd	Reserved
19:18	IVTIR	Inner VLAN Tag Insert or Replace When this field is 1, it requests MAC to perform inner VLAN tagging or un-tagging before transmitting the packets. If the packet is modified for VLAN tags, MAC automatically recalculates and replaces the CRC bytes. The following list describes the values of these bits: • 2'b00: Do not add the inner VLAN tag. • 2'b01: Remove the inner VLAN tag from the packets before transmission. You must use this option only with the VLAN frames. • 2'b10: Insert an inner VLAN tag with the tag value programmed in MAC_Inner_VLAN_Incl or context descriptor. • 2'b11: Replace the inner VLAN tag in packets with the tag value programmed in MAC_Inner_VLAN_Incl or context descriptor. You must use this option only with the VLAN frames.. These fields are valid when you select the enable SA and VLAN insertion on transit and enable double VLAN processing options.
17	IVLTV	Inner VLAN Tag Valid When this field is 1, it indicates that IVT field of TDES2 is valid.

Table continues on the next page...

Table 664. TDES3 context descriptor (continued)

Bit	Name	Description
16	VLTV	VLAN Tag Valid When this field is 1, it indicates that VT field of TDES3 is valid.
15:0	VT	VLAN Tag Contains the VLAN tag to insert or replace in the packet. This field is used as VLAN tag only when MAC_VLAN_Incl[VLTI] becomes 0.

78.15.4 Receive descriptor

DMA in the module reads a descriptor only if the tail pointer is different from the base pointer or current pointer. It is recommended to have a descriptor ring with a length that accommodates at least two complete packets which MAC receives. Otherwise, the performance of DMA is impacted because of the unavailability of the descriptors. In such situations, the RxFIFO in MTL becomes full and starts dropping packets.

The following receive descriptors are present:

- Normal descriptors
- Context descriptors

You can prepare all the receive descriptors and give to DMA as normal descriptors with the content as shown in receive normal descriptor (read format). DMA reads this descriptor and the receive DMA closes the descriptor with the corresponding packet status after transferring a received packet (or part of) to the buffers indicated by the descriptor. The receive normal descriptor (write-back format) describes the format of this status.

For some packets, only the normal descriptor bits cannot write the complete status. For such packets, the receive DMA writes the extended status to the next descriptor (without processing or using the buffers or pointers embedded in that descriptor). Receive context descriptor describes the descriptor write back format and content.

78.15.4.1 Receive normal descriptor (read format)

The read format for a receive normal descriptor is made up of the following:

- A header or buffer 1 address
- Reserved field
- Payload or buffer 2 or next descriptor address
- A 30-bit reserved field
- OWN bit
- An interrupt field

Figure 585 shows the read format for a receive normal descriptor.

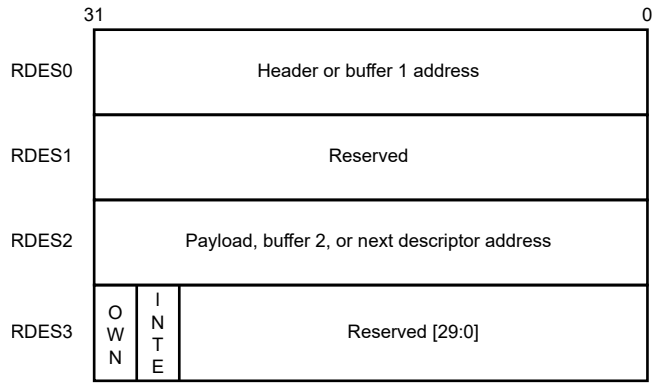

Figure 585. Receive normal descriptor read format

NOTE

In the receive descriptor (read format), if the buffer address field is all zeros, the module does not transfer data to that buffer and skips to the next buffer or next descriptor.

78.15.4.1.1 RDES0 normal descriptor (read format)

Table 665 shows the RDES0 normal descriptor read format.

Table 665. RDES0 normal descriptor (read format)

Bit	Name	Description
31:0	BUF1AP	Header or Buffer 1 Address Pointer When the SPH field of control register of a channel becomes 0, these field indicates the physical address of buffer 1. When the SPH field is 1, these field indicates the physical address of header buffer where the receive DMA writes the L2/L3/L4 header bytes of the received packet. The application can program a byte-aligned address for this buffer which means that the LS bits of this field can be non-zero. However, DMA performs a write operation with RDES0[1:0] (or RDES0[2:0]/[3:0] in case of 64-/128-bit configuration) as zero, when the start of packet is transferred. However, the packet data shifts per the actual offset which the buffer address pointer provides. If the address pointer points to a buffer where the middle or last part of the packet is stored, DMA ignores the offset address and writes to the full location which the data-width indicates .

78.15.4.1.2 RDES1 normal descriptor (read format)

Table 666 shows the RDES1 normal descriptor read format.

Table 666. RDES1 normal descriptor (read format)

Bit	Name	Description
31:0	Reserved or BUF1AP	Contains the most-significant 32 bits of the buffer 1 address pointer in 64-bit Addressing mode. Otherwise, this field is reserved.

78.15.4.1.3 RDES2 normal descriptor (read format)

Table 667 shows the RDES2 normal descriptor read format.

Table 667. RDES2 normal descriptor (read format)

Bit	Name	Description
31:0	BUF2AP	Buffer 2 Address Pointer Indicates the physical address of buffer 2. When the SPH bit of the DMA_CH#_Control register = 1, it indicates that the buffer address pointer must be bus width-aligned, that is, RDES2[3:0, 2:0, or 1:0] = 0 corresponding to 128, 64, or 32 bus width. LSBs are ignored internally. When the SPH bit of the DMA_CH#_Control register becomes 0, it indicates that there is no limitations on the RDES2 value. However, the RxDMA uses the LS fields of the pointer address only when it transfers the start bytes of a packet. If the BUF2AP provides the address of a buffer in which the middle or last part of a packet is stored, DMA ignores BUF2AP[3:0 or 2:0 or 1:0] (corresponding to 128- or 64- or 32-bit data-bus) and writes to the complete location.

78.15.4.1.4 RDES3 normal descriptor (read format)

Following table describes the RDES3 normal descriptor read format.

31	30	19-26	25	24	23:0
OWN	IOC	Rsvd	BUF2V	BUF1V	Rsvd

Table 668. RDES3 normal descriptor (read format)

Bit	Name	Description
31	OWN	Own Bit When this field is 1, it indicates that the module DMA owns the descriptor. When this field becomes 0, it indicates that the application owns the descriptor. DMA write 0 this field when either of the following conditions is true: • DMA completes the packet reception. • The buffers associated with the descriptor are full.
30	IOC	Interrupt Enabled on Completion When this field is 1, it indicates that an interrupt is issued to the application when DMA closes this descriptor.
29:26	Rsvd	Reserved
25	BUF2V	Buffer 2 Address Valid When this field is 1, it indicates to the DMA that the buffer 2 address specified in RDES2 is valid. The application must write 1 to this field so that DMA can use the address, to which the buffer 2 address in RDES2 points to write received packet data.
24	BUF1V	Buffer 1 Address Valid When this field is 1, it indicates to the DMA that the buffer 1 address specified in RDES1 is valid.

Table continues on the next page...

Table 668. RDES3 normal descriptor (read format) (continued)

Bit	Name	Description
		The application must write 1 to this field, if DMA uses the address to which the buffer 1 address in RDES1 points to write the received packet data.
23:0	Rsvd	Reserved

78.15.4.1.5 Receive normal descriptor (write-back format)

Following figure shows the write-back format for a receive normal descriptor.

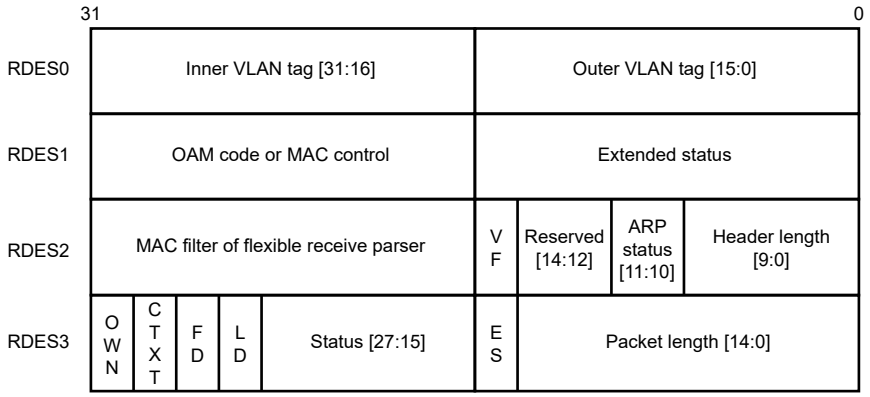

Figure 586. Receive normal descriptor (write-back format)

NOTE

When you enables the flexible receive parser, RDES2[31:16] indicates the parser status, and not the MAC filter status. The MAC filter status is not available when flexible receive parser is enabled.

78.15.4.1.5.1 RDES0 normal descriptor (write-back format)

Table 669 shows the write-back format for the RDES0 normal descriptor.

Table 669. RDES0 normal descriptor (write-back format)

Bit	Name	Description
31:16	IVT	Inner VLAN Tag Contains the inner VLAN tag of the received packet if the RS0V bit of RDES3 = 1. This field is valid only when you enables the double VLAN tag processing and VLAN tag stripping.
15:0	OVT	Outer VLAN Tag Contains the outer VLAN tag of the received packet if the RS0V bit of RDES3 = 1.

78.15.4.1.5.2 RDES1 normal descriptor (write-back format)

The status fields in the write-back format are valid only for the last descriptor (RDES3[28] = 1). Following table provide the details of the write-back format for RDES1 normal descriptor.

31:16	15	14	13	12	11:8	7	6	5	4	3	2:0
OPC	TD	TSA	PV	PFT	PMT	IPCE	IPCB	IPV6	IPV4	IPHE	PT

Table 670. RDES1 normal descriptor (write-back format)

Bit	Name	Description
31:16	OPC	Indicates any one of the following: • OAM sub-type code: If bits [18:16] of RDES3 as described in RDES3 normal descriptor (read format) are 111b, this field contains the OAM sub-type and code fields. • MAC control packet opcode: Bits 15:8 of RDES3 as described in RDES3 normal descriptor (read format) contain the subtype and bits 7:0 contain the code.
15	TD	Timestamp Dropped Indicates that the timestamp was captured for this packet but it dropped in the MTL Rx FIFO because of overflow. This field is available only when you select the timestamp feature. Otherwise, this field is reserved.
14	TSA	Timestamp Available Indicates that the timestamp value is available in a context descriptor word 2 (RDES2) and word 1(RDES1) when timestamp is present. This is valid only when the last descriptor field (RDES3 [28]) = 1 You can write the context descriptor in the next descriptor just after the last normal descriptor for a packet.
13	PV	PTP Version Indicates that the received PTP message has the IEEE 1588 version 2 format. When this field becomes 0, it indicates the IEEE 1588 version 1 format. This field is available only when you select the timestamp feature. Otherwise, this field is reserved.
12	PFT	PTP Packet Type Indicates that the PTP message is sent directly over Ethernet. This field is available only when you select the timestamp feature. Otherwise, this field is reserved.
11:8	PMT	PTP Message Type Encodes to give the type of the message received: • 0000: No PTP message received • 0001: SYNC (all clock types) • 0010: Follow_Up (all clock types) • 0011: Delay_Req (all clock types) • 0100: Delay_Resp (all clock types) • 0101: Pdelay_Req (in peer-to-peer transparent clock) • 0110: Pdelay_Resp (in peer-to-peer transparent clock) • 0111: Pdelay_Resp_Follow_Up (in peer-to-peer transparent clock)

Table continues on the next page...

Table 670. RDES1 normal descriptor (write-back format) (continued)

Bit	Name	Description
		• 1000: Announce • 1001: Management • 1010: Signaling • 1011–1110: Reserved • 1111: PTP packet with reserved message type These fields are available only when you select the timestamp feature.
7	IPCE	IP Payload Error When this field is 1, it indicates either of the following: • The 16-bit IP payload checksum (that is, the TCP, UDP, or ICMP checksum) which MAC calculates does not match the corresponding checksum field in the received segment. • The TCP, UDP, or ICMP segment length does not match the payload length value in the IP header field. • The TCP, UDP, or ICMP segment length is less than minimum allowed segment length for TCP, UDP, or ICMP. Bit 15 (ES) of RDES3 is not set when this field is 1.
6	IPCB	IP Checksum Bypassed Indicates that the checksum offload engine is bypassed. This field is available when you select the enable receive TCP/IP checksum check feature.
5	IPV6	IPv6 header Present Indicates that an IPV6 header is detected. When you select the enable split header feature option and the SPH bit of control register of a channel is 1, the IPV6 header is available in the header buffer area to which RDES0 points.
4	IPV4	IPV4 Header Present Indicates that an IPV4 header is detected. When the SPH bit of RDES3 is 1, the IPV4 header is available in the header buffer area to which RDES0 points.
3	IPHE	IP Header Error When this field is 1, it indicates either of the following: • The 16-bit IPv4 header checksum which MAC calculates does not match the received checksum bytes. • The IP datagram version is not consistent with the Ethernet type value. • Ethernet packet does not have the expected number of IP header bytes. This field is valid when either bit 5 or bit 4 is 1. This field is available when you select the enable receive TCP/IP checksum check feature.
2:0	PT	Payload Type Indicates the type of payload encapsulated in the IP datagram that the receive checksum offload engine (COE) process.

Table continues on the next page...

Table 670. RDES1 normal descriptor (write-back format) (continued)

Bit	Name	Description
		• 3'b000: Unknown type or IP/AV payload not processed • 3'b001: UDP • 3'b010: TCP • 3'b011: ICMP • 3'b110: AV tagged data packet • 3'b111: AV tagged control packet • 3'b101: AV untagged control packet • 3'b100: IGMP, if IPV4 header present field = 1, else DCB (LLDP) control packet If the COE does not process the payload of an IP datagram because there is an IP header error or fragmented IP, it sets these fields to 3'b000.

78.15.4.1.5.3 RDES2 normal descriptor (Write-back format)

31:29	28	27	26:19	18	17	16	15	14	13:11	10	9:0
L3L4FM	L4FM	L3FM	MADRM	HF	DAF	SAF	OTS	ITS	Rsvd	ARPNR	HL

Table 671. RDES2 normal descriptor (Write-back format)

Bit	Name	Description
31:29	L3L4FM	Layer 3 and Layer 4 Filter Number Matched Indicates the number of the layer 3 and layer 4 filter that matches the received packet: • 000: Filter 0 • 001: Filter 1 • 010: Filter 2 • 011: Filter 3 • 100: Filter 4 • 101: Filter 5 • 110: Filter 6 • 111: Filter 7 This field is valid only when bit 28 or bit 27 = 1. When more than one filter matches, these fields provide the number of lowest filter. **NOTE** This status is not available when Flexible RX Parser is enabled.
28	L4FM	Layer 4 Filter Match

Table continues on the next page...

Table 671. RDES2 normal descriptor (Write-back format) (continued)

Bit	Name	Description
		When this field is 1, it indicates that the received packet matches one of the enabled layer 4 port number fields. This status is given only when one of these conditions is true: • Layer 3 fields are not enabled and all enabled layer 4 fields match • All enabled layer 3 and layer 4 filter fields match When more than one filter matches, this bit gives the layer 4 filter status of filter indicated by Bits[31:29]. **NOTE** This status is not available when the flexible receive parser is enabled.
27	L3FM	Layer 3 Filter Match When this field is 1, it indicates that the received packet matches one of the enabled layer 3 IP address fields. This status is given only when one of these conditions is true: • All enabled layer 3 fields match and bypasses all enabled layer 4 fields. • All enabled filter fields match. When more than one filter matches, this field gives the layer 3 filter status of filter which bits[31:29] indicate. **NOTE** This status is not available when the flexible receive parser is enabled.
26:19	MADRM	MAC Address Match or Hash Value When HF becomes 0, it indicates that this field contains the MAC address register number that matches the received packet destination address. This field is valid only if the DAF field becomes 0. When HF = 1, it indicates that this field contains the hash value that MAC computes. A packet passes the hash filter when the field corresponding to the hash value is 1 in the hash filter register. **NOTE** This status is not available when the flexible receive parser is enabled.
18	HF	Hash Filter Status When this field is 1, it indicates that the packet passes the MAC address hash filter. Bits[26:19] indicate the hash value. **NOTE** This status is not available when the flexible receive parser is enabled.
17	DAF/RXPI	Destination Address Filter Fail When flexible receive parser is disabled, and this field is 1, it indicates that the packet fails the DA filter in MAC. When flexible receive parser is enabled, and this field is 1, it indicates that the packet parsing is incomplete (RXPI) due to ECC error.

Table continues on the next page...

Table 671. RDES2 normal descriptor (Write-back format) (continued)

Bit	Name	Description
		NOTE When this field is 1, RDES3 ES field is also 1.
16	SAF/RXPD	SA Address Filter Fail When flexible receive parser is disabled, and this field is 1, it indicates that the packet fails the SA filter in MAC. When flexible receive parser is enabled and this field is 1, it indicates that the parser drops the RXPD packet. **NOTE** When this field is 1, RDES3 ES field is also 1.
15	OTS	VLAN Filter Status When this field is 1, it indicates that the received packet VLAN tag passes the VLAN filter. This field redefines as an outer VLAN tag filter status (OTS). This field is valid for both single and double VLAN tagged frames.
14	ITS	Inner VLAN Tag Filter Status (ITS) This field is valid only for double VLAN tagged frames, when double VLAN processing is enabled. See Filter status for more information.
13:11	Rsvd	Reserved
10	ARPNR	ARP Reply Not Generated When this field is 1, it indicates that MAC did not generate the ARP reply for the ARP request packet it receives.. This field is 1 when MAC is busy transmitting ARP reply to earlier ARP request (only one ARP request is processed at a time). This field is reserved when you do not select the enable IPv4 ARP offload option.
9:0	HL	L3/L4 Header Length Contains the length of the packet header which MAC splits at L3 or L4 header boundary which the MAC receiver identifies. This field is valid only when the first descriptor bit = 1 (FD = 1). You can write the header data to the buffer 1 address of corresponding descriptor. If the header length is zero, this field is not valid. It implies that MAC does not identify and split the header. This field is valid when you select the enable split header feature option.

78.15.4.1.5.4 RDES3 normal descriptor (Write-back format)

Following table describes the write-back format for the RDES3 normal descriptor.

31	30	29	28	27	26	25	24	23	22	21	20	19	18:16	15	14:0
OWN	CTXT	FD	LD	RS2V	RS1V	RS0V	CE	GP	RWT	OE	RE	DE	LT	ES	PL

Table 672. RDES3 normal descriptor (Write-back format)

Bit	Name	Description
31	OWN	Own Bit When this field is 1, it indicates that the module DMA owns the descriptor. If this field becomes 0, it indicates that the application owns the descriptor. DMA writes 0 to this field when either of these conditions is true: • DMA completes the packet reception. • The buffers associated with the descriptor are full.
30	CTXT	Receive Context Descriptor When this field is 1, it indicates that the current descriptor is a context type descriptor. DMA writes 1'b0 to this field for a normal receive descriptor. When CTXT and FD bits are used together, {CTXT, FD} • 2’b00: Intermediate descriptor • 2’b01: First descriptor • 2’b10: Reserved • 2’b11: Descriptor error (due to all 1s) **NOTE** When descriptor error occurs, the receive DMA closes the receive descriptor indicating a descriptor error. This receive descriptor is skipped and the buffer addresses are not used to write the packet data. Receive DMA will write 1 to the CDE bit in DMA_CH#_Status register but not to the RI bit even when IOC = 1, as this is not marked as the last receive descriptor for the packet. The subsequent valid receive descriptor writes the packet data.
29	FD	First Descriptor When this field is 1, it indicates that this descriptor contains the first buffer of the packet. If the size of the first buffer is 0, the second buffer contains the beginning of the packet and if the size of the second buffer is also 0, the next descriptor will contain the beginning of the packet. See the CTXT bit description for more information on how to use the CTXT bit and FD bit together.
28	LD	Last Descriptor When this field is 1, it indicates that this descriptor buffers points to the last buffers of the packet.
27	RS2V	Receive Status RDES2 Valid When this field is 1, it indicates that the status in RDES2 is valid and DMA writes it. This field is valid only when the LD bit of RDES3 = 1.
26	RS1V	Receive Status RDES1 Valid When this field is 1, it indicates that the status in RDES1 is valid and DMA writes it. This field is valid only when the LD bit of RDES3 = 1.
25	RS0V	Receive Status RDES0 Valid When this field is 1, it indicates that the status in RDES0 is valid and DMA writes it. This field is valid only when the LD bit of RDES3 = 1.

Table continues on the next page...

Table 672. RDES3 normal descriptor (Write-back format) (continued)

Bit	Name	Description
24	CE	CRC Error When this field is 1, it indicates that a cyclic redundancy check (CRC) error occurs on the received packet. This field is valid only when the LD bit of RDES3 = 1.
23	GP	Giant Packet When this field is 1, it indicates that the packet length exceeds the specified maximum Ethernet size of 1518, 1522, or 2000 bytes (9018 or 9022 bytes if jumbo packet enable = 1). **NOTE** Giant packet indicates only the packet length. It does not cause any packet truncation.
22	RWT	Receive Watchdog Timeout When this field is 1, it indicates that the receive watchdog timer expires when it receives the current packet. The current packet truncates after watchdog timeout.
21	OE	Overflow Error When this field is 1, it indicates that the received packet is damaged because of buffer overflow in receive FIFO. **NOTE** This field is 1 only when DMA transfers a partial packet to the application. This happens only when the receive FIFO operates in the Threshold mode. In the Store-and-Forward mode, all the partial packets drops completely in the receive FIFO.
20	RE	Receive Error When this field is 1, it indicates that the gmii_rxer_i signal asserts when the gmii_rxdv_i signal asserts during the packet reception. This error also includes carrier extension error in the GMII and Half-duplex mode. Error can be of less or no extension, or error (rxd!= 0f) during extension.
19	DE	Dribble Bit Error When this field is 1, it indicates that the received packet has a non-integer multiple of bytes (odd nibbles). This field is valid only in the MII mode.
18:16	LT	Length/Type Field Indicates if the packet received is a length packet or a type packet. The encoding of the 3 bits is as follows: • 3'b000: The packet is a length packet. • 3'b001: The packet is a type packet. • 3'b011: The packet is a ARP request packet type • 3'b100: The packet is a type packet with VLAN tag • 3'b101: The packet is a type packet with double VLAN tag • 3'b110: The packet is a MAC control packet type • 3'b111: The packet is a OAM packet type

Table continues on the next page...

Table 672. RDES3 normal descriptor (Write-back format) (continued)

Bit	Name	Description
		• 3'b010: Reserved
15	ES	Error Summary When this field is 1, it indicates the logical OR of these bits, : • RDES3[24]: CRC error • RDES3[19]: Dribble error • RDES3[20]: Receive error • RDES3[22]: Watchdog timeout • RDES3[21]: Overflow error • RDES3[23]: Giant packet • RDES2[17]: Destination address filter fail, when the flexible receive parser is enabled • RDES2[16]: SA address filter fail, when flexible receive parser is enabled This field is valid only when the LD bit of RDES3 = 1.
14:0	PL	Packet Length Indicates the byte length of the received packet that was transferred to system memory (including CRC). This field is valid when the LD bit of RDES3 = 1 and overflow error bits becomes 0. The packet length also includes the two bytes that appends to the Ethernet packet when IP checksum calculation is enabled and the received packet is not a MAC control packet. This field is valid when the LD bit of RDES3 = 1. When the last descriptor and error summary bits are not 1, this field indicates the accumulated number of bytes that are transferred for the current packet.

78.15.4.1.6 Receive context descriptor

This descriptor is read-only for the application. Only DMA can write to this descriptor. The context descriptor provides information about the extended status related to the last received packet. Bit 30 of RDES3 indicates the context type descriptor.

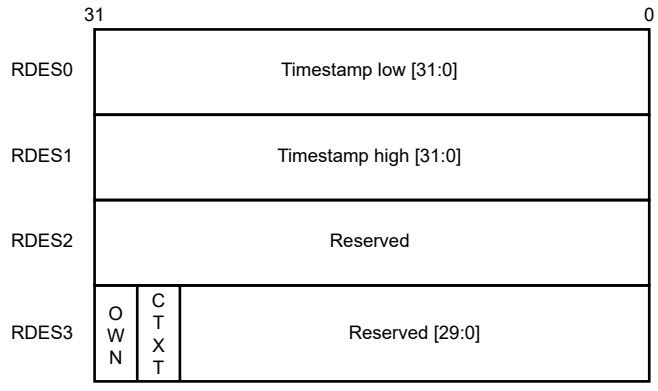

Figure 587. Receive context descriptor format

78.15.4.1.6.1 RDES0 context descriptor

Table 673. RDES0 context descriptor

Bit	Name	Description
31:0	RTSL	Receive Packet Timestamp Low DMA updates this field with least significant 32-bits of the timestamp captured for the corresponding receive packet. When this field and the RTSH field of RDES1 show all-ones value, you must consider the timestamp as corrupt.

78.15.4.1.6.2 RDES1 context descriptor

Table 674. RDES1 context descriptor

Bit	Field	Description
31:0	RTSH	Receive Packet Timestamp High DMA updates this field with the most significant 32-bits of the timestamp captured for the corresponding receive packet. When this field and the RTSL field of RDES0 show all-ones value, you must consider the timestamp as corrupt.

78.15.4.1.6.3 RDES2 context descriptor

Table 675. RDES2 context descriptor

Bit	Description
31:0	Reserved

78.15.4.1.6.4 RDES3 context descriptor

31	30	29	28:0
OWN	CTXT	DE	Rsvd

Table 676. RDES3 context descriptor

Bit	Name	Description
31	OWN	Own Bit When this field is 1, it indicates that DMA owns the descriptor. When this field becomes 0, it indicates that the application owns the descriptor. DMA clears this field when either of these conditions is true: • DMA completes the packet reception. • The buffers associated with the descriptor are full.
30	CTXT	Receive Context Descriptor

Table continues on the next page...

Table 676. RDES3 context descriptor (continued)

Bit	Name	Description
		When this field is 1, it indicates that the current descriptor is a context descriptor. DMA writes 1'b1 to this field for context descriptor. DMA writes 2'b11 to indicate a descriptor error due to all = 1. When CTXT and DE bits are used together {CTXT, DE} • 2'b00: Reserved • 2'b01: Reserved • 2'b10: Context descriptor • 2'b11: Descriptor error Note: When descriptor error occurs, the receive DMA closes the receive descriptor indicating descriptor error. This receive descriptor is skipped and the buffer addresses does not write the packet data. The receive DMA writes 1 to the CDE bit in DMA_CH#_Status register but not to the RI bit even when IOC = 1, because this is not marked as last receive descriptor for the packet. The subsequent valid receive descriptor writes the packet data.
29	DE	Descriptor Error See the CTXT bit description for more information about how to use the DE bit along with CTXT bit.
28:0	Rsvd	Reserved

78.15.5 Enhanced descriptor for time-based scheduling

This feature needs 32 bytes enhanced descriptors to enable on all the DMA channels that uses this feature (write 1 to EDSE bit of DMA_CH(#i)_TX_Control register).

The structure of 32-byte descriptor for the context and the normal descriptor in read and write formats are described in the upcoming sections.

78.15.5.1 Enhanced normal descriptor - Read (32-bit mode)

These fields are present in the first 16 bytes of the enhanced descriptor format of normal descriptor:

- LTV- Indicates that the launch time (LT) and GSN fields present in the descriptor are valid. The LTV must be = 1 only if the FD bit of the descriptor is not.
- GSN- Indicates the GCL slot number associated with the packet.
- LT- Indicates the launch time associated with the packet.

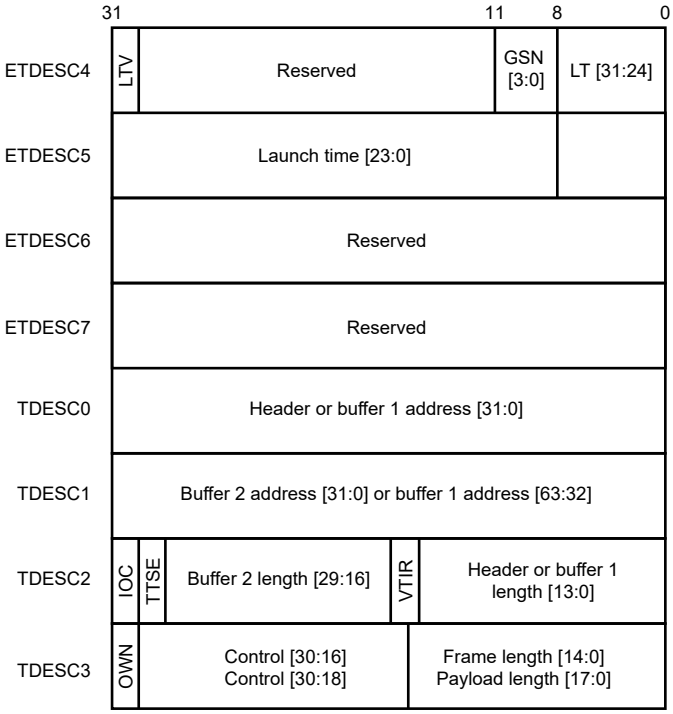

Figure 588. Enhanced normal descriptor - Read (32-bit mode)

78.15.5.2 Enhanced normal descriptor (Write, 32-bit mode)

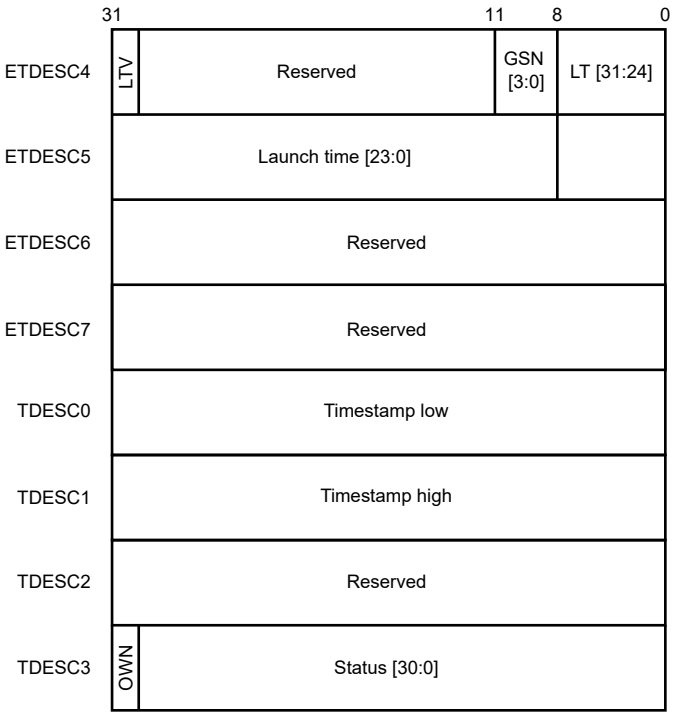

Figure 589. Enhanced normal descriptor write (32-bit mode)

NOTE

- All the enhanced descriptors, example, assumes a 32-bit data width configurations. However, the same definitions are valid in 64-bit and 128-bit configurations.
- In both the write back formats, you cannot modify the extended 16 bytes. The remaining 16 bytes (TDESC0 to TDESC3) are written back per the previous 16 bytes descriptor format.
- When you enable the fetch time it overrides the AV slot function
- When an unaligned new GCL list (with a different CTR) is installed it is recommended not to have traffic during the installation of the new list. Any traffic during the switching of the lists might have unpredictable behavior regarding fetch, launch, and launch expiry because the CTR and BTR values get updated when the frame is processed

78.15.5.3 Enhanced context descriptor (Read, 32-bit mode)

The first 16 bytes of the enhanced context descriptor (ETDESC4 to ETDESC7) are reserved and must be = 0. The fields present in the last bytes of the descriptor (TDESC0 to TDESC3) are same as the context descriptor (TDESC0 to TDESC3) in 16 byte format.

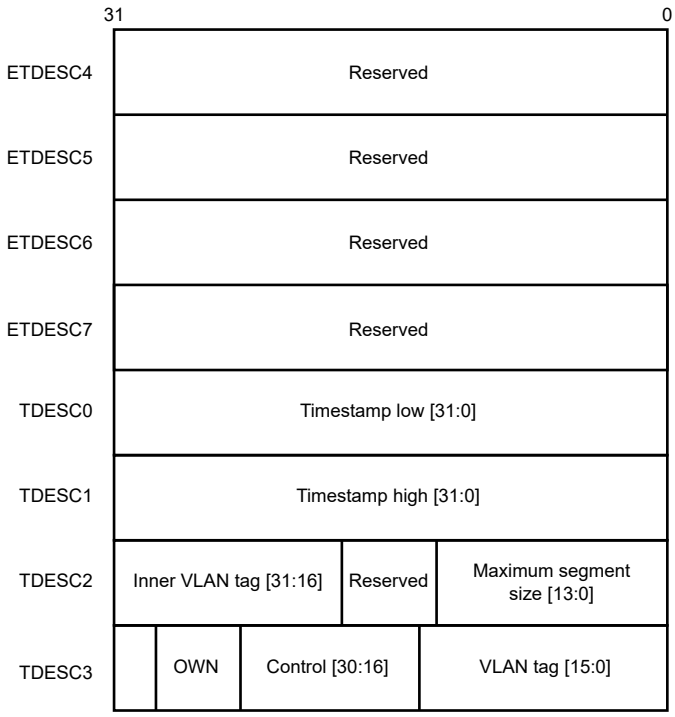

Figure 590. Enhanced context descriptor - Read

78.15.5.4 Enhanced context descriptor (Write, 32-bit mode)

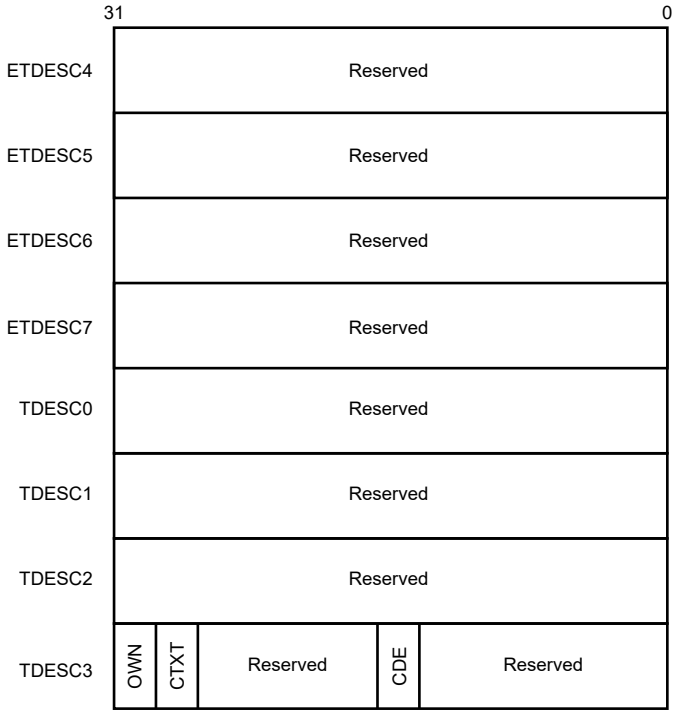

Figure 591. Enhanced context descriptor - Write

78.16 Programming

This section and all its sub-sections are Synopsys Proprietary. Used with permission.

This section provides the instructions for initializing the DMA or MAC registers in the proper sequence.

78.16.1 Initializing DMA

Perform these steps to initialize DMA:

1. Provide a software reset. This resets all the MAC internal registers and logic (bit-0 of DMA_Mode).
2. Wait for the reset process (poll bit 0 of DMA_Mode which is only clears after the reset operation completes) to complete.
3. Program these fields to initialize DMA_SysBus_Mode:
    a. DMA_SysBus_Mode[AAL]
    b. Fixed burst or undefined burst
    c. Burst mode values in case of AHB bus interface, OSR_LMT in case of AXI bus interface.
    d. Select the maximum burst length possible on the AXI bus (bits [7:1]), if fixed length value is enabled.
4. Create a descriptor list for a transmit and receive. Also, ensure that DMA (write 1 to bit 31 of descriptor TDES3/RDES3) owns the descriptors. See Descriptors for more information about descriptors.
5. Program the transmit and receive ring length registers (DMA_CH(#i)_TxDesc_Ring_Length (for i = 0; i <= 1) and DMA_CH(#i)_RxDesc_Ring_Length (for i = 0; i <= 1)). The programmed ring length must be at least 4.

NOTE

The descriptor address from the start to the end of the ring must not cross the 4 GB boundary.

6. Initialize the receive and transmit descriptor list address with the base address of the transmit and receive descriptor (DMA_CH(#i)_TxDesc_List_Address (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1), DMA_CH(#i)_RxDesc_List_Address (for i = 0; i <= DWC_EQOS_NUM_DMA_RX_CH-1)). Also, program the transmit and receive tail pointer registers that indicates DMA about the available descriptors (DMA_CH(#i)_TxDesc_Tail_Pointer (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) and DMA_CH(#i)_RxDesc_Tail_Pointer (for i = 0; i <= DWC_EQOS_NUM_DMA_RX_CH-1)).

   NOTE

   For 40-bit or 48-bit addressing mode, program the higher address List registers (DMA_CH[n]_TxDesc_List_HAddress, DMA_CH[n]_RxDesc_List_HAddress).

   The tailpointer registers must advance to the location immediately after the descriptors that are set so that DMA is aware that the additional descriptors are available.

7. Program the settings of these registers for the parameters like maximum burst-length (PBL) which DMA initiates, descriptor skip lengths, OSP in case of TxDMA, RBSZ in case of RxDMA, and so on:
   - DMA_CH(#i)_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1)
   - DMA_CH(#i)_TX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1)
   - DMA_CH(#i)_RX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_RX_CH-1)
8. Program the DMA_CH(#i)_Interrupt_Enable (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) register to enable the interrupts.
9. Write 1 to SR (bit 0) of the DMA_CH(#i)_RX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_RX_CH-1) and ST (bit 0) of the DMA_CH(#i)_TX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) register to start the receive and transmit DMAs.
10. Repeat steps 4 to 9 for all the transit DMA and receive DMA channels selected in the hardware.

78.16.2 Initializing MTL registers

The transaction layer (MTL) registers must initialize to establish the transmit and receive operating modes and commands.

Perform these steps to initialize the MTL registers:

1. Program MTL_Operation_Mode[SCHALG] and MTL_Operation_Mode[RAA] to initialize the MTL operation in case of multiple transit and receive queues.
2. Program the receive queue to DMA mapping in MTL_RxQ_DMA_Map0.
3. Program these fields to initialize the mode of operation in MTL_TxQ0_Operation_Mode.
   a. MTL_TxQ0_Operation_Mode[TSF] or MTL_TxQ0_Operation_Mode[TTC] in case of Threshold mode.
   b. MTL_TxQ0_Operation_Mode[TXQEN] to value 2'b10 to enable transmit queue0.
   c. MTL_TxQ0_Operation_Mode[TQS]
4. Program these fields to initialize the mode of operation in MTL_RxQ0_Operation_Mode:
   a. MTL_RxQ0_Operation_Mode[RSF] or MTL_RxQ0_Operation_Mode[RTC] in case of Threshold mode.
   b. Flow control activation and de-activation thresholds for MTL receive FIFO (MTL_RxQ0_Operation_Mode[RFA] and MTL_RxQ0_Operation_Mode[RFD]).
   c. Error Packet and undersized good Packet forwarding enable (MTL_RxQ0_Operation_Mode[FEP] and MTL_RxQ0_Operation_Mode[FUP]).
   d. MTL_RxQ0_Operation_Mode[RQS]
5. Repeat previous two steps for all MTL transit and receive queues selected in the configuration.

78.16.3 Initializing MAC

The MAC configuration registers establish the operating mode of MAC. These registers must initialize before initializing DMA.

You can perform these MAC initialization operations after DMA initialization. If the MAC initialization completes before DMA is configured, enable the MAC receiver (last step in the following sequence) only after the DMA is active. Otherwise, the received frames fill the receive FIFO and overflow.

1. Provide the MAC address registers: MAC_Address0_High and MAC_Address0_Low. If more than one MAC address is enabled, , program the MAC addresses appropriately.

2. Program these fields to set the appropriate filters for the incoming frames in MAC_Packet_Filter:

a. Receive all

b. Promiscuous mode

c. Hash or perfect filter

d. Unicast, multicast, broadcast, and control frames filter settings

3. Program these fields for proper flow control in MAC_Q0_Tx_Flow_Ctrl:

a. Pause time and other Pause frame control bits

b. Transmit flow control bits

c. Flow control busy

4. Program MAC_Interrupt_Enable as required, and if applicable, for your configuration.

5. Program the appropriate fields in MAC_Configuration. For example Inter-packet gap when transmission and jabber disable.

6. Write 1 to MAC_Configuration[RE] and MAC_Configuration[TE] to start the MAC transmitter and receiver.

78.16.4 Performing normal receive and transmit operation

During normal operation of the module, read the normal and transmit interrupts, poll the descriptors, suspend the DMA (if it does not own descriptors), and read the values of the current host transmitter or receiver descriptor pointers for debugging.

For normal operation, perform these steps:

1. Read the interrupt status for normal transmit and receive interrupts. Then poll the descriptors, read the status of the descriptor which the host owns (either transmit or receive).

2. Set appropriate values for the descriptors, ensure that the DMA owns the transmit and receive descriptors to resume the data transmission and reception.

3. If DMA does not own the descriptors (or no descriptor is available), DMA enters into SUSPEND state. The transmission or reception can resume by freeing the descriptors and writing the descriptor tail pointer to Tx/Rx tail pointer register (DMA_CH[n]_TxDesc_Tail_Pointer and DMA_CH[n]_RxDesc_Tail_Pointer).

4. Read the current host transmitter or receiver descriptor address pointer values for the debug process (DMA_CH[n]_Current_App_TxDesc and DMA_CH[n]_Current_App_RxDesc register).

5. Read the current host transmit buffer address pointer and receive buffer address pointer values for the debug process (Register DMA_CH[n]_Current_App_TxBuffer and DMA_CH[n]_Cur-rent_App_RxBuffer).

78.16.5 Stopping and starting transmission

Perform these steps to pause the transmission for some time. The steps are provided for channel 0.

1. Write 0 to bit 0 (ST) of DMA_CH(#i)_TX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) register to disable the transmit DMA (if applicable) .

2. Wait for any previous frame transmissions to complete. Read the appropriate fields of MTL_TxQ0_Debug (MTL_TxQ0_Debug[TRCSTS] is not 01 and MTL_TxQ0_Debug[TXQSTS] = 0) to check this.

3. Write 0 to MAC_Configuration[RE] and MAC_Configuration[TE] to disable the MAC transmitter and MAC receiver.

4. Disable the receive DMA (if applicable), after you ensure that the data in the receive FIFO transfers to the system memory (read the appropriate fields MTL_RxQ0_Debug[PRXQ] = 0 and MTL_RxQ0_Debug[RXQSTS] = 00).

5. Ensure that both the transit queue and receive queue are empty (MTL_TxQ0_Debug[TXQSTS] = 0 and MTL_RxQ0_Debug[RXQSTS] = 0).

6. Restart the operation by first starting the DMAs, and then enable the MAC transmitter and receiver.

NOTE

- Do not change the configuration (such as duplex mode, speed, port, or loop back) when the MAC is actively transmitting or receiving. You can change these parameters only when the MAC transmitter and receiver are not active.
- Similarly, do not change the DMA related configuration when transmit and receive DMA are active.

78.16.6 Programming guidelines for switching to new descriptor list in RxDMA

Switching to a new descriptor list is different in the receive DMA as compared to the transit DMA. It is permitted when the RxDMA is in SUSPEND state as described below:

- RxDMA prepares the descriptors in advance.
- If the RxDMA goes to SUSPEND state because the descriptors are not available, a major failure occurs (you are not able to free the filled-up descriptors or buffers). If this issue does not rectify immediately, frames will be lost because of an RxFIFO overflow. Therefore, you can create a new descriptor list and program the RxDMA to start using it immediately, without going into STOP state.

78.16.7 Programming guidelines for multi-channel multi-queuing

78.16.7.1 Transmit

1. Program the transmit queue size in TQS field of MTL_TxQ[n]_Operation_Mode register. Based on the value programmed in TQS field, you can determine the queue size.

In the transmit operation, the number of channels is equal to the number of the queues, because of this reason, the channel-to-queue mapping is fixed.

2. Enable the queue in TXQEN in the corresponding MTL_TxQ[n]_Operation_Mode register to use the queue. In DMA configurations, enable the ST field of DMA_CH[n]_Tx_Con-trol register and corresponding TXQEN in MTL_TxQ[n]_Operation Mode register.

3. Program the scheduling method in MTL_Operation_Mode[SCHALG].

4. Program MTL_TxQ[n]_Quantum_Weight register for DCB queue per the selected algorithm. In case of CBS algorithm in AVB queues program the MTL_TxQ[n]_ETS_Control, MTL_TxQ[n]_SendSlopeCredit, MTL_TxQ[n]_HiCredit, and MTL_TxQ[n]_LoCredit registers as required.

5. Program the MAC_TxQ_Prty_Map0 register to assign a fixed priority to the queue, if DCB is enabled and PFC function is required. You can use this assigned priority to determine if the corresponding queue must stop transmitting packet on the basis of the received PFC packet.

78.16.7.2 Receive

1. Program the receive queue size in RQS field of MTL_RxQ[n]_Operation_Mode register. Determine the size of the queue, based on the value programmed in RQS field.
2. Enable the receive queues 0 to 7 in the fields RXQ0EN to RXQ7EN in MAC_RxQ_Ctrl0 for AV or DCB. In DMA configurations, SR bit of statically or dynamically map DMA_CH[n]_Rx_Control register and the corresponding RXQ[n]_EN in MAC_RxQ_Ctrl0 is enabled.

3. Based on these packet types MAC routes the receive packets to the receive queues :
    a. AV PTP packets: Based on the programming of MAC_RxQ_Ctrl1[PTPQ].
    b. AV untagged control packets: Based on the programming of MAC_RxQ_Ctrl1[AVCPQ].
    c. Data center bridging (DCB) related link layer discovery protocol (LLDP) packets. Program DCBCPQ in MAC_RxQ_Ctrl1 to indicate MAC which queue should get the DCB packets.
    d. VLAN tag priority field in VLAN tagged packets: Program PSRQ7-0 of the MAC_RxQ_Ctrl2 and MAC_RxQ_Ctrl3 register for routing the tagged packets based on the received packets USP (user priority) field to the receive queues 0 to 7.
    e. Route the AV tagged control and data packets based on PSRQ field of MAC_RxQ_Ctrl2 and MAC_RxQ_Ctrl3 registers.

NOTE

The priorities set in PSRQ7-0 must be unique.

4. If multiple receive DMA channels are enabled, you must perform the following programming for proper arbitration and mapping:
    a. Program MTL_Operation_Mode[RAA] to select the arbitration algorithm to decide which RxQ is read out from the RxFIFO memory.
    b. Program the MTL_RxQ[n]_Control register to decide the weights and the packet arbitration for each RxQ.
    c. If you program the static mapping in MTL_RxQ_DMA_Map[n] register (RXQ[n]DADMACH becomes 0), fields RXQx2DMA and others are programmed to select the channel to map each queue.
    d. Write 1 to RXQ[n]DADMACH field in MTL_RxQ_DMA_Map0 to select the dynamic mapping of packets in each receive queue.
    e. In dynamic channel mapping, the value of DCS field in the lowest MAC address register the decides the routing of a packet to a specific RxDMA channel.

78.16.7.2.1 Programming guidelines for recovering from DMA channel failure

When the DMA channel issues a bus error, follow these steps to recover from the failure.

Recovering from the receive DMA channel failure.

Perform these steps if you get bus error in the receive DMA channel:

1. Write 1 to DMA_CH0_Rx_Control[RPF]. This flushes all the packets one after the other.

This step is optional. However, writing 1 to this field prevents head-of-line blocking in the receive queues when packets sent to the RXDMA are stopped due to the bus error.

2. Re-program the specific registers of the DMA channel.

3. Start the DMA channel.

Recovering from the transmit DMA channel failure.

1. Stop the specific DMA channel, even if it is in active state.

2. Flush the corresponding MTL queue.

3. Re-program the specific registers of the DMA channel.

4. Start the DMA channel.

NOTE

Due to the known limitations in the design, reprogramming the DMA channel registers might not be always successful in recovering from a bus error. If the module is not fully functional after reprogramming the DMA, you can issue a soft reset to recover from the bus error.

78.16.8 Programming guidelines for GMII link state transitions

78.16.8.1 Transmit and receive clocks running when link down

Perform these steps when the link is down but the transmit and receive clocks are running:

NOTE

The steps are provided for channel 0.

1. Write 0 to bit 0 (ST) of DMA_CH(#i)_TX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) register to disable the transmit DMA (if applicable).

2. Write 0 to MAC_Configuration[RE] to disable the MAC receiver.

3. Wait for any previous frame transmissions to complete. You can check this by reading the appropriate fields of MTL_TxQ0_Debug (MTL_TxQ0_Debug[TRCSTS] is not 01) or, flush the Tx FIFO for faster empty operation.

4. Write 0 to MAC_Configuration[TE] to disable the MAC transmitter.

5. Make sure that both the transit queue and receive queue are empty (MTL_TxQ0_Debug[TXQSTS] and MTL_RxQ0_Debug[RXQSTS] are 0).

6. Read the PHY registers to know the latest configuration and accordingly program the MAC registers, after the link is up.

7. Start the transit DMA to restart the operation, and then enable the MAC transmitter and receiver.

You do not disable the receive DMA because the receiver is disabled and the FIFO does not get any data in the receive FIFO.

78.16.8.2 Transmit and receive clocks stopped when link down

Perform these steps when the link is down and the transmit and receive clocks are stopped:

NOTE

The steps are provided for channel 0.

1. Write 0 to MAC_Configuration[RE] and MAC_Configuration[TE] to disable the MAC transmitter and receiver. This does not take effect immediately as the clocks are absent.

2. Wait until the link is up and the clocks are restored.

3. Wait for the transfer of any partial frame, if any to complete at time of stopping of the transmit or receive clock. To check this, read MAC_Debug (should be all-zero). Some old packets may still remain in the TXFIFO because the MAC transmitter is stopped.

4. Read the PHY registers to know the latest operating mode and accordingly program the MAC registers.

5. Write 1 to MAC_Configuration[RE] and MAC_Configuration[TE] to restart the MAC transmitter and receiver.

78.16.9 Programming guidelines for IEEE 1588 timestamping

78.16.9.1 Initialization guidelines for system time generation

Write 1 MAC_Timestamp_Control[TSENA] to enable the timestamp feature. However, it is essential to initialize the timestamp counter after MAC_Timestamp_Control[TSENA] = 1. Perform these steps during the module initialization:

1. Write 0 to the bit 16 of MAC_Interrupt_Enable to mask the timestamp trigger interrupt.
2. Write 1 to MAC_Timestamp_Control[TSENA] to enable timestamping.
3. Program MAC_Sub_Second_Increment based on the PTP clock frequency.
4. Program MAC_Timestamp_Addend and write 1 to MAC_Timestamp_Control[TSADDREG], if you are using the fine correction approach.
5. Poll MAC_Timestamp_Control until MAC_Timestamp_Control[TSADDREG] = 0.
6. Program MAC_Timestamp_Control[TSCFUPDT] to select the fine update method (if required).

7. Program MAC_System_Time_Seconds_Update and MAC_System_Time_Nanoseconds_Update with the appropriate time value.
8. Write 1 to MAC_Timestamp_Control[TSINIT].
9. Initialize the timestamp counter with the value written in the timestamp update registers so that the timestamp counter can start operation. If one-step timestamping is enabled
    a. Program Bit 27 of the TDES3 context descriptor, to enable one-step timestamping.
    b. Program MAC_Timestamp_Ingress_Asym_Corr and MAC_Timestamp_Egress_Asym_Corr to update the correction field in PDelay_Req PTP messages.
10. Enable the MAC receiver and transmitter for proper timestamping.

NOTE

If the timestamp operation is disabled by writing 0 to MAC_Timestamp_Control[TSENA], repeat all these steps to restart the timestamp operation.

78.16.9.2 System time correction

78.16.9.2.1 Coarse correction method

Perform these steps to synchronize or update the system time in one process (coarse correction method):

1. Set the offset (positive or negative) in the timestamp registers that is MAC_System_Time_Seconds_Update and MAC_System_Time_Nanoseconds_Update.

2. Write 1 to MAC_Timestamp_Control[TSUPDT].

The value in the timestamp update registers is added to or subtracted from the system time when MAC_Timestamp_Control[TSUPDT] = 0.

78.16.9.2.2 Fine correction method

Perform these steps to synchronize or update the system time to reduce system-time jitter (fine correction method):

1. Calculate the rate by which you want to increment the system time slower or faster, with the help of the algorithm.

2. Update MAC_Timestamp_Addend with the new value and write 1 to MAC_Timestamp_Control[TSADDREG].

3. Wait for the time for which you want the new value of the addend register to be active. You can do this by enabling the timestamp trigger interrupt after the system time reaches the target value.

4. Program the required target time in MAC_PPS[n]_Target_Time_Seconds register and MAC_PPS[n]_Target_Time_Nanoseconds register.

5. Enable the timestamp interrupt in MAC_Interrupt_Enable[TSIE].

6. Write 1 to bit 4 in MAC_Timestamp_Control.

7. Read MAC_Interrupt_Status when this trigger causes an interrupt.

8. Reprogram MAC_Timestamp_Addend with the old value and write 1 to MAC_Timestamp_Control[TSADDREG] again.

78.16.10 Programming guidelines for AV feature

After you enable the AV feature in the module controller, follow these programming tasks:

- Initializing the DMA for QOS-AHB configurations only
- Enabling slot number checking
- Enabling average bits per slot reporting
- Disabling flow control for AV-enabled queues (transmit and receive flow control)

78.16.10.1 Initializing the DMA in audio video feature

The first step to program the AV feature in a QOS-AHB configuration is to initialize the DMA.

Use this initialization sequence for QOS-AHB/QOS-AXI/QOS-AXI4 configurations with AV feature.

1. Provide a software reset to reset all the QOS internal registers and logic (DMA_Mode[SWR]).

2. Wait for the reset process to complete. Poll DMA_Mode[SWR], which clears only after the reset operation completes.

3. Set the values in DMA_Mode to program the fields to initialize the DMA register.

4. Create a descriptor list for transmit and receive. In addition, ensure that the DMA owns the transmit and receive descriptors. When you use OSF mode, at least two transmit descriptors are required.

See Descriptors for more information about descriptors.

5. Ensure that you create three or more different transmit or receive descriptors in the list before reusing any descriptors.

6. Program the transmit and receive ring length registers (DMA_CH(#i)_TxDesc_Ring_Length (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) and DMA_CH(#i)_RxDesc_Ring_Length (for i = 0; i <= DWC_EQOS_NUM_DMA_RX_CH-1)). The ring length programmed must be at least 4.

7. Initialize receive and transmit descriptor list address with the base address of the transmit and receive descriptor (DMA_CH(#i)_TxDesc_List_Address (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1), DMA_CH(#i)_TxDesc_List_Address (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1)). In addition, you must program the transmit and receive tail pointer registers to indicate the DMA about the available descriptors (DMA_CH(#i)_TxDesc_Tail_Pointer (for i = 0; i <= DWC_EQOS_NUM_D-MA_TX_CH-1) and DMA_CH(#i)_RxDesc_Tail_Pointer (for i = 0; i <= DWC_EQOS_NUM_D-MA_RX_CH-1)).

8. Program these fields to initialize the mode of operation in MTL_TxQ0_Operation_Mode:

a. MTL_TxQ0_Operation_Mode[TSF]

b. MTL_TxQ0_Operation_Mode[TTC]

c. MTL_TxQ0_Operation_Mode[TXQEN] to value 2'b10 to enable transmit queue0

d. MTL_TxQ0_Operation_Mode[TQS]

9. Enable the interrupts by programming DMA_CH(#i)_Interrupt_Enable (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) register.

10. Repeat steps 4 through 9 for all the additional channels of AV feature.

11. Program the AV queues CBS control register, idleSlope, sendSlope, hiCredit, and loCredit registers.

12. Write 1 to bit 0 of DMA_CH(#i)_TX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) and DMA_CH(#i)_RX_Control (for i = 0; i <= DWC_EQOS_NUM_DMA_RX_CH-1) register to start the receive and transmit DMA.

78.16.10.2 Enabling slot number checking

You can enable slot number checking feature if you specifies the intervals at which the DMA channels map to AV queues fetch the frames from the AHB/AXI system bus.

You must complete these steps after step 11 and before step 12 of Initializing the DMA in audio video feature .

You can use the slot number check feature to specify the intervals at which the DMA channels map to AV queues fetch the frames from the AHB/AXI system bus. This feature is useful for an uniform and periodic transfer of the AV traffic from the host memory and it is available only when you enable timestamping and programs MAC_Sub_Second_Increment. Perform these steps to enable the slot number checking:

1. Follow the steps described in Initialization guidelines for system time generation to enable timestamping.

2. Ensure that the SLOTNUM field (bits 22:19) of TDES3 normal descriptor (Read format) contains a valid slot number. You can read the current reference slot number from the DMA_CH(#i)_Slot_Func-tion_Control_Status (for i = 0; i <= DWC_EQOS_NUM_DMA_TX_CH-1) register.

3. Write 1 to bit 0 (ESC) of the slot function control and status register of a channel to enable the slot number checking.

78.16.10.3 Enabling average bits per slot reporting

You can enable the reporting of average bits transmitted in a slot.

The CBS status register of the additional AV channels provide information about the average bits that are transmitted in a slot. You can asynchronously read this register to retrieve information about the average bits transmitted per slot. Perform these steps to enable average bits per slot reporting:

1. Follow the steps as described in the Initialization guidelines for system time generation to enable timestamping.

2. Program SLC bits [6:4], of the MTL_TxQ[n]_ETS_Control register of a channel with the number of slots over which the average transmitted bits per slot are computed.

3. Enable bit 9(ABPSSIE) of the MTL_Q[n]_Interrupt_Control_Status register of a channel to generate the average bits per slot interrupt.

NOTE

- The frequency of this interrupt depends on the value programmed in step 2. For example, when you program value 0 in the SLC field, the interrupt generates at every 125 microsecond.
- You can disable this interrupt to stop the interrupt flooding, when it is not required.

4. Read ABS bits [16:0], of the MTL_TxQ[n]_ETS_Status register of a channel on each interrupt.

NOTE

You can read the ABS fields in the polling mode even if ABPSIE bit is not enabled. When bit 1 (ABPSIS) of the MTL_TxQ[n]_ETS_Status register is 1, it indicates that a new value is updated in the ABS field.

78.16.10.4 Disabling flow control for AV enabled queues

78.16.10.4.1 Transmit flow

Program the EHFC (Enable Hardware Flow Control) field of the corresponding receive queue's MTL_RxQ[n]_Operation_Mode register to 0.

78.16.10.4.2 Receive flow control

Program PSTQ[n] field, corresponding to AV enabled transit queue in MAC_TxQ_Prty_Map0/1 register to 0.

78.16.10.5 Programming guidelines for flexible pulse-per-second output

After you enable the flexible pulse-per-second output feature in the module controller, you can perform these tasks:

- Generating single pulse on PPS
- Generating next pulse on PPS
- Generating a pulse train on PPS
- Generating an interrupt without affecting the PPS

78.16.10.5.1 Generating single pulse on PPS

Perform these steps to generate single pulse on PPS:

1. Program 11 or 10 (for interrupt) in TRGTMODSEL bits [6:5], of MAC_PPS_Control. This instructs MAC to use the target time registers (MAC_PPS0_Target_Time_Seconds and MAC_PPS0_Target_Time_Nanoseconds) for a start time of the PPS signal output.
2. Program the start time value in the target time registers (MAC_PPS0_Target_Time_Seconds and MAC_PPS0_Target_Time_Nanoseconds).
3. Program the PPS signal output width in MAC_PPS(#i)_Width (for i = 0; i <= 3) register.

4. Program PPSCMD bits [3:0], of MAC_PPS_Control to 0001. This instructs MAC to generate single pulse on the PPS signal output at the time programmed in the target time registers.

78.16.10.5.2 Generating next pulse on PPS

When the PPSCMD is executed (PPSCMD bits = 0), you can give the cancel start command (PPSCMD=0011) before the programmed start time elapses to cancel the pulse generation. You can also program the behavior of the next pulse in advance.

Follow these steps to program the next pulse:

1. Program the start time for the next pulse in the target time registers. This time must be more than the time at which the falling edge occurs for the previous pulse.

2. Program the next PPS signal output width in MAC_PPS(#i)_Width (for i = 0; i <= DWC_EQOS_PPS_OUT_NUM-1) register.

3. Program PPSCMD bits [3:0], of MAC_PPS_Control to generate a single pulse after the time at which the previous pulse is de-asserted. This instructs MAC to generate single pulse on the PPS signal output, at the time programmed in target time registers.

If you give this command before the previous pulse becomes low, then the new command overwrites the previous command and the QOS may generate only 1 extended pulse.

78.16.10.5.3 Generating a pulse train on PPS

Perform these steps to generate a pulse train on PPS:

1. Program 11 or 10 (for interrupt) in TRGTMODSEL bits [6:5] , of MAC_PPS_Control. This instructs MAC to use the target time registers for the start time of the PPS signal output.

2. Program the start time value in the target time registers.

3. Program the interval value between the train of pulses on the PPS signal output in MAC_PPS(#i)_Interval (for i = 0; i <= DWC_EQOS_PPS_OUT_NUM-1) register.

4. Program the PPS signal output width in MAC_PPS(#i)_Width (for i = 0; i <= DWC_EQOS_PPS_OUT_NUM-1) register.

5. Program PPSCMD bits [3:0], of MAC_PPS_Control to 0010. This instructs MAC to generate train of pulses on the PPS signal output with start time programmed in target time registers.

By default, the PPS pulse train is free-running unless the STOP pulse train at time or STOP pulse train immediately commands stop it.

6. Program the stop value in the target time registers. Ensure that bit 31 (TSTRBUSY) of MAC_PPS(#i)_Target_Time_Nanoseconds (for i = 0; i <= DWC_EQOS_PPS_OUT_NUM-1) register becomes 0 before programming the target time registers again.

7. Program PPSCMD field [bit 3:0] of MAC_PPS_Control to 0100. This stops the train of pulses on the PPS signal output after the programmed stop time specified in step 6 elapses.

You can program 0101 in PPSCMD field [bit 3:0] of MAC_PPS_Control to stop the pulse train at any time. Similarly, you can program 0110 in PPSCMD field [bit 3:0] of MAC_PPS_Control before the time (programmed in step 6) elapses to cancel the stop pulse train command (given in Step 7). Also, program 0011 in PPSCMD field [bit 3:0] of MAC_PPS_Control before the programmed start time (in Step 2) elapses to cancel the pulse train generation.

78.16.10.5.4 Generating an interrupt without affecting the PPS

MAC_PPS_Control TRGTMODSEL bits [6:5] enables you to program the target time registers to perform any one of these actions:

- Generate only interrupts.
- Generate interrupts and the PPS start and stop time.
- Generate only PPS start and stop time.

Perform these steps to program the target time registers to generate only interrupt event:

1. Program 00 (for interrupt) in MAC_PPS_Control TRGTMODSEL bits [6:5]. This instructs the MAC to use the target time registers for target time interrupt.

2. Program a target time value in the target time registers. This instructs the MAC to generate an interrupt when the target time elapses.

If TRGTMODSEL bits [6:5], are changed (for example, to control the PPS) then over-write the interrupt generation with the new mode and new programmed target time register value.

78.16.10.6 Programming guidelines for VLAN filtering on receive

Perform these steps to program VLAN filtering on receive:

1. Program MAC_VLAN_Tag register for the following fields to select the filtering method:

a. ETV: Enables 12-Bit VLAN tag comparison or 16-bit VLAN tag comparison.

b. VTHM: VLAN tag hash table match enable.

c. ERIVLT: Enables inner VLAN tag or outer VLAN Tag (to enable the inner or outer VLAN tag filtering, writing 1 to MAC_VLAN_Tag_Ctrl[EDVLP] enables the double VLAN processing).

d. ERSVLM: Enables receive S-VLAN match or C-VLAN match (write 1 to MAC_VLAN_Tag_Ctrl[ESVL] to enable S-VLAN processing).

e. DOVLTC: Ignores VLAN type for tag match

f. VTIM: Enables VLAN tag inverse match instead of the normal VLAN tag matching

2. Program VL of MAC_VLAN_Tag register for the 12-bit or 16-bit VLAN tag.

3. Program MAC_VLAN_Hash_Table, if hash filtering of VLAN tag is enabled. When MAC_VLAN_Tag_Ctrl[ETV] becomes 0, it indicates that the upper 4 bits of the calculated CRC-32 of VLAN tag are inverted and index the content of MAC_VLAN_Hash_Table. When MAC_VLAN_Tag_Ctrl[ETV] is 1, it indicates that the upper 4 bits of calculated CRC-32 of VLAN Tag index the content of MAC_VLAN_Hash_Table. For example, when MAC_VLAN_Tag_Ctrl[ETV] is 1, a hash value of 4b'1000 selects bit 8 of MAC_VLAN_Hash_Table. When MAC_VLAN_Tag_Ctrl[ETV] becomes 0 a hash value of 4'b1000 selects bit 7 of MAC_VLAN_Hash_Table.

78.16.10.7 Programming guidelines for extended VLAN filtering and routing on receive

Perform these steps, for the indirect access of the per VLAN tag registers:

- Write
  - Write the required data into MAC_VLAN_Tag_Data.
  - Program MAC_VLAN_Tag_Ctrl[OFS] with the required filter register's offset and command type to MAC_VLAN_Tag_Ctrl[CT]. For a write command, set this field to 0.
  - Write 1 to MAC_VLAN_Tag_Ctrl[OB] and wait till it becomes 0 to do the next write. This will guarantee that you have programmed the appropriate VLAN Tag Filter register.
- Read
  - Program MAC_VLAN_Tag_Ctrl[OFS] with the required register's offset and command type to MAC_VLAN_Tag_Ctrl[CT]. For a read command, set this field to 1.
  - Write 1 to MAC_VLAN_Tag_Ctrl[OB] and wait till it becomes 0. The appropriate value of the VLAN Tag Filter register is available in MAC_VLAN_Tag_Data.

78.16.10.8 Programming sequence for queue/channel based VLAN inclusion register

Perform these steps to program the queue/channel-based VLAN inclusion register:

NOTE

When MAC_VLAN_Incl[CBTI] = 1 you cannot access the indirect VLAN include registers.

1. Write 1 to MAC_VLAN_Incl[CBTI], to enable queue or channel based VLAN tag insertion on all the transmitted packets. This field must be 1 before any indirect access to the queue or channel specific MAC_VLAN_Incl(#i) register.

2. Program the VLAN tag and VLAN type to insert in packets from a particular queue or channel in MAC_VLAN_Incl[VLT] and MAC_VLAN_Incl[CSVL], corresponding offset address in ADDR field (0 for queue/channel 0, 1 for queue/channel 1, and so on) must be set. Write 0 to MAC_VLAN_Incl[RDWR] to indicate write access. The write to byte 0 (byte 3 in Big Endian mode) of MAC_VLAN_Incl initiates access to indirect access MAC_VLAN_Incl(#i) register.

3. Write 1 to MAC_VLAN_Incl[BUSY] via the module to indicate the progress of access to indirect access MAC_VLAN_Incl(#i) register. After the access completes, MAC_VLAN_Incl[BUSY] = 0. The application must not attempt subsequent access to MAC_VLAN_Incl(#i) register when the MAC_VLAN_Incl[BUSY] is 1.

4. Repeat step 2 and step 3 to program VLAN tag and VLAN type to insert in packets from the remaining queues or channels. The application must ensure that the required VLAN tag and VLAN type for all the queues or channels are programmed, otherwise an unintended VLAN tag and VLAN type might be inserted.

78.16.11 Programming guidelines for EST

Program the gate control values and time intervals in MTL_EST_Status[SWOL] along with the other EST related registers that are described in EMAC register descriptions to appropriate values. The upcoming sub-sections provide step by step details for programming the GCL and the other EST related registers.

78.16.11.1 Programming the GCL and GCL linked registers

Perform these steps to program the GCL and the four other registers implemented per GCL:

1. Access the GCL and the four other GCL-linked registers via indirect addressing using MTL_EST_GCL_Control and MTL_EST_GCL_Data. MTL_EST_Status[SWOL] indicates whether the software owns GCL0 or GCL1.
2. Write the 32-bit write data to MTL_EST_GCL_Data, to program the GCL. Then program MTL_EST_GCL_Control to write the write address and other control information.
3. In MTL_EST_GCL_Data, write data consists of up to 8 bits (configurable) of gate controls and up to 24 bits (configurable) of time interval. Programming a 0 indicates gate close and programming a 1 indicates gate open. For a 4-TC and 20-bit time interval configuration, the data width is 24-bits and the remaining 8-bits are reserved/read-only. You must write the data in the following format.

   {8'h0, TC3, TC2, TC1, TC0, 20-bit Time Interval} where TCx = 0 or 1.
4. Program MTL_EST_GCL_Control[SRWO] to 1 (to start a Write Op) and program the address and R/W fields appropriately.
5. Poll and check that the hardware clears MTL_EST_GCL_Control[SRWO] to indicate that the previous operation completes before initiating a new read-write operation via the same indirect addressing mode.
6. Repeat steps 3, 4, 5 until the programming of the GCL completes.
7. Program the BTR, CTR, TER and LLR registers, using the same indirect addressing method as described above. Write 1 to MTL_EST_GCL_Control[GCRR] appropriately. MTL_EST_GCL_Control[GCRR] interprets the address field as belonging to these registers (instead of the GCL).

After the GCL and the related registers are programmed, program MTL_EST_GCL_Control to allow hardware to own and process the GCL. When the list length (as indicated in LLR) is 1, the associated time interval must be smaller than the cycle time register value. Otherwise, an error is reported (as described in the Error handling section) as a single set of gate controls add no value in the TSN context.

NOTE

The time unit in all the GCL related registers is seconds and nanoseconds. In cases where internally generated PTP system time is used, you must program the nanoseconds field to use the Digital Rollover mode. (The value of MAC_Timestamp_Control[TSCTRLSSR]must be 1)

78.16.11.2 Programming the EST registers

After the steps mentioned in "Programming the GCL and GCL Linked Registers" completes, program MTL_EST_Control

1. Write 1 to MTL_EST_Control[CTOV] and MTL_EST_Control[TILS]. Also, write 1 to MTL_EST_Control[EEST] and MTL_EST_Control[SWOL].

   NOTE

   The CTOV recommendations for GMII for SPRAM configurations are:

   - 96 * Tx clock period, for 32 and 64 bit data width configurations.
   - 128 * Tx clock period for 128 bit data width configurations.

   The CTOV recommendations for GMII for non-SPRAM configurations are:

   - 30 * Tx clock period, when SA/VLAN insertion is enabled.
   - 22 * Tx clock period, when SA/VLAN insertion is not enabled.

2. Enables the hardware to own and process the new GCL and make a switch to the new GCL at the BTR value. The hardware provides an interrupt (if enabled) when the switch to the new list happens.
3. Performs an appropriate action to address any other interrupts (explained in the Interrupts section) received during the hardware execution of the GCL.

Write 1 to MTL_EST_Control[SSWL] to handoff to hardware. Software is not allowed to write to the GCL and GCL linked registers when MTL_EST_Control[SSWL] = 1, because the hardware might be using the new GCL.

The hardware resets or clears MTL_EST_Control[SSWL] when it successfully switches to the new list. The hardware also flips MTL_EST_Status[SWOL] to indicate the new GCL that the software owns.

Program the GCL that software owns (MTL_EST_Status[SWOL] indicates) as described in "Programming the GCL and GCL Linked Registers" and then program MTL_EST_Control as described above, to install a new GCL. Ensure that the new BTR is set to an appropriate value to avoid BTR Error that may require software intervention in some cases.

The packet length (frame size) information must be available at all times, to avoid transmission overruns. Therefore, in the DMA configurations, program the packet length in the first descriptor of every transmit frame. Similarly, in the MTL configuration, provide the packet length in the control word.

NOTE

The packet length provided in the transmit descriptor must account for the SA and VLAN insertion, to avoid transmission overruns, if applicable, that is, packet length must represent the actual packet length on the Ethernet line.

78.16.12 Programming the launch time in time-based scheduling

Configure the launch time in the enhanced normal transmit descriptors in DMA configurations and is driven as a control word in MTL configurations as follows:

The OSTC and launch time features are mutually exclusive and must not be used together. In case of a conflict (if OSTC = LTV = 1 in MTL configuration), give priority to OSTC and ignore the launch time.

In DMA configuration, if a context descriptor is received with a valid OSTC values immediately before receiving a first normal descriptor with LTV = 1, then the LTV is ignored.

78.16.13 Programming guidelines for media clock generation and recovery

78.16.13.1 Programming guidelines for media clock generation

These are the guidelines for the media clock generation:

1. Program the appropriate presentation time control (supported generation modes "1001-1011") to PPSCTRL_PPSCMD (for 0th instance)/PPSCMD#i (for 1,2,3 instances) of MAC_PPS_Control, to define the PPS instance in Media clock generation mode.

2. Based on the selected PPS instance, application must drive the appropriate trigger signal to the corresponding MCG_PST_TRIG_I[#i].

3. Based on the programmed mode, DUT captures the timestamp and programs it in the MAC_PPS(#i)_Target_Time_Seconds register. Then, mcgr_dma_req_o[#i] is set.

4. For every request which DUT generates, the module reads the corresponding MAC_PPS(#i)_Target_Time_Seconds register and asserts the corresponding mcgr_d-ma_ack_i[#i] to acknowledge the read request.

78.16.13.2 Programming guidelines for media clock recovery

These are the guidelines for the media clock recovery:

- Writing 1 to MAC_Timestamp_Control[PTGE] enables the CPT counter. In addition to configuring the initialization values for the system time, update MAC_Presn_Time_Updt with the equivalent presentation time initialization value, then MAC_Timestamp_Control[TSINIT] = 1.
- Use the increment values for the system time and also for the CPT because the increment value is in sub-seconds and sub-nanoseconds.
- Update MAC_Presn_Time_Updt with the equivalent presentation time update value (32 bit ns), when an update is required, and also configure the updated values for the system time. Finally, MAC_Timestamp_Control[TSUPDT] must be 1 for the update.
- Program the MCGREN#i field of MAC_PPS_Control to enable the PPS instance to operate in MCGR mode.
- Program the appropriate presentation time control (supported recovery modes "0001 - 0011") to PPSCTRL_PPSCMD (for 0th instance) or PPSCMD#i (for 1,2,3 instances) of MAC_PPS_Control register, to set the PPS instance in Media clock recovery mode.
- After the PPS instance is set in Recovery mode, DUT sets the corresponding mcgr_dma_req_o[#i]. For every request which DUT generates, program the target presentation time into the MAC_PPS(#i)_Target_Time_Seconds register and assert the corresponding mcgr_dma_ack_i[#i] to acknowledge the request. Acknowledgment can be given before/after programming the Target presentation time.
- Observe the recovered media clock on the corresponding PTP_PPS_O[#i].

78.16.14 Programming guidelines for ECC protection for memories

These are the guidelines for the ECC protection for memories:

- Write 1 to the appropriate field of MTL_ECC_Control to enable the ECC features for the respective memory.
- Generate a correctable interrupt (sbd_sfty_ce_intr_o) or an uncorrectable interrupt (sbd_sfty_ue_intr_o) to indicate the application, if any correctable, uncorrectable, or address errors are detected. DMA_Interrupt_Status or MTL_ECC_Interrupt_Status indicates an appropriate status.
- Provide debug mode for each memory to specify errors.

NOTE

Enable the ECC feature before the traffic is online (or after the reset), otherwise the false interrupts may trigger.

78.16.14.1 Programming guidelines for ECC hardware error injection (Debug mode)

Follow these steps for ECC hardware error injection:

- Write 1 to the appropriate field in MTL_DBG_CTL to enable the ECC error injection feature for MTL TX/RX and DMA TSO.
- Write 1 to the appropriate field in MTL_EST_GCL_Control to enable the ECC error injection feature for the EST memory.
- Write 1 to the appropriate field in MTL_RXP_Indirect_Acc_Control_Status to enable the ECC error injection for the receive parser memory. To access the receive parser memory in Debug mode, write 0 to MTL_RXP_Indirect_Acc_Control_Status[FRPE] to disable the receive parser feature.
- Ensure that all the CSR writes corresponding to one memory write must have the same value for the error injection control word, where multiple CSR writes are required for writing single data word into the memory.

78.16.15 Programming guidelines for on-chip datapath parity protection

Follow these steps for on-chip datapath parity protection:

- Writing 1 to MTL_DPP_Control[EDPP] enables the parity generation and parity detection mismatch on datapath.
- Generates an uncorrectable interrupt (sbd_sfty_ue_intr_o) to indicate the application if any parity mismatch is detected. DMA_Safety_Interrupt_Status or MTL_Safety_Interrupt_Status and MAC_DPP_FSM_Interrupt_Status indicates the appropriate status.
- Supports Debug mode for each parity generator to insert an error.

NOTE

Enable the datapath parity protection before the receive or transit traffic starts, to avoid the false safety interrupts.

78.16.16 Programming guidelines for FSM parity and timeout

Follow these steps to configure the FSM parity and timeout:

- Write 1 to MAC_FSM_Control[PRTYEN] and MAC_FSM_Control[TMOUTEN] to enable the FSM parity and timeout feature respectively.
- Force the FSMs to enter into a state with even number of 1s and wait for the safety uncorrectable interrupt to define with MAC_DPP_FSM_Interrupt_Status[FSMPES] for a parity error detection.
- Write 1 to the parity error injection using the [23:16] bits of MAC_FSM_Control to select the appropriate clock domain, for Error injection mode in FSM parity. Wait for the safety uncorrectable interrupt to be defined with MAC_DPP_FSM_Interrupt_Status[FSMPES].
- Configure the large and normal mode values which MAC_FSM_ACT_Timer[LTMRMD] and MAC_FSM_ACT_Timer[NTMRMD] indicates , for FSM timeouts.
- Use the [31:24] bits of MAC_FSM_Control to select the large or normal mode tic generation per clock domain.
- Write 1 to MAC_FSM_ACT_Timer[TMR] with the appropriate number of CSR clock cycles to generate 1us tic.
- Force the FSM in a particular clock domain to remain in an active state for timeout duration (for example, T-2T). You can check the safety interrupt and the status field for the corresponding clock domain that sets in the [15:8] bits of the MAC_DPP_FSM_Interrupt_Status .
- Select the appropriate clock domain for which timeout error injection must be set using the [15:8] bits of MAC_FSM_Control, for Error injection mode in FSM timeout. Wait for the safety uncorrectable interrupt to define with the corresponding error status in the MAC_DPP_FSM_Interrupt_Status .
- Use only normal mode tic generation, for application or CSR interface timeout. On the basis of the time-outs of configured interface, appropriate fields (MSTTES, SLVTES) of MAC_DPP_FSM_Interrupt_Status is defined with the safety interrupt.

78.17 EMAC register descriptions

This section and all its sub-sections are Synopsys Proprietary. Used with permission.

NOTE

This chip has 16 KB allocated per Ethernet controller for configuration space. EMAC uses only 8 KB of this memory and the remaining 8 KB is reserved for future use. Writing to the reserved memory may lead to unintended behavior.

78.17.1 EMAC memory map

EMAC base address: 4048_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	MAC Configuration (MAC_Configuration)	32	RW	0000_8000h
4h	MAC Extended Configuration (MAC_Ext_Configuration)	32	RW	0000_0000h
8h	MAC Packet Filter (MAC_Packet_Filter)	32	RW	0000_0000h
Ch	MAC Watchdog Timeout (MAC_Watchdog_Timeout)	32	RW	0000_0000h
10h	MAC Hash Table First 32 Bits (MAC_Hash_Table_Reg0)	32	RW	0000_0000h
14h	MAC Hash Table Second 32 Bits (MAC_Hash_Table_Reg1)	32	RW	0000_0000h
50h	MAC VLAN Tag (MAC_VLAN_Tag)	32	RW	0000_0000h
50h	MAC VLAN Tag Control (MAC_VLAN_Tag_Ctrl)	32	RW	0000_0000h
54h	MAC VLAN Tag Data (MAC_VLAN_Tag_Data)	32	RW	0000_0000h
54h	MAC VLAN Tag Filter 0 (MAC_VLAN_Tag_Filter0)	32	RW	0000_0000h
54h	MAC VLAN Tag Filter 1 (MAC_VLAN_Tag_Filter1)	32	RW	0000_0000h
54h	MAC VLAN Tag Filter 2 (MAC_VLAN_Tag_Filter2)	32	RW	0000_0000h
54h	MAC VLAN Tag Filter 3 (MAC_VLAN_Tag_Filter3)	32	RW	0000_0000h
58h	MAC VLAN Hash Table (MAC_VLAN_Hash_Table)	32	RW	0000_0000h
60h	MAC VLAN Inclusion Or Replacement (MAC_VLAN_Incl)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 0 (MAC_VLAN_Incl0)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 1 (MAC_VLAN_Incl1)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 2 (MAC_VLAN_Incl2)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 3 (MAC_VLAN_Incl3)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 4 (MAC_VLAN_Incl4)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 5 (MAC_VLAN_Incl5)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 6 (MAC_VLAN_Incl6)	32	RW	0000_0000h
60h	MAC VLAN Inclusion 7 (MAC_VLAN_Incl7)	32	RW	0000_0000h
64h	Inner VLAN Tag Inclusion Or Replacement (MAC_Inner_VLAN_Incl)	32	RW	0000_0000h
70h	MAC Q0 Tx Flow Control (MAC_Q0_Tx_Flow_Ctrl)	32	RW	0000_0000h
90h	MAC Receive Flow Control (MAC_Rx_Flow_Ctrl)	32	RW	0000_0000h
94h	MAC RxQ Control 4 (MAC_RxQ_Ctrl4)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
A0h	MAC RxQ Control 0 (MAC_RxQ_Ctrl0)	32	RW	0000_0000h
A4h	Receive Queue Control 1 (MAC_RxQ_Ctrl1)	32	RW	0000_0000h
A8h	MAC RxQ Control 2 (MAC_RxQ_Ctrl2)	32	RW	0000_0000h
B0h	MAC Interrupt Status (MAC_Interrupt_Status)	32	R	0000_0000h
B4h	MAC Interrupt Enable (MAC_Interrupt_Enable)	32	RW	0000_0000h
B8h	MAC Rx Transmit Status (MAC_Rx_Tx_Status)	32	R	0000_0000h
110h	MAC Version (MAC_Version)	32	R	0000_1051h
114h	MAC Debug (MAC_Debug)	32	R	0000_0000h
11Ch	MAC Hardware Feature 0 (MAC_HW_Feature0)	32	R	0E09_5135h
120h	MAC Hardware Feature 1 (MAC_HW_Feature1)	32	R	2118_29A6h
124h	MAC Hardware Feature 2 (MAC_HW_Feature2)	32	R	0404_1041h
128h	MAC Hardware Feature 3 (MAC_HW_Feature3)	32	R	2C37_0E31h
140h	MAC DPP FSM Interrupt Status (MAC_DPP_FSM_Interrupt_Status)	32	R	0000_0000h
148h	MAC FSM Control (MAC_FSM_Control)	32	RW	0000_0000h
14Ch	MAC FSM ACT Timer (MAC_FSM_ACT_Timer)	32	RW	0000_0000h
150h	SCS_REG 1 (SCS_REG1)	32	RW	0000_0000h
200h	MAC MDIO Address (MAC_MDIO_Address)	32	RW	0000_0000h
204h	MAC MDIO Data (MAC_MDIO_Data)	32	RW	0000_0000h
230h	MAC CSR Software Control (MAC_CSR_SW_Ctrl)	32	RW	0000_0000h
234h	MAC FPE Control STS (MAC_FPE_CTRL_STS)	32	RW	0000_0000h
240h	MAC Presentation Time (MAC_Presn_Time_ns)	32	R	0000_0000h
244h	MAC Presentation Time Update (MAC_Presn_Time_Updt)	32	RW	0000_0000h
300h	MAC Address 0 High (MAC_Address0_High)	32	RW	8000_FFFFh
304h	MAC Address 0 Low (MAC_Address0_Low)	32	RW	FFFF_FFFFh
308h	MAC Address 1 High (MAC_Address1_High)	32	RW	0000_FFFFh
30Ch	MAC Address 1 Low (MAC_Address1_Low)	32	RW	FFFF_FFFFh
310h	MAC Address 2 High (MAC_Address2_High)	32	RW	0000_FFFFh
314h	MAC Address 2 Low (MAC_Address2_Low)	32	RW	FFFF_FFFFh
700h	MMC Control (MMC_Control)	32	RW	0000_0000h
704h	MMC Receive Interrupt (MMC_Rx_Interrupt)	32	R	0000_0000h
708h	MMC Transmit Interrupt (MMC_Tx_Interrupt)	32	R	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
70Ch	MMC Receive Interrupt Mask (MMC_Rx_Interrupt_Mask)	32	RW	0000_0000h
710h	MMC Transmit Interrupt Mask (MMC_Tx_Interrupt_Mask)	32	RW	0000_0000h
714h	Transmit Octet Count Good Bad (Tx_Octet_Count_Good_Bad)	32	R	0000_0000h
718h	Transmit Packet Count Good Bad (Tx_Packet_Count_Good_Bad)	32	R	0000_0000h
71Ch	Transmit Broadcast Packets Good (Tx_Broadcast_Packets_Good)	32	R	0000_0000h
720h	Transmit Multicast Packets Good (Tx_Multicast_Packets_Good)	32	R	0000_0000h
724h	Transmit 64-Octet Packets Good Bad (Tx_64Octets_Packets_Good_Bad)	32	R	0000_0000h
728h	Transmit 65 To 127 Octet Packets Good Bad (Tx_65To127Octets_Packets_Good_Bad)	32	R	0000_0000h
72Ch	Transmit 128 To 255 Octet Packets Good Bad (Tx_128To255Octets_Packets_Good_Bad)	32	R	0000_0000h
730h	Transmit 256 To 511 Octet Packets Good Bad (Tx_256To511Octets_Packets_Good_Bad)	32	R	0000_0000h
734h	Transmit 512 To 1023 Octet Packets Good Bad (Tx_512To1023Octets_Packets_Good_Bad)	32	R	0000_0000h
738h	Transmit 1024 To Max Octet Packets Good Bad (Tx_1024ToMaxOctets_Packets_Good_Bad)	32	R	0000_0000h
73Ch	Transmit Unicast Packets Good Bad (Tx_Unicast_Packets_Good_Bad)	32	R	0000_0000h
740h	Transmit Multicast Packets Good Bad (Tx_Multicast_Packets_Good_Bad)	32	R	0000_0000h
744h	Transmit Broadcast Packets Good Bad (Tx_Broadcast_Packets_Good_Bad)	32	R	0000_0000h
748h	Transmit Underflow Error Packets (Tx_Underflow_Error_Packets)	32	R	0000_0000h
74Ch	Transmit Single Collision Good Packets (Tx_Single_Collision_Good_Packets)	32	R	0000_0000h
750h	Transmit Multiple Collision Good Packets (Tx_Multiple_Collision_Good_Packets)	32	R	0000_0000h
754h	Transmit Deferred Packets (Tx_Deferred_Packets)	32	R	0000_0000h
758h	Transmit Late Collision Packets (Tx_Late_Collision_Packets)	32	R	0000_0000h
75Ch	Transmit Excessive Collision Packets (Tx_Excessive_Collision_Packets)	32	R	0000_0000h
760h	Transmit Carrier Error Packets (Tx_Carrier_Error_Packets)	32	R	0000_0000h
764h	Transmit Octet Count Good (Tx_Octet_Count_Good)	32	R	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
768h	Transmit Packet Count Good (Tx_Packet_Count_Good)	32	R	0000_0000h
76Ch	Transmit Excessive Deferral Error (Tx_Excessive_Deferral_Error)	32	R	0000_0000h
770h	Transmit Pause Packets (Tx_Pause_Packets)	32	R	0000_0000h
774h	Transmit VLAN Packets Good (Tx_VLAN_Packets_Good)	32	R	0000_0000h
778h	Transmit O Size Packets Good (Tx_OSize_Packets_Good)	32	R	0000_0000h
780h	Receive Packets Count Good Bad (Rx_Packets_Count_Good_Bad)	32	R	0000_0000h
784h	Receive Octet Count Good Bad (Rx_Octet_Count_Good_Bad)	32	R	0000_0000h
788h	Receive Octet Count Good (Rx_Octet_Count_Good)	32	R	0000_0000h
78Ch	Receive Broadcast Packets Good (Rx_Broadcast_Packets_Good)	32	R	0000_0000h
790h	Receive Multicast Packets Good (Rx_Multicast_Packets_Good)	32	R	0000_0000h
794h	Receive CRC Error Packets (Rx_CRC_Error_Packets)	32	R	0000_0000h
798h	Receive Alignment Error Packets (Rx_Alignment_Error_Packets)	32	R	0000_0000h
79Ch	Receive Runt Error Packets (Rx_Runt_Error_Packets)	32	R	0000_0000h
7A0h	Receive Jabber Error Packets (Rx_Jabber_Error_Packets)	32	R	0000_0000h
7A4h	Receive Undersize Packets Good (Rx_Undersize_Packets_Good)	32	R	0000_0000h
7A8h	Receive Oversize Packets Good (Rx_Oversize_Packets_Good)	32	R	0000_0000h
7ACh	Receive 64 Octets Packets Good Bad (Rx_64Octets_Packets_Good_Bad)	32	R	0000_0000h
7B0h	Receive 65-127 Octets Packets Good Bad (Rx_65To127Octets_Packets_Good_Bad)	32	R	0000_0000h
7B4h	Receive 128-255 Octets Packets Good Bad (Rx_128To255Octets_Packets_Good_Bad)	32	R	0000_0000h
7B8h	Receive 256-511 Octets Packets Good Bad (Rx_256To511Octets_Packets_Good_Bad)	32	R	0000_0000h
7BCh	Receive 512-1023 Octets Packets Good Bad (Rx_512To1023Octets_Packets_Good_Bad)	32	R	0000_0000h
7C0h	Receive 1024 To Max Octets Good Bad (Rx_1024ToMaxOctets_Packets_Good_Bad)	32	R	0000_0000h
7C4h	Receive Unicast Packets Good (Rx_Unicast_Packets_Good)	32	R	0000_0000h
7C8h	Receive Length Error Packets (Rx_Length_Error_Packets)	32	R	0000_0000h
7CCh	Receive Out of Range Type Packet (Rx_Out_Of_Range_Type_Packets)	32	R	0000_0000h
7D0h	Receive Pause Packets (Rx_Pause_Packets)	32	R	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
7D4h	Receive FIFO Overflow Packets (Rx_FIFO_Overflow_Packets)	32	R	0000_0000h
7D8h	Receive VLAN Packets Good Bad (Rx_VLAN_Packets_Good_Bad)	32	R	0000_0000h
7DCh	Receive Watchdog Error Packets (Rx_Watchdog_Error_Packets)	32	R	0000_0000h
7E0h	Receive Error Packets (Rx_Receive_Error_Packets)	32	R	0000_0000h
7E4h	Receive Control Packets Good (Rx_Control_Packets_Good)	32	R	0000_0000h
8A0h	MMC Transmit FPE Fragment Counter Interrupt Status (MMC_FPE_Tx_Interrupt)	32	R	0000_0000h
8A4h	MMC FPE Transmit Interrupt Mask (MMC_FPE_Tx_Interrupt_Mask)	32	RW	0000_0000h
8A8h	Transmit FPE Fragment Counter (MMC_Tx_FPE_Fragment_Cntr)	32	R	0000_0000h
8ACh	Transmit Hold Request Counter (MMC_Tx_Hold_Req_Cntr)	32	R	0000_0000h
8C0h	MMC Receive Packet Assembly Error Counter Interrupt Status (MMC_FPE_Rx_Interrupt)	32	R	0000_0000h
8C4h	MMC FPE Receive Interrupt Mask (MMC_FPE_Rx_Interrupt_Mask)	32	RW	0000_0000h
8C8h	MMC Receive Packet Assembly Error Counter (MMC_Rx_Packet_Assembly_Err_Cntr)	32	R	0000_0000h
8CCh	MMC Receive Packet SMD Error Counter (MMC_Rx_Packet_SMD_Err_Cntr)	32	R	0000_0000h
8D0h	MMC Receive Packet Assembly OK Counter (MMC_Rx_Packet_Assembly_OK_Cntr)	32	R	0000_0000h
8D4h	MMC Receive FPE Fragment Counter (MMC_Rx_FPE_Fragment_Cntr)	32	R	0000_0000h
900h	MAC Layer 3 Layer 4 Control 0 (MAC_L3_L4_Control0)	32	RW	0000_0000h
904h	MAC Layer 4 Address 0 (MAC_Layer4_Address0)	32	RW	0000_0000h
910h	MAC Layer 3 Address 0 Reg 0 (MAC_Layer3_Addr0_Reg0)	32	RW	0000_0000h
914h	MAC Layer 3 Address 1 Reg 0 (MAC_Layer3_Addr1_Reg0)	32	RW	0000_0000h
918h	MAC Layer 3 Address 2 Reg 0 (MAC_Layer3_Addr2_Reg0)	32	RW	0000_0000h
91Ch	MAC Layer 3 Address 3 Reg 0 (MAC_Layer3_Addr3_Reg0)	32	RW	0000_0000h
930h	MAC L3 L4 Control 1 (MAC_L3_L4_Control1)	32	RW	0000_0000h
934h	MAC Layer 4 Address 1 (MAC_Layer4_Address1)	32	RW	0000_0000h
940h	MAC Layer 3 Address 0 Reg 1 (MAC_Layer3_Addr0_Reg1)	32	RW	0000_0000h
944h	MAC Layer 3 Address 1 Reg 1 (MAC_Layer3_Addr1_Reg1)	32	RW	0000_0000h
948h	MAC Layer 3 Address 2 Reg 1 (MAC_Layer3_Addr2_Reg1)	32	RW	0000_0000h
94Ch	MAC Layer 3 Address 3 Reg 1 (MAC_Layer3_Addr3_Reg1)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
960h	MAC L3 L4 Control 2 (MAC_L3_L4_Control2)	32	RW	0000_0000h
964h	MAC Layer 4 Address 2 (MAC_Layer4_Address2)	32	RW	0000_0000h
970h	MAC Layer 3 Address 0 Reg 2 (MAC_Layer3_Addr0_Reg2)	32	RW	0000_0000h
974h	MAC Layer 3 Address 1 Reg 2 (MAC_Layer3_Addr1_Reg2)	32	RW	0000_0000h
978h	MAC Layer 3 Address 2 Reg 2 (MAC_Layer3_Addr2_Reg2)	32	RW	0000_0000h
97Ch	MAC Layer 3 Address 3 Reg 2 (MAC_Layer3_Addr3_Reg2)	32	RW	0000_0000h
990h	MAC L3 L4 Control 3 (MAC_L3_L4_Control3)	32	RW	0000_0000h
994h	MAC Layer 4 Address 3 (MAC_Layer4_Address3)	32	RW	0000_0000h
9A0h	MAC Layer 3 Address 0 Reg 3 (MAC_Layer3_Addr0_Reg3)	32	RW	0000_0000h
9A4h	MAC Layer 3 Address 1 Reg 3 (MAC_Layer3_Addr1_Reg3)	32	RW	0000_0000h
9A8h	MAC Layer 3 Address 2 Reg 3 (MAC_Layer3_Addr2_Reg3)	32	RW	0000_0000h
9ACh	MAC Layer 3 Address 3 Reg 3 (MAC_Layer3_Addr3_Reg3)	32	RW	0000_0000h
B00h	MAC Timestamp Control (MAC_Timestamp_Control)	32	RW	0000_2000h
B04h	MAC Sub Second Increment (MAC_Sub_Second_Increment)	32	RW	0000_0000h
B08h	MAC System Time In Seconds (MAC_System_Time_Seconds)	32	R	0000_0000h
B0Ch	MAC System Time In Nanoseconds (MAC_System_Time_Nanoseconds)	32	R	0000_0000h
B10h	MAC System Time Seconds Update (MAC_System_Time_Seconds_Update)	32	RW	0000_0000h
B14h	MAC System Time Nanoseconds Update (MAC_System_Time_Nanoseconds_Update)	32	RW	0000_0000h
B18h	MAC Timestamp Addend (MAC_Timestamp_Addend)	32	RW	0000_0000h
B1Ch	MAC System Time Higher Word In Seconds (MAC_System_Time_Higher_Word_Seconds)	32	RW	0000_0000h
B20h	MAC Timestamp Status (MAC_Timestamp_Status)	32	R	0000_0000h
B30h	MAC Transmit Timestamp Status In Nanoseconds (MAC_Tx_Timestamp_Status_Nanoseconds)	32	R	0000_0000h
B34h	MAC Transmit Timestamp Status In Seconds (MAC_Tx_Timestamp_Status_Seconds)	32	R	0000_0000h
B50h	MAC Timestamp Ingress Asymmetry Correction (MAC_Timestamp_Ingress_Asym_Corr)	32	RW	0000_0000h
B54h	MAC Timestamp Egress Asymmetry Correction (MAC_Timestamp_Egress_Asym_Corr)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
B58h	MAC Timestamp Ingress Correction In Nanoseconds (MAC_Timestamp_Ingress_Corr_Nanosecond)	32	RW	0000_0000h
B5Ch	MAC Timestamp Egress Correction In Nanoseconds (MAC_Timestamp_Egress_Corr_Nanosecond)	32	RW	0000_0000h
B60h	MAC Timestamp Ingress Correction In Subnanoseconds (MAC_Timestamp_Ingress_Corr_Subnanosec)	32	RW	0000_0000h
B64h	MAC Timestamp Engress Correction In Subnanoseconds (MAC_Timestamp_Egress_Corr_Subnanosec)	32	RW	0000_0000h
B68h	MAC Timestamp Ingress Latency (MAC_Timestamp_Ingress_Latency)	32	R	0000_0000h
B6Ch	MAC Timestamp Egress Latency (MAC_Timestamp_Egress_Latency)	32	R	0000_0000h
B70h	MAC PPS Control (MAC_PPS_Control)	32	RW	0000_0000h
B80h	MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds)	32	RW	0000_0000h
B84h	MAC PPS0 Target Time In Nanoseconds (MAC_PPS0_Target_Time_Nanoseconds)	32	RW	0000_0000h
B88h	MAC PPS0 Interval (MAC_PPS0_Interval)	32	RW	0000_0000h
B8Ch	MAC PPS0 Width (MAC_PPS0_Width)	32	RW	0000_0000h
B90h	MAC PPS1 Target Time In Seconds (MAC_PPS1_Target_Time_Seconds)	32	RW	0000_0000h
B94h	MAC PPS1 Target Time In Nanoseconds (MAC_PPS1_Target_Time_Nanoseconds)	32	RW	0000_0000h
B98h	MAC PPS1 Interval (MAC_PPS1_Interval)	32	RW	0000_0000h
B9Ch	MAC PPS1 Width (MAC_PPS1_Width)	32	RW	0000_0000h
BA0h	MAC PPS2 Target Time In Seconds (MAC_PPS2_Target_Time_Seconds)	32	RW	0000_0000h
BA4h	MAC PPS2 Target Time In Nanoseconds (MAC_PPS2_Target_Time_Nanoseconds)	32	RW	0000_0000h
BA8h	MAC PPS2 Interval (MAC_PPS2_Interval)	32	RW	0000_0000h
BACh	MAC PPS2 Width (MAC_PPS2_Width)	32	RW	0000_0000h
BB0h	MAC PPS3 Target Time In Seconds (MAC_PPS3_Target_Time_Seconds)	32	RW	0000_0000h
BB4h	MAC PPS3 Target Time In Nanoseconds (MAC_PPS3_Target_Time_Nanoseconds)	32	RW	0000_0000h
BB8h	MAC PPS3 Interval (MAC_PPS3_Interval)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
BBCh	MAC PPS3 Width (MAC_PPS3_Width)	32	RW	0000_0000h
C00h	MTL Operation Mode (MTL_Operation_Mode)	32	RW	0000_0000h
C08h	MTL Debug Control (MTL_DBG_CTL)	32	RW	0000_0000h
C0Ch	MTL Debug Status (MTL_DBG_STS)	32	RW	0000_0018h
C10h	MTL FIFO Debug Data (MTL_FIFO_Debug_Data)	32	RW	0000_0000h
C20h	MTL Interrupt Status (MTL_Interrupt_Status)	32	R	0000_0000h
C30h	MTL Receive Queue DMA Map 0 (MTL_RxQ_DMA_Map0)	32	RW	0000_0000h
C40h	MTL TBS Control (MTL_TBS_CTRL)	32	RW	0000_0000h
C50h	MTL EST Control (MTL_EST_Control)	32	RW	0000_0000h
C58h	MTL EST Status (MTL_EST_Status)	32	RW	0000_0000h
C60h	MTL EST Scheduling Error (MTL_EST_Sch_Error)	32	RW	0000_0000h
C64h	MTL EST Frame Size Error (MTL_EST_Frm_Size_Error)	32	RW	0000_0000h
C68h	MTL EST Frame Size Capture (MTL_EST_Frm_Size_Capture)	32	R	0000_0000h
C70h	MTL EST Interrupt Enable (MTL_EST_Intr_Enable)	32	RW	0000_0000h
C80h	MTL EST GCL Control (MTL_EST_GCL_Control)	32	RW	0000_0000h
C84h	MTL EST GCL Data (MTL_EST_GCL_Data)	32	RW	0000_0000h
C90h	MTL FPE Control Status (MTL_FPE_CTRL_STS)	32	RW	0000_0000h
C94h	MTL FPE Advance (MTL_FPE_Advance)	32	RW	0000_0000h
CA0h	MTL Rx Parser Control Status (MTL_RXP_Control_Status)	32	RW	803F_003Fh
CA4h	MTL Rx Parser Interrupt Control Status (MTL_RXP_Interrupt_Control_Status)	32	RW	0000_0000h
CA8h	MTL Rx Parser Drop Count (MTL_RXP_Drop_Cnt)	32	R	0000_0000h
CACh	MTL Rx Parser Error Count (MTL_RXP_Error_Cnt)	32	R	0000_0000h
CB0h	MTL Rx Parser Indirect Access Control Status (MTL_RXP_Indirect_Acc_Control_Status)	32	RW	0000_0000h
CB4h	MTL Rx Parser Indirect Access Data (MTL_RXP_Indirect_Acc_Data)	32	R	0000_0000h
CC0h	MTL ECC Control (MTL_ECC_Control)	32	RW	0000_000Fh
CC4h	MTL Safety Interrupt Status (MTL_Safety_Interrupt_Status)	32	R	0000_0000h
CC8h	MTL ECC Interrupt Enable (MTL_ECC_Interrupt_Enable)	32	RW	0000_1111h
CCCh	MTL ECC Interrupt Status (MTL_ECC_Interrupt_Status)	32	RW	0000_0000h
CD0h	MTL ECC Error Status (MTL_ECC_Err_Sts_Rctl)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
CD4h	MTL ECC Error Address Status (MTL_ECC_Err_Addr_Status)	32	R	0000_0000h
CD8h	MTL ECC Error Control Status (MTL_ECC_Err_Cntr_Status)	32	R	0000_0000h
CE0h	MTL DPP Control (MTL_DPP_Control)	32	RW	0000_0003h
D00h	MTL Tx Queue 0 Operation Mode (MTL_TxQ0_Operation_Mode)	32	RW	0000_0000h
D04h	MTL Tx Queue 0 Underflow (MTL_TxQ0_Underflow)	32	R	0000_0000h
D08h	MTL Tx Queue 0 Debug (MTL_TxQ0_Debug)	32	R	0000_0000h
D14h	MTL Tx Queue 0 ETS Status (MTL_TxQ0_ETS_Status)	32	R	0000_0000h
D18h	MTL Tx Queue Quantum Weight (MTL_TxQ0_Quantum_Weight)	32	RW	0000_0000h
D2Ch	MTL Queue 0 Interrupt Control Status (MTL_Q0_Interrupt_Control_Status)	32	RW	0000_0000h
D30h	MTL Rx Queue 0 Operation Mode (MTL_RxQ0_Operation_Mode)	32	RW	0000_0000h
D34h	MTL Rx Queue Missed Packet Overflow Count (MTL_RxQ0_Missed_Packet_Overflow_Cnt)	32	R	0000_0000h
D38h	MTL Rx Queue 0 Debug (MTL_RxQ0_Debug)	32	R	0000_0000h
D3Ch	MTL Rx Queue 0 Control 0 (MTL_RxQ0_Control)	32	RW	0000_0000h
D40h	MTL Tx Queue 1 Operation Mode (MTL_TxQ1_Operation_Mode)	32	RW	0000_0000h
D44h	MTL Tx Queue 1 Underflow (MTL_TxQ1_Underflow)	32	R	0000_0000h
D48h	MTL Tx Queue 1 Debug (MTL_TxQ1_Debug)	32	R	0000_0000h
D50h	MTL Tx Queue 1 ETS Control (MTL_TxQ1_ETS_Control)	32	RW	0000_0000h
D54h	MTL Tx Queue 1 ETS Status (MTL_TxQ1_ETS_Status)	32	R	0000_0000h
D58h	MTL Tx Queue 1 Quantum Weight (MTL_TxQ1_Quantum_Weight)	32	RW	0000_0000h
D5Ch	MTL Tx Queue 1 Sendslope Credit (MTL_TxQ1_SendSlopeCredit)	32	RW	0000_0000h
D60h	MTL Tx Queue 1 HiCredit (MTL_TxQ1_HiCredit)	32	RW	0000_0000h
D64h	MTL Tx Queue 1 LoCredit (MTL_TxQ1_LoCredit)	32	RW	0000_0000h
D6Ch	MTL Queue 1 Interrupt Control Status (MTL_Q1_Interrupt_Control_Status)	32	RW	0000_0000h
D70h	MTL Rx Queue 1 Operation Mode (MTL_RxQ1_Operation_Mode)	32	RW	0000_0000h
D74h	MTL Rx Queue 1 Missed Packet Overflow Counter (MTL_RxQ1_Missed_Packet_Overflow_Cnt)	32	R	0000_0000h
D78h	MTL Rx Queue 1 Debug (MTL_RxQ1_Debug)	32	R	0000_0000h
D7Ch	MTL Rx Queue 1 Control (MTL_RxQ1_Control)	32	RW	0000_0000h
1000h	DMA Mode (DMA_Mode)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1004h	DMA System Bus Mode (DMA_SysBus_Mode)	32	RW	0000_0000h
1008h	DMA Interrupt Status (DMA_Interrupt_Status)	32	R	0000_0000h
100Ch	DMA Debug Status 0 (DMA_Debug_Status0)	32	R	0000_0000h
1050h	DMA TBS Control (DMA_TBS_CTRL)	32	RW	0000_0000h
1080h	DMA Safety Interrupt Status (DMA_Safety_Interrupt_Status)	32	R	0000_0000h
1100h	DMA Channel 0 Control (DMA_CH0_Control)	32	RW	0000_0000h
1104h	DMA Channel Tx Control (DMA_CH0_Tx_Control)	32	RW	0000_0000h
1108h	DMA Channel Rx Control (DMA_CH0_Rx_Control)	32	RW	0000_0000h
1114h	DMA Channel 0 Tx Descriptor List Address (DMA_CH0_TxDesc_List_Address)	32	RW	0000_0000h
111Ch	DMA Channel 0 Rx Descriptor List Address (DMA_CH0_RxDesc_List_Address)	32	RW	0000_0000h
1120h	DMA Channel 0 Tx Descriptor Tail Pointer (DMA_CH0_TxDesc_Tail_Pointer)	32	RW	0000_0000h
1128h	DMA Channel 0 Rx Descriptor List Pointer (DMA_CH0_RxDesc_Tail_Pointer)	32	RW	0000_0000h
112Ch	DMA Channel 0 Tx Descriptor Ring Length (DMA_CH0_TxDesc_Ring_Length)	32	RW	0000_0000h
1130h	DMA Channel 0 Rx Descriptor Ring Length (DMA_CH0_RxDesc_Ring_Length)	32	RW	0000_0000h
1134h	DMA Channel 0 Interrupt Enable (DMA_CH0_Interrupt_Enable)	32	RW	0000_0000h
1138h	DMA Channel 0 Rx Interrupt Watchdog Timer (DMA_CH0_Rx_Interrupt_Watchdog_Timer)	32	RW	0000_0000h
113Ch	DMA Channel 0 Slot Function Control Status (DMA_CH0_Slot_Function_Control_Status)	32	RW	0000_07C0h
1144h	DMA Channel 0 Current Application Transmit Descriptor (DMA_CH0_Current_App_TxDesc)	32	R	0000_0000h
114Ch	DMA Channel 0 Current Application Receive Descriptor (DMA_CH0_Current_App_RxDesc)	32	R	0000_0000h
1154h	DMA Channel 0 Current Application Transmit Descriptor (DMA_CH0_Current_App_TxBuffer)	32	R	0000_0000h
115Ch	DMA Channel 0 Current Application Receive Buffer (DMA_CH0_Current_App_RxBuffer)	32	R	0000_0000h
1160h	DMA Channel 0 Status (DMA_CH0_Status)	32	RW	0000_0000h
1164h	DMA Channel 0 Miss Frame Counter (DMA_CH0_Miss_Frame_Cnt)	32	R	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
1168h	DMA Channel 0 Rx Parser Accept Count (DMA_CH0_RXP_Accept_Cnt)	32	R	0000_0000h
116Ch	DMA Channel 0 Rx ERI Count (DMA_CH0_RX_ERI_Cnt)	32	R	0000_0000h
1180h	DMA Channel 1 Control (DMA_CH1_Control)	32	RW	0000_0000h
1184h	DMA Channel 1 Tx Control (DMA_CH1_Tx_Control)	32	RW	0000_0000h
1188h	DMA Channel 1 Rx Control (DMA_CH1_Rx_Control)	32	RW	0000_0000h
1194h	DMA Channel 1 Tx Descriptor List Address (DMA_CH1_TxDesc_List_Address)	32	RW	0000_0000h
119Ch	DMA Channel 1 Rx Descriptor List Address (DMA_CH1_RxDesc_List_Address)	32	RW	0000_0000h
11A0h	DMA Channel 1 Tx Descriptor Tail Pointer (DMA_CH1_TxDesc_Tail_Pointer)	32	RW	0000_0000h
11A8h	DMA Channel 1 Rx Descriptor Tail Pointer (DMA_CH1_RxDesc_Tail_Pointer)	32	RW	0000_0000h
11ACh	DMA Channel 1 Tx Descriptor Ring Length (DMA_CH1_TxDesc_Ring_Length)	32	RW	0000_0000h
11B0h	DMA Channel 1 Rx Descriptor Ring Length (DMA_CH1_RxDesc_Ring_Length)	32	RW	0000_0000h
11B4h	DMA Channel 1 Interrupt Enable (DMA_CH1_Interrupt_Enable)	32	RW	0000_0000h
11B8h	DMA Channel 1 Rx Interrupt Watchdog Timer (DMA_CH1_Rx_Interrupt_Watchdog_Timer)	32	RW	0000_0000h
11BCh	DMA Channel 1 Slot Function Control Status (DMA_CH1_Slot_Function_Control_Status)	32	RW	0000_07C0h
11C4h	DMA Channel 1 Current Application Transmit Descriptor (DMA_CH1_Current_App_TxDesc)	32	R	0000_0000h
11CCh	DMA Channel 1 Current Application Receive Descriptor (DMA_CH1_Current_App_RxDesc)	32	R	0000_0000h
11D4h	DMA Channel 1 Current Application Transmit Buffer (DMA_CH1_Current_App_TxBuffer)	32	R	0000_0000h
11DCh	DMA Channel 1 Current Application Receive Buffer (DMA_CH1_Current_App_RxBuffer)	32	R	0000_0000h
11E0h	DMA Channel 1 Status (DMA_CH1_Status)	32	RW	0000_0000h
11E4h	DMA Channel 1 Miss Frame Counter (DMA_CH1_Miss_Frame_Cnt)	32	R	0000_0000h
11E8h	DMA Channel 1 Rx Parser Accept Count (DMA_CH1_RXP_Accept_Cnt)	32	R	0000_0000h
11ECh	DMA Channel 1 Rx ERI Count (DMA_CH1_RX_ERI_Cnt)	32	R	0000_0000h

Table continues on the next page...

Offset	Register	Width (In bits)	Access	Reset value

78.17.2 MAC Configuration (MAC_Configuration)

Offset

Register	Offset
MAC_Configuration	0h

Function

Establishes MAC's operating mode.

Table 677. Packet length based on CST and ACS bits

Received packet length	CST	ACS	FCS stripping done
<1536	—	0	No
	—	1	Yes (for Ethernet packets)
>=1536	0	—	No
	1	—	Yes (for Type packets)
<1536	—	0	No
	—	1	Yes (for Ethernet packets)

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	SARC			IPC	IPG			GPSLCE	S2KP	CST	ACS	WD	Reserved	JD	JE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PS	FES	DM	LM	ECRSFD	DO	DCRS	DR	Reserved	BL		DC	PRELEN		TE	RE
W																
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30-28 SARC	Source Address Insertion Or Replacement Control Controls the source address insertion or replacement for all the transmitted packets. Bit 30 of this field specifies which MAC Address register (0 or 1) is used for source address insertion or replacement based on the values of bits [29:28]: • 2'b0x: The mti_sa_ctrl_i and ati_sa_ctrl_i input signals control the SA field generation. • 2'b10: If bit 30 = 0, MAC inserts the content of the MAC Address 0 registers in the SA field of all the transmitted packets. If bit 30 = 1 and the Enable MAC Address Register 1 option is selected while configuring the core, MAC inserts the content of the MAC Address 1 registers in the SA field of all the transmitted packets. • 2'b11: If bit 30 = 0, MAC replaces the content of the MAC Address 0 registers in the SA field of all the transmitted packets. If bit 30 = 1 and the MAC Address Register 1 is enabled, MAC replaces the content of the MAC Address 1 registers in the SA field of all the transmitted packets. **NOTE** Changes to this field take effect only on the start of a packet. If you write to the field when a packet is being transmitted, only the subsequent packet can use the updated value. This means that the current packet does not use the updated value. 000b - mti_sa_ctrl_i and ati_sa_ctrl_i input signals control the SA field generation 010b - Contents of are inserted in the SA field 011b - Contents of replace the SA field 110b - Contents of are inserted in the SA field 111b - Contents of replace the SA field
27 IPC	Checksum Offload Indicates the status of IP header or payload checksum checking. If this field is 1, the field enables IPv4 header checksum checking and IPv4 or IPv6 TCP, UDP, or ICMP payload checksum checking. When the field becomes 0, the COE function in the receiver is disabled. The Layer 3 and Layer 4 packet filter and enable split header features automatically select the IPC full checksum offload engine on the receive side. When any of these features are enabled, you must write 1 to this field. 0b - Disabled 1b - Enabled
26-24 IPG	Inter-Packet Gap Controls the minimum IPG between packets during transmission. The range of minimum IPG is valid in Full-Duplex mode, and in this mode, the minimum IPG can be configured only for 64-bit times (IPG = 100). Lower values are not considered.

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Field	Function
	When a JAM pattern is being transmitted because of backpressure activation, MAC does not consider the minimum IPG. This function (IPG less than 96-bit times) is valid only when MAC_Ext_Configuration[EIPGEN] is 0. If this field is 1, the minimum IPG (greater than 96-bit times) is controlled according to the field's description. 000b - 96-bit times IPG 001b - 88-bit times IPG 010b - 80-bit times IPG 011b - 72-bit times IPG 100b - 64-bit times IPG 101b - 56-bit times IPG 110b - 48-bit times IPG 111b - 40-bit times IPG
23 GPSLCE	Giant Packet Size Limit Control Enable Enables and disables giant packet size limit control. If this field = 1, MAC considers the value of MAC_Ext_Configuration[GPSL] to declare a received packet as a giant packet. This field must be programmed to have a size of more than 1,518 bytes. Otherwise, MAC considers 1,518 bytes as the giant packet limit. When this field becomes 0, MAC considers the received packet as a giant packet if its size is greater than 1,518 bytes (1522 bytes for a tagged packet). The WD, JE, and S2KP fields have a higher precedence over this field, which means MAC considers a received packet as a giant packet when its size is greater than 9,018 bytes (9,022 bytes for a tagged packet) with JE = 1 and the size of the jumbo packet greater than 2,000 bytes and S2KP = 1. If the WD field is 1, the field terminates the received packet if it reaches the watchdog limit. Therefore, the programmed giant packet limit must be less than the watchdog limit to get the giant packet status. 0b - Disabled 1b - Enabled
22 S2KP	IEEE 802.3 Support For 2K Packets Indicates the status of IEEE 802.3 support for 2K packets. If this field is 1, MAC considers all the packets with up to 2,000-byte length as normal. When the JE field is not 1, MAC considers all the received packets of size more than 2K bytes as giant packets. When this field becomes 0 and the JE field is not 1, MAC considers all the received packets of size more than 1,518 bytes (1,522 bytes for tagged) as giant packets. For more information about how the setting of this field and the JE field impacts the giant packet status, see this status based on the S2KP and JE fields. If the JE field is 1, writing 1 to the S2KP field has no effect on the giant packet status. 0b - Disabled 1b - Enabled

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Field	Function
21 CST	CRC Stripping For Type Packets Indicates the status of CRC stripping for Type packets. If this field is 1, the last four bytes (FCS) of all the Ether-type packets are stripped and dropped before forwarding the packet to the application. This field is valid only when the receive packet size is more than or equal to 1536 bytes. For information about how the settings of this field and the ACS field impact the packet length, see MAC Configuration (MAC_Configuration). 0b - Disabled 1b - Enabled
20 ACS	Automatic Pad Or CRC Stripping Indicates the status of automatic pad or CRC stripping. If this field is 1, MAC strips the pad or the FCS field on the incoming packets only if the size of the packets is less than 1,536 bytes. All the received packets with a size greater than or equal to 1,536 bytes are passed to the application without stripping the pad or the FCS field. When this field becomes 0, MAC passes all the incoming packets to the application, without any modification. For information about how the settings of this field and the CST field impact the packet length, see MAC Configuration (MAC_Configuration). 0b - Disabled 1b - Enabled
19 WD	Watchdog Disable Indicates the status of watchdog. If this field is 1, MAC disables the watchdog timer on the receiver. MAC can receive packets of up to 16,383 bytes. When this field becomes 0, MAC does not allow more than 2,048 bytes (10,240 if the JE field = 1) of the packet being received. MAC cuts off bytes received after 2,048. 0b - Enabled 1b - Disabled
18 —	Reserved
17 JD	Jabber Disable Indicates the status of jabber. If this field is 1, MAC disables the jabber timer on the transmitter. It can transfer packets of up to 16,383 bytes.

Table continues on the next page...

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Field	Function
	If this field is 0 and the application sends more than 2,048 bytes of data (10,240 if the JE field = 1) during transmission, MAC does not send the rest of the bytes in that packet. 0b - Enabled 1b - Disabled
16 JE	Jumbo Packet Enable Indicates the status of jumbo packets. If this field is 1, MAC allows jumbo packets of 9,018 bytes (9,022 bytes for VLAN-tagged packets) without reporting a giant packet error in the receive packet status. 0b - Disabled 1b - Enabled
15 PS	Port Select Selects the Ethernet line speed. This field, along with the FES field, selects the exact line speed. In the 10/100 Mbit/s-only (always 1) or 1000 Mbit/s-only (always 0) configurations, this field is read-only (RO) with an appropriate value. By default, with 10/100/1000 Mbit/s configurations, this field is read-write (R/W). The mac_speed_o[1] signal reflects the value of this field. 0b - For 1000 or 2500 Mbit/s operations 1b - For 10 or 100 Mbit/s operations
14 FES	Speed Indicates the speed. This field selects the speed mode. The mac_speed_o[0] signal indicates the value of this field. 0b - 10 Mbit/s if PS = 1 and 1 Gbps if PS = 0 1b - 100 Mbit/s if PS = 1 and 2.5 Gbps if PS = 0
13 DM	Duplex Mode Indicates the mode in which MAC operates. If this field is 1, MAC operates in Full-Duplex mode in which it can transmit and receive simultaneously. The field can only be read, with 1 as its default value, in full-duplex-only configurations. 0b - Half-duplex mode 1b - Full-duplex mode
12 LM	Loopback Mode Indicates the status of Loopback mode If this field is 1, MAC operates in Loopback mode at GMII or MII. This mode requires the (G)MII Rx clock input (CLK_RX_I) signal to function properly because the transmit clock is not internally looped back.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
11 ECRSFD	Enable Carrier Sense In Full-Duplex Mode Indicates whether ECRSFD is enabled or disabled. If this field is 1, the MAC transmitter checks the CRS signal before packet transmission in Full-Duplex mode. MAC starts transmitting only when the CRS signal is low. If this field becomes 0, the MAC transmitter ignores the status of the CRS signal. 0b - Disabled 1b - Enabled
10 DO	Disable Receive Own Enables or disables receive own. If this field is 1, MAC disables the reception of packets when the gmii_txen_o signal asserts in Half-Duplex mode. When the field is 0, MAC receives all the packets that PHY sent. This field is not applicable in Full-Duplex mode. 0b - Enabled 1b - Disabled
9 DCRS	Disable Carrier Sense During Transmission Enables or disables carrier sense during transmission. If this field is 1, the MAC transmitter ignores the (G)MII CRS signal during packet transmission in Half-Duplex mode. As a result, no errors generate because of loss of carrier or no carrier during transmission. When this field becomes 0, the MAC transmitter generates errors because of carrier sense. MAC can even abort the transmission. 0b - Enabled 1b - Disabled
8 DR	Disable Retry Enables or disables retry attempts. If this field is 1, MAC attempts only one transmission. When a collision occurs on GMII or MII, MAC ignores the current packet transmission and reports a packet abort with excessive collision errors in the transmit packet status. If this field becomes 0, MAC retries based on the settings of the BL field of this register. The settings of this field apply only in Half-Duplex mode. 0b - Enabled 1b - Disabled
7	Reserved

Table continues on the next page...

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Field	Function
—	
6-5 BL	Back-Off Limit Determines the random integer number (r) of slot time delays (4,096 bit times for 1000/2500 Mbit/s; 512 bit times for 10/100 Mbit/s) for which MAC waits before rescheduling a transmission attempt during retry attempts after a collision. • *n* = retransmission attempt • *r* = random integer that takes the value in the range 0 <= r < 2^k This field is applicable only in Half-Duplex mode. 00b - k = min(n,10) 01b - k = min(n,8) 10b - k = min(n,4) 11b - k = min(n,1)
4 DC	Deferral Check Indicates the status of the deferral check function. If this field is 1, the deferral check function is enabled in MAC, which issues a packet abort status, with Tx_Excessive_Deferral_Error[TXEXSDEF] = 1 in the transmit packet status, when the transmit state machine is deferred for more than 24,288 bit times in 10 Mbit/s or 100 Mbit/s mode. If MAC is configured for a 1000/2500 Mbit/s operation, the threshold for deferral is 155,680 bit times. Deferral begins when the transmitter is ready to transmit, but it is prevented because of an active carrier sense signal (CRS) on GMII or MII. The defer time is not cumulative. For example, if the transmitter defers for 10,000 bit times because the CRS signal is active, and then the CRS signal becomes inactive, the transmitter transmits and collision happens. Because of this collision, the transmitter needs to back off and then defer again after back off completion. In such a scenario, the deferral timer resets to 0 and restarts. When this field becomes 0, the deferral check function disables and MAC defers until the CRS signal becomes inactive. This field is applicable only in Half-Duplex mode. 0b - Disabled 1b - Enabled
3-2 PRELEN	Preamble Length for Transmit Packets Controls the number of preamble bytes that are added to the beginning of every transmit packet. Preamble reduction occurs only when MAC operates in Full-Duplex mode. 00b - 7 bytes 01b - 5 bytes 10b - 3 bytes 11b - Reserved

Table continues on the next page...

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Field	Function
1 TE	Transmitter Enable Indicates the status of the transmitter. • If this field is 1, the MAC transmit state machine is enabled for transmission on GMII or MII. • When the field becomes 0, the MAC transmit state machine is disabled after it completes the transmission of the current packet. The transmit state machine does not transmit any more packets. 0b - Disabled 1b - Enabled
0 RE	Receiver Enable Indicates the status of the receiver. If this field is 1, MAC's receive state machine is enabled for receiving packets from GMII or MII. When this field becomes 0, the MAC receive state machine is disabled after it completes the reception of the current packet. The receive state machine does not receive any more packets from GMII or MII. 0b - Disabled 1b - Enabled

78.17.3 MAC Extended Configuration (MAC_Ext_Configuration)

Offset

Register	Offset
MAC_Ext_Configuration	4h

Function

Establishes MAC's operating mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved	Reserved	EIPG					EIPGEN	Reserved	Reserved			PDC	USP	SPEN	DCRCC
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved		GPSL													
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29-25 EIPG	Extended Inter-Packet Gap Indicates the value of the extended inter-packet gap. The value of this field is applicable when EIPGEN = 1. The most-significant bits of this field, along with those of MAC_Configuration[IPG], render the minimum IPG greater than 96-bit times in steps of 8-bit times. 8'h00: 104-bit times 8'h01: 112-bit times 8'h02: 120-bit times ---------- 8'hFF: 2144-bit times
24 EIPGEN	Extended Inter-Packet Gap Enable Indicates the status of the extended inter-packet gap. • If this field is 1, MAC interprets the EIPG field of this register and the IPG field of MAC Configuration (MAC_Configuration) together as minimum IPG greater than 96-bit times in steps of 8-bit times. • If this field is 0, MAC ignores the EIPG field of this register and interprets the IPG field of MAC Configuration (MAC_Configuration) as minimum IPG less than or equal to 96-bit times in steps of 8-bit times. **NOTE** You must enable the extended inter-packet gap feature when operating in Full-Duplex mode only. There could be undesirable effects on the back-pressure function and frame transmission if the feature is enabled in Half-Duplex mode. 0b - Disabled 1b - Enabled
23 —	Reserved
22-20 —	Reserved
19 PDC	Packet Duplication Control Indicates the packet duplication control status.

Table continues on the next page...

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Field	Function
	• If this field is 1, the received packet with multicast or broadcast destination address is routed to multiple receive DMA channels. MAC_Address0_High[DCS] identifies the receive DMA channels (corresponding to the MAC Address register) that match the multicast or broadcast destination addresses in the received packet. The DCS field is interpreted to be a one-hot value, each bit corresponding to the receive DMA channel. • If this field is 0, the received packet routes to a single receive DMA channel. MAC_Address0_High[DCS] identifies the receive DMA channel corresponding to the MAC Address register that matches the destination address in the received packet. The DCS field is interpreted as a binary value. 0b - Disabled 1b - Enabled
18 USP	Unicast Slow Protocol Packet Detect Indicates the status of unicast slow-protocol packet detection. • If this field is 1, MAC detects the slow-protocol packets with unicast address of the station specified in MAC Address 0 High (MAC_Address0_High) and MAC Address 0 Low (MAC_Address0_Low). MAC also detects the slow-protocol packets with the slow-protocol multicast address (01-80-C2-00-00-02). • If this field is 0, MAC detects only slow-protocol packets with the slow protocol multicast address specified in IEEE 802.3-2015, section 5. 0b - Disabled 1b - Enabled
17 SPEN	Slow Protocol Detection Enable Enables or disables slow protocol detection. • If this field is 0, EMAC forwards all error-free, slow-protocol packets to the application. EMAC considers such packets as normal-type packets. • If this field is 1, EMAC processes the slow-protocol packets (Ether type 8809h) and provides the slow protocol sub-type and code fields in receive status. 0b - Disabled 1b - Enabled
16 DCRCC	Disable CRC Checking For Received Packets Indicates the status of CRC checking. If this field is 1, MAC receiver does not check the CRC field in the received packets. When this field becomes 0, the MAC receiver always checks the CRC field in the received packets. 0b - Enabled 1b - Disabled
15-14	Reserved

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Field	Function
—	
13-0 GPSL	Giant Packet Size Limit Declares the status of a packet based on its size. If the received packet size (in bytes) is greater than the value programmed in this field, MAC declares the received packet as a giant packet. The value programmed in this field must be greater than or equal to 1,518 bytes. Also, any other programmed value is considered as 1,518 bytes. For VLAN-tagged packets, MAC adds 4 bytes to the programmed value. If MAC_VLAN_Tag_Ctrl[EDVLP] = 1, MAC adds 8 bytes to the programmed value for double VLAN-tagged packets. The value of GPSL is valid if MAC_Configuration[GPSLCE] = 1.

78.17.4 MAC Packet Filter (MAC_Packet_Filter)

Offset

Register	Offset
MAC_Packet_Filter	8h

Function

Contains the filter controls for receiving packets.

Some of the controls from this register go to MAC's address check block that performs the first level of address filtering. The second level of filtering is performed on the incoming packet based on other controls such as pass bad packets and pass control packets.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	RA	Reserved									DNTU	IPFE	Reserved			VTFE
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved				HPF	SAF	SAIF	PCF			DBF	PM	DAIF	HMC	HUC	PR
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 RA	Receive All Indicates whether the received packets are enabled or disabled. • If this field is 1, the MAC Receiver module passes all the received packets to the application, irrespective of their passing the address filter. The result (pass or fail) of the SA or DA filtering is updated in the corresponding field of the receive status word. • If this field is 0, the module passes only those packets to the application that pass the SA or DA address filter. 0b - Receive All is disabled 1b - Receive All is enabled
30-22 —	Reserved
21 DNTU	Drop Non-TCP/UDP Over IP Packets Indicates whether MAC drops or forwards non-TCP/UDP protocols over IP packets. • If this field is 1, MAC drops these protocols over IP packets. MAC forwards only those packets that the layer 4 filter processes. • If this field is 0, MAC forwards all these protocols over IP packets. 0b - Forwards 1b - Drops
20 IPFE	Layer 3 and Layer 4 Filter Enable Indicates the status of layer 3 and layer 4 filters. • If this field is 1, MAC drops packets that do not match the enabled layer 3 and layer 4 filters. If these two filters are not enabled for matching, this field does not have any effect. • If this field is 0, MAC forwards all the packets irrespective of the match status of the layer 3 and layer 4 fields. 0b - Disabled 1b - Enabled
19-17 —	Reserved
16 VTFE	VLAN Tag Filter Enable Indicates the status of VLAN tag filter. • If this field is 1, MAC drops the VLAN-tagged packets that do not match the VLAN tag. • If this field is 0, MAC forwards all the packets irrespective of the match status of the VLAN tag. 0b - Disabled 1b - Enabled

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Field	Function
15-11 —	Reserved
10 HPF	Hash Or Perfect Filter Indicates the status of hash or perfect filter. • If this field is 1, the address filter passes a packet if it matches either perfect filtering or hash filtering as defined by the HMC or HUC fields of this register. • If this field is 0 and HUC = 1 or HMC = 1, the packet passes only if it matches the hash filter. 0b - Disabled 1b - Enabled
9 SAF	Source Address Filter Enable Indicates the status of SA filtering. • If this field is 1, MAC compares the SA field of the received packets with the values programmed in the enabled SA registers. If the comparison fails, MAC drops the packet. • When this field becomes 0, MAC forwards the received packet to the application with an updated field value, depending on the SA address comparison. **NOTE** According to the IEEE specification, bit 47 of the SA field is reserved. However, MAC compares all the 48 bits. You must consider this when programming the MAC address registers for SA. 0b - Disabled 1b - Enabled
8 SAIF	SA Inverse Filtering Indicates the status of SA inverse filtering. • If this field is 1, the address check block operates in the inverse filtering mode for SA address comparison. If the SA of a packet matches the values programmed in the SA registers, it is marked as failing the SA address filter. • If this field becomes 0 and the SA of a packet does not match the values programmed in the SA registers, the SA is marked as failing the SA address filter. 0b - Disabled 1b - Enabled
7-6 PCF	Pass Control Packets Controls the forwarding of all the control packets (including unicast and multicast pause packets). 00b - MAC filters all the control packets from reaching the application 01b - MAC forwards all the control packets, except pause packets, to the application even if they fail the address filter

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Field	Function
	10b - MAC forwards all the control packets to the application even if they fail the address filter 11b - MAC forwards all the control packets that pass the address filter
5 DBF	Disable Broadcast Packets Enables or disables broadcast packets. • If this field is 1, AFM blocks all the incoming broadcast packets. In addition, it overrides all the other filter settings. • If this field is 0, AFM passes all the received broadcast packets. 0b - Enabled 1b - Disabled
4 PM	Pass All Multicast Enables or disables the passing of received packets. • If this field is 1, it indicates that all the received packets with a multicast destination address (first bit in the destination address field is 1) are passed. • If this field is 0, filtering of multicast packets depends on the settings of the HMC field. 0b - Disabled 1b - Enabled
3 DAIF	DA Inverse Filtering Indicates the status of DA inverse filtering. • If this field is 1, the Address Check block operates in Inverse Filtering mode for the DA address comparison of both unicast and multicast packets. • If this field is 0, normal filtering of packets is performed. 0b - Disabled 1b - Enabled
2 HMC	Hash Multicast Indicates the status of hast multicast. • If this field is 1, MAC performs the destination address filtering of received multicast packets according to the hash table. • If this field is 0, MAC performs the perfect destination address filtering for multicast packets, that is, it compares the DA field with the values programmed in DA registers. 0b - Disabled 1b - Enabled
1 HUC	Hash Unicast Indicates the status of hash unicast.

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Field	Function
	• If this field is 1, MAC performs the destination address filtering of unicast packets according to the hash table. • When this field becomes 0, MAC performs a perfect destination address filtering for unicast packets, that is, it compares the DA field with the values you program in the MAC Address registers. 0b - Disabled 1b - Enabled
0 PR	Promiscuous Mode Indicates the status of Promiscuous mode. If this field is 1, the address filtering module passes all the incoming packets irrespective of the destination or source address. MAC clears the SA or DA filter fail status fields of the receive status word when PR = 1. 0b - Disabled 1b - Enabled

78.17.5 MAC Watchdog Timeout (MAC_Watchdog_Timeout)

Offset

Register	Offset
MAC_Watchdog_Timeout	Ch

Function

Controls the watchdog timeout for received packets.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved							PWE	Reserved				WTO			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-9 —	Reserved
8 PWE	Programmable Watchdog Enable Indicates the status of programmable watchdog. • If this field is 1 and MAC_Configuration[WD] is 0, the WTO field of this register is used as watchdog timeout for a received packet. • If this field is 0, MAC_Configuration[WD] and MAC_Configuration[JE] control the watchdog timeout for a received packet. 0b - Disabled 1b - Enabled
7-4 —	Reserved
3-0 WTO	Watchdog Timeout Indicates the size of watchdog timer. If PWE = 1 and MAC_Configuration[WD] = 0, this field is used as watchdog timeout for a received packet. If the length of a received packet exceeds the value of this field, the packet terminates as an error packet. **NOTE** If PWE = 1, the value in this field must exceed 1,522 (05F2h). Otherwise, the IEEE 802.3-specified valid tagged packets are declared as error packets and dropped. 0000b - 2 KB 0001b - 3 KB 0010b - 4 KB 0011b - 5 KB 0100b - 6 KB 0101b - 7 KB 0110b - 8 KB 0111b - 9 KB 1000b - 10 KB 1001b - 11 KB 1010b - 12 KB 1011b - 13 KB 1100b - 14 KB 1101b - 15 KB

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Field	Function
	1110b - 16383 bytes 1111b - Reserved

78.17.6 MAC Hash Table First 32 Bits (MAC_Hash_Table_Reg0)

Offset

Register	Offset
MAC_Hash_Table_Reg0	10h

Function

Contains the first 32 bits of the hash table, when the total width of the hash table is 128 bits or 256 bits.

NOTE

In this chip, upper 6 bits should be used for 64-bit Hash Table.

The hash table is used for group address filtering, for which the content of the destination address in the incoming packet is passed through the CRC logic and the bits of Receive CRC Error Packets (Rx_CRC_Error_Packets) are used to index the contents of the hash table as follows:

- 6 bits when you have a 64-bit hash
- 7 bits when you have a 128-bit hash
- 8 bits when you have a 256-bit hash

The most-significant bits determine the Hash Table register to be used, and the least-significant 5 bits determine the bit within the register. For example, a hash value of 10_0000b (in 64-bit hash) selects bit 0 of MAC Hash Table Second 32 Bits (MAC_Hash_Table_Reg1).

Perform these steps to calculate the hash value of the destination address:

1. Calculate the 32-bit CRC for DA (see section 3.2.8 in IEEE 802.3 for the steps to calculate CRC32).
2. Perform bit-wise reversal for the value obtained in step 1.
3. Use the upper 6, 7, or 8 bits from the value obtained in step 2.

If this field is 1, the packet is accepted. Otherwise, it is rejected. If MAC_Packet_Filter[PM] = 1, all multicast packets are accepted regardless of the multicast hash values.

If this register is configured to be double-synchronized with the (G)MII clock domain, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of the Hash Table registers are written to.

If double-synchronization is enabled, consecutive writes to this register must be performed after at least four clock cycles in the destination clock domain.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	HT31T0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	HT31T0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 HT31T0	MAC Hash Table First 32 Bits Contains the first 32 bits [31:0] of the hash table.

78.17.7 MAC Hash Table Second 32 Bits (MAC_Hash_Table_Reg1)

Offset

Register	Offset
MAC_Hash_Table_Reg1	14h

Function

Contains the second 32 bits of the hash table, when the width of the hash table is 128 or 256 bits.

NOTE

In this chip, upper 6 bits should be used for 64-bit Hash Table.

The hash table is used for group address filtering, for which the content of the destination address in the incoming packet is passed through the CRC logic and the bits of Receive CRC Error Packets (Rx_CRC_Error_Packets) are used to index the contents of the hash table as follows:

- 6 bits when you have a 64-bit hash
- 7 bits when you have a 128-bit hash
- 8 bits when you have a 256-bit hash

The most-significant bits determine the Hash Table register to be used, and the least-significant 5 bits determine the bit within the register. For example, a hash value of 10_0000b (in 64-bit hash) selects bit 0 of MAC Hash Table Second 32 Bits (MAC_Hash_Table_Reg1).

Perform these steps to calculate the hash value of the destination address:

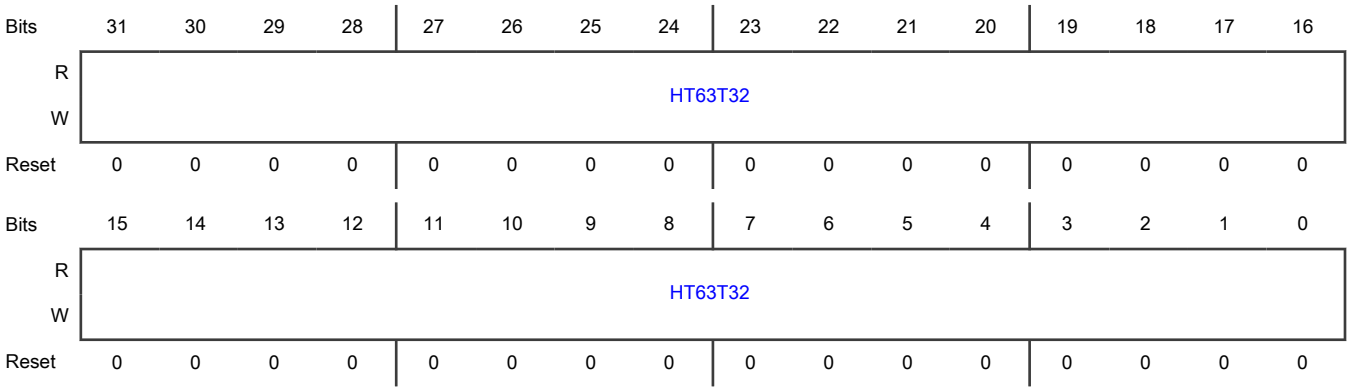
1. Calculate the 32-bit CRC for DA (see section 3.2.8 in IEEE 802.3 for the steps to calculate CRC32).
2. Perform bit-wise reversal for the value obtained in step 1.
3. Take the upper 6, 7, or 8 bits from the value obtained in step 2.

If the corresponding bit value of this register is 1'b1, the packet is accepted. Otherwise, it is rejected. If MAC_Packet_Filter[PM] = 1, all multicast packets are accepted regardless of the multicast hash values.

If this register is configured to be double-synchronized with the (G)MII clock domain, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of the Hash Table registers are written to.

If double-synchronization is enabled, consecutive writes to this register must be performed after at least four clock cycles in the destination clock domain.

Diagram



Fields

Field	Function
31-0 HT63T32	MAC Hash Table Second 32 Bits Contains the second 32 bits [63:32] of the hash table.

78.17.8 MAC VLAN Tag (MAC_VLAN_Tag)

Offset

Register	Offset
MAC_VLAN_Tag	50h

Function

Identifies the IEEE 802.1Q VLAN type packets.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	EIVLRXS	Reserved	EIVLS		ERIVLT	EDVLP	VTHM	EVLRXS	Reserved	EVLS		DOVLTC	ERSVLM	ESVL	VTIM	ETV
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	VL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EIVLRXS	Enable Inner VLAN Tag In Receive Status Indicates whether the inner VLAN tag in receive status is enabled or disabled. • If this field is 1, MAC provides the inner VLAN tag in the receive status. • If this field is 0, MAC does not provide the inner VLAN tag in the receive status. 0b - Disabled 1b - Enabled
30 —	Reserved
29-28 EIVLS	Enable Inner VLAN Tag Stripping Indicates the stripping operation on the inner VLAN tag in a received packet. The field enables or disables inner VLAN tag stripping on receive. 00b - Do not strip 01b - Strip if VLAN filter passes 10b - Strip if VLAN filter fails 11b - Always strip
27 ERIVLT	Enable Inner VLAN Tag Comparison Enables or disables the inner VLAN tag. • If ERIVLT = VTHM = EDVLP = 1, the EMAC receiver enables the VLAN hash filtering operation on the inner VLAN tag (if present). • If ERIVLT = 0 and VTHM = 1, the EMAC receiver enables the VLAN hash filtering operation on the outer VLAN tag (if present). ERSVLM and DOVLTC determine which VLAN type is enabled for filtering. 0b - Disabled 1b - Enabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
26 EDVLP	Enable Double VLAN Processing Enables or disables double VLAN processing. • If this field is 1, MAC enables processing of up to two VLAN tags on transmit and receive (if present). • If this field is 0, MAC enables processing of up to one VLAN tag on transmit and receive (if present). 0b - Disabled 1b - Enabled
25 VTHM	VLAN Tag Hash Table Match Indicates the status of VLAN tag hash table match. • If this field is 1, the most-significant four bits of CRC-32 of VLAN tag are used to index the content of MAC VLAN Hash Table (MAC_VLAN_Hash_Table). See VLAN filtering for details. • If MAC_VLAN_Hash_Table[VLHT] = 1, corresponding to the index, it indicates that the Ethernet packet matches the VLAN hash table. See VLAN filtering for details. • If ETV = 1, the CRC of the 12-bit VLAN identifier (VID) is used for comparison. When the ETV field becomes 0, the CRC of the 16-bit VLAN tag is used for comparison. • If VTHM = 1, the VLAN hash match operation is not performed. 0b - Disabled 1b - Enabled
24 EVLRXS	Enable VLAN Tag In Receive Status Indicates whether the VLAN tag in receive status is enabled. • If this field is 1, MAC provides the outer VLAN tag in the receive status. • If this field is 0, MAC does not provide the outer VLAN tag in receive status. 0b - Disabled 1b - Enabled
23 —	Reserved
22-21 EVLS	Enable VLAN Tag Stripping Indicates the stripping operation on the outer VLAN tag in received packets. The field enables or disables VLAN tag stripping on receive. 00b - Do not strip 01b - Strip if VLAN filter passes 10b - Strip if VLAN filter fails 11b - Always strip
20	Disable VLAN Type Check

Table continues on the next page...

Table continued from the previous page...

Field	Function
DOVLTC	Enables or disables VLAN type check for VLAN hash filtering. • If this field is 1, the MAC VLAN hash filter matches or filters the VLAN tag that the ERIVLT field specifies only when the VLAN tag type is similar to the one that the ERSVLM field specifies. • If this field is 0, the MAC VLAN hash filter does not check whether the VLAN tag that the ERIVLT field specifies is of type S-VLAN or C-VLAN. • The VLAN filter is bypassed when VLAN type of received packet do not match the programmed VLAN type in the VLAN filter. 0b - Enabled 1b - Disabled
19 ERSVLM	Enable Receive S-VLAN Match Enables or disables receive S-VLAN match for VLAN hash filtering. • If this field is 1, the MAC receiver enables VLAN hash filtering or S-VLAN matching (type = 88A8h) packets. • If this field is 0, the MAC receiver enables VLAN hash filtering or matching for C-VLAN (type = 8100h) packets. The ERIVLT field determines the VLAN tag position considered for VLAN hash filtering or matching. 0b - Disabled 1b - Enabled
18 ESVL	Enable S-VLAN Enables or disables S-VLAN. If this field is 1, the MAC transmitter and receiver consider the S-VLAN packets (type = 88A8h) as valid VLAN-tagged packets. 0b - Disabled 1b - Enabled
17 VTIM	VLAN Tag Inverse Match Enable Enables or disables VLAN tag inverse matching. • If this field is 1, it enables the VLAN tag inverse matching. The packets without matching VLAN tag are marked as matched. • If this field is 0, it enables the VLAN tag perfect matching. The packets with matched VLAN tag are marked as matched. 0b - Disabled 1b - Enabled
16 ETV	Enable Tag For VLAN Enables or disables 12-bit VLAN tag comparison for VLAN hash filtering.

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Field	Function
	• If this field is 1, a 12-bit VLAN identifier is used for VLAN hash filtering instead of the complete 16-bit VLAN tag. Bits [11:0] of the VLAN tag in the received VLAN-tagged packet are used for hash-based VLAN filtering. • When this field becomes 0, all 16 bits of the 15th and 16th bytes of the received VLAN packet are used for VLAN hash filtering. 0b - Disabled 1b - Enabled
15-0 VL	VLAN Tag Identifier for Receive Packets Contains the 802.1Q VLAN tag to identify the VLAN packets. This VLAN tag identifier is compared to the 15th and 16th bytes of the packets being received for VLAN packets. The following list describes the bits of this field: • 15:13 — User priority • 12 — Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • 11:0 — VID field of VLAN tag When ETV = 1, only the VID is used for comparison. When VL = 0, and ETV = 1, MAC does not check the 15th and 16th bytes for VLAN tag comparison and declares all packets with Type field value of 8100h or 88a8h as VLAN packets.

78.17.9 MAC VLAN Tag Control (MAC_VLAN_Tag_Ctrl)

Offset

Register	Offset
MAC_VLAN_Tag_Ctrl	50h

Function

Is the redefined version of the MAC_VLAN_Tag register.

This register provides the control and addressing fields required for indirect access to the MAC_VLAN_Tag_Filter registers. It also contains the address offset, command type, and busy bit for CSR access of the MAC VLAN Hash Filter registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	EIVLRXS	Reserved	EIVLS		ERIVLT	EDVLP	VTHM	EVLRXS	Reserved	EVLS		DOVLTC	ERSVLM	ESVL	VTIM	ETV
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved												OFS		CT	OB
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 EIVLRXS	Enable Inner VLAN Tag In Receive Status Indicates whether the inner VLAN tag in receive status is enabled or disabled. • If this field is 1, MAC provides the inner VLAN tag in the receive status. • If this field is 0, MAC does not provide the inner VLAN tag in the receive status. 0b - Disabled 1b - Enabled
30 —	Reserved
29-28 EIVLS	Enable Inner VLAN Tag Stripping Indicates the stripping operation on the inner VLAN tag in a received packet. The field enables or disables inner VLAN tag stripping on receive. 00b - Do not strip 01b - Strip if VLAN filter passes 10b - Strip if VLAN filter fails 11b - Always strip
27 ERIVLT	Enable Inner VLAN Tag Comparison Enables or disables the inner VLAN tag. • If ERIVLT = VTHM = EDVLP = 1, the EMAC receiver enables the VLAN hash filtering operation on the inner VLAN tag (if present). • If ERIVLT = 0 and VTHM = 1, the EMAC receiver enables the VLAN hash filtering operation on the outer VLAN tag (if present). ERSVLM and DOVLTC determine which VLAN type is enabled for filtering. 0b - Disabled 1b - Enabled

Table continues on the next page...

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Field	Function
26 EDVLP	Enable Double VLAN Processing Enables or disables double VLAN processing. • If this field is 1, MAC enables processing of up to two VLAN tags on transmit and receive (if present). • If this field is 0, MAC enables processing of up to one VLAN tag on transmit and receive (if present). 0b - Disabled 1b - Enabled
25 VTHM	VLAN Tag Hash Table Match Indicates the status of VLAN tag hash table match. • If this field is 1, the most-significant four bits of CRC-32 of VLAN tag are used to index the content of MAC VLAN Hash Table (MAC_VLAN_Hash_Table). See VLAN filtering for details. • If MAC_VLAN_Hash_Table[VLHT] = 1, corresponding to the index, it indicates that the Ethernet packet matches the VLAN hash table. See VLAN filtering for details. • If ETV = 1, the CRC of the 12-bit VLAN identifier (VID) is used for comparison. When the ETV field becomes 0, the CRC of the 16-bit VLAN tag is used for comparison. • If VTHM = 1, the VLAN hash match operation is not performed. 0b - Disabled 1b - Enabled
24 EVLRXS	Enable VLAN Tag In Receive Status Indicates whether the VLAN tag in receive status is enabled. • If this field is 1, MAC provides the outer VLAN tag in the receive status. • If this field is 0, MAC does not provide the outer VLAN tag in receive status. 0b - Disabled 1b - Enabled
23 —	Reserved
22-21 EVLS	Enable VLAN Tag Stripping Indicates the stripping operation on the outer VLAN tag in received packets. The field enables or disables VLAN tag stripping on receive. 00b - Do not strip 01b - Strip if VLAN filter passes 10b - Strip if VLAN filter fails 11b - Always strip
20	Disable VLAN Type Check

Table continues on the next page...

Table continued from the previous page...

Field	Function
DOVLTC	Enables or disables VLAN type check for VLAN hash filtering. • If this field is 1, the MAC VLAN hash filter matches or filters the VLAN tag that the ERIVLT field specifies only when the VLAN tag type is similar to the one that the ERSVLM field specifies. • If this field is 0, the MAC VLAN hash filter does not check whether the VLAN tag that the ERIVLT field specifies is of type S-VLAN or C-VLAN. 0b - Enabled 1b - Disabled
19 ERSVLM	Enable Receive S-VLAN Match Enables or disables receive S-VLAN match for VLAN hash filtering. • If this field is 1, the MAC receiver enables VLAN hash filtering or S-VLAN matching (type = 88A8h) packets. • If this field is 0, the MAC receiver enables VLAN hash filtering or matching for C-VLAN (type = 8100h) packets. The ERIVLT field determines the VLAN tag position considered for VLAN hash filtering or matching. 0b - Disabled 1b - Enabled
18 ESVL	Enable S-VLAN Enables or disables S-VLAN. If this field is 1, the MAC transmitter and receiver consider the S-VLAN packets (type = 88A8h) as valid VLAN-tagged packets. 0b - Disabled 1b - Enabled
17 VTIM	VLAN Tag Inverse Match Enable Enables or disables VLAN tag inverse matching. • If this field is 1, it enables the VLAN tag inverse matching. The packets without matching VLAN tag are marked as matched. • If this field is 0, it enables the VLAN tag perfect matching. The packets with matched VLAN tag are marked as matched. 0b - Disabled 1b - Enabled
16 ETV	Enable Tag For VLAN Enables or disables 12-bit VLAN tag comparison for VLAN hash filtering. • If this field is 1, a 12-bit VLAN identifier is used for VLAN hash filtering instead of the complete 16-bit VLAN tag. Bits [11:0] of the VLAN tag in the received VLAN-tagged packet are used for hash-based VLAN filtering.

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Field	Function
	• When this field becomes 0, all 16 bits of the 15th and 16th bytes of the received VLAN packet are used for VLAN hash filtering. 0b - Disabled 1b - Enabled
15-4 —	Reserved
3-2 OFS	Offset Holds the address offset of the MAC VLAN Tag Filter register that the application tries to access. The width of this field depends on the number of enabled MAC VLAN Tag registers.
1 CT	Command Type Specifies whether the current register access indicates a read or a write operation. It indicates a read operation if this field is 1 and a write operation when the field is 0. 0b - Write operation 1b - Read operation
0 OB	Operation Busy Indicates the operation busy status. • This field becomes 1 to initiate a read or write command for an indirect access to the Per VLAN Tag Filter register. • The field becomes 0 when the read or write command to Per VLAN Tag Filter indirect access register completes. The next indirect register access can be initiated only after the field resets. During a write operation, the field becomes 0 only after the data is written into a MAC_VLAN_Tag_Filter register. During a read operation, the data must be read from MAC VLAN Tag Data (MAC_VLAN_Tag_Data) only after this field becomes 0. 0b - Disabled 1b - Enabled

78.17.10 MAC VLAN Tag Data (MAC_VLAN_Tag_Data)

Offset

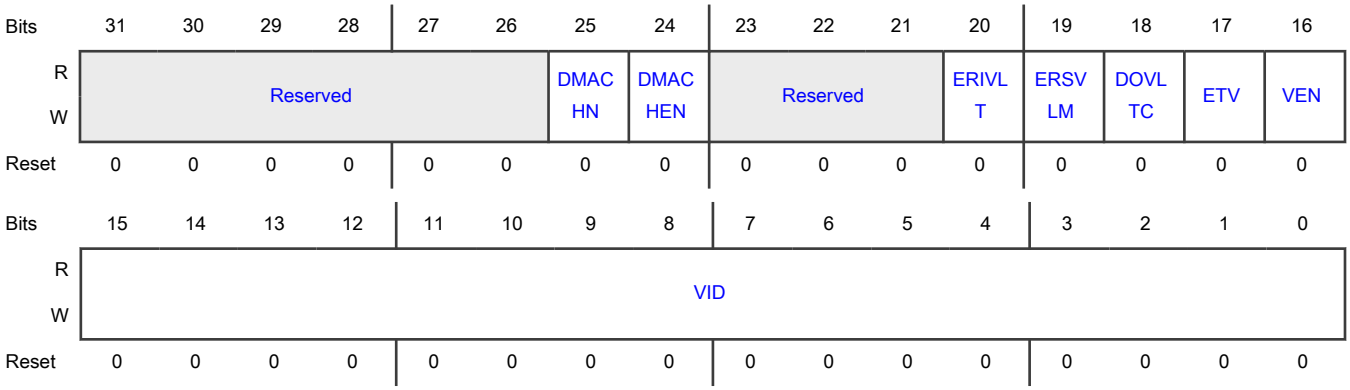
Register	Offset
MAC_VLAN_Tag_Data	54h

Function

Holds the read and write data for indirect access to the Per VLAN Tag registers.

- During read access, this register contains valid read data only after MAC_VLAN_Tag_Ctrl[OB] becomes 0.
- During write access, this register must become valid before you write 1 to MAC_VLAN_Tag_Ctrl[OB].

Diagram



Fields

Field	Function
31-26 —	Reserved
25 DMACHN	DMA Channel Number Indicates the DMA channel number to which the VLAN-tagged frame is to be routed if it passes the VLAN tag filter programmed using this field. If the routing based on VLAN tag filter is not necessary, this field does not need to be programmed.
24 DMACHEN	DMA Channel Number Enable Enables or disables the DMA channel number value programmed using the DMACHN field. If this field is 0, the routing does not occur based on the VLAN filter result. The frame is routed on the basis of DA-based DMA channel routing. 0b - Disabled 1b - Enabled
23-21 —	Reserved
20 ERIVLT	Enable Inner VLAN Tag Enables or disables inner VLAN tag comparison. • This field is valid only when the double VLAN tag enable of the filter is set. • If this field and the EDVLP field is 1, the MAC receiver enables operation on the inner VLAN tag (if present). • If this field is 0, the MAC receiver enables operation on the outer VLAN tag (if present).

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled
19 ERSVLM	Enable S-VLAN Match Enables or disables S-VLAN match for received frames. This field is valid only when the VLAN tag enable of the filter is set. • If this field is 1, the MAC receiver enables filtering or matching for S-VLAN (type = 88A8h) packets. • If this field is 0, the MAC receiver enables filtering or matching for C-VLAN (type = 8100h) packets. 0b - Disabled 1b - Enabled
18 DOVLTC	Disable VLAN Type Comparison Enables or disables VLAN type comparison. This field is valid only when the VEN field is 1. • If this field is 1, MAC does not check whether the VLAN tag that ERIVLT specifies is of type S-VLAN or C-VLAN. • If this field is 0, MAC filters or matches the VLAN tag that the ERIVLT field specifies only when the VLAN tag type is similar to the one that the ERSVLM field specifies. 0b - Enabled 1b - Disabled
17 ETV	VLAN Comparison Indicates 12-bit or 16-bit VLAN comparison. • This field is valid only when the VEN field is 1. • When the value of this field is 1, a 12-bit VLAN identifier is used for filter and comparison instead of the complete 16-bit VLAN tag. Bits [11:0] of the VLAN tag are compared with the corresponding field in the received VLAN-tagged packet. 0b - 16-bit VLAN comparison 1b - 12-bit VLAN comparison
16 VEN	VLAN Tag Enable Enables or disables the VLAN tag. • If this field is 1, MAC compares the VLAN tag of the received packet with the VLAN tag ID. • If this field is 0, no comparison is performed irrespective of the programming of the other fields. 0b - Disabled 1b - Enabled
15-0	VLAN Tag ID

Table continues on the next page...

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Field	Function
VID	Holds the VLAN tag value that MAC uses for perfect comparison. The field is valid when VEN = 1.

78.17.11 MAC VLAN Tag Filter 0 (MAC_VLAN_Tag_Filter0)

Offset

Register	Offset
MAC_VLAN_Tag_Filter0	54h

Function

Contains VLAN tag filter 0 control information.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved						DMACHN	DMACHEN	Reserved			ERIVLT	ERSVLM	DOVLTC	ETV	VEN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	VID															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 —	Reserved
25 DMACHN	DMA Channel Number Indicates the DMA channel number to which the VLAN-tagged frame is to be routed if it passes the VLAN tag filter programmed using this field. If the routing based on VLAN tag filter is not necessary, this field does not need to be programmed.
24 DMACHEN	DMA Channel Number Enable Enables or disables the DMA channel number value programmed using the DMACHN field. If this field is 0, the routing does not occur based on the VLAN filter result. The frame is routed on the basis of DA-based DMA channel routing.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled
23-21 —	Reserved
20 ERIVLT	Enable Inner VLAN Tag Enables or disables inner VLAN tag comparison. • This field is valid only when the double VLAN tag enable of the filter is set. • If this field and the EDVLP field is 1, the MAC receiver enables operation on the inner VLAN tag (if present). • If this field is 0, the MAC receiver enables operation on the outer VLAN tag (if present). 0b - Disabled 1b - Enabled
19 ERSVLM	Enable S-VLAN Match Enables or disables S-VLAN match for received frames. This field is valid only when the VLAN tag enable of the filter is set. • If this field is 1, the MAC receiver enables filtering or matching for S-VLAN (type = 88A8h) packets. • If this field is 0, the MAC receiver enables filtering or matching for C-VLAN (type = 8100h) packets. 0b - Disabled 1b - Enabled
18 DOVLTC	Disable VLAN Type Comparison Enables or disables VLAN type comparison. This field is valid only when the VEN field is 1. • If this field is 1, MAC does not check whether the VLAN tag that ERIVLT specifies is of type S-VLAN or C-VLAN. • If this field is 0, MAC filters or matches the VLAN tag that the ERIVLT field specifies only when the VLAN tag type is similar to the one that the ERSVLM field specifies. 0b - Enabled 1b - Disabled
17 ETV	VLAN Comparison Indicates 12-bit or 16-bit VLAN comparison. • This field is valid only when the VEN field is 1. • When the value of this field is 1, a 12-bit VLAN identifier is used for filter and comparison instead of the complete 16-bit VLAN tag. Bits [11:0] of the VLAN tag are compared with the corresponding field in the received VLAN-tagged packet.

Table continues on the next page...

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Field	Function
	0b - 16-bit VLAN comparison 1b - 12-bit VLAN comparison
16 VEN	VLAN Tag Enable Enables or disables the VLAN tag. • If this field is 1, MAC compares the VLAN tag of the received packet with the VLAN tag ID. • If this field is 0, no comparison is performed irrespective of the programming of the other fields. 0b - Disabled 1b - Enabled
15-0 VID	VLAN Tag ID Holds the VLAN tag value that MAC uses for perfect comparison. The field is valid when VEN = 1.

78.17.12 MAC VLAN Tag Filter 1 (MAC_VLAN_Tag_Filter1)

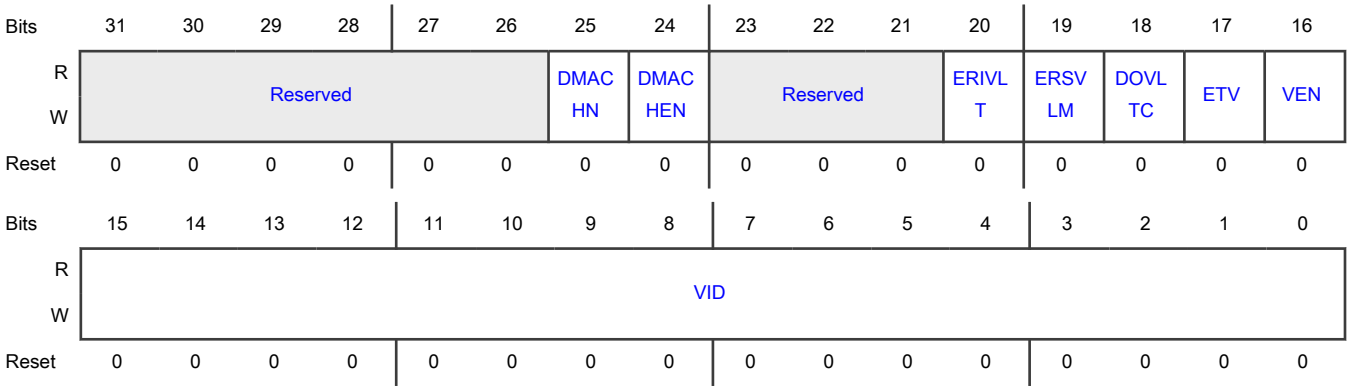
Offset

Register	Offset
MAC_VLAN_Tag_Filter1	54h

Function

Contains VLAN tag filter 1 control information.

Diagram



Fields

Field	Function
31-26 —	Reserved
25 DMACHN	DMA Channel Number Indicates the DMA channel number to which the VLAN-tagged frame is to be routed if it passes the VLAN tag filter programmed using this field. If the routing based on VLAN tag filter is not necessary, this field does not need to be programmed.
24 DMACHEN	DMA Channel Number Enable Enables or disables the DMA channel number value programmed using the DMACHN field. If this field is 0, the routing does not occur based on the VLAN filter result. The frame is routed on the basis of DA-based DMA channel routing. 0b - Disabled 1b - Enabled
23-21 —	Reserved
20 ERIVLT	Enable Inner VLAN Tag Enables or disables inner VLAN tag comparison. • This field is valid only when the double VLAN tag enable of the filter is set. • If this field and the EDVLP field is 1, the MAC receiver enables operation on the inner VLAN tag (if present). • If this field is 0, the MAC receiver enables operation on the outer VLAN tag (if present). 0b - Disabled 1b - Enabled
19 ERSVLM	Enable S-VLAN Match Enables or disables S-VLAN match for received frames. This field is valid only when the VLAN tag enable of the filter is set. • If this field is 1, the MAC receiver enables filtering or matching for S-VLAN (type = 88A8h) packets. • If this field is 0, the MAC receiver enables filtering or matching for C-VLAN (type = 8100h) packets. 0b - Disabled 1b - Enabled
18 DOVLTC	Disable VLAN Type Comparison Enables or disables VLAN type comparison. This field is valid only when the VEN field is 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	• If this field is 1, MAC does not check whether the VLAN tag that ERIVLT specifies is of type S-VLAN or C-VLAN. • If this field is 0, MAC filters or matches the VLAN tag that the ERIVLT field specifies only when the VLAN tag type is similar to the one that the ERSVLM field specifies. 0b - Enabled 1b - Disabled
17 ETV	VLAN Comparison Indicates 12-bit or 16-bit VLAN comparison. • This field is valid only when the VEN field is 1. • When the value of this field is 1, a 12-bit VLAN identifier is used for filter and comparison instead of the complete 16-bit VLAN tag. Bits [11:0] of the VLAN tag are compared with the corresponding field in the received VLAN-tagged packet. 0b - 16-bit VLAN comparison 1b - 12-bit VLAN comparison
16 VEN	VLAN Tag Enable Enables or disables the VLAN tag. • If this field is 1, MAC compares the VLAN tag of the received packet with the VLAN tag ID. • If this field is 0, no comparison is performed irrespective of the programming of the other fields. 0b - Disabled 1b - Enabled
15-0 VID	VLAN Tag ID Holds the VLAN tag value that MAC uses for perfect comparison. The field is valid when VEN = 1.

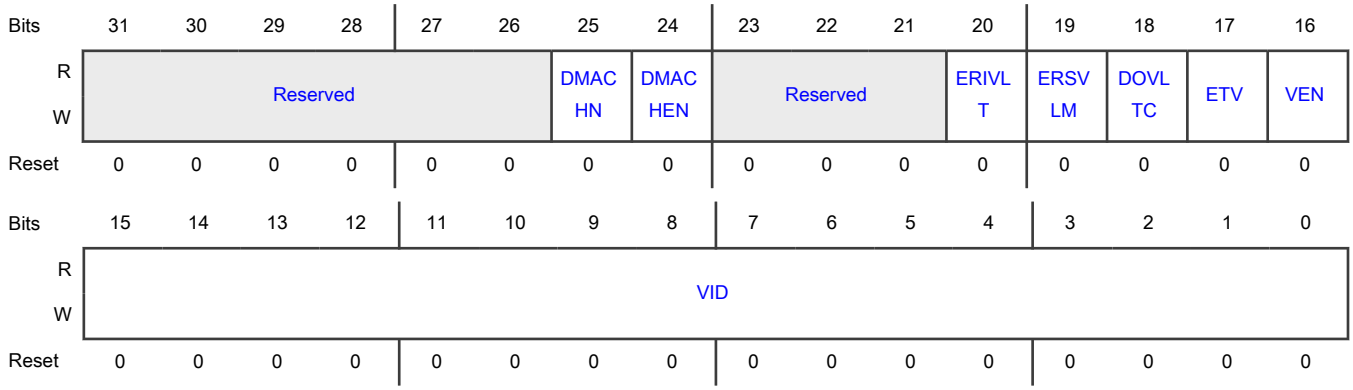
78.17.13 MAC VLAN Tag Filter 2 (MAC_VLAN_Tag_Filter2)

Offset

Register	Offset
MAC_VLAN_Tag_Filter2	54h

Function
Contains VLAN tag filter 2 control information.

Diagram



Fields

Field	Function
31-26 —	Reserved
25 DMACHN	DMA Channel Number Indicates the DMA channel number to which the VLAN-tagged frame is to be routed if it passes the VLAN tag filter programmed using this field. If the routing based on VLAN tag filter is not necessary, this field does not need to be programmed.
24 DMACHEN	DMA Channel Number Enable Enables or disables the DMA channel number value programmed using the DMACHN field. If this field is 0, the routing does not occur based on the VLAN filter result. The frame is routed on the basis of DA-based DMA channel routing. 0b - Disabled 1b - Enabled
23-21 —	Reserved
20 ERIVLT	Enable Inner VLAN Tag Enables or disables inner VLAN tag comparison. • This field is valid only when the double VLAN tag enable of the filter is set. • If this field and the EDVLP field is 1, the MAC receiver enables operation on the inner VLAN tag (if present). • If this field is 0, the MAC receiver enables operation on the outer VLAN tag (if present). 0b - Disabled 1b - Enabled
19	Enable S-VLAN Match

Table continues on the next page...

Table continued from the previous page...

Field	Function
ERSVLM	Enables or disables S-VLAN match for received frames. This field is valid only when the VLAN tag enable of the filter is set. • If this field is 1, the MAC receiver enables filtering or matching for S-VLAN (type = 88A8h) packets. • If this field is 0, the MAC receiver enables filtering or matching for C-VLAN (type = 8100h) packets. 0b - Disabled 1b - Enabled
18 DOVLTC	Disable VLAN Type Comparison Enables or disables VLAN type comparison. This field is valid only when the VEN field is 1. • If this field is 1, MAC does not check whether the VLAN tag that ERIVLT specifies is of type S-VLAN or C-VLAN. • If this field is 0, MAC filters or matches the VLAN tag that the ERIVLT field specifies only when the VLAN tag type is similar to the one that the ERSVLM field specifies. 0b - Enabled 1b - Disabled
17 ETV	VLAN Comparison Indicates 12-bit or 16-bit VLAN comparison. • This field is valid only when the VEN field is 1. • When the value of this field is 1, a 12-bit VLAN identifier is used for filter and comparison instead of the complete 16-bit VLAN tag. Bits [11:0] of the VLAN tag are compared with the corresponding field in the received VLAN-tagged packet. 0b - 16-bit VLAN comparison 1b - 12-bit VLAN comparison
16 VEN	VLAN Tag Enable Enables or disables the VLAN tag. • If this field is 1, MAC compares the VLAN tag of the received packet with the VLAN tag ID. • If this field is 0, no comparison is performed irrespective of the programming of the other fields. 0b - Disabled 1b - Enabled
15-0 VID	VLAN Tag ID Holds the VLAN tag value that MAC uses for perfect comparison. The field is valid when VEN = 1.

78.17.14 MAC VLAN Tag Filter 3 (MAC_VLAN_Tag_Filter3)

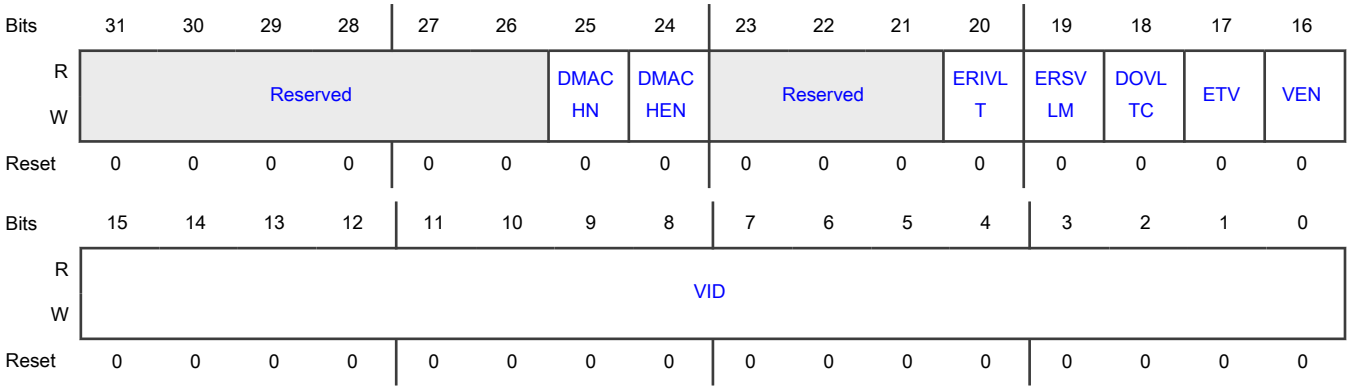
Offset

Register	Offset
MAC_VLAN_Tag_Filter3	54h

Function

Contains VLAN tag filter 3 control information.

Diagram



Fields

Field	Function
31-26 —	Reserved
25 DMACHN	DMA Channel Number Indicates the DMA channel number to which the VLAN-tagged frame is to be routed if it passes the VLAN tag filter programmed using this field. If the routing based on VLAN tag filter is not necessary, this field does not need to be programmed.
24 DMACHEN	DMA Channel Number Enable Enables or disables the DMA channel number value programmed using the DMACHN field. If this field is 0, the routing does not occur based on the VLAN filter result. The frame is routed on the basis of DA-based DMA channel routing. 0b - Disabled 1b - Enabled
23-21 —	Reserved

Table continues on the next page...

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Field	Function
20 ERIVLT	Enable Inner VLAN Tag Enables or disables inner VLAN tag comparison. • This field is valid only when the double VLAN tag enable of the filter is set. • If this field and the EDVLP field is 1, the MAC receiver enables operation on the inner VLAN tag (if present). • If this field is 0, the MAC receiver enables operation on the outer VLAN tag (if present). 0b - Disabled 1b - Enabled
19 ERSVLM	Enable S-VLAN Match Enables or disables S-VLAN match for received frames. This field is valid only when the VLAN tag enable of the filter is set. • If this field is 1, the MAC receiver enables filtering or matching for S-VLAN (type = 88A8h) packets. • If this field is 0, the MAC receiver enables filtering or matching for C-VLAN (type = 8100h) packets. 0b - Disabled 1b - Enabled
18 DOVLTC	Disable VLAN Type Comparison Enables or disables VLAN type comparison. This field is valid only when the VEN field is 1. • If this field is 1, MAC does not check whether the VLAN tag that ERIVLT specifies is of type S-VLAN or C-VLAN. • If this field is 0, MAC filters or matches the VLAN tag that the ERIVLT field specifies only when the VLAN tag type is similar to the one that the ERSVLM field specifies. 0b - Enabled 1b - Disabled
17 ETV	VLAN Comparison Indicates 12-bit or 16-bit VLAN comparison. • This field is valid only when the VEN field is 1. • When the value of this field is 1, a 12-bit VLAN identifier is used for filter and comparison instead of the complete 16-bit VLAN tag. Bits [11:0] of the VLAN tag are compared with the corresponding field in the received VLAN-tagged packet. 0b - 16-bit VLAN comparison 1b - 12-bit VLAN comparison
16 VEN	VLAN Tag Enable Enables or disables the VLAN tag.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	• If this field is 1, MAC compares the VLAN tag of the received packet with the VLAN tag ID. • If this field is 0, no comparison is performed irrespective of the programming of the other fields. 0b - Disabled 1b - Enabled
15-0 VID	VLAN Tag ID Holds the VLAN tag value that MAC uses for perfect comparison. The field is valid when VEN = 1.

78.17.15 MAC VLAN Hash Table (MAC_VLAN_Hash_Table)

Offset

Register	Offset
MAC_VLAN_Hash_Table	58h

Function

If MAC_VLAN_Tag_Ctrl[VTHM] = 1, the 16-bit VLAN hash table register is used for group address filtering based on the VLAN tag. For hash filtering, the content of the 16-bit VLAN tag or 12-bit VLAN ID (based on MAC_VLAN_Tag_Ctrl[ETV]) in the incoming packet is passed through the CRC logic. The upper four bits of the calculated CRC value are used to index the contents of the VLAN hash table. For example, hash value of 1000b selects bit 8 of the VLAN hash table.

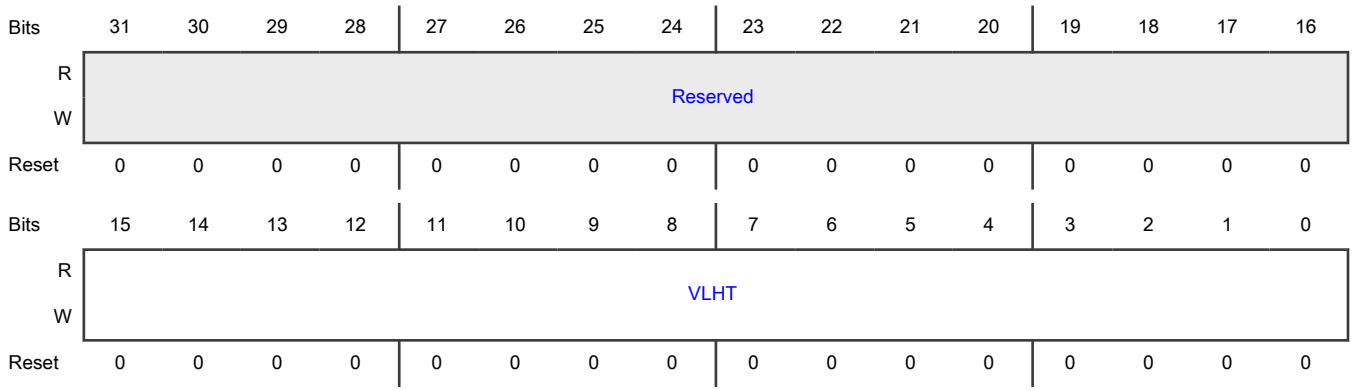
Perform these steps to calculate the hash value of the destination address:

1. Calculate the 32-bit CRC for DA (see section 3.2.8 of IEEE 802.3 for steps to calculate CRC32).
2. Perform bit-wise reversal for the value obtained in step 1.
3. Take the upper 4 bits from the value obtained in step 2.

If this register is configured to be double-synchronized with the (G)MII clock domain, the synchronization is triggered only when bits [15:8] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of the register are written to.

If double-synchronization is enabled, consecutive writes to this register must be performed after at least four clock cycles in the destination clock domain.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 VLHT	VLAN Hash Table Contains the 16-bit VLAN hash table.

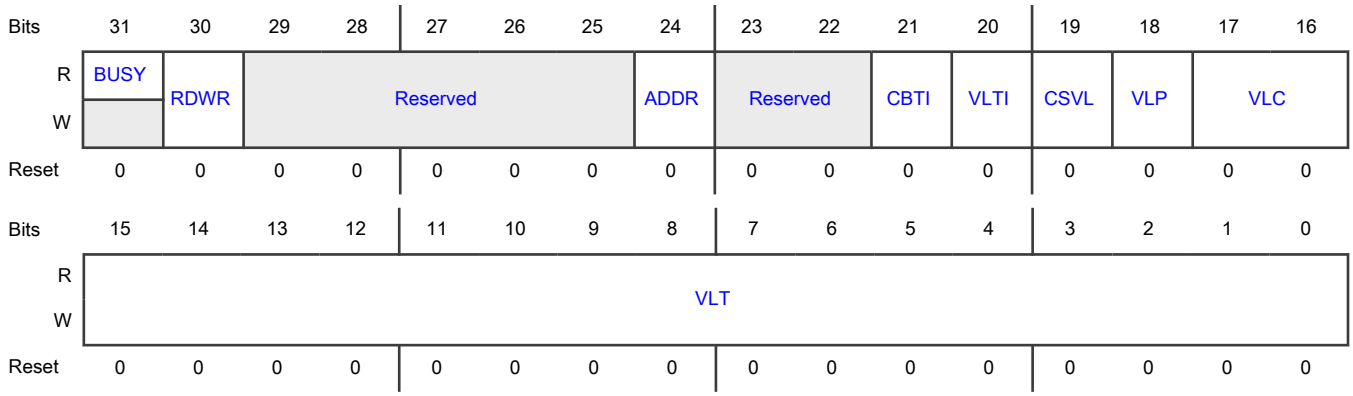
78.17.16 MAC VLAN Inclusion Or Replacement (MAC_VLAN_Incl)

Offset

Register	Offset
MAC_VLAN_Incl	60h

Function
Contains the VLAN tag for insertion or replacement in the transmit packets and the VLAN tag insertion controls.

Diagram



Fields

Field	Function
31 BUSY	Busy Indicates the status of the read or write operation of indirect access to the queue- or channel-specific VLAN inclusion register. The write operation to a register completes when this field becomes 0. For a read operation, the read data is valid when the field becomes 0. The application must make sure that this field becomes 0 before attempting subsequent accesses to this register.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Busy status not detected 1b - Busy status detected
30 RDWR	Read Write Control Controls the read or write operation for indirectly accessing the queue- or channel-specific VLAN inclusion register. • If this field is 1, it indicates the write operation. • If this field is 0, it indicates the read operation. The value of this field is not impacted when the CBTI field becomes 0. 0b - Read operation of indirect access 1b - Write operation of indirect access
29-25 —	Reserved
24 ADDR	Address Selects one of the queue- or channel-specific VLAN inclusion registers for read or write access. The value of this field is not impacted when the CBTI field is 0.
23-22 —	Reserved
21 CBTI	Channel-Based Tag Insertion Indicates the status of channel-based tag insertion. If this field is 1: • The outer VLAN tag is inserted for all the packets that MAC transmits. • The tag value is taken from the queue- or channel-specific VLAN tag register. Also, the VLTI, VLP, VLC, and VLT fields of the register are ignored. • A write operation to byte 3 of this register initiates the read or write access to the indirect register. If this field is 0, the outer VLAN operation is based on the settings of the VLTI, VLP, VLC, and VLT fields of this register. 0b - Disabled 1b - Enabled
20 VLTI	VLAN Tag Input Indicates the status of the VLAN tag input. The value of this field being 1 indicates that the VLAN tag to be inserted or replaced in the transmit packet must be taken from the transmit descriptor.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled
19 CSVL	C-VLAN Or S-VLAN Indicates whether C-VLAN or S-VLAN is inserted or replaced in the transmitted packets. • If this field is 1, S-VLAN type (88A8h) is inserted or replaced in the 13th and 14th bytes of the transmitted packets. • If this field is 0, C-VLAN type (8100h) is inserted or replaced in the 13th and 14th bytes of the transmitted packets. 0b - C-VLAN 1b - S-VLAN
18 VLP	VLAN Priority Control Indicates the status of VLAN priority control. • If this field is 1, the control bits [17:16] are used for VLAN deletion, insertion, or replacement. • If this field is 0, the mti_vlan_ctrl_i control input is used and bits [17:16] are ignored. 0b - Disabled 1b - Enabled
17-16 VLC	VLAN Tag Control Contains values for VLAN tag control in transmit packets. MAC: • Removes the VLAN type (bytes 13 and 14) and VLAN tag (bytes 15 and 16) of all the transmitted packets with VLAN tags. • Replaces VLT in bytes 15 and 16 of all the VLAN-type transmitted packets (bytes 13 and 14 are 8100h or 88a8h). MAC inserts the following into the packet in the order shown: 1. Type value (8100h or 88A8h) into bytes 13 and 14 2. MAC_VLAN_Tag_Data[VLT] into bytes 15 and 16 This operation is performed on all the transmitted packets, irrespective of whether they already have a VLAN tag. **NOTE** Changes to this field take effect only on the start of a packet. If you write to this field when a packet is being transmitted, only the subsequent packets can use the updated value. That is, the current packet does not use the updated value. 00b - No VLAN tag deletion, insertion, or replacement 01b - VLAN tag deletion

Table continues on the next page...

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Field	Function
	10b - VLAN tag insertion 11b - VLAN tag replacement
15-0 VLT	VLAN Tag For Transmit Packets Contains the value of the VLAN tag to be inserted or replaced. This value must only be changed during the initialization phase or when the transmit lines are inactive. The following list describes the bits of this field: • Bits [15:13]: User priority • Bit 12: Canonical format indicator (CFI) or drop eligible indicator (DEI) • Bits [11:0]: MAC_VLAN_Tag_Data[VID]

78.17.17 MAC VLAN Inclusion 0 (MAC_VLAN_Incl0)

Offset

Register	Offset
MAC_VLAN_Incl0	60h

Function

Contains the VLAN tag for insertion in the transmit packets from transmit queue 0. The register also contains the VLAN tag insertion controls.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved												CSVL	Reserved		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	VLT															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.18 MAC VLAN Inclusion 1 (MAC_VLAN_Incl1)

Offset

Register	Offset
MAC_VLAN_Incl1	60h

Function
Contains the VLAN tag for insertion in the transmit packets from transmit queue 1. The register also contains the VLAN tag insertion controls.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved												CSVL	Reserved		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	VLT															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20 —	Reserved
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.19 MAC VLAN Inclusion 2 (MAC_VLAN_Incl2)

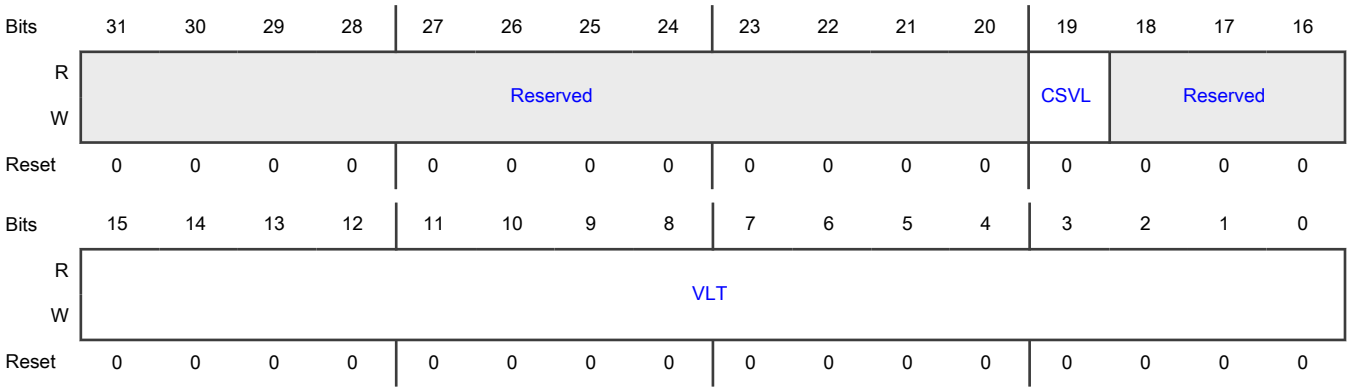
Offset

Register	Offset
MAC_VLAN_Incl2	60h

Function

Contains the VLAN tag for insertion in the transmit packets from transmit queue 2. The register also contains the VLAN tag insertion controls.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.20 MAC VLAN Inclusion 3 (MAC_VLAN_Incl3)

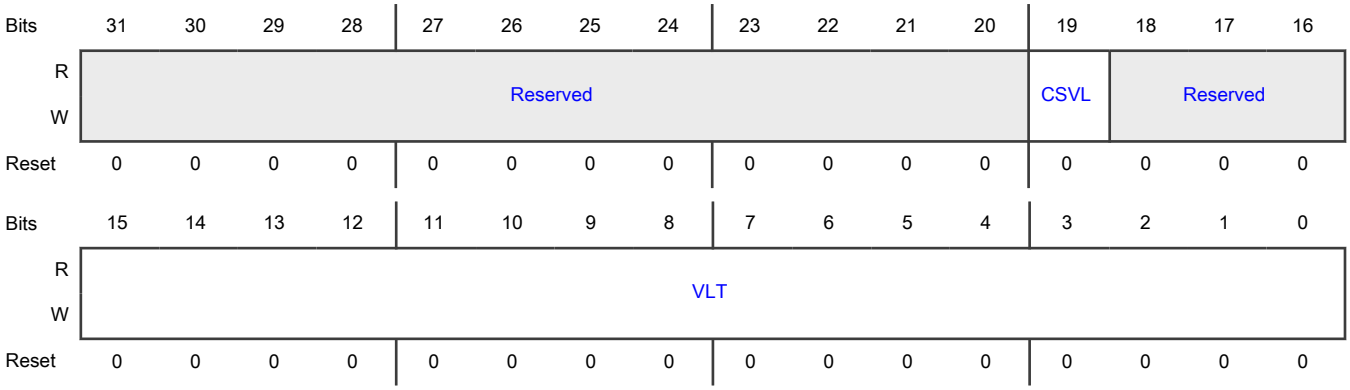
Offset

Register	Offset
MAC_VLAN_Incl3	60h

Function

Contains the VLAN tag for insertion in the transmit packets from transmit queue 3. The register also contains the VLAN tag insertion controls.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field:

Table continues on the next page...

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Field	Function
	• Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.21 MAC VLAN Inclusion 4 (MAC_VLAN_Incl4)

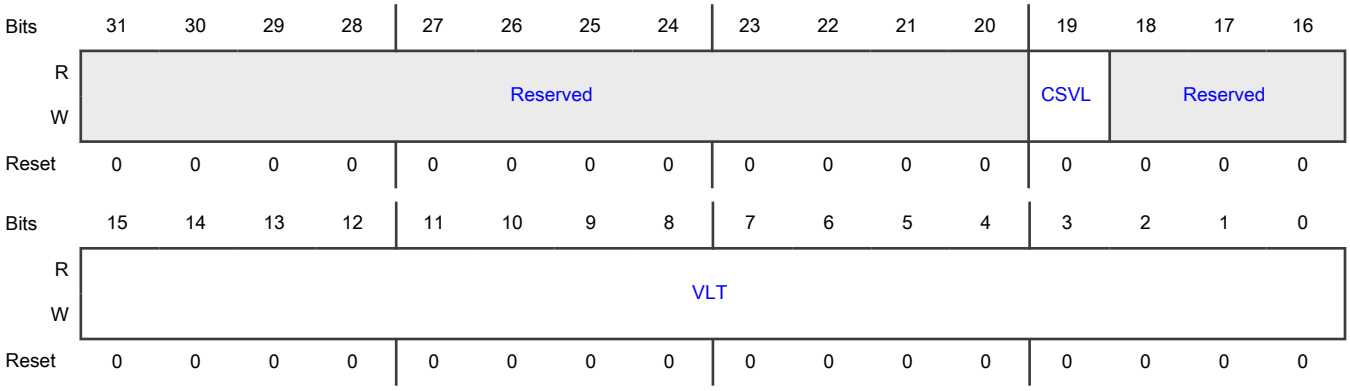
Offset

Register	Offset
MAC_VLAN_Incl4	60h

Function

Contains the VLAN tag for insertion in the transmit packets from transmit queue 4. The register also contains the VLAN tag insertion controls.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted

Table continues on the next page...

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Field	Function
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.22 MAC VLAN Inclusion 5 (MAC_VLAN_Incl5)

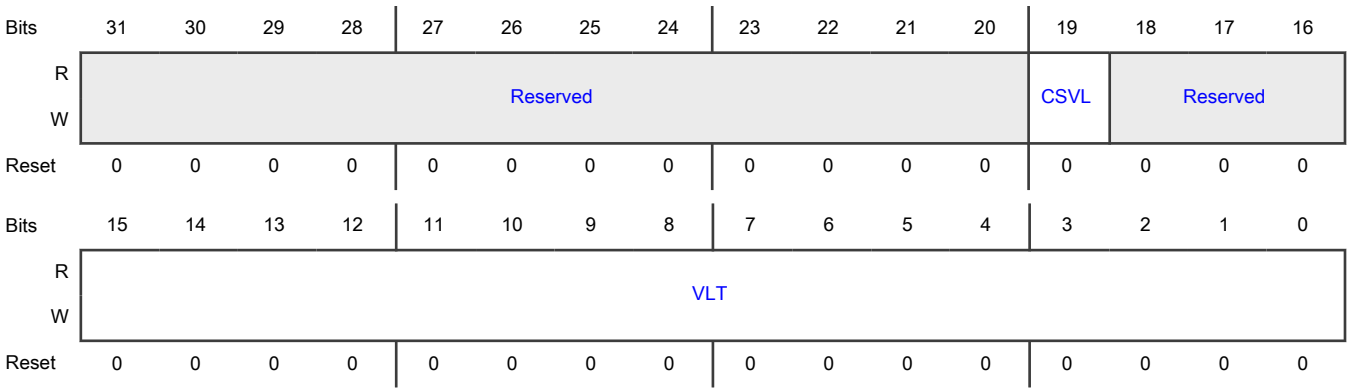
Offset

Register	Offset
MAC_VLAN_Incl5	60h

Function

Contains the VLAN tag for insertion in the transmit packets from transmit queue 5. The register also contains the VLAN tag insertion controls.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.23 MAC VLAN Inclusion 6 (MAC_VLAN_Incl6)

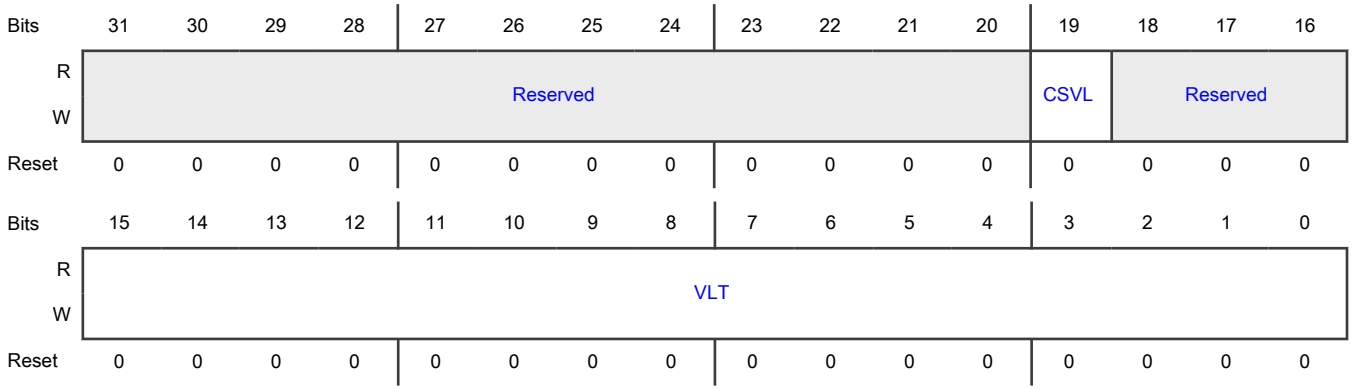
Offset

Register	Offset
MAC_VLAN_Incl6	60h

Function

Contains the VLAN tag for insertion in the transmit packets from transmit queue 6. The register also contains the VLAN tag insertion controls.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.24 MAC VLAN Inclusion 7 (MAC_VLAN_Incl7)

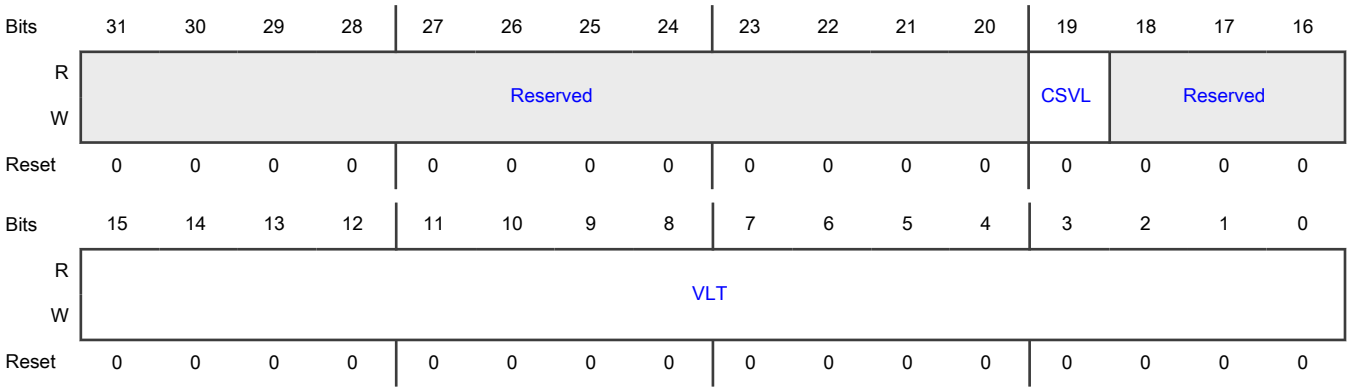
Offset

Register	Offset
MAC_VLAN_Incl7	60h

Function

Contains the VLAN tag for insertion in the transmit packets from transmit queue 7. The register also contains the VLAN tag insertion controls.

Diagram



Fields

Field	Function
31-20 —	Reserved
19 CSVL	C-VLAN or S-VLAN When this field is 1, S-VLAN type (0x88A8) is inserted in the 13th and 14th bytes of transmitted packets. When this field is reset, C-VLAN type (0x8100) is inserted in the 13th and 14th bytes of transmitted packets. 0b - C-VLAN type (0x8100) is inserted 1b - S-VLAN type (0x88A8) is inserted
18-16 —	Reserved
15-0 VLT	VLAN Tag for Transmit Packets Contains the value of the VLAN tag to be inserted. The value of this field must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits[15:13]: User Priority • Bit 12: Canonical Format Indicator (CFI) or Drop Eligible Indicator (DEI) • Bits[11:0]: VLAN Identifier (VID) field of VLAN tag

78.17.25 Inner VLAN Tag Inclusion Or Replacement (MAC_Inner_VLAN_Incl)

Offset

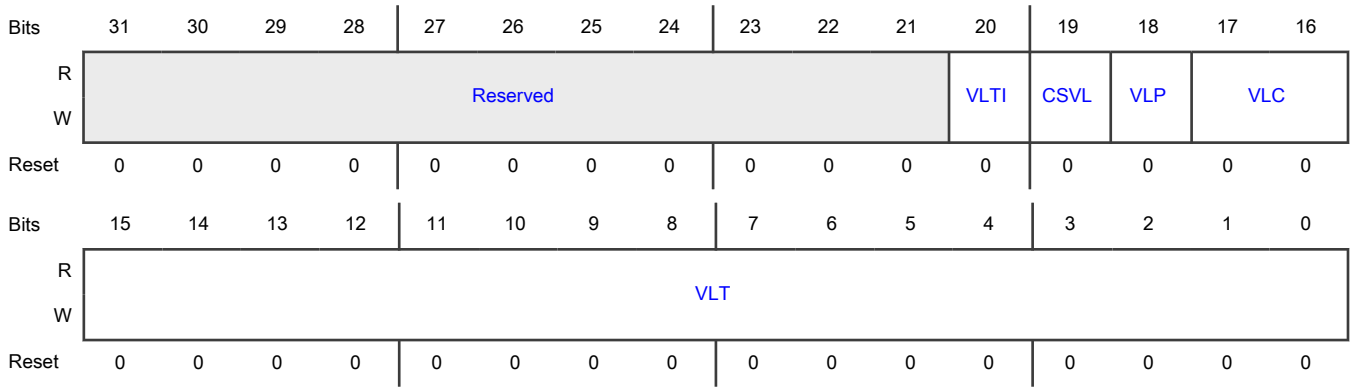
Register	Offset
MAC_Inner_VLAN_Incl	64h

Function

Contains:

- The inner VLAN tag to be inserted or replaced in the transmit packet
- The inner VLAN tag insertion controls

Diagram



Fields

Field	Function
31-21 —	Reserved
20 VLTI	VLAN Tag Input Indicates the status of VLAN tag input. If this field is 1, it indicates that the VLAN tag to be inserted or replaced in the transmit packet must be taken from the transmit descriptor. 0b - Disabled 1b - Enabled
19 CSVL	C-VLAN Or S-VLAN Controls the insertion or replacement type in the 17th and 18th bytes of the transmitted packets. 0b - C-VLAN type (8100h) 1b - S-VLAN type (88A8h)

Table continues on the next page...

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Field	Function
18 VLP	VLAN Priority Control Indicates the status of VLAN priority control. • If this field is 1, it's used for VLAN deletion, insertion, or replacement. • If this field is 0, the mti_vlan_ctrl_i control input is used and MAC_VLAN_Incl[VLC] is ignored. 0b - Disabled 1b - Enabled
17-16 VLC	VLAN Tag Control in Transmit Packets Indicates the value of VLAN tag control in transmit packets. The following list specifies these values: • 2'b00: No VLAN tag deletion, insertion, or replacement • 2'b01: VLAN tag deletion • 2'b10: VLAN tag insertion • 2'b11: VLAN tag replacement MAC: • Removes the VLAN type (bytes 17 and 18) and VLAN tag (bytes 19 and 20) of all the transmitted packets with VLAN tags • Inserts VLT in bytes 19 and 20 of the packet after inserting the Type value (8100h or 88a8h) in bytes 17 and 18. This operation is performed on all the transmitted packets, irrespective of whether they already have a VLAN tag. • Replaces VLT in bytes 19 and 20 for all the VLAN-type transmitted packets (bytes 17 and 18 are 8100h or 88a8h). **NOTE** Changes to this field take effect only on the start of a packet. If you write to the field when a packet is being transmitted, only the subsequent packets can use the updated value. That is, the current packet does not use the updated value. 00b - No VLAN tag deletion, insertion, or replacement 01b - VLAN tag deletion 10b - VLAN tag insertion 11b - VLAN tag replacement
15-0 VLT	VLAN Tag For Transmit Packets Contains the value of the VLAN tag to be inserted or replaced. The value must only be changed when the transmit lines are inactive or during the initialization phase. The following list describes the bits of this field: • Bits [15:13]: User priority

Table continues on the next page...

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Field	Function
	• Bit 12: CFI or DEI • Bits [11:0]: MAC_VLAN_Tag_Data[VID]

78.17.26 MAC Q0 Tx Flow Control (MAC_Q0_Tx_Flow_Ctrl)

Offset

Register	Offset
MAC_Q0_Tx_Flow_Ctrl	70h

Function

Controls the generation and reception of the control (pause command) packets by MAC's flow control module. A write to the register with the Busy field = 1 triggers the flow control block to generate a pause packet. The 802.3x specification indicates the way the fields of the control packet are selected, and the pause time value from this register is used in the PT field of the control packet. The Busy field remains 1 until the control packet is transferred onto the cable. You must make sure that the Busy field is 0 before writing to this register.

If the value of the PFCE field in the MAC_Rx_Flow_Ctrl register is 1, this register controls the generation of priority flow control (PFC) frames with priorities mapped according to MAC_RxQ_Ctrl2[PSRQ0].

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PT															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved								DZPQ	PLT			Reserved		TFE	FCB_ BPA
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 PT	Pause Time Holds the value to be used in this field in the transmit control packet. If the bits of this field are configured to be double-synchronized with the (G)MII clock domain, consecutive writes to this register must be performed only after at least four clock cycles in the destination clock domain.

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Field	Function
15-8 —	Reserved
7 DZPQ	Disable Zero-Quanta Pause Enables or disables zero-quanta pause packet generation. • If this field is 1, it disables the automatic generation of the zero-quanta pause packets that the flow-control signal from the FIFO layer (MTL or external sideband flow control signal sbd_flowctrl_i or mti_flowctrl_i) deasserts. • If this field is 0, normal operations with automatic zero-quanta pause packet generation are enabled. 0b - Enabled 1b - Disabled
6-4 PLT	Pause Low Threshold Configures the threshold of the pause timer at which the input flow control signal mti_flowctrl_i (or sbd_flowctrl_i) is checked for automatic retransmission of the pause packet. The threshold values must always be less than the pause time configured in bits [31:16]. For example, if the PT field = 100H (256 slot times), and the PLT field = 001, a second pause packet automatically transmits if the mti_flowctrl_i signal is asserted at 228 (256-28) slot times after the first pause packet transmits. This list provides the threshold values for different values: • The slot time is defined as the time taken to transmit 512 bits (64 bytes) on GMII or MII. • This (approximate) computation is based on the packet size (64, 1518, 2000, 9018, 16384, or 32768) + two pause packet sizes + IPG in slot times. 000b - Pause time minus 4 slot times (PT is 4 slot times) 001b - Pause time minus 28 slot times (PT is 28 slot times) 010b - Pause time minus 36 slot times (PT is 36 slot times) 011b - Pause time minus 144 slot times (PT is 144 slot times) 100b - Pause time minus 256 slot times (PT is 256 slot times) 101b - Pause time minus 512 slot times (PT is 512 slot times) 110b - Reserved
3-2 —	Reserved
1 TFE	Transmit Flow Control Enable Indicates whether transmit flow control is enabled or disabled. • Full-Duplex mode: If this field is 1, MAC enables the flow control operation to the transmit pause packets. When the field becomes 0, MAC's flow control operation disables and MAC does not transmit any pause packets.

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Field	Function
	• Half-Duplex mode: If this field is 1, MAC enables the backpressure operation. When the field becomes 0, the backpressure operation disables. 0b - Disabled 1b - Enabled
0 FCB_BPA	Flow Control Busy Or Backpressure Activate Initiates if a pause packet is in Full-Duplex mode and activates the backpressure function in Half-Duplex mode if the TFE field is 1. • Full-Duplex mode: In this mode, FCB_BPA must be read as 1'b0 before writing to this register. To initiate a pause packet, the application must set this field to 1'b1. During control packet transfer, the field's value continues to be 1 to indicate that a packet transmission is in progress. When pause packet transmission is complete, MAC resets this field to 1'b0. You must not write to this register until this field becomes 0. • Half-Duplex mode: If FCB_BPA = 1 and TFE = 1 too, MAC asserts backpressure in this mode. During the backpressure function, when MAC receives a new packet, the transmitter starts sending a JAM pattern resulting in a collision. This control register field is logically ORed with the mti_flowctrl_i input signal for the backpressure function. When you configure MAC using Full-Duplex mode, this field automatically becomes 0. Access restrictions apply to this field: writing 1 sets it, writing 0 has no effect, and the field is self-clearing. 0b - Flow control busy or backpressure activate is disabled 1b - Flow control busy or backpressure activate is enabled

78.17.27 MAC Receive Flow Control (MAC_Rx_Flow_Ctrl)

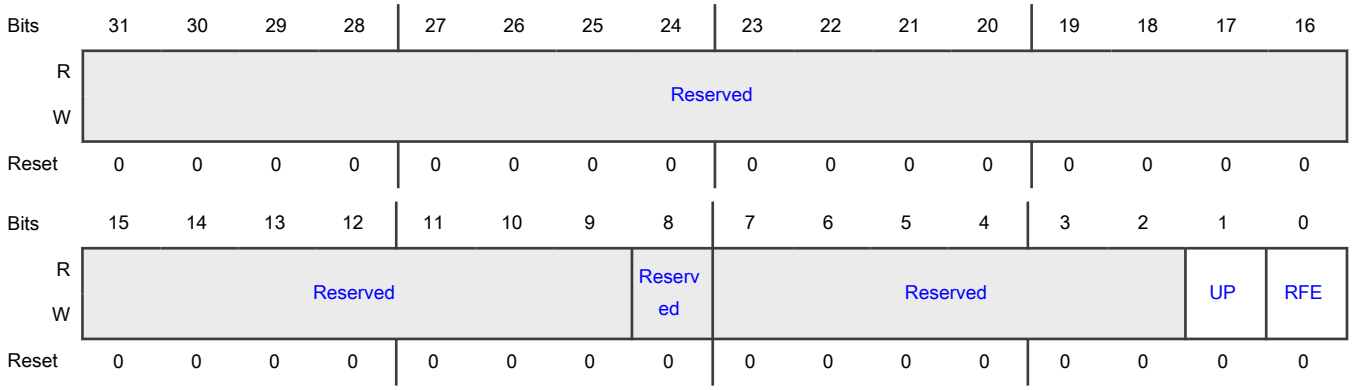
Offset

Register	Offset
MAC_Rx_Flow_Ctrl	90h

Function

Controls the pausing of MAC transmit based on the received pause packet.

Diagram



Fields

Field	Function
31-9 —	Reserved
8 —	Reserved
7-2 —	Reserved
1 UP	Unicast Pause Packet Detect Indicates whether the unicast pause packet is enabled or disabled. A pause packet is processed when it has the unique multicast address specified in IEEE 802.3. • If this field is 1, MAC can detect pause packets with a unicast address of the station. This address must comply with the specifications in MAC Address 0 High (MAC_Address0_High) and MAC Address 0 Low (MAC_Address0_Low). • If this field is 0, MAC only detects pause packets with a unique multicast address. **NOTE** MAC does not process a pause packet if the multicast address is different from the unique multicast address. This applies to the received PFC packet if PFC is enabled. The unique multicast address (01_80_C2_00_00_01h) complies with the IEEE 802.1 Qbb-2011 specifications. 0b - Disabled 1b - Enabled
0 RFE	Receive Flow Control Enable Indicates whether the receive flow control is enabled or disabled. • If this field is 1 and MAC is operating in Full-Duplex mode, MAC decodes the received pause packet and disables its transmitter for a specified (pause) time.

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Field	Function
	• If this field is 0 or if MAC is operating in Half-Duplex mode, the decode function of the pause packet disables. When PFC is enabled, the flow control for PFC packets is enabled too. MAC decodes the received PFC packet and disables the transmit queue, with matching priorities, for a duration of the received pause time. 0b - Disabled 1b - Enabled

78.17.28 MAC RxQ Control 4 (MAC_RxQ_Ctrl4)

Offset

Register	Offset
MAC_RxQ_Ctrl4	94h

Function

Controls the routing of unicast and multicast packets that fail the destination or source address filter to the receive queues.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved														VFFQ	VFFQE
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved						MFFQ	MFFQE	Reserved						UFFQ	UFFQE
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-18 —	Reserved
17 VFFQ	VLAN Tag Filter Fail Packets Queue Holds the receive queue number to which the tagged packets failing the destination or source address filter (and UFFQE and MFFQE not being 1) or failing the VLAN tag filter must be routed to. This field is valid only when the VFFQE field = 1.

Table continues on the next page...

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Field	Function
16 VFFQE	VLAN Tag Filter Fail Packets Queuing Enable Indicates whether VLAN tag filter fail packet queuing is enabled or disabled. • If this field is 1, the tagged packets that fail the destination or source address filter or fail the VLAN tag filter are routed to the receive queue number programmed using the VFFQ field. • If this field is 0, the tagged packets that fail the destination or source address filter or fail the VLAN tag filter are routed based on the other routing options. This field is valid only when MAC_Packet_Filter[RA] = 1. 0b - Disabled 1b - Enabled
15-10 —	Reserved
9 MFFQ	Multicast Address Filter Fail Packets Queue Holds the receive queue number to which the multicast packets failing the destination or source address filter are routed to. This field is valid only when the MFFQE field = 1.
8 MFFQE	Multicast Address Filter Fail Packets Queuing Enable Indicates whether multicast address filter fail packet queuing is enabled or disabled. • If this field is 1, the multicast packets that fail the destination or source address filter are routed to the receive queue number programmed using the MFFQ field. • If this field is 0, the multicast packets that fail the destination or source address filter are routed based on the other routing options. This field is valid only when MAC_Packet_Filter[RA] = 1. 0b - Disabled 1b - Enabled
7-2 —	Reserved
1 UFFQ	Unicast Address Filter Fail Packets Queue Holds the receive queue number to which the unicast packets failing the destination or source address filter are routed to. This field is valid only when the UFFQE field = 1.
0 UFFQE	Unicast Address Filter Fail Packets Queuing Enable Indicates whether unicast address filter fail packet queuing is enabled or disabled. • When the value of this field is 1, the unicast packets that fail the destination or source address filter are routed to the receive queue number programmed using the UFFQ field. • If this field is 0, the unicast packets that fail the destination or source address filter are routed based on the other routing options.

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Field	Function
	This field is valid only when MAC_Packet_Filter[RA] = 1. 0b - Disabled 1b - Enabled

78.17.29 MAC RxQ Control 0 (MAC_RxQ_Ctrl0)

Offset

Register	Offset
MAC_RxQ_Ctrl0	A0h

Function

Controls queue management in the MAC receiver.

NOTE

In multiple receive queues configuration, all the queues are disabled by default. Enable the receive queue by programming the corresponding field in this register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved		Reserved		Reserved		Reserved		Reserved		Reserved		RXQ1EN		RXQ0EN	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-14 —	Reserved

Table continues on the next page...

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Field	Function
13-12 —	Reserved
11-10 —	Reserved
9-8 —	Reserved
7-6 —	Reserved
5-4 —	Reserved
3-2 RXQ1EN	Receive Queue 1 Enable Performs in a manner similar to the RXQ0EN field and indicates if receive queue 1 is enabled for AV or DCB. 00b - Queue not enabled 01b - Queue enabled for AV 10b - Queue enabled for DCB/generic 11b - Reserved
1-0 RXQ0EN	Receive Queue 0 Enable Indicates whether receive queue 0 is enabled for AV or DCB. 00b - Queue not enabled 01b - Queue enabled for AV 10b - Queue enabled for DCB/generic 11b - Reserved

78.17.30 Receive Queue Control 1 (MAC_RxQ_Ctrl1)

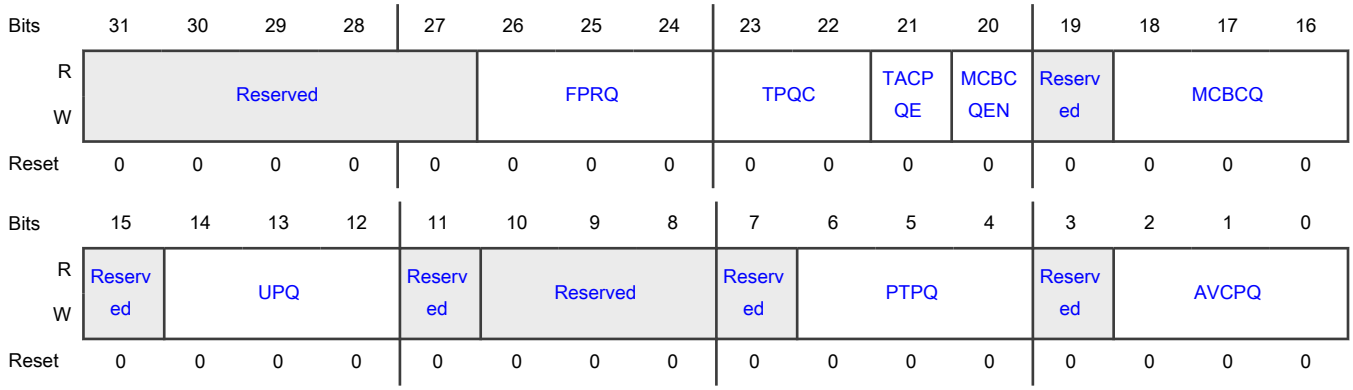
Offset

Register	Offset
MAC_RxQ_Ctrl1	A4h

Function

Controls the routing of multicast, broadcast, AV, DCB, and untagged packets to the receive queues.

Diagram



Fields

Field	Function
31-27 —	Reserved
26-24 FPRQ	Frame Preemption Residue Queue Holds the receive queue number to which the residual preemption frames must be forwarded. Preemption frames that are tagged and pass the SA, DA, or VLAN filtering are routed based on the settings of the PSRQ fields in MAC RxQ Control 2 (MAC_RxQ_Ctrl2). All other frames are treated as residual frames and are routed to the queue number mentioned in this field. Queue 0 is used as the default queue for express frames, so you cannot write 0 to this field.
23-22 TPQC	Tagged PTP Over Ethernet Packets Queuing Control Controls the routing of the VLAN-tagged PTPoE packets. These are the allowed programmable options: • 2'b00: VLAN-tagged PTPoE packets are routed as generic VLAN-tagged packets (based on the PSRQ fields in MAC RxQ Control 2 (MAC_RxQ_Ctrl2) for only non-AV enabled receive queues). • 2'b01: VLAN-tagged PTPoE packets are routed to the receive queue that the PTPQ field of this register specifies (this Rx queue can be enabled for AV or non-AV traffic). • 2'b10: VLAN-tagged PTPoE packets are routed to only AV-enabled receive queues based on the settings of the PSRQ fields.
21 TACPQE	Tagged AV Control Packets Queuing Enable Indicates the status of tagged AV control packet queuing. • If this field is 1, MAC routes the received tagged AV control packets to the receive queue that the AVCPQ field specifies. • If this field is 0, MAC routes the received tagged AV control packets based on the tag priority matching the PSRQ fields in MAC RxQ Control 2 (MAC_RxQ_Ctrl2). 0b - Disabled 1b - Enabled

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Field	Function
20 MCBCQEN	Multicast And Broadcast Queue Enable Specifies whether multicast or broadcast packet routing to the receive queue is enabled or disabled. The multicast or broadcast packets must be routed to the receive queue specified in the MCBCQ field. 0b - Disabled 1b - Enabled
19 —	Reserved
18-16 MCBCQ	Multicast And Broadcast Queue Specifies the receive queue onto which multicast or broadcast packets are routed. Any receive queue enabled for Generic, DCB, or AV traffic can be used to route the multicast or broadcast packets. 000b - Receive queue 0 001b - Receive queue 1 010b - Receive queue 2 011b - Receive queue 3 100b - Receive queue 4 101b - Receive queue 5 110b - Receive queue 6 111b - Receive queue 7
15 —	Reserved
14-12 UPQ	Untagged Packet Queue Indicates the receive queue to which the untagged packets need to be routed. Any receive queue enabled for generic, DCB, or AV traffic can be used to route the untagged packets. 000b - Receive queue 0 001b - Receive queue 1 010b - Receive queue 2 011b - Receive queue 3 100b - Receive queue 4 101b - Receive queue 5 110b - Receive queue 6 111b - Receive queue 7
11 —	Reserved

Table continues on the next page...

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Field	Function
10-8 —	Reserved
7 —	Reserved
6-4 PTPQ	PTP Packets Queue Specifies the receive queue on which the PTP packets sent over the Ethernet payload (not over IPv4 or IPv6) are routed. When MAC_Timestamp_Control[AV8021ASMEN] = 1, only untagged PTP over Ethernet packets are routed to a receive queue. If this field is not 1, then based on the settings of the TPQC field, both tagged and untagged PTPoE packets can be routed to this receive queue. 000b - Receive queue 0 001b - Receive queue 1 010b - Receive queue 2 011b - Receive queue 3 100b - Receive queue 4 101b - Receive queue 5 110b - Receive queue 6 111b - Receive queue 7
3 —	Reserved
2-0 AVCPQ	AV Untagged Control Packets Queue Specifies the receive queue on which the received AV tagged and untagged control packets are routed. The AV tagged (when the TACPQE field = 1) and untagged control packets are routed to the receive queue that this field specifies. 000b - Receive queue 0 001b - Receive queue 1 010b - Receive queue 2 011b - Receive queue 3 100b - Receive queue 4 101b - Receive queue 5 110b - Receive queue 6 111b - Receive queue 7

78.17.31 MAC RxQ Control 2 (MAC_RxQ_Ctrl2)

Offset

Register	Offset
MAC_RxQ_Ctrl2	A8h

Function

Controls the routing of tagged packets based on the settings of MAC_Ext_Configuration[USP] for packets received in receive queues 0-3.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved								Reserved							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PSRQ1								PSRQ0							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-16 —	Reserved
15-8 PSRQ1	Priorities Selected In Receive Queue 1 Determines the priorities assigned to receive queue 1. All the packets with priorities that match the values defined in this field are routed to receive queue 1. For example, if PSRQ1[4] = 1, packets with MAC_Ext_Configuration[USP] equal to 4 are routed to receive queue 1. You must ensure that the content of this field is mutually exclusive to the PSRQ fields for other queues. This means that the same priority is not mapped to multiple receive queues.
7-0 PSRQ0	Priorities Selected In Receive Queue 0 Determines the priorities assigned to receive queue 0. All the packets with priorities that match the values defined in this field are routed to receive queue 0. For example, if PSRQ0[5] = 1, packets with MAC_Ext_Configuration[USP] equal to 5 are routed to receive queue 0. You must ensure that the content of this field is mutually exclusive to the PSRQ fields for other queues. This means that the same priority is not mapped to multiple receive queues.

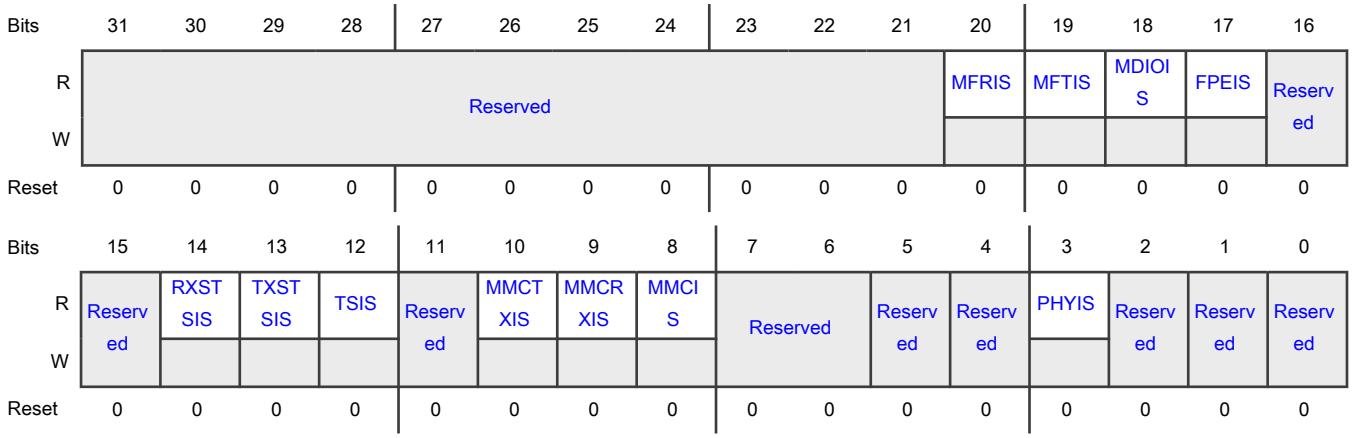
78.17.32 MAC Interrupt Status (MAC_Interrupt_Status)

Offset

Register	Offset
MAC_Interrupt_Status	B0h

Function
Contains the status of interrupts.

Diagram



Fields

Field	Function
31-21 —	Reserved
20 MFRIS	MMC FPE Receive Interrupt Status Indicates the status of MMC FPE receive interrupt. This field becomes 1 when any of the fields in MMC Receive Packet Assembly Error Counter Interrupt Status (MMC_FPE_Rx_Interrupt) is 1. The field becomes 0 when all the other fields in MMC Receive Packet Assembly Error Counter Interrupt Status (MMC_FPE_Rx_Interrupt) become 0 too. 0b - Inactive 1b - Active
19 MFTIS	MMC FPE Transmit Interrupt Status Indicates the status of MMC FPE transmit interrupt. This field becomes 1 when an interrupt generates in MMC Transmit FPE Fragment Counter Interrupt Status (MMC_FPE_Tx_Interrupt). The field becomes 0 when all the other fields in this register become 0 too. This field is valid only when you select the Enable MAC Management Counters (MMC) option along with FPE support.

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Field	Function
	0b - Inactive 1b - Active
18 MDIOIS	MDIO Interrupt Status Indicates the status of an interrupt event after the completion of an MDIO operation. To reset this field, you must read this field or write 1 to it when MAC_CSR_SW_Ctrl[RCWE] = 1. Access restrictions apply to this field. It clears on a read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. The field automatically becomes 1 on an internal event. 0b - Inactive 1b - Active
17 FPEIS	Frame Preemption Interrupt Status Indicates the status of an interrupt event during the frame preemption operation (the value of RVER, RRSP, TVER, and TRSP fields of MAC FPE Control STS (MAC_FPE_CTRL_STS) = 1). To reset this field, you must clear the event in MAC FPE Control STS (MAC_FPE_CTRL_STS) that caused the interrupt. 0b - Inactive 1b - Active
16 —	Reserved
15 —	Reserved
14 RXSTSIS	Receive Status Interrupt Indicates the status of received packets. This field becomes 1 when MAC_Rx_Tx_Status[RWT] = 1. The field becomes 0 when you read the corresponding interrupt source field in MAC Rx Transmit Status (MAC_Rx_Tx_Status), or if you write to this interrupt source field when MAC_CSR_SW_Ctrl[RCWE] = 1. The field becomes 0 in either of these circumstances: • You read the corresponding interrupt-source field in MAC Rx Transmit Status (MAC_Rx_Tx_Status). • You write 1 to the corresponding interrupt-source field in MAC Rx Transmit Status (MAC_Rx_Tx_Status) when MAC_CSR_SW_Ctrl[RCWE] = 1. 0b - Inactive 1b - Active
13 TXSTSIS	Transmit Status Interrupt Indicates the status of transmitted packets.

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Field	Function
	This field becomes 1 when any of the following fields is 1 in MAC Rx Transmit Status (MAC_Rx_Tx_Status): • Excessive collision (EXCOL) • Late collision (LCOL) • Excessive deferral (EXDEF) • Loss of carrier (LCARR) • No carrier (NCARR) • Jabber timeout (TJT) This field becomes 0 in either of these circumstances: • You read the corresponding interrupt-source field in MAC Rx Transmit Status (MAC_Rx_Tx_Status). • You write 1 to the corresponding interrupt-source field in MAC Rx Transmit Status (MAC_Rx_Tx_Status) when MAC_CSR_SW_Ctrl[RCWE] = 1. 0b - Inactive 1b - Active
12 TSIS	Timestamp Interrupt Status Indicates the status of timestamp interrupt. If the timestamp feature is enabled, this field becomes 1 when any of the following conditions is true: • The system time value is equal to or exceeds the value specified in MAC PPS1 Target Time In Seconds (MAC_PPS1_Target_Time_Seconds) and MAC PPS1 Target Time In Nanoseconds (MAC_PPS1_Target_Time_Nanoseconds). • There is an overflow in MAC System Time In Seconds (MAC_System_Time_Seconds). • The target time error occurred, which means, the programmed target time already elapsed. In configurations other than EQOS_CORE, when the drop transmit status is enabled in MTL, this field becomes 1 when the captured transmit timestamp is updated in MAC Transmit Timestamp Status In Nanoseconds (MAC_Tx_Timestamp_Status_Nanoseconds) and MAC Transmit Timestamp Status In Seconds (MAC_Tx_Timestamp_Status_Seconds). The field becomes 0 in either of these circumstances: • You read the corresponding interrupt-source field in MAC Rx Transmit Status (MAC_Rx_Tx_Status). • You write 1 to the corresponding interrupt-source field in MAC Rx Transmit Status (MAC_Rx_Tx_Status) when MAC_CSR_SW_Ctrl[RCWE] = 1. 0b - Inactive 1b - Active
11 —	Reserved
10 MMCTXIS	MMC Transmit Interrupt Status Indicates the status of MMC transmit interrupt.

Table continues on the next page...

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Field	Function
	This field: • Becomes 1 when any field in MMC Transmit Interrupt (MMC_Tx_Interrupt) becomes 1. • Becomes 0 when all the fields in MMC Transmit Interrupt (MMC_Tx_Interrupt)return to 0. This field is valid only when you select the Enable MAC Management Counters (MMC) option. 0b - Inactive 1b - Active
9 MMCRXIS	MMC Receive Interrupt Status Indicates the status of MMC receive interrupt. This field: • Becomes 1 when any field in MMC Receive Interrupt (MMC_Rx_Interrupt) becomes 1. • Becomes 0 when all the fields in MMC Receive Interrupt (MMC_Rx_Interrupt)return to 0. This field is valid only when you select the Enable MAC Management Counters (MMC) option. 0b - Inactive 1b - Active
8 MMCIS	MMC Interrupt Status Indicates the status of MMC interrupt. This field becomes 1 when MMCRXIS = MMCTXIS = 1, and the field becomes 0 only when MMCRXIS = MMCTXIS = 0. MMCIS is valid only when you select the Enable MAC Management Counters (MMC) option. 0b - Inactive 1b - Active
7-6 —	Reserved
5 —	Reserved
4 —	Reserved
3 PHYIS	PHY Interrupt Indicates whether the PHY interrupt is detected. This field becomes 1 when rising edge is detected on the phy_intr_i input signal. The field becomes 0 when you read this register (or if you write 1 to this field when MAC_CSR_SW_Ctrl[RCWE] = 1). 0b - Not detected

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Field	Function
	1b - Detected
2 —	Reserved
1 —	Reserved
0 —	Reserved

78.17.33 MAC Interrupt Enable (MAC_Interrupt_Enable)

Offset

Register	Offset
MAC_Interrupt_Enable	B4h

Function
Contains masks for generating MAC interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved													MDIOIE	FPEIE	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	RXSTSIE	TXSTSIE	TSIE	Reserved						Reserved	Reserved	PHYIE	Reserved	Reserved	Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18	MDIO Interrupt Enable

Table continues on the next page...

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Field	Function
MDIOIE	Indicates whether the MDIO interrupt is enabled or disabled. If this field is 1, it enables the assertion of the interrupt when MAC_Interrupt_Status[MDIOIS] = 1. 0b - Disabled 1b - Enabled
17 FPEIE	Frame Preemption Interrupt Enable Indicates whether the frame preemption interrupt is enabled or disabled. If this field is 1, it enables the assertion of the interrupt when MAC_Interrupt_Status[FPEIS] = 1. 0b - Disabled 1b - Enabled
16 —	Reserved
15 —	Reserved
14 RXSTSIE	Receive Status Interrupt Enable Indicates whether the receive status interrupt is enabled or disabled. If this field is 1, it enables the assertion of the interrupt signal because of the setting of MAC_Interrupt_Status[RXSTSIS]. 0b - Disabled 1b - Enabled
13 TXSTSIE	Transmit Status Interrupt Enable Indicates whether the timestamp status interrupt is enabled or disabled. If this field is 1, it enables the assertion of the interrupt signal because of the setting of MAC_Interrupt_Status[TXSTSIS]. 0b - Disabled 1b - Enabled
12 TSIE	Timestamp Interrupt Enable Indicates whether the timestamp interrupt is enabled or disabled. If this field is 1, it enables the assertion of the interrupt signal because of the setting MAC_Interrupt_Status[TSIS]. 0b - Disabled 1b - Enabled
11-6	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
5 —	Reserved
4 —	Reserved
3 PHYIE	PHY Interrupt Enable Indicates whether the assertion of the interrupt signal is enabled or disabled. If this field is 1, it enables the assertion of the interrupt signal because of the setting of MAC_Interrupt_Status[PHYIS]. 0b - Disabled 1b - Enabled
2 —	Reserved
1 —	Reserved
0 —	Reserved

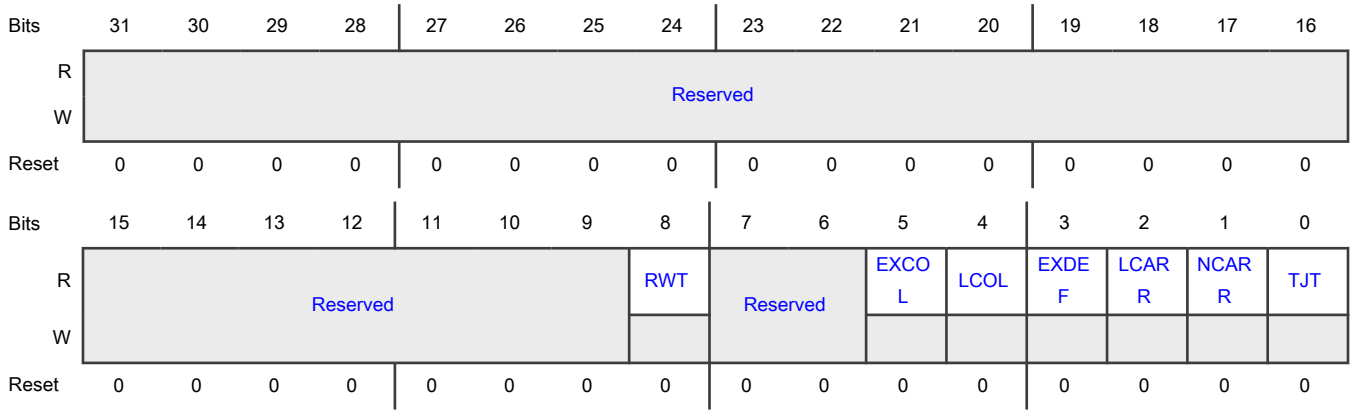
78.17.34 MAC Rx Transmit Status (MAC_Rx_Tx_Status)

Offset

Register	Offset
MAC_Rx_Tx_Status	B8h

Function
Contains the receive and transmit error status.

Diagram



Fields

Field	Function
31-9 —	Reserved
8 RWT	Receive Watchdog Timeout Indicates the status of receive watchdog. This field becomes 1 when a packet with a length greater than 2,048 bytes is received (10,240 bytes when Jumbo Packet mode is enabled) and MAC_Configuration[WD] = 0. RWT becomes 1 when a packet with length greater than 16,383 bytes is received and MAC_Configuration[WD] = 1. Access restrictions apply to RWT. It becomes 0 on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. RWT automatically becomes 1 on an internal event occurrence. 0b - No receive watchdog timed out 1b - Receive watchdog timed out
7-6 —	Reserved
5 EXCOL	Excessive Collisions Indicates the status of excessive collision. If MTL_Operation_Mode[DTXSTS] = 1, this field, EXCOL, indicates that the transmission aborted after 16 successive collisions while attempting to transmit the current packet. If MAC_Configuration[DR] = 1, EXCOL becomes 1 after the first collision and the packet transmission is aborted. Access restrictions apply to EXCOL. It becomes 0 on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. EXCOL automatically becomes 1 on an internal event occurrence. 0b - No collision 1b - Excessive collision is sensed
4	Late Collision

Table continues on the next page...

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Field	Function
LCOL	Indicates the status of late collision. If MTL_Operation_Mode[DTXSTS] = 1, this field, LCOL, indicates that the packet transmission aborted because a collision occurred after the collision window (64 bytes including preamble in MII mode; 512 bytes including preamble and carrier extension in GMII mode). This field is invalid if an underflow error occurs. Access restrictions apply to LCOL. It becomes 0 on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. LCOL automatically becomes 1 on an internal event occurrence. 0b - No collision 1b - Late collision is sensed
3 EXDEF	Excessive Deferral Indicates whether the transmission ended because of excessive deferral. If MTL_Operation_Mode[DTXSTS] = 1 and MAC_Configuration[DC] = 1 too, this field, EXDEF, indicates that the transmission ended because of excessive deferral of over 24,288 bit times (155,680 in 1000/2500 Mbit/s mode or when the jumbo packet is enabled). Access restrictions apply to EXDEF. It becomes 0 on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. EXDEF automatically becomes 1 on an internal event occurrence. 0b - No excessive deferral 1b - Excessive deferral
2 LCARR	Loss of Carrier Indicates the status of carrier signal. If MTL_Operation_Mode[DTXSTS] = 1, this field, LCARR, indicates that the loss of carrier occurred during packet transmission, which means, the PHY_CRS_I signal was inactive for one or more transmission clock periods during packet transmission. The field is valid only for packets transmitted without collision. Access restrictions apply to LCARR. It becomes 0 on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. LCARR automatically becomes 1 on an internal event occurrence. 0b - Carrier is present 1b - Loss of carrier
1 NCARR	No Carrier Indicates whether the carrier signal is present from the PHY at the end of preamble transmission. If MTL_Operation_Mode[DTXSTS] = 1, NCARR indicates that the carrier signal from the PHY is absent at the end of preamble transmission. Access restrictions apply to NCARR. It becomes 0 after either of these actions: • You read NCARR. • You write 1 to NCARR when MAC_CSR_SW_Ctrl[RCWE] = 1. NCARR automatically becomes 1 after an internal event occurs.

Table continues on the next page...

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Field	Function
	0b - Present 1b - Absent
0 TJT	Transmit Jabber Timeout Indicates whether a transmit-jabber timer timeout occurred. The timeout occurs after any of these events: • MAC_Configuration[JD] = 0 and the normal packet size exceeds 2,048 bytes. • MAC_Configuration[JD] = 0 and the jumbo packet size exceeds 10240 bytes. • MAC_Configuration[JD] = 1 and the normal packet size exceeds 16383 bytes. Access restrictions apply to TJT. It becomes 0 after either of these actions: • You read TJT. • You write 1 to TJT when MAC_CSR_SW_Ctrl[RCWE] = 1. TJT automatically becomes 1 after an internal event occurs. 0b - No transmit jabber timeout occurred 1b - Transmit jabber timeout occurred

78.17.35 MAC Version (MAC_Version)

Offset

Register	Offset
MAC_Version	110h

Function

Identifies the version of the module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CFGVER								IPVER							
W																
Reset	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1

Fields

Field	Function
31-16 —	Reserved
15-8 CFGVER	IP Configuration Version
7-0 IPVER	IP Version

78.17.36 MAC Debug (MAC_Debug)

Offset

Register	Offset
MAC_Debug	114h

Function
Provides the debug status of the various MAC blocks.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved													TFCSTS		TPESTS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved													RFCFCSTS		RPESTS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18-17	MAC Transmit Packet Controller Status

Table continues on the next page...

Table continued from the previous page...

Field	Function
TFCSTS	Indicates the state of the MAC transmit packet controller module. 00b - Idle state 01b - Waiting for one of these: status of the previous packet or IPG, or for the back-off period to be over 10b - Generating and transmitting a pause control packet (in Full-Duplex mode) 11b - Transferring input packet for transmission
16 TPESTS	MAC GMII Or MII Transmit Protocol Engine Status Indicates whether MAC GMII or MII transmit protocol engine is detected. If this field is 1, it indicates that the MAC GMII or MII transmit protocol engine is actively transmitting data and is not in an idle state. 0b - Not detected 1b - Detected
15-3 —	Reserved
2-1 RFCFCSTS	MAC Receive Packet Controller FIFO Status Indicates the status of the small FIFO read and write controllers of the MAC receive packet controller module. If this field is 1, it indicates that the small FIFO read and write controllers of the MAC receive packet controller module are in an active state. 00b - Inactive 01b - Active
0 RPESTS	Receive Protocol Engine Status Indicates whether MAC GMII or MII receive protocol engine is detected. If this field is 1, it indicates that the MAC GMII or MII receive protocol engine is actively receiving data and is not in an idle state. 0b - Not detected 1b - Detected

78.17.37 MAC Hardware Feature 0 (MAC_HW_Feature0)

Offset

Register	Offset
MAC_HW_Feature0	11Ch

Function

Indicates the presence of the first set of EMAC optional features or functions. You can use this register to dynamically enable or disable the programs related to these features.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	ACTPHYSEL			SAVLANI...	TSSTSSEL		MACADR6...	MACADR3...	ADDMACADRSEL					Reserved	RXCOESEL
W																
Reset	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	TXCOESEL	EEESEL	TSSEL	Reserved		ARPOFFS...	MMCSEL	MGKSEL	RWKSEL	SMASEL	VLHASH	PCSSEL	HDSEL	GMIISEL	MIISEL
W																
Reset	0	1	0	1	0	0	0	1	0	0	1	1	0	1	0	1

Fields

Field	Function
31 —	Reserved
30-28 ACTPHYSEL	Active PHY Feature Indicates the selected active PHY interface. If you have multiple PHY interfaces (GMII, MII, RevMII, RGMII, RMII, RTBI, SGMII, SGMII, or TBI) in your configuration, this field indicates the sampled value of the PHY_INTF_SEL_I signal during reset deassertion. 000b - GMII or MII 001b - RGMII 010b - SGMII 011b - TBI 100b - RMII 101b - RTBI 110b - SMII 111b - RevMII
27 SAVLANINS	SA or VLAN Insertion Feature Indicates whether the feature that enables SA or VLAN insertion on transmit is selected. This field becomes 1 if you select the "enable SA and VLAN insertion on Tx" option. 0b - Not selected 1b - Selected

Table continues on the next page...

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Field	Function
26-25 TSTSSEL	Timestamp System Time Source Feature Indicates the source of the timestamp system time. This field becomes 1 if you select the "enable IEEE 1588 timestamp support" option. 00b - Internal 01b - External 10b - Both internal and external 11b - Reserved
24 MACADR64SEL	MAC Addresses 64-127 Indicates whether the feature that enables additional 64 MAC address registers (64-127) is selected. This field becomes 1 if you enable the "MAC addresses (64-127) select" option. 0b - Not selected 1b - Selected
23 MACADR32SEL	MAC Addresses 32-63 Indicates whether the feature that enables additional 32 MAC address registers (32-63) is selected. This field becomes 1 if you select the "MAC addresses 32-63 select" option. 0b - Not selected 1b - Selected
22-18 ADDMACADRSEL	MAC Addresses 1-31 Indicates whether the feature that enables additional 1-31 MAC address registers is selected. This field becomes 1 if you select a non-zero value for enabling the "MAC addresses 1-31 select" option. 0_0000b - Not selected 0_0001b - Selected
17 —	Reserved
16 RXCOESEL	Receive Checksum Offload Feature Indicates whether the feature that enables receive TCP/IP checksum offload is selected. This field becomes 1 if you select the "enable receive TCP/IP checksum check" option. 0b - Not selected 1b - Selected
15 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
14 TXCOESEL	Transmit Checksum Offload Feature Indicates whether the feature that enables transmit TCP/IP checksum insertion is selected. This field becomes 1 if you select the "enable transmit TCP/IP checksum insertion" option. 0b - Not selected 1b - Selected
13 EEESEL	Energy Efficient Ethernet (EEE) Feature Indicates whether the feature that enables EEE is selected. This field becomes 1 if you select the "enable EEE" option. 0b - Not selected 1b - Selected
12 TSSEL	IEEE 1588-2008 Timestamp Feature Indicates whether the option that enables IEEE 1588-2008 timestamp is selected. This field becomes 1 if you select the "enable IEEE 1588 timestamp support" option. 0b - Not selected 1b - Selected
11-10 —	Reserved
9 ARPOFFSEL	ARP Offload Feature Indicates whether the feature that enables ARP offload is selected. This field becomes 1 if you select the "enable IPv4 ARP offload" option. 0b - Not selected 1b - Selected
8 MMCSEL	MAC Management Counters (MMC) Feature Indicates whether the feature that enables MMC is selected. This field becomes 1 if you select the "enable MMC" option. 0b - Not selected 1b - Selected
7 MGKSEL	PMT Magic Packet Feature Indicates whether the feature that enables PMT magic detection is selected. This field becomes 1 if you select the "enable magic packet detection" option. 0b - Not selected

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Selected
6 RWKSEL	PMT Remote Wake-Up Packet Feature Indicates whether the feature that enables PMT remote wake-up packet detection is selected. This field becomes 1 if you select the "enable remote wake-up packet detection" option. 0b - Not selected 1b - Selected
5 SMASEL	SMA (MDIO) Interface Feature Indicates whether the feature that enables station management (MDIO interface) is selected. This field becomes 1 if you select the "enable station management (MDIO interface)" option. 0b - Not selected 1b - Selected
4 VLHASH	VLAN Hash Filter Feature Indicates whether the filtering option based on VLAN hash table is selected. This field becomes 1 if you select the "enable VLAN hash table based filtering" option. 0b - Not selected 1b - Selected
3 PCSSEL	PCS Select Indicates if either of the TBI, SGMII, or RTBI PHY interface options is selected. This field becomes 1 if you select any one of the TBI, SGMII, or RTBI PHY interface options. 0b - No 1b - Yes
2 HDSEL	Half-Duplex Support Feature Indicates whether half-duplex support is available as the mode of operation. This field becomes 1 if you select Half-Duplex as the mode of operation. 0b - Unavailable 1b - Available
1 GMIISEL	1000 Mbit/s Support Feature Indicates whether 1000 Mbit/s support is available as the mode of operation. This field becomes 1 if you select 1000 Mbit/s as the mode of operation. 0b - Unavailable 1b - Available

Table continues on the next page...

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Field	Function
0 MIISEL	10 or 100 Mbit/s Support Feature Indicates whether 10 or 100 Mbit/s support is available as the mode of operation. This field becomes 1 if you select 10/100 Mbit/s as the mode of operation. 0b - Unavailable 1b - Available

78.17.38 MAC Hardware Feature 1 (MAC_HW_Feature1)

Offset

Register	Offset
MAC_HW_Feature1	120h

Function

Indicates the presence of the second set of optional features or functions of the module. You can use this register to dynamically enable or disable the programs related to these features.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	L3L4FNUM			Reserved	HASHTBLSZ			POUOST	Reserved	RAVSEL	AVSEL	DBGMEMA	TSOEN	SPHEN	DCBEN
W																
Reset	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	ADDR64		ADVTHWO...	PTOEN	OSTEN	TXFIFOSIZE					SPRAM	RXFIFOSIZE				
W																
Reset	0	0	1	0	1	0	0	1	1	0	1	0	0	1	1	0

Fields

Field	Function
31 —	Reserved
30-27	L3 Or L4 Filter Number

Table continues on the next page...

Table continued from the previous page...

Field	Function
L3L4FNUM	Indicates the total number of L3 or L4 filters. 0000b - No filters (0) 0001b - 1 0010b - 2 0011b - 3 0100b - 4 0101b - 5 0110b - 6 0111b - 7 1000b - 8
26 —	Reserved
25-24 HASHTBLSZ	Hash Table Size Indicates the size of the hash table. 00b - No hash table 01b - 64 10b - 128 11b - 256
23 POUOST	One Step For PTP Over UDP/IP Feature Indicates whether the feature that enables one step for PTP over UDP/IP is selected. This field becomes 1 if you select the "enable one-step timestamp for PTP over UDP/IP" option. 0b - Not selected 1b - Selected
22 —	Reserved
21 RAVSEL	Receive Side-Only AV Feature Indicates whether the feature that enables audio-video bridging only on the receive side is selected. This field becomes 1 if you select the "enable audio-video bridging on receive side only" option. 0b - Not selected 1b - Selected
20	AV Feature Indicates whether the feature that enables audio-video bridging is selected.

Table continues on the next page...

Table continued from the previous page...

Field	Function
AVSEL	This field becomes 1 if you select the "enable audio video bridging" option. 0b - Not selected 1b - Selected
19 DBGMEMA	DMA Debug Registers Enable Feature Indicates whether the feature that enables DMA debug registers is selected. This field becomes 1 if you select the "enable DMA debug mode" option. 0b - Not selected 1b - Selected
18 TSOEN	TCP Segmentation Offload Enable Feature Indicates whether the feature that enables TCP segmentation offload for TCP/IP packets is selected. This field becomes 1 if you select the "enable TCP segmentation offloading for TCP/IP packets" option. 0b - Not selected 1b - Selected
17 SPHEN	Split Header Enable Feature Indicates whether the feature that enables a split header structure is selected. This field becomes 1 if you select the "enable split header structure" option. 0b - Not selected 1b - Selected
16 DCBEN	DCB Enable Feature Indicates whether the feature that enables data center bridging is selected. This field becomes 1 if you select the "enable data center bridging" option. 0b - Not selected 1b - Selected
15-14 ADDR64	Address Width Feature Indicates the configured address width. 00b - 32 01b - 40 10b - 48 11b - Reserved
13 ADVTHWORD	IEEE 1588 High-Word Feature Indicates whether the feature that enables the IEEE 1588 high-word register is selected. This field becomes 1 if you select the "enable/add IEEE 1588 higher-word register" option.

Table continues on the next page...

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Field	Function
	0b - Not selected 1b - Selected
12 PTOEN	PTP Offload Enable Feature Indicates whether the feature that enables PTP offload is selected. This field becomes 1 if you select the "enable PTP timestamp offload" option. 0b - Not selected 1b - Selected
11 OSTEN	One-Step Timestamping Enable Feature Indicates whether the feature that enables one-step timestamping is selected. This field becomes 1 if you select the "enable one-step timestamp" option. 0b - Not selected 1b - Selected
10-6 TXFIFOSIZE	MTL Transmit FIFO Size Feature Contains the configured value of MTL transmit FIFO (in bytes) expressed as log to base 2 minus 7, which means, Log 2 (TXFIFO_SIZE) - 7. 0_0000b - 128 bytes 0_0001b - 256 bytes 0_0010b - 512 bytes 0_0011b - 1024 bytes 0_0100b - 2048 bytes 0_0101b - 4096 bytes 0_0110b - 8192 bytes 0_0111b - 16384 bytes 0_1000b - 32 KB 0_1001b - 64 KB 0_1010b - 128 KB 0_1011b - Reserved
5 SPRAM	Single Port RAM Feature Indicates whether the single-port RAM feature is selected. This field becomes 1 if you select the option that enables the "use single port RAM" feature. 0b - Not selected 1b - Selected

Table continues on the next page...

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Field	Function
4-0 RXFIFOSIZE	MTL Receive FIFO Size Feature Contains the configured value of MTL receive FIFO (in bytes) expressed as log to base 2 minus 7, which means, Log 2 (RXFIFO_SIZE) - 7. 0_0000b - 128 bytes 0_0001b - 256 bytes 0_0010b - 512 bytes 0_0011b - 1024 bytes 0_0100b - 2048 bytes 0_0101b - 4096 bytes 0_0110b - 8192 bytes 0_0111b - 16384 bytes 0_1000b - 32 KB 0_1001b - 64 KB 0_1010b - 128 KB 0_1011b - 256 KB 0_1100b - Reserved

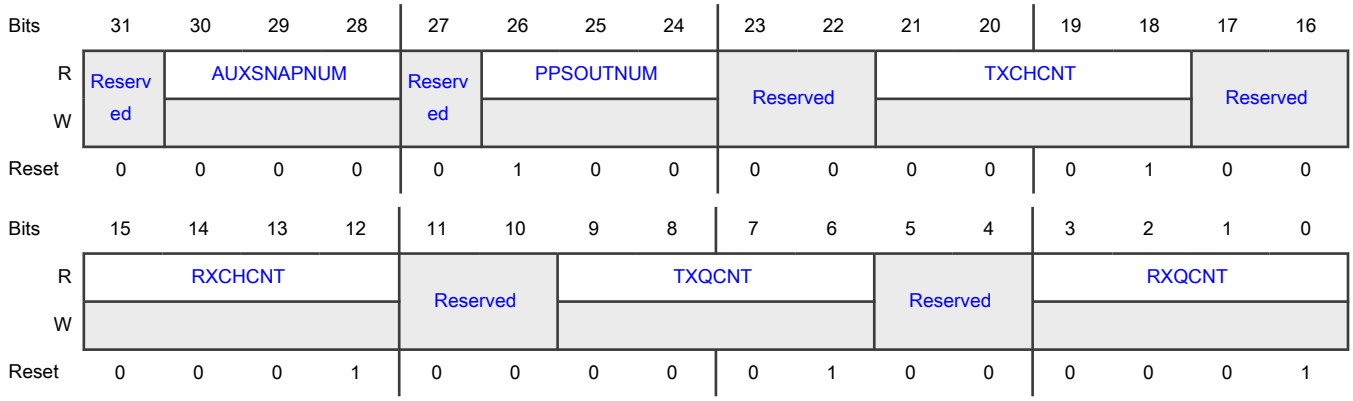
78.17.39 MAC Hardware Feature 2 (MAC_HW_Feature2)

Offset

Register	Offset
MAC_HW_Feature2	124h

Function
Indicates the presence of the third set of optional features or functions of the module. You can use this register to dynamically enable or disable the programs related to these features.

Diagram



Fields

Field	Function
31 —	Reserved
30-28 AUXSNAPNUM	Number Of Auxiliary Snapshot Inputs Indicates the number of auxiliary snapshot inputs. 000b - No auxiliary input (0) 001b - 1 010b - 2 011b - 3 100b - 4 101b - Reserved
27 —	Reserved
26-24 PPSOUTNUM	Number Of PPS Outputs Indicates the number of PPS outputs. 000b - No PPS output (0) 001b - 1 010b - 2 011b - 3 100b - 4 101b - Reserved
23-22 —	Reserved

Table continues on the next page...

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Field	Function
21-18 TXCHCNT	Number Of DMA Transmit Channels Indicates the number of DMA transmit channels. 0000b - 1 0001b - 2 0010b - 3 0011b - 4 0100b - 5 0101b - 6 0110b - 7 0111b - 8
17-16 —	Reserved
15-12 RXCHCNT	Number Of DMA Receive Channels Indicates the number of DMA receive channels. 0000b - 1 0001b - 2 0010b - 3 0011b - 4 0100b - 5 0101b - 6 0110b - 7 0111b - 8
11-10 —	Reserved
9-6 TXQCNT	Number Of MTL Transmit Queues Indicates the number of MTL transmit queues. 0000b - 1 0001b - 2 0010b - 3 0011b - 4 0100b - 5 0101b - 6

Table continues on the next page...

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Field	Function
	0110b - 7 0111b - 8
5-4 —	Reserved
3-0 RXQCNT	Number Of MTL Receive Queues Indicates the number of MTL receive queues. 0000b - 1 0001b - 2 0010b - 3 0011b - 4 0100b - 5 0101b - 6 0110b - 7 0111b - 8

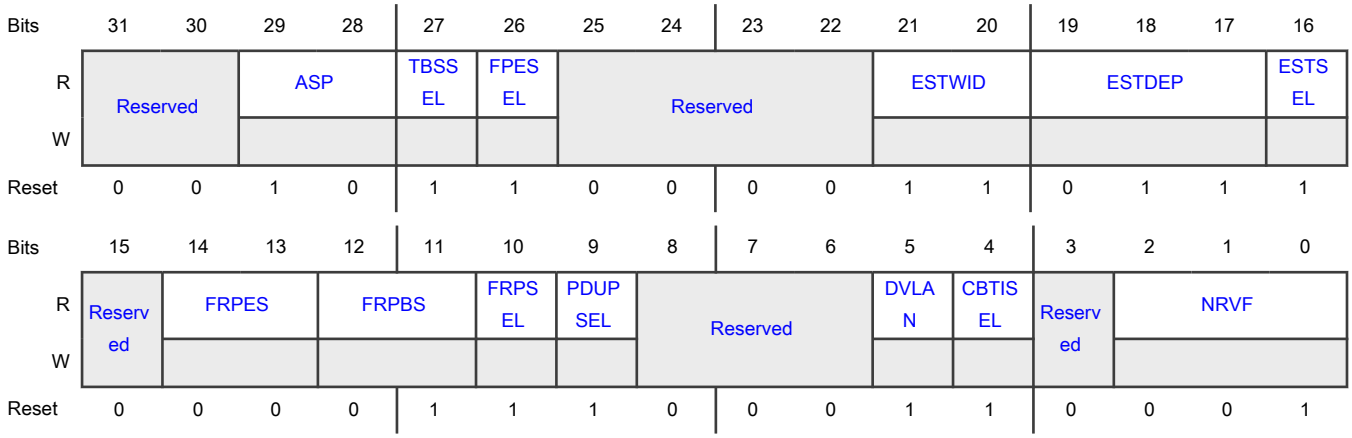
78.17.40 MAC Hardware Feature 3 (MAC_HW_Feature3)

Offset

Register	Offset
MAC_HW_Feature3	128h

Function
Indicates the presence of the fourth set of optional features or functions of the module. You can use this register to dynamically enable or disable the programs related to these features.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-28 ASP	Automotive Safety Package Indicates the encoding for the different automotive safety features. 00b - No safety features selected 01b - Only "ECC protection for external memory" feature is selected 10b - All the safety features are selected without the "parity port enable for external interface" feature 11b - All the safety features are selected with the "parity port enable for external interface" feature
27 TBSSEL	Time-Based Scheduling Feature Indicates whether the time-based scheduling feature is selected. This field becomes 1 if you select the option that enables the time-based scheduling feature. 0b - Selected 1b - Selected
26 FPESEL	Frame Preemption Feature Indicates whether the feature that enables frame preemption is selected. This field becomes 1 if you select the "enable frame preemption" option. 0b - Not selected 1b - Selected
25-22 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
21-20 ESTWID	Estimated Time Interval Width Indicates the width configured for the time interval field in the gate control list. 00b - Width not configured 01b - 16 bits 10b - 20 bits 11b - 24 bits
19-17 ESTDEP	Depth Of Gate Control List Indicates the depth of gate control list expressed as Log 2 (DWC_EQOS_EST_DEP) - 5. 000b - No depth configured 001b - 64 bytes 010b - 128 bytes 011b - 256 bytes 100b - 512 bytes 101b - 1024 bytes 110b - Reserved
16 ESTSEL	Enhancements To Scheduling Traffic Feature Indicates whether the "enhancements to scheduling traffic" feature is selected. This field becomes 1 if you select the "enable enhancements to scheduling traffic" option. 0b - Not selected 1b - Selected
15 —	Reserved
14-13 FRPES	Flexible Receive Parser Table Entry Size Indicates the maximum number of parser entries that the flexible receive parser supports. 00b - 64 01b - 128 10b - 256 11b - Reserved
12-11 FRPBS	Flexible Receive Parser Buffer Size Indicates the maximum number of packet data bytes that the flexible receive parser supports. 00b - 64

Table continues on the next page...

Table continued from the previous page...

Field	Function
	01b - 128 10b - 256 11b - Reserved
10 FRPSEL	Flexible Receive Parser Feature Indicates whether the flexible receive parser feature is selected. This field becomes 1 if you select the "enable flexible programmable receive parser" option. 0b - Not selected 1b - Selected
9 PDUPSEL	Broadcast/Multicast Packet Duplication Feature Indicates whether the broadcast or multicast duplication feature is selected. This field becomes 1 if you select the "broadcast or multicast packet duplication" option. 0b - Not selected 1b - Selected
8-6 —	Reserved
5 DVLAN	Double VLAN Tag Processing Feature Indicates whether the double VLAN processing feature is selected. 0b - Not selected 1b - Selected
4 CBTISEL	Queue/Channel Based VLAN Tag Insertion On Transmit Feature Indicates whether the "queue- or channel-based VLAN tag insertion on Tx" feature is selected. This field becomes 1 if you select the "enable queue- or channel-based VLAN tag insertion on Tx" option. 0b - Not selected 1b - Selected
3 —	Reserved
2-0 NRVF	Number Of Extended VLAN Tag Filters Indicates the number of selected extended VLAN tag filters. 000b - No filters (0) 001b - 4 010b - 8

Table continues on the next page...

Table continued from the previous page...

Field	Function
	011b - 16 100b - 24 101b - 32 110b - Reserved

78.17.41 MAC DPP FSM Interrupt Status (MAC_DPP_FSM_Interrupt_Status)

Offset

Register	Offset
MAC_DPP_FSM_Interrupt_Status	140h

Function

Contains the status of automative-safety related data path parity errors, interface timeout errors, FSM state parity errors, and FSM state timeout errors.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved							FSMPES	Reserved						Reserved	MSTTES
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	Reserved	Reserved	PTES	ATES	Reserved	RTES	TTES	Reserved	Reserved	ARPES	MTSPES	MPES	RDPES	Reserved	Reserved
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-25 —	Reserved
24 FSMPES	FSM State Parity Error Status Indicates whether a parity error is detected on one of the FSM state registers.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
23-18 —	Reserved
17 —	Reserved
16 MSTTES	Master Read Or Write Timeout Error Status Indicates whether an application or CSR timeout error is detected on the master (AXI, AHB, ARI, or ATI) interface. After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
15 —	Reserved
14 —	Reserved
13 —	Reserved
12 PTES	PTP FSM Timeout Error Status Indicates whether one of the PTP FSM timeout errors is detected. After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
11 ATES	APP FSM Timeout Error Status Indicates whether one of the APP FSM timeout errors is detected. After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
10 —	Reserved

Table continues on the next page...

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Field	Function
9 RTES	Receive FSM Timeout Error Status Indicates whether one of the receive FSM timeout errors is detected. After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
8 TTES	Transmit FSM Timeout Error Status Indicates whether one of the transmit FSM timeout errors is detected. After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
7 —	Reserved
6 —	Reserved
5 ARPES	Application Receive Interface Data Path Parity Error Status Indicates whether the parity checker detected a parity error on the application receive interface (or on PC6 as shown in the transmit data path parity protection diagram). After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
4 MTSPES	MTL Transmit Status Data Path Parity Checker Error Status Indicates whether the parity checker detected a parity error for the MTL transmit status data on ATI (or on PC5 as shown in the transmit data path parity protection diagram). After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
3 MPES	MTL Data Path Parity Checker Error Status Indicates whether the parity checker detected a parity error on the MTL transmit write controller interface (or on PC4 as shown in the transmit data path parity protection diagram). After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected

Table continues on the next page...

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Field	Function
2 RDPES	Read Descriptor Parity Checker Error Status Indicates whether the parity checker detected a parity error on the DMA read descriptor interface (or on PC3 as shown in the transmit data path parity protection diagram). After a read operation, the field's value clears to 0. 0b - Not detected 1b - Detected
1 —	Reserved
0 —	Reserved

78.17.42 MAC FSM Control (MAC_FSM_Control)

Offset

Register	Offset
MAC_FSM_Control	148h

Function

Is used to control the FSM state parity and timeout error injection in Debug mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved	Reserved	Reserved	PLGRNML	ALGRNML	Reserved	RLGRNML	TLGRNML	Reserved	Reserved	Reserved	PPEIN	APEIN	Reserved	RPEIN	TPEIN
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	Reserved	Reserved	PTEIN	ATEIN	Reserved	RTEIN	TTEIN	Reserved						PRTYEN	TMOUTEN
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
30 —	Reserved
29 —	Reserved
28 PLGRNML	PTP Large Or Normal Mode Select Indicates which mode of tic generation is used for the PTP domain. 0b - Normal mode 1b - Large mode
27 ALGRNML	APP Large Or Normal Mode Select Indicates which mode of tic generation is used for the APP domain. 0b - Normal mode 1b - Large mode
26 —	Reserved
25 RLGRNML	Receive Large Or Normal Mode Select Indicates which mode of tic generation is used for the receive domain. 0b - Normal mode 1b - Large mode
24 TLGRNML	Transmit Large Or Normal Mode Select Indicates which mode of tic generation is used for the transmit domain. 0b - Normal mode 1b - Large mode
23 —	Reserved
22 —	Reserved
21 —	Reserved
20	PTP FSM Parity Error Injection

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPEIN	Indicates the status of error injection for PTP FSM parity. 0b - Disabled 1b - Enabled
19 APEIN	APP FSM Parity Error Injection Indicates the status of error injection for APP FSM parity. 0b - Disabled 1b - Enabled
18 —	Reserved
17 RPEIN	Receive FSM Parity Error Injection Indicates the status of error injection for receive FSM parity. 0b - Disabled 1b - Enabled
16 TPEIN	Transmit FSM Parity Error Injection Indicates the status of error injection for transmit FSM parity. 0b - Disabled 1b - Enabled
15 —	Reserved
14 —	Reserved
13 —	Reserved
12 PTEIN	PTP FSM Timeout Error Injection Indicates the status of error injection for PTP FSM timeout. 0b - Disabled 1b - Enabled
11 ATEIN	APP FSM Timeout Error Injection Indicates the status of APP FSM timeout error injection. 0b - Disabled

Table continues on the next page...

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Field	Function
	1b - Enabled
10 —	Reserved
9 RTEIN	Receive FSM Timeout Error Injection Indicates the status of receive FSM timeout error injection. 0b - Disabled 1b - Enabled
8 TTEIN	Transmit FSM Timeout Error Injection Indicates the status of transmit FSM timeout eror injection. 0b - Disabled 1b - Enabled
7-2 —	Reserved
1 PRTYEN	Parity Enable Indicates whether the FSM parity feature is enabled. 0b - Disabled 1b - Enabled
0 TMOUTEN	Time Out Enable Indicates the status of the FSM timeout feature. 0b - Disabled 1b - Enabled

78.17.43 MAC FSM ACT Timer (MAC_FSM_ACT_Timer)

Offset

Register	Offset
MAC_FSM_ACT_Timer	14Ch

Function
Is used to select the FSM and interface timeout values.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved								LTMRMD				NTMRMD			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved						TMR									
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-20 LTMRMD	Large Mode Timeout Value Provides the timeout duration value to be used for large mode FSM and other interface timeouts. 0000b - Timer disabled 0001b - 1 us 0010b - 1.024 ms (~4 ms) 0011b - 16.384 ms (~16 ms) 0100b - 65.536 ms (~64 ms) 0101b - 262.144 ms (~256 ms) 0110b - 1.048 sec (~1 sec) 0111b - 4.194 sec (~4sec) 1000b - 16.777 sec (~16 sec) 1001b - 33.554 sec (~32 sec) 1010b - 67.108 sec (~64 sec) 1011b - Reserved
19-16 NTMRMD	Normal Mode Timeout Value Provides the timeout duration value to be used for normal mode FSM and other interface timeouts. 0000b - Timer disabled 0001b - 1 us 0010b - 1.024 ms (~4 ms) 0011b - 16.384 ms (~16 ms)

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Field	Function
	0100b - 65.536 ms (~64 ms) 0101b - 262.144 ms (~256 ms) 0110b - 1.048 sec (~1 sec) 0111b - 4.194 sec (~4 sec) 1000b - 16.777 sec (~16 sec) 1001b - 33.554 sec (~32 sec) 1010b - 67.108 sec (~64 sec) 1011b - Reserved
15-10 —	Reserved
9-0 TMR	CSR Clocks For 1 µs Tic Indicates the number of CSR clocks required to generate 1 µs tic.

78.17.44 SCS_REG 1 (SCS_REG1)

Offset

Register	Offset
SCS_REG1	150h

Function
Is an NXP-reserved register for internal use.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	MAC_SCS1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	MAC_SCS1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 MAC_SCS1	MAC SCS 1 Is reserved for NXP internal use. The value of this field must always be 0 unless NXP instructs you otherwise. Writing 1 to any of the bits of this field might cause expected chip behavior.

78.17.45 MAC MDIO Address (MAC_MDIO_Address)

Offset

Register	Offset
MAC_MDIO_Address	200h

Function
Controls the management cycles to external PHY through a management interface.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved				PSE	BTB	PA						RDA			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	NTC			CR				Reserved			SKAP	GOC_1	GOC_0	C45E	GB
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 PSE	Preamble Suppression Enable Indicates the status of preamble suppression. • If this field is 1, SMA suppresses the 32-bit preamble and transmits MDIO frames with only 1 preamble bit. • If this field is 0, the MDIO frame always includes 32 bits of preamble as defined in the IEEE specification.

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Field	Function
	0b - Disabled 1b - Enabled
26 BTB	Back-To-Back Transactions Indicates the status of back-to-back transactions. When BTB = 1 and NTC > 0, MAC indicates the completion of a read or write command at the end of a frame transfer (before the trailing clocks are transmitted). Therefore, you can initiate the next command, and that command executes immediately irrespective of the number of trailing clocks generated for the previous frame. When BTB = 0, the read or write command completes (GB = 0) only after the trailing clocks generate. In this mode, you must ensure that: • NTC is always generated after each frame. • BTB must not be equal to 1 when NTC = 0. 0b - Disabled 1b - Enabled
25-21 PA	Physical Layer Address Indicates whether MAC accesses clause 22 PHY devices (out of 32) or clause 45 capable PHYs (out of 32).
20-16 RDA	Register Or Device Address Indicates whether MAC accesses clause 22 PHY devices (out of 32) or clause 45 capable PHYs (out of 32).
15 —	Reserved
14-12 NTC	Number Of Trailing Clocks Controls the number of trailing clock cycles generated on the GMII_MDC_O (MDC) signal after the end of MDIO frame transmission. The valid values can range from 0 to 7. Writing 3h to this field indicates that there are additional three clock cycles on the MDC line after the end of MDIO frame transfer.
11-8 CR	CSR Clock Range Determines the frequency of the MDC clock according to the CSR clock frequencies used in your design: • 0000: CSR clock = 60-100 MHz; MDC clock = CSR clock/42 • 0001: CSR clock = 100-150 MHz; MDC clock = CSR clock/62 • 0010: CSR clock = 20-35 MHz; MDC clock = CSR clock/16 • 0011: CSR clock = 35-60 MHz; MDC clock = CSR clock/26 • 0100: CSR clock = 150-250 MHz; MDC clock = CSR clock/102 • 0101: CSR clock = 250-300 MHz; MDC clock = CSR clock/124

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Field	Function
	• 0110: CSR clock = 300-500 MHz; MDC clock = CSR clock/204 • 0111: CSR clock = 500-800 MHz; MDC clock = CSR clock/324 When bit 3 of this field is 0, the suggested CSR clock-frequency range applicable to each value ensures that the MDC clock frequency is approximately between 1.0 MHz and 2.5 MHz. When bit 3 of this field is 1, you can achieve a higher MDC clock frequency than the IEEE 802.3 frequency limit of 2.5 MHz, and program a clock divider of a lower value. For example, if the CSR clock frequency is 100 MHz and you write 1010 to this field, the resultant MDC clock frequency equals 12.5 MHz, which is above the range specified in IEEE 802.3. Program these values only if the interfacing chips support faster MDC clocks: • 1000: CSR clock/4 • 1001: CSR clock/6 • 1010: CSR clock/8 • 1011: CSR clock/10 • 1100: CSR clock/12 • 1101: CSR clock/14 • 1110: CSR clock/16 • 1111: CSR clock/18 These bits are not used for accessing RevMII. They are read-only if the RevMII interface is selected as a single PHY interface.
7-5 —	Reserved
4 SKAP	Skip Address Packet Indicates the status of the skip address packet. If this field is 1, SMA does not send the address packets before read, write, or post-read increment address packets. This field is valid only when C45E = 1. 0b - Disabled 1b - Enabled
3 GOC_1	GMII Operation Command 1 Indicates the status of GMII operation command 1. GMII operation command 1 represents the higher bit of the operation command to PHY or RevMII. The fields GOC_1 and GOC_O indicate these values: • 00: Reserved • 01: Write • 10: Post-read increment address for clause 45 PHY • 11: Read

Table continues on the next page...

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Field	Function
	When clause 22 PHY or RevMII is enabled, only write and read commands are valid. 0b - Disabled 1b - Enabled
2 GOC_0	GMII Operation Command 0 Indicates the status of GMII operation command 0. GMII operation command 0 represents the lower bit of the operation command to PHY or RevMII. When in SMA mode (MDIO master), this field, along with the GOC_1 field, determines the operation to be performed to PHY. This field is read-only and tied to 1 when only RevMII is selected in configuration. 0b - Disabled 1b - Enabled
1 C45E	Clause 45 PHY Enable Indicates the status of clause 45 PHY. • If this field is 1, clause 45 capable PHY is connected to MDIO. • If this field is 0, clause 22 capable PHY is connected to MDIO. 0b - Disabled 1b - Enabled
0 GB	GMII Busy Indicates the status of GMII busy. Writing 1 to this field instructs SMA to initiate a read or write access to the MDIO slave. MAC writes 0 to the field after the MDIO frame transfer is complete. Therefore, you must not write or change any of the fields in the MAC_MDIO_Address and MAC_MDIO_Data registers as long as the value of this field is 1. For write transfers, before writing 1 to this field, you must write a 16-bit data to MAC_MDIO_Data[GD] and MAC_MDIO_Data[RA] if C45E = 1. If C45E = 1, you must also write to MAC_MDIO_Data[RA] before initiating a read transfer. After a read transfer completes (GB = 0), a data read from the PHY register is valid in MAC_MDIO_Data[GD]. **NOTE** Even if the addressed PHY is not present, there is no change in the functionality of this field. Access restrictions apply to this field. It clears automatically and writing 0 to it has no effect. 0b - Disabled 1b - Enabled

78.17.46 MAC MDIO Data (MAC_MDIO_Data)

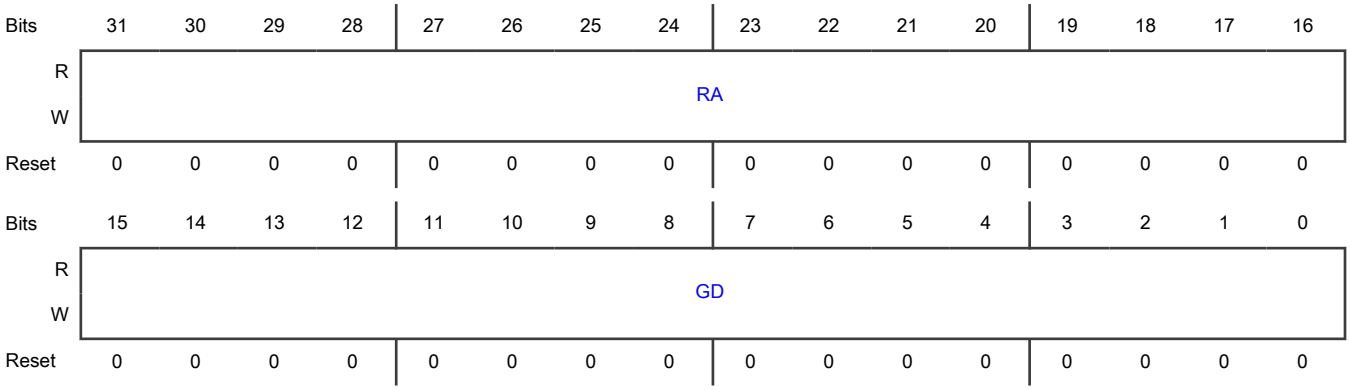
Offset

Register	Offset
MAC_MDIO_Data	204h

Function

Is used to store the write data to be written to the PHY register located at the address specified in MAC MDIO Address (MAC_MDIO_Address). This register also stores the read data from the PHY register located at the address that MAC MDIO Address (MAC_MDIO_Address) specifies.

Diagram



Fields

Field	Function
31-16 RA	Register Address Contains the PHY register address intended for the MDIO frame. This field is valid only when MAC_MDIO_Address[C45E] = 1.
15-0 GD	GMII Data Contains the 16-bit data value read from PHY or RevMII after a management read operation or the 16-bit data value to be written to PHY or RevMII before a management write operation.

78.17.47 MAC CSR Software Control (MAC_CSR_SW_Ctrl)

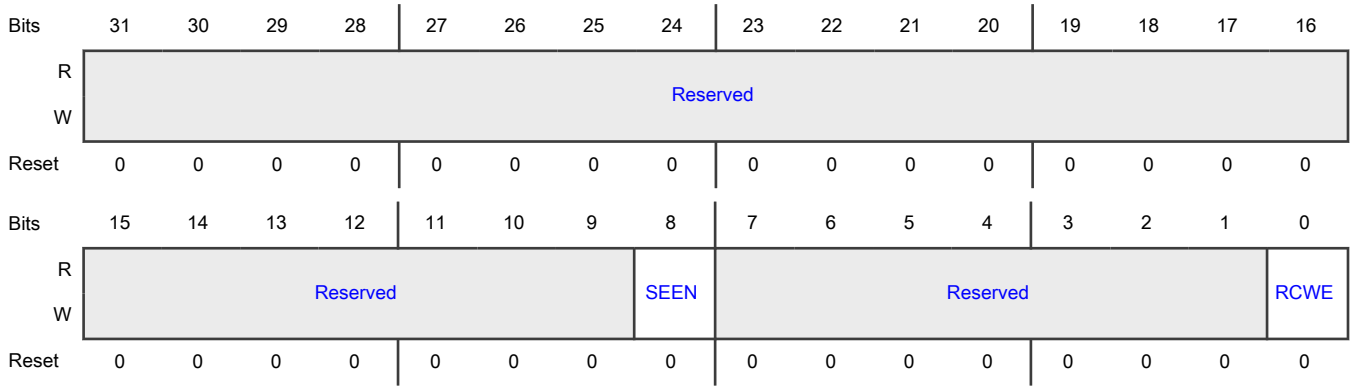
Offset

Register	Offset
MAC_CSR_SW_Ctrl	230h

Function

Contains software programmable controls for changing the CSR access response and clearing the status bits on read.

Diagram



Fields

Field	Function
31-9 —	Reserved
8 SEEN	Slave Error Response Enable Indicates the status of the slave error response. • If this field is 1, MAC responds with a slave error for accesses to reserved registers in the CSR space. • If this field is 0, MAC sends an "okay" response to registers accessed from the CSR space. 0b - Disabled 1b - Enabled
7-1 —	Reserved
0 RCWE	Enable Register Write 1 To Clear (W1C) Enables and disables the W1C feature for some registers. When this field is 1, the access mode of some of the other fields changes from R2C to W1C. When this field is 0, the access mode of those fields remains R2C. 0b - Disabled 1b - Enabled

78.17.48 MAC FPE Control STS (MAC_FPE_CTRL_STS)

Offset

Register	Offset
MAC_FPE_CTRL_STS	234h

Function

Controls the operation of frame preemption.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved												TRSP	TVER	RRSP	RVER
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved												S1_SET_0	SRSP	SVER	EFPE
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20 —	Reserved
19 TRSP	Transmitted Respond Frame Indicates whether the respond frame is transmitted. This field becomes 1 when a respond frame is transmitted (triggered by writing 1 to the SRSP field). An interrupt can be generated for this event if you write 1 to MAC_Interrupt_Enable[FPEIE]. Access restrictions apply to this field. TRSP becomes a W1C field when MAC_CSR_SW_Ctrl[RCWE] = 1, and becomes an R2C field when MAC_CSR_SW_Ctrl[RCWE] = 0. Thus, TRSP becomes 0 sometimes when you read it and sometimes when you write 1 to it. It automatically becomes 1 on an internal event. 0b - Not transmitted 1b - Transmitted
18 TVER	Transmitted Verify Frame Indicates whether the verify frame is transmitted. This field becomes 1 when a verify frame is transmitted (triggered by writing 1 to the SVER field). An interrupt can be generated for this event if you write 1 to MAC_Interrupt_Enable[FPEIE]. Access restrictions apply to this field. The field clears on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. It automatically becomes 1 on an internal event. 0b - Not transmitted 1b - Transmitted
17 RRSP	Received Respond Frame Indicates whether the respond frame is received.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field becomes 1 when a respond frame is received. An interrupt can be generated for this event if you write 1 to MAC_Interrupt_Enable[FPEIE]. Access restrictions apply to this field. The field clears on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. It automatically becomes 1 on an internal event. 0b - Not received 1b - Received
16 RVER	Received Verify Frame Indicates whether the verify frame is received. This field becomes 1 when a verify frame is received. An interrupt can be generated on the transmission of a packet if you write 1 to MAC_Interrupt_Enable[FPEIE]. Access restrictions apply to this field. The field clears on read or write of 1 when MAC_CSR_SW_Ctrl[RCWE] = 1. It automatically becomes 1 on an internal event. 0b - Not received 1b - Received
15-4 —	Reserved
3 S1_SET_0	S1 SET 0 Is reserved for NXP internal use and must always be 0 unless instructed by NXP. Writing 1 to this field may cause unexpected behavior.
2 SRSP	Send Respond mPacket Indicates the status of the send respond mPacket. If this field is 1, it indicates the hardware to send a respond mPacket. The hardware resets the field after sending the respond mPacket. Access restrictions apply to this field. It clears automatically and writing 0 to it has no effect. 0b - Disabled 1b - Enabled
1 SVER	Send Verify mPacket Enables and disables the sending of a verify mPacket. Write 1 to this field to command EMAC to send a verify mPacket. EMAC writes 0 to this field after sending the verify mPacket. Access restrictions apply to this field. It clears automatically and writing 0 to it has no effect. 0b - Disabled 1b - Enabled
0	Enable Transmit Frame Preemption

Table continues on the next page...

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Field	Function
EFPE	Enables or disables the frame preemption transmit functionality. 0b - Disabled 1b - Enabled

78.17.49 MAC Presentation Time (MAC_Presn_Time_ns)

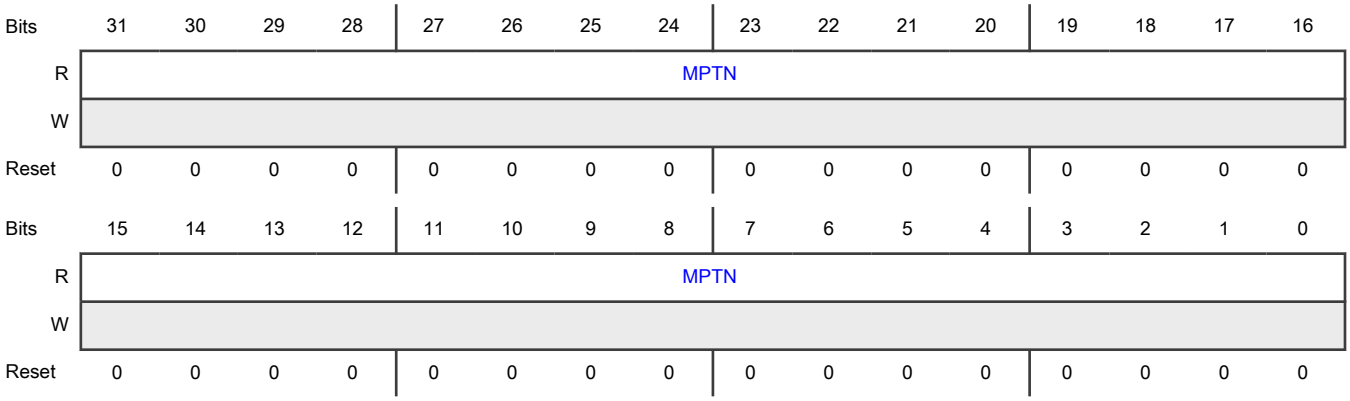
Offset

Register	Offset
MAC_Presn_Time_ns	240h

Function

Contains the 32-bit binary rollover equivalent time of the PTP system time (in nanoseconds) and exists when DWC_EQOS_FLEXI_PPS_OUT_EN is configured.

Diagram



Fields

Field	Function
31-0 MPTN	MAC 1722 Presentation Time (In Nanoseconds) Indicates the value of the 32-bit binary rollover equivalent time of the PTP System Time (in ns).

78.17.50 MAC Presentation Time Update (MAC_Presn_Time_Updt)

Offset

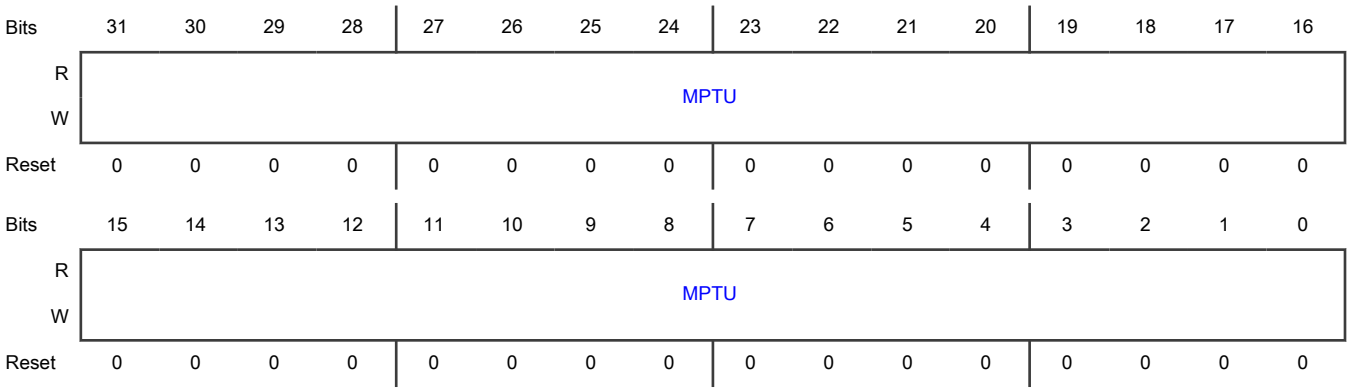
Register	Offset
MAC_Presn_Time_Updt	244h

Function

Holds the 32-bit value of MAC 1722 presentation time (in ns), which must be added to the current presentation time counter value. Initialization happens when MAC_Timestamp_Control[TSINIT] = 1, and an update happens when MAC_Timestamp_Control[TSUPDT] = 1.

Exists when DWC_EQOS_FLEXI_PPS_OUT_EN is configured.

Diagram



Fields

Field	Function
31-0 MPTU	MAC 1722 Presentation Time Update Holds the initial value or the update value for the presentation time. When used for an update, this field holds the 32-bit value (in ns), which must be added to the current presentation time counter value. Initialization happens when MAC_Timestamp_Control[TSINIT] = 1, and an update happens when MAC_Timestamp_Control[TSUPDT] = 1. When MAC_System_Time_Nanoseconds_Update[ADDSUB] = 1, this value is directly used for subtraction.

78.17.51 MAC Address 0 High (MAC_Address0_High)

Offset

Register	Offset
MAC_Address0_High	300h

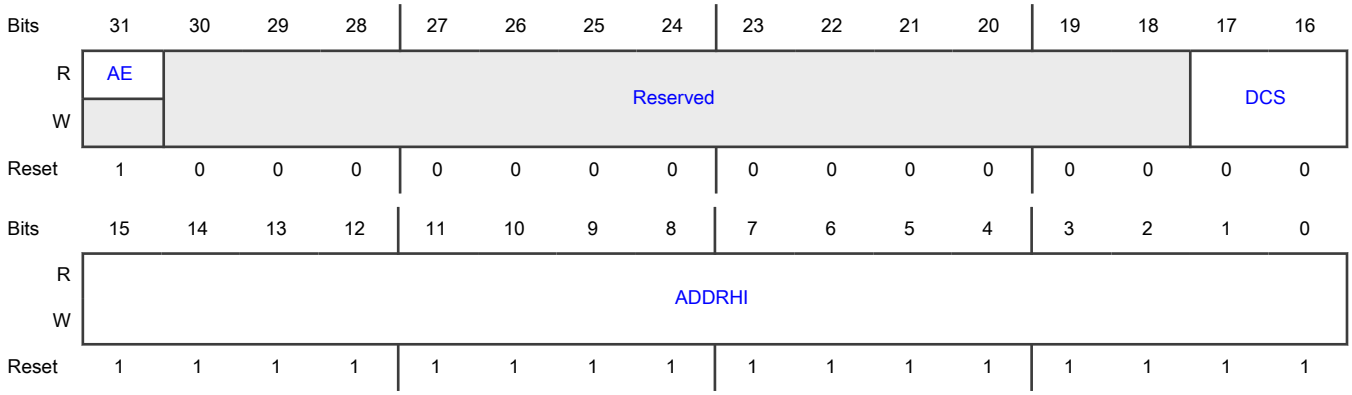
Function

Holds the upper 16 bits of the first 6-byte MAC address of the station.

The first DA byte that is received on the (G)MII interface corresponds to the LS byte (bits [7:0]) of MAC Address 0 Low (MAC_Address0_Low). For example, if 112233445566h is received (11h in lane 0 of the first column) on (G)MII as the destination address, MAC Address 0 Low (MAC_Address0_Low)[47:0] is compared to 665544332211h.

If MAC address registers are configured to be double-synchronized with the (G)MII clock domains, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of MAC Address 0 Low (MAC_Address0_Low) are written to. For proper synchronization updates, the consecutive writes to MAC Address 0 Low (MAC_Address0_Low) must be performed after at least four clock cycles in the destination clock domain.

Diagram



Fields

Field	Function
31 AE	Address Enable Enables MAC address 0b - Disabled and invalid (the field's value must always be 1) 1b - Enabled
30-18 —	Reserved
17-16 DCS	DMA Channel Select If MAC_Ext_Configuration[PDC] = 0, this field contains the binary representation of the DMA channel number to which a receive packet whose DA matches MAC Address 0 Low (MAC_Address0_Low) content is routed. If MAC_Ext_Configuration[PDC] = 1, this field contains the one-hot representation of one or more DMA channel numbers to which a receive packet whose DA matches MAC Address 0 Low (MAC_Address0_Low) content is routed.
15-0 ADDRHI	MAC Address 0 [47:32] Contains the upper 16 bits [47:32] of the first 6-byte MAC address. MAC uses this field for filtering the received packets and inserting the MAC address in the transmit flow control (pause) packets.

78.17.52 MAC Address 0 Low (MAC_Address0_Low)

Offset

Register	Offset
MAC_Address0_Low	304h

Function

Holds the lower 32 bits of the 6-byte first MAC address of the station.

Diagram

Fields

Field	Function
31-0 ADDRLO	MAC Address 0 [31:0] Contains the lower 32 bits of the first 6-byte MAC address. MAC uses this field to filter the received packets and insert the MAC address in the transmit flow control (pause) packets.

78.17.53 MAC Address 1 High (MAC_Address1_High)

Offset

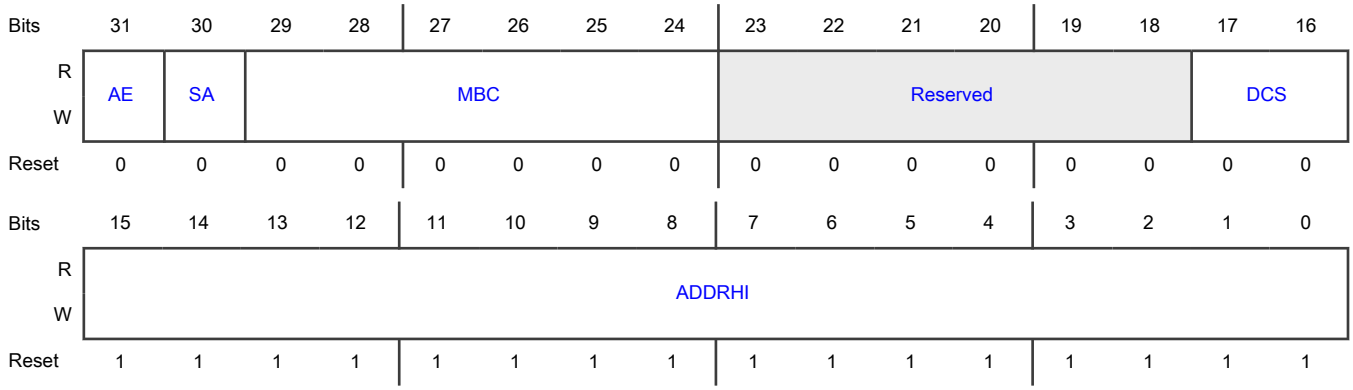
Register	Offset
MAC_Address1_High	308h

Function

Holds the upper 16 bits of the second 6-byte MAC address of the station.

If the MAC address registers are configured to be double-synchronized with the (G)MII clock domains, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of MAC Address 1 Low (MAC_Address1_Low) are written to. For proper synchronization updates, the consecutive writes to MAC Address 1 Low (MAC_Address1_Low) must be performed after at least four clock cycles in the destination clock domain.

Diagram



Fields

Field	Function
31 AE	Address Enable Indicates whether the MAC address is enabled or ignored. If this field is 1, the address filter module uses the second MAC address for perfect filtering. If this field is 0, the address filter module ignores the address used for filtering. 0b - Ignored 1b - Enabled
30 SA	Source Address Indicates whether the MAC address is compared to the source or destination address. If this field is 1, MAC Address 1[47:0] is compared to the SA fields of the received packet. If this field is 0, MAC Address 1[47:0] is compared to the DA fields of the received packet. 0b - Destination address 1b - Source address
29-24 MBC	Mask Byte Control Contains mask control bits for comparing each of the MAC address bytes. If this field is 1, MAC does not compare the corresponding byte of the received DA or SA with the contents of the MAC address 1 registers. Each bit controls the masking of the bytes as follows: • Bit 29: MAC Address 1 High[15:8] • Bit 28: MAC Address 1 High[7:0] • Bit 27: MAC Address 1 Low[31:24] • - .. • Bit 24: MAC Address 1 Low[7:0] You can filter a group of addresses (known as group address filtering) by masking one or more bytes of the address.
23-18	Reserved

Table continues on the next page...

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Field	Function
—	
17-16 DCS	DMA Channel Select If MAC_Ext_Configuration[PDC] = 0, this field contains the binary representation of the DMA channel number to which a receive packet whose DA matches MAC Address 1 Low (MAC_Address1_Low) content is routed. If MAC_Ext_Configuration[PDC] = 1, this field contains the one-hot representation of one or more DMA Channel numbers to which a receive packet whose DA matches MAC Address 1 Low (MAC_Address1_Low) content is routed.
15-0 ADDRHI	MAC Address 1 [47:32] Contains the upper 16 bits [47:32] of the second 6-byte MAC address.

78.17.54 MAC Address 1 Low (MAC_Address1_Low)

Offset

Register	Offset
MAC_Address1_Low	30Ch

Function

Holds the lower 32 bits of the second 6-byte MAC address of the station.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	ADDRLO															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ADDRLO															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-0	MAC Address 1 [31:0] Contains the lower 32 bits of the second 6-byte MAC address.

Table continues on the next page...

Field	Function
ADDRLO	The contents of this field are undefined until you load them after the initialization process.

78.17.55 MAC Address 2 High (MAC_Address2_High)

Offset

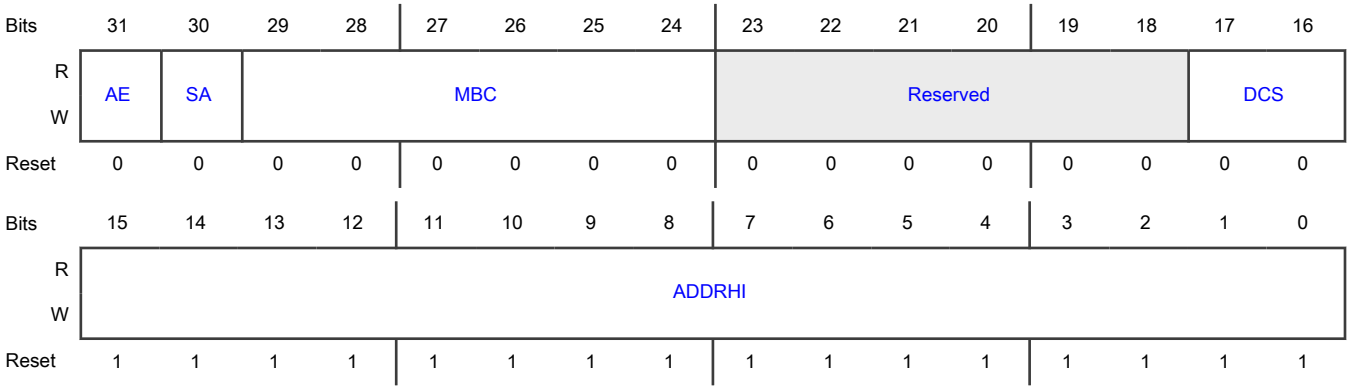
Register	Offset
MAC_Address2_High	310h

Function

Holds the upper 16 bits of the second 6-byte MAC address of the station.

If the MAC address registers are configured to be double-synchronized with the (G)MII clock domains, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of MAC Address 1 Low (MAC_Address1_Low) are written to. For proper synchronization updates, the consecutive writes to MAC Address 1 Low (MAC_Address1_Low) must be performed after at least four clock cycles in the destination clock domain.

Diagram



Fields

Field	Function
31 AE	Address Enable Indicates whether the MAC address is enabled or ignored. If this field is 1, the address filter module uses the second MAC address for perfect filtering. If this field is 0, the address filter module ignores the address for filtering. 0b - Ignored 1b - Enabled
30 SA	Source Address Indicates whether the MAC address is compared to the source or destination address.

Table continues on the next page...

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Field	Function
	If this field is 1, MAC Address 1[47:0] is compared to the SA fields of the received packet. If this field is 0, MAC Address 1[47:0] is compared to the DA fields of the received packet. 0b - Destination address 1b - Source address
29-24 MBC	Mask Byte Control Contains mask control bits for comparing each of the MAC address bytes. If this field is 1, MAC does not compare the corresponding byte of the received DA or SA with the contents of MAC address 1 registers. Each bit controls the masking of the bytes as follows: • Bit 29: MAC Address 1 High[15:8] • Bit 28: MAC Address 1 High[7:0] • Bit 27: MAC Address 1 Low[31:24] • - .. • Bit 24: MAC Address 1 Low[7:0] You can filter a group of addresses (known as group address filtering) by masking one or more bytes of the address.
23-18 —	Reserved
17-16 DCS	DMA Channel Select If MAC_Ext_Configuration[PDC] = 0, this field contains the binary representation of the DMA channel number to which a receive packet whose DA matches MAC Address 2 Low (MAC_Address2_Low) content is routed. If MAC_Ext_Configuration[PDC] = 1, this field contains the one-hot representation of one or more DMA Channel numbers to which a receive packet whose DA matches MAC Address 2 Low (MAC_Address2_Low) content is routed.
15-0 ADDRHI	MAC Address 1 [47:32] Contains the upper 16 bits [47:32] of the second 6-byte MAC address.

78.17.56 MAC Address 2 Low (MAC_Address2_Low)

Offset

Register	Offset
MAC_Address2_Low	314h

Function

Holds the lower 32 bits of the second 6-byte MAC address of the station.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	ADDRLO															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ADDRLO															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-0 ADDRLO	MAC Address 1 [31:0] Contains the lower 32 bits of the second 6-byte MAC address. The content of this field remains undefined until you load it after the initialization process.

78.17.57 MMC Control (MMC_Control)

Offset

Register	Offset
MMC_Control	700h

Function

Establishes the operating mode for MMC.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved							UCDBC	Reserved		CNTPRST...	CNTPRST	CNTFREEZ	RSTONRD	CNTSTOP...	CNTRST
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-9 —	Reserved
8 UCDBC	Update MMC Counters For Dropped Broadcast Packets Indicates the status of MMC counters for dropped broadcast packets. • If this field is 1, MAC updates all the related MMC counters for broadcast packets that are dropped because MAC_Packet_Filter[DBF] = 1. • If this field is 0, the MMC counters are not updated for dropped broadcast packets. **NOTE** The CNTRST field has a higher priority than the CNTPRST field. Therefore, if you write 1 to both these fields in the same write cycle, all the counters are cleared and the CNTPRST field becomes 0. 0b - Disabled 1b - Enabled
7-6 —	Reserved
5 CNTPRSTLVL	Full-Half Preset Indicates whether full-half preset is enabled or disabled. • If this field is 0 and the CNTPRST field is 1, all the MMC counters are preset to the almost-half value. All octet counters are preset to 7FFF_F800h (half 2 Kbytes) and all packet counters are preset to 7FFF_FFF0h (half 16). • If this field is 1 and the CNTPRST field is 1 too, all MMC counters are preset to the almost-full value. All octet counters are preset to FFFF_F800h (full 2 Kbytes) and all packet counters are preset to FFFF_FFF0h (full 16). For 16-bit counters, the almost-half preset values are 7800h and 7FF0h for the respective octet and packet counters. Similarly, the almost-full preset values for the 16-bit counters are 0xF800 and 0xFFF0. 0b - Disabled 1b - Enabled
4 CNTPRST	Counters Preset Indicates whether MMC counter preset is enabled or disabled. If this field is 1, all the counters are initialized or preset to almost full or almost half according to the settings of the CNTPRSTLVL field. This field clears automatically after 1 clock cycle, and along with the CNTPRSTLVL field, is useful for debugging and testing the assertion of interrupts because of the MMC counter becoming half-full or full. Access restrictions apply to this field, which clears automatically. 0b - Disabled

Table continues on the next page...

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Field	Function
	1b - Enabled
3 CNTFREEZ	MMC Counter Freeze Indicates the status of MMC counter freeze. If this field is 1, the field freezes all the MMC counters to their current values. Until this field becomes 0, no MMC counter is updated because of any transmitted or received packets. If an MMC counter is read when RSTONRD = 1, that counter is also cleared in this mode. 0b - Disabled 1b - Enabled
2 RSTONRD	Reset On Read Indicates whether the reset on read for MMC counters is enabled or disabled. If this field is 1, MMC counters are reset to 0 after read (they clear automatically after reset). The counters are cleared when the least significant byte lane (bits [7:0]) is read. 0b - Disabled 1b - Enabled
1 CNTSTOPRO	Counter Stop Rollover Indicates the status of counter stop rollover. If this field is 1, the counter does not roll over to 0 after reaching the maximum value. 0b - Disabled 1b - Enabled
0 CNTRST	Counters Reset Indicates whether MMC counters are reset. If this field is 1, all the counters are reset. This field clears automatically after 1 clock cycle. Access restrictions apply to this field that clears automatically. 0b - Counters are not reset 1b - All counters are reset

78.17.58 MMC Receive Interrupt (MMC_Rx_Interrupt)

Offset

Register	Offset
MMC_Rx_Interrupt	704h

Function

Maintains the interrupts generated from all receive statistics counters when the following conditions occur:

- Receive statistic counters reach half of their maximum values (8000_0000h for a 32-bit counter and 8000h for a 16-bit counter).
- Receive statistic counters cross their maximum values (FFFF_FFFFh for a 32-bit counter and FFFFh for a 16-bit counter).

If MMC_Control[CNTSTOPRO] = 1, interrupts are set but the counter remains at all-ones. This is a 32-bit register. An interrupt bit is cleared when the respective MMC counter that caused the interrupt is read. The least significant byte lane (bits [7:0]) of the respective counter must be read to clear the interrupt bit.

NOTE

R_SS_RC means that this register bit is set internally, and is cleared when the counter register is read.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved				Reserved	Reserved	RXCTRLP...	RXRCVER...	RXWDOGP...	RXVLANG...	RXFOVPIS	RXPAUSP...	RXORANG...	RXLENER...	RXUCGPIS	RX1024T...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RX512T1...	RX256T5...	RX128T2...	RX65T12...	RX64OCT...	RXOSIZE...	RXUSIZE...	RXJABER...	RXRUNTP...	RXALGNE...	RXCRCER...	RXMCGPIS	RXBCGPIS	RXGOCTIS	RXGBOCT...	RXGBPKT...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 —	Reserved
26 —	Reserved
25 RXCTRLPIS	MMC Receive Control Packet Counter Interrupt Status Indicates whether the status of the MMC receive control packet counter interrupt is detected. This field becomes 1 when the rxctrlpackets_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

Table continues on the next page...

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Field	Function
24 RXRCVERRPIS	MMC Receive Error Packet Counter Interrupt Status Indicates whether the status of the MMC receive error packet counter interrupt is detected. This field becomes 1 when the rxrcverror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
23 RXWDOGPIS	MMC Receive Watchdog Error Packet Counter Interrupt Status Indicates whether the status of the MMC receive watchdog error packet counter interrupt is detected. This field becomes 1 when the rxwatchdog error counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
22 RXVLANGBPIS	MMC Receive VLAN Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive VLAN good bad packet counter interrupt is detected. This field becomes 1 when the rxvlanpackets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
21 RXFOVPIS	MMC Receive FIFO Overflow Packet Counter Interrupt Status Indicates whether the status of the MMC receive FIFO overflow packet counter interrupt is detected. This field becomes 1 when the rxfifooverflow counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
20 RXPAUSPIS	MMC Receive Pause Packet Counter Interrupt Status Indicates whether the status of the MMC receive pause packet counter interrupt is detected. This field becomes 1 when the rxpausepackets counter reaches half of its maximum value or the maximum value.

Table continues on the next page...

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Field	Function
	Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
19 RXORANGEPIS	MMC Receive Out-Of-Range Error Packet Counter Interrupt Status Indicates whether the status of the MMC receive out-of-range error packet counter interrupt is detected. This field becomes 1 when the rxoutofrangetype counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
18 RXLENERPIS	MMC Receive Length Error Packet Counter Interrupt Status Indicates whether the status of the MMC receive length error packet counter interrupt is detected. This field becomes 1 when the rxlengtherror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
17 RXUCGPIS	MMC Receive Unicast Good Packet Counter Interrupt Status Indicates whether the status of the MMC receive unicast good packet counter interrupt is detected. This field becomes 1 when the rxunicastpackets_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
16 RX1024TMAXOCTGBPIS	MMC Receive 1024 To Maximum Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive 1024 to maximum octet good bad packet counter interrupt is detected. This field becomes 1 when the rx1024tomaxoctets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence.

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Field	Function
	0b - Not detected 1b - Detected
15 RX512T1023OCTGBPIS	MMC Receive 512 To 1023 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive 512 to 1023 octet good bad packet counter interrupt is detected. This field becomes 1 when the rx512to1023octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
14 RX256T511OCTGBPIS	MMC Receive 256 To 511 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive 256 to 511 octet good bad packet counter interrupt is detected. This field becomes 1 when the rx256to511octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
13 RX128T255OCTGBPIS	MMC Receive 128 To 255 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive 128 to 255 octet good bad packet counter interrupt is detected. This field becomes 1 when the rx128to255octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
12 RX65T127OCTGBPIS	MMC Receive 65 To 127 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive 65 to 127 octet good bad packet counter interrupt is detected. The field becomes 1 when the rx65to127octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence.

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Field	Function
	0b - Not detected 1b - Detected
11 RX64OCTGBPIS	MMC Receive 64 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive 64-octet good bad packet counter interrupt is detected. The field becomes 1 when the rx64octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
10 RXOSIZEGPIS	MMC Receive Oversize Good Packet Counter Interrupt Status Indicates whether the status of the MMC receive oversize good packet counter interrupt is detected. This field becomes 1 when the rxoversize_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
9 RXUSIZEGPIS	MMC Receive Undersize Good Packet Counter Interrupt Status Indicates whether the status of MMC receive undersize good packet counter interrupt is detected. This field becomes 1 when the rxundersize_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
8 RXJABERPIS	MMC Receive Jabber Error Packet Counter Interrupt Status Indicates whether the status of MMC receive jabber error packet counter interrupt is detected. This field becomes 1 when the rxjabbererror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

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Field	Function
7 RXRUNTPIS	MMC Receive Runt Packet Counter Interrupt Status Indicates whether the status of the MMC receive runt packet counter interrupt is detected. This field becomes 1 when the rxrunterror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
6 RXALGNERPIS	MMC Receive Alignment Error Packet Counter Interrupt Status Indicates whether the status of the MMC receive alignment error packet counter interrupt is detected. This field becomes 1 when the rxalignmenterror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
5 RXCRCERPIS	MMC Receive CRC Error Packet Counter Interrupt Status Indicates whether the status of the MMC receive CRC error packet counter interrupt is detected. This field becomes 1 when the rxcrcerror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
4 RXMCGPIS	MMC Receive Multicast Good Packet Counter Interrupt Status Indicates whether the status of the MMC receive multicast good packet counter interrupt is detected. This field becomes 1 when the rxmulticastpackets_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
3 RXBCGPIS	MMC Receive Broadcast Good Packet Counter Interrupt Status Indicates whether the status of the MMC receive broadcast good packet counter interrupt is detected. This field becomes 1 when the rxbroadcastpackets_g counter reaches half of its maximum value or the maximum value.

Table continues on the next page...

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Field	Function
	Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
2 RXGOCTIS	MMC Receive Good Octet Counter Interrupt Status Indicates whether the status of the MMC receive good octet counter interrupt is detected. This field becomes 1 when the rxoctetcount_g counter reaches half of its maximum value or its maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
1 RXGBOCTIS	MMC Receive Good Bad Octet Counter Interrupt Status Indicates whether the status of the MMC receive good bad octet counter interrupt is detected. This field becomes 1 when the rxoctetcount_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
0 RXGBPKTIS	MMC Receive Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC receive good bad packet counter interrupt is detected. This field becomes 1 when the rxpacketcount_gb counter reaches half of its maximum value or its maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

78.17.59 MMC Transmit Interrupt (MMC_Tx_Interrupt)

Offset

Register	Offset
MMC_Tx_Interrupt	708h

Function

Maintains the interrupts generated from all the transmit statistics counters.

This register maintains those interrupts that are generated when transmit statistic counters:

- Reach half of their maximum values (8000_0000h for a 32-bit counter and 0x8000 for a 16-bit counter)
- Cross their maximum values (FFFF_FFFFh for a 32-bit counter and FFFFh for a 16-bit counter)

If MMC_Control[CNTSTOPRO] = 1, the interrupts are set but the counter remains at all-ones.

This is a 32 bit register. An interrupt bit is cleared when the respective MMC counter that caused the interrupt is read.

The least significant byte lane (bits [7:0]) of the respective counter must be read to clear the interrupt bit.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved				Reserved	Reserved	TXOSIZE...	TXVLANG...	TXPAUSP...	TXEXDEF...	TXGPKTIS	TXGOCTIS	TXCARER...	TXEXCOL...	TXLATCO...	TXDEFPIS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXMCOLG...	TXSCOLG...	TXUFLOW...	TXBCGBP...	TXMCGBP...	TXUCGBP...	TX1024T...	TX512T1...	TX256T5...	TX128T2...	TX65T12...	TX64OCT...	TXMCGPIS	TXBCGPIS	TXGBPKT...	TXGBOCT...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 —	Reserved
26 —	Reserved
25 TXOSIZEGPIS	MMC Transmit Oversize Good Packet Counter Interrupt Status Indicates whether the status of the MMC transmit oversize good packet counter interrupt is detected. This field becomes 1 when the txoversize_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected

Table continues on the next page...

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Field	Function
	1b - Detected
24 TXVLANGPIS	MMC Transmit VLAN Good Packet Counter Interrupt Status Indicates whether the status of the MMC transmit VLAN good packet counter interrupt is detected. This field becomes 1 when the txvlanpackets_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
23 TXPAUSPIS	MMC Transmit Pause Packet Counter Interrupt Status Indicates whether the status of the MMC transmit pause packet counter interrupt is detected. This field becomes 1 when the txpausepacketserror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
22 TXEXDEFPIS	MMC Transmit Excessive Deferral Packet Counter Interrupt Status Indicates whether the status of the MMC transmit excessive deferral packet counter interrupt is detected. This field becomes 1 when the txexcessdef counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
21 TXGPKTIS	MMC Transmit Good Packet Counter Interrupt Status Indicates whether the status of the MMC transmit good packet counter interrupt is detected. This field becomes 1 when the txpacketcount_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
20	MMC Transmit Good Octet Counter Interrupt Status

Table continues on the next page...

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Field	Function
TXGOCTIS	Indicates whether the status of the MMC transmit good octet counter interrupt is detected. This field becomes 1 when the txoctetcount_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
19 TXCARERPIS	MMC Transmit Carrier Error Packet Counter Interrupt Status Indicates whether the status of the MMC transmit carrier error packet counter interrupt is detected. This field becomes 1 when the txcarriererror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
18 TXEXCOLPIS	MMC Transmit Excessive Collision Packet Counter Interrupt Status Indicates whether the status of the MMC transmit excessive collision packet counter interrupt is detected. This field becomes 1 when the txexesscol counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
17 TXLATCOLPIS	MMC Transmit Late Collision Packet Counter Interrupt Status Indicates whether the status of the MMC transmit late collision packet counter interrupt is detected. This field becomes 1 when the txlatecol counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
16 TXDEFPIS	MMC Transmit Deferred Packet Counter Interrupt Status Indicates whether the status of the MMC transmit deferred packet counter interrupt is detected. This field becomes 1 when the txdeferred counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence.

Table continues on the next page...

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Field	Function
	0b - Not detected 1b - Detected
15 TXMCOLGPIS	MMC Transmit Multiple Collision Good Packet Counter Interrupt Status Indicates whether the status of the MMC transmit multiple collision good packet counter interrupt is detected. This field becomes 1 when the txmulticol_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
14 TXSCOLGPIS	MMC Transmit Single Collision Good Packet Counter Interrupt Status Indicates whether the status of the MMC transmit single collision good packet counter interrupt is detected. This field becomes 1 when the txsinglecol_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
13 TXUFLOWERPIS	MMC Transmit Underflow Error Packet Counter Interrupt Status Indicates whether the status of the MMC transmit underflow error packet counter interrupt is detected. This field becomes 1 when the txunderflowerror counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
12 TXBCGBPIS	MMC Transmit Broadcast Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit broadcast good bad packet counter interrupt is detected. This field becomes 1 when the txbroadcastpackets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

Table continues on the next page...

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Field	Function
11 TXMCGBPIS	MMC Transmit Multicast Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit multicast good bad packet counter interrupt is detected. This field becomes 1 when the txmulticastpackets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
10 TXUCGBPIS	MMC Transmit Unicast Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit unicast good bad packet counter interrupt is detected. This field becomes 1 when the txunicastpackets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
9 TX1024TMAXOCTGBPIS	MMC Transmit 1024 To Maximum Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit 1024 to maximum octet good bad packet counter interrupt is detected. This field becomes 1 when the tx1024tomaxoctets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
8 TX512T1023OCTGBPIS	MMC Transmit 512 To 1023 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit 512 to 1023 octet good bad packet counter interrupt is detected. This field becomes 1 when the tx512to1023octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
7	MMC Transmit 256 To 511 Octet Good Bad Packet Counter Interrupt Status

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Field	Function
TX256T511OCTGBPIS	Indicates whether the status of the MMC transmit 256 to 511 octet good bad packet counter interrupt is detected. This field becomes 1 when the tx256to511octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
6 TX128T255OCTGBPIS	MMC Transmit 128 To 255 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit 128 to 255 octet good bad packet counter interrupt is detected. This field becomes 1 when the tx128to255octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
5 TX65T127OCTGBPIS	MMC Transmit 65 To 127 Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit 65 to 127 octet good bad packet counter interrupt is detected. This field becomes 1 when the tx65to127octets_gb counter reaches half of its maximum value, and also when it reaches the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
4 TX64OCTGBPIS	MMC Transmit 64-Octet Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit 64-octet good bad packet counter interrupt is detected. This field becomes 1 when the tx64octets_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
3 TXMCGPIS	MMC Transmit Multicast Good Packet Counter Interrupt Status Indicates whether the status of the MMC transmit multicast good packet counter interrupt is detected.

Table continues on the next page...

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Field	Function
	This field becomes 1 when the txmulticastpackets_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
2 TXBCGPIS	MMC Transmit Broadcast Good Packet Counter Interrupt Status Indicates whether the status of the MMC transmit broadcast good packet counter interrupt is detected. This field becomes 1 when the txbroadcastpackets_g counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
1 TXGBPKTIS	MMC Transmit Good Bad Packet Counter Interrupt Status Indicates whether the status of the MMC transmit good bad packet counter interrupt is detected. This field becomes 1 when the txpacketcount_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
0 TXGBOCTIS	MMC Transmit Good Bad Octet Counter Interrupt Status Indicates whether the status of the MMC transmit good bad octet counter interrupt is detected. This field becomes 1 when the txoctetcount_gb counter reaches half of its maximum value or the maximum value. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

78.17.60 MMC Receive Interrupt Mask (MMC_Rx_Interrupt_Mask)

Offset

Register	Offset
MMC_Rx_Interrupt_Mask	70Ch

Function

Maintains the masks for interrupts generated from all the receive statistic counters. These interrupts are generated when the receive statistic counters reach half of their maximum values or the maximum values.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved				Reserved	Reserved	RXCTRLP...	RXRCVER...	RXWDOGP...	RXVLANG...	RXFOVPIM	RXPAUSP...	RXORANG...	RXLENER...	RXUCGPIM	RX1024T...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RX512T1...	RX256T5...	RX128T2...	RX65T12...	RX64OCT...	RXOSIZE...	RXUSIZE...	RXJABER...	RXRUNTP...	RXALGNE...	RXCRCER...	RXMCGPIM	RXBCGPIM	RXGOCTIM	RXGBOCT...	RXGBPKT...
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 —	Reserved
26 —	Reserved
25 RXCTRLPIM	MMC Receive Control Packet Counter Interrupt Mask Indicates the status of the MMC receive control packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxctrlpackets_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
24 RXRCVERRPIM	MMC Receive Error Packet Counter Interrupt Mask Indicates the status of the MMC receive error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxrcverror counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
23	MMC Receive Watchdog Error Packet Counter Interrupt Mask

Table continues on the next page...

Table continued from the previous page...

Field	Function
RXWDOGPIM	Indicates the status of the MMC receive watchdog error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxwatchdog counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
22 RXVLANGBPIM	MMC Receive VLAN Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC receive VLAN good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxvlanpackets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
21 RXFOVPIM	MMC Receive FIFO Overflow Packet Counter Interrupt Mask Indicates the status of the MMC receive FIFO overflow packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxfifooverflow counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
20 RXPAUSPIM	MMC Receive Pause Packet Counter Interrupt Mask Indicates the status of the MMC receive pause packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxpausepackets counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
19 RXORANGEPIM	MMC Receive Out-Of-Range Error Packet Counter Interrupt Mask Indicates the status of the MMC receive out-of-range error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxoutofrangetype counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
18 RXLENERPIM	MMC Receive Length Error Packet Counter Interrupt Mask Indicates the status of the MMC receive length error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxlengtherror counter reaches half of its maximum value or the maximum value.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled
17 RXUCGPIM	MMC Receive Unicast Good Packet Counter Interrupt Mask Indicates the status of the MMC receive unicast good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxunicastpackets_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
16 RX1024TMAXOCTGBPIM	MMC Receive 1024 To Maximum Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC receive 1024 to maximum octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rx1024tomaxoctets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
15 RX512T1023OCTGBPIM	MMC Receive 512 To 1023 Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC receive 512 to 1023 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rx512to1023octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
14 RX256T511OCTGBPIM	MMC Receive 256 To 511 Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC receive 256 to 511 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rx256to511octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
13 RX128T255OCTGBPIM	MMC Receive 128 To 255 Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC receive 128 to 255 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rx128to255octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
12	MMC Receive 65 To 127 Octet Good Bad Packet Counter Interrupt Mask

Table continues on the next page...

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Field	Function
RX65T127OCTGBPIM	Indicates the status of the MMC receive 65 to 127 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rx65to127octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
11 RX64OCTGBPIM	MMC Receive 64-Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC receive 64-octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rx64octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
10 RXOSIZEGPIM	MMC Receive Oversize Good Packet Counter Interrupt Mask Indicates the status of the MMC receive oversize good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxoversize_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
9 RXUSIZEGPIM	MMC Receive Undersize Good Packet Counter Interrupt Mask Indicates the status of the MMC receive undersize good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxundersize_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
8 RXJABERPIM	MMC Receive Jabber Error Packet Counter Interrupt Mask Indicates the status of the MMC receive jabber error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxjabbererror counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
7 RXRUNTPIM	MMC Receive Runt Packet Counter Interrupt Mask Indicates the status of the MMC receive runt packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxrunterror counter reaches half of its maximum value or the maximum value.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
6 RXALGNERPIM	MMC Receive Alignment Error Packet Counter Interrupt Mask Indicates the status of the MMC receive alignment error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxalignmenterror counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
5 RXCRCERPIM	MMC Receive CRC Error Packet Counter Interrupt Mask Indicates the status of the MMC receive CRC error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxcrcerror counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
4 RXMCGPIM	MMC Receive Multicast Good Packet Counter Interrupt Mask Indicates the status of the MMC receive multicast good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxmulticastpackets_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
3 RXBCGPIM	MMC Receive Broadcast Good Packet Counter Interrupt Mask Indicates the status of the MMC receive broadcast good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxbroadcastpackets_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
2 RXGOCTIM	MMC Receive Good Octet Counter Interrupt Mask Indicates the status of the MMC receive good octet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxoctetcount_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
1	MMC Receive Good Bad Octet Counter Interrupt Mask

Table continues on the next page...

Table continued from the previous page...

Field	Function
RXGBOCTIM	Indicates the status of the MMC receive good bad octet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxoctetcount_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
0 RXGBPKTIM	MMC Receive Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC receive good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the rxpacketcount_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled

78.17.61 MMC Transmit Interrupt Mask (MMC_Tx_Interrupt_Mask)

Offset

Register	Offset
MMC_Tx_Interrupt_Mask	710h

Function

Maintains the masks for interrupts that are generated when the transmit statistic counters reach half of their maximum values or their maximum values.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved				Reserved	Reserved	TXOSIZE...	TXVLANG...	TXPAUSP...	TXEXDEF...	TXGPKTIM	TXGOCTIM	TXCARER...	TXEXCOL...	TXLATCO...	TXDEFPIM
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TXMCOLG...	TXSCOLG...	TXUFLOW...	TXBCGBP...	TXMCGBP...	TXUCGBP...	TX1024T...	TX512T1...	TX256T5...	TX128T2...	TX65T12...	TX64OCT...	TXMCGPIM	TXBCGPIM	TXGBPKT...	TXGBOCT...
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27 —	Reserved
26 —	Reserved
25 TXOSIZEGPIM	MMC Transmit Oversize Good Packet Counter Interrupt Mask Indicates the status of the MMC transmit oversize good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txoversize_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
24 TXVLANGPIM	MMC Transmit VLAN Good Packet Counter Interrupt Mask Indicates the status of the MMC transmit VLAN good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txvlanpackets_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
23 TXPAUSPIM	MMC Transmit Pause Packet Counter Interrupt Mask Indicates the status of the MMC transmit pause packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txpausepackets counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
22 TXEXDEFPIM	MMC Transmit Excessive Deferral Packet Counter Interrupt Mask Indicates the status of the MMC transmit excessive deferral packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txexcessdef counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
21 TXGPKTIM	MMC Transmit Good Packet Counter Interrupt Mask Indicates the status of the MMC transmit good packet counter interrupt mask.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Writing 1 to this field masks the interrupt when the txpacketcount_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
20 TXGOCTIM	MMC Transmit Good Octet Counter Interrupt Mask Indicates the status of the MMC transmit good octet counter interrupt mask. Writing 1 to this field masks the interrupt when the txoctetcount_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
19 TXCARERPIM	MMC Transmit Carrier Error Packet Counter Interrupt Mask Indicates the status of the MMC transmit carrier error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txcarriererror counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
18 TXEXCOLPIM	MMC Transmit Excessive Collision Packet Counter Interrupt Mask Indicates the status of the MMC transmit excessive collision packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txexcesscol counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
17 TXLATCOLPIM	MMC Transmit Late Collision Packet Counter Interrupt Mask Indicates the status of the MMC transmit late collision packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txlatecol counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
16 TXDEFPIM	MMC Transmit Deferred Packet Counter Interrupt Mask Indicates the status of the MMC transmit deferred packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txdeferred counter reaches half of the maximum value or the maximum value. 0b - Disabled 1b - Enabled

Table continues on the next page...

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Field	Function
15 TXMCOLGPIM	MMC Transmit Multiple Collision Good Packet Counter Interrupt Mask Indicates the status of the MMC transmit multiple collision good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txmulticol_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
14 TXSCOLGPIM	MMC Transmit Single Collision Good Packet Counter Interrupt Mask Indicates the status of the MMC transmit single collision good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txsinglecol_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
13 TXUFLOWERPIM	MMC Transmit Underflow Error Packet Counter Interrupt Mask Indicates the status of the MMC transmit underflow error packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txunderflowerror counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
12 TXBCGBPIM	MMC Transmit Broadcast Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit broadcast good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txbroadcastpackets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
11 TXMCGBPIM	MMC Transmit Multicast Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit multicast good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txmulticastpackets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
10 TXUCGBPIM	MMC Transmit Unicast Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit unicast good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txunicastpackets_gb counter reaches half of its maximum value or the maximum value.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled
9 TX1024TMAXOCTGBPIM	MMC Transmit 1024 To Maximum Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit 1024 to maximum octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the tx1024tomaxoctets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
8 TX512T1023OCTGBPIM	MMC Transmit 512 To 1023 Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit 512 to 1023 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the tx512to1023octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
7 TX256T511OCTGBPIM	MMC Transmit 256 To 511 Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit 256 to 511 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the tx256to511octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
6 TX128T255OCTGBPIM	MMC Transmit 128 To 255 Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit 128 to 255 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the tx128to255octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
5 TX65T127OCTGBPIM	MMC Transmit 65 To 127 Octet Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit 65 to 127 octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the tx65to127octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
4	MMC Transmit 64-Octet Good Bad Packet Counter Interrupt Mask

Table continues on the next page...

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Field	Function
TX64OCTGBPIM	Indicates the status of the MMC transmit 64-octet good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the tx64octets_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
3 TXMCGPIM	MMC Transmit Multicast Good Packet Counter Interrupt Mask Indicates the status of the MMC transmit multicast good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txmulticastpackets_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
2 TXBCGPIM	MMC Transmit Broadcast Good Packet Counter Interrupt Mask Indicates the status of the MMC transmit broadcast good packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txbroadcastpackets_g counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
1 TXGBPKTIM	MMC Transmit Good Bad Packet Counter Interrupt Mask Indicates the status of the MMC transmit good bad packet counter interrupt mask. Writing 1 to this field masks the interrupt when the txpacketcount_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled
0 TXGBOCTIM	MMC Transmit Good Bad Octet Counter Interrupt Mask Indicates the status of the MMC transmit good bad octet counter interrupt mask. Writing 1 to this field masks the interrupt when the txoctetcount_gb counter reaches half of its maximum value or the maximum value. 0b - Disabled 1b - Enabled

78.17.62 Transmit Octet Count Good Bad (Tx_Octet_Count_Good_Bad)

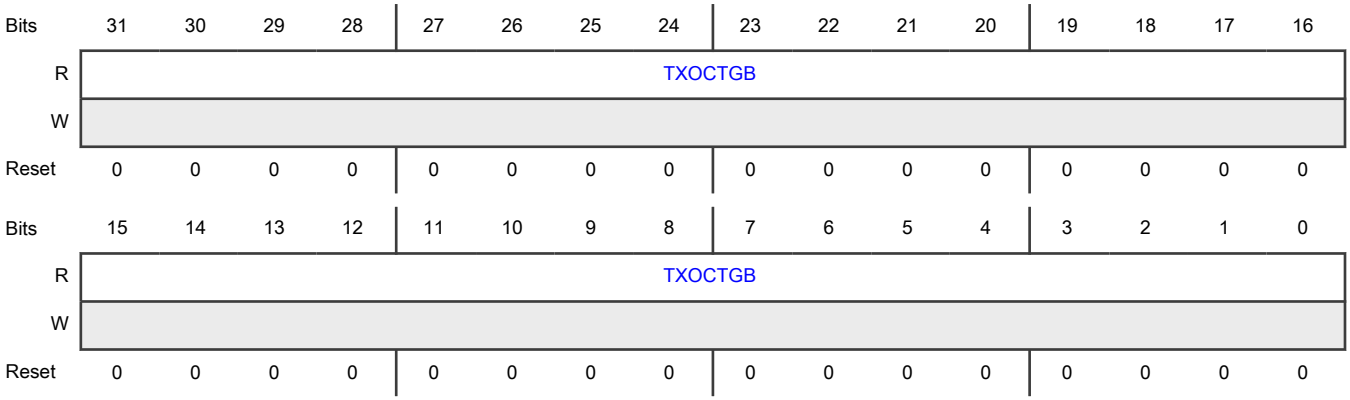
Offset

Register	Offset
Tx_Octet_Count_Good_Bad	714h

Function

Provides the number of bytes that the module transmitted, exclusive of preamble and retried bytes, in good and bad packets.

Diagram



Fields

Field	Function
31-0 TXOCTGB	Transmit Octet Count Good Bad Indicates the number of bytes transmitted, exclusive of preamble and retried bytes, in good and bad packets.

78.17.63 Transmit Packet Count Good Bad (Tx_Packet_Count_Good_Bad)

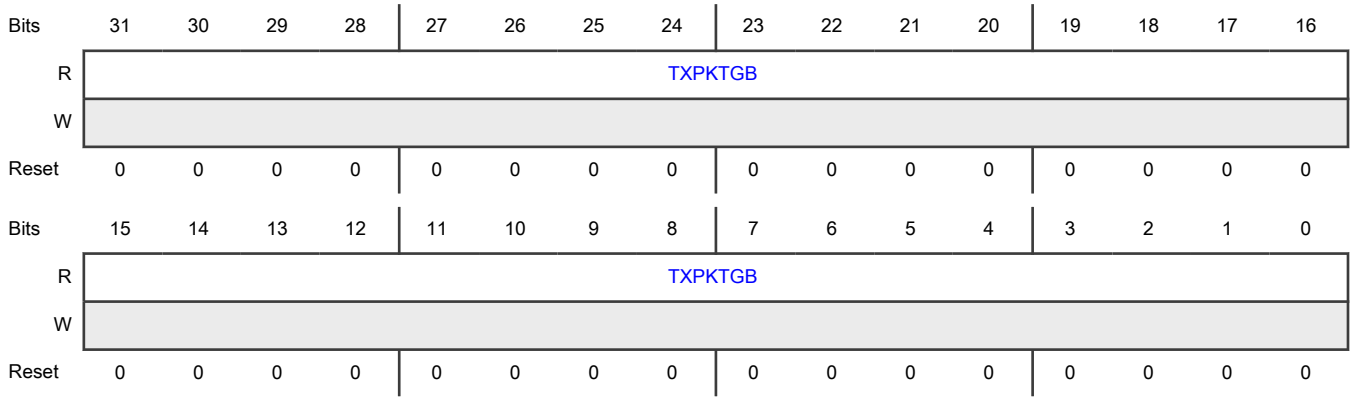
Offset

Register	Offset
Tx_Packet_Count_Good_Bad	718h

Function

Provides the number of good and bad packets that the module transmitted, exclusive of retried packets.

Diagram



Fields

Field	Function
31-0 TXPKTGB	Transmit Packet Count Good Bad Indicates the number of good and bad packets transmitted, exclusive of retried packets.

78.17.64 Transmit Broadcast Packets Good (Tx_Broadcast_Packets_Good)

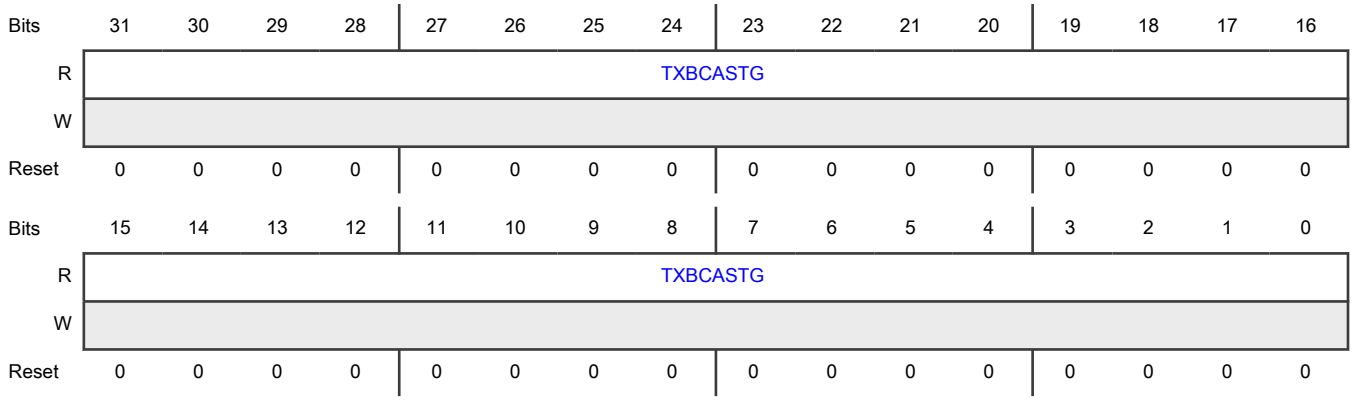
Offset

Register	Offset
Tx_Broadcast_Packets_Good	71Ch

Function

Provides the number of good broadcast packets that the module transmitted.

Diagram



Fields

Field	Function
31-0 TXBCASTG	Transmit Broadcast Packets Good Indicates the number of good broadcast packets transmitted.

78.17.65 Transmit Multicast Packets Good (Tx_Multicast_Packets_Good)

Offset

Register	Offset
Tx_Multicast_Packets_Good	720h

Function
Provides the number of good multicast packets that the module transmitted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXMCASTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXMCASTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXMCASTG	Transmit Multicast Packets Good Indicates the number of good multicast packets transmitted.

78.17.66 Transmit 64-Octet Packets Good Bad (Tx_64Octets_Packets_Good_Bad)

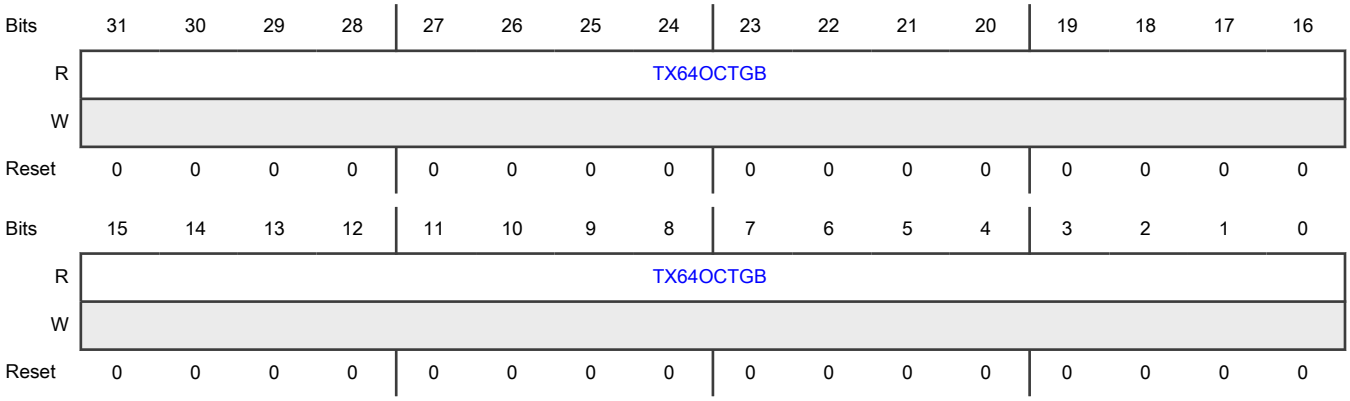
Offset

Register	Offset
Tx_64Octets_Packets_Good_Bad	724h

Function

Provides the number of 64-byte good and bad packets that the module transmitted, exclusive of preamble and retried packets.

Diagram



Fields

Field	Function
31-0 TX64OCTGB	Transmit 64-Octet Packets Good Bad Indicates the number of transmitted 64-byte good and bad packets, exclusive of preamble and retried packets.

78.17.67 Transmit 65 To 127 Octet Packets Good Bad (Tx_65To127Octets_Packets_Good_Bad)

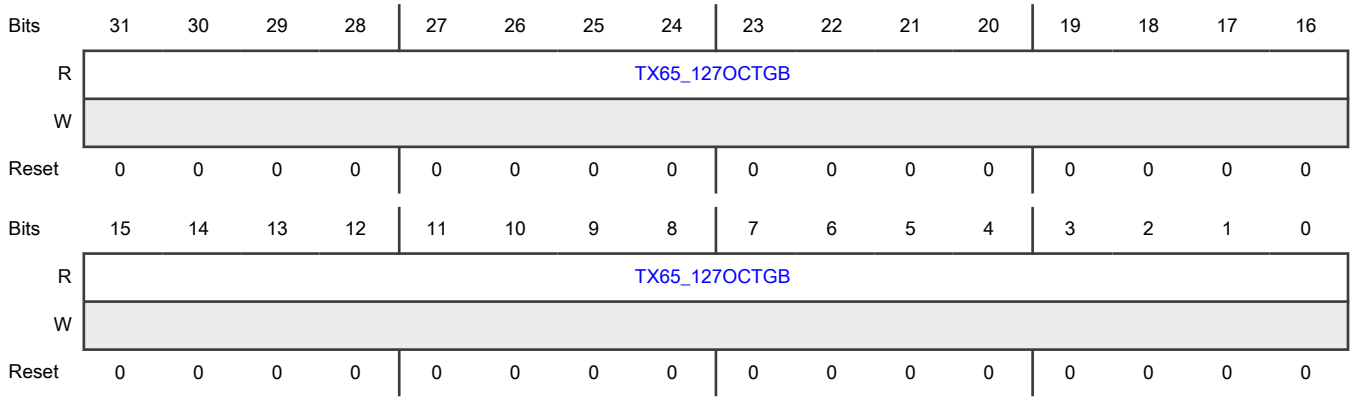
Offset

Register	Offset
Tx_65To127Octets_Packets_Good_Bad	728h

Function

Provides the number of good and bad packets, having length between 65 and 127 (inclusive) bytes, that the module transmitted, exclusive of preamble and retried packets.

Diagram



Fields

Field	Function
31-0 TX65_127OCTGB	Transmit 65 To 127 Octet Packets Good Bad Indicates the number of good and bad packets transmitted, having length between 65 and 127 (inclusive) bytes, exclusive of preamble and retried packets.

78.17.68 Transmit 128 To 255 Octet Packets Good Bad (Tx_128To255Octets_Packets_Good_Bad)

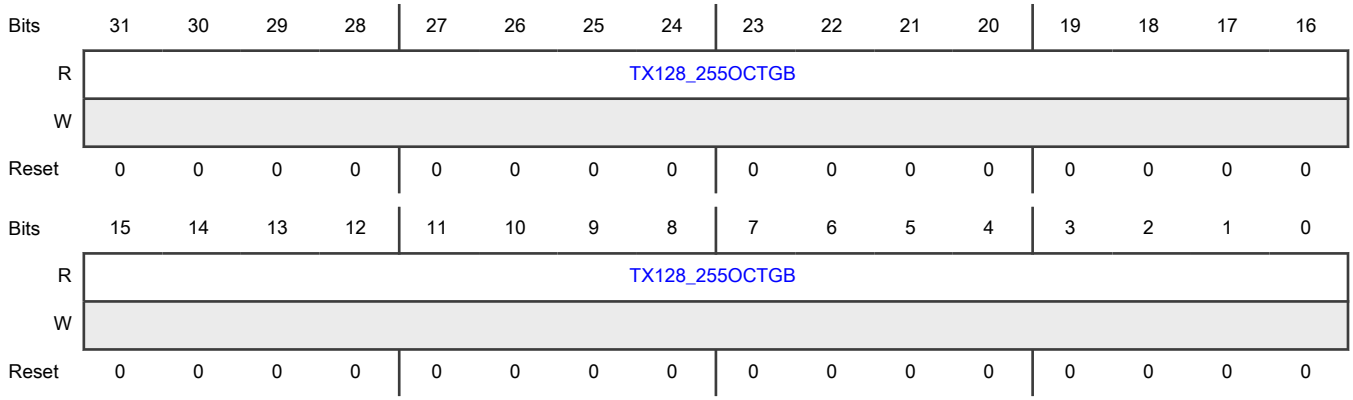
Offset

Register	Offset
Tx_128To255Octets_Packets_Good_Bad	72Ch

Function

Provides the number of good and bad packets that the module transmitted, having length between 128 to 255 (inclusive) bytes, exclusive of preamble and retried packets.

Diagram



Fields

Field	Function
31-0 TX128_255OCTGB	Transmit 128 To 255 Octet Packets Good Bad Indicates the number of good and bad packets transmitted, having length between 128 and 255 (inclusive) bytes, exclusive of preamble and retried packets.

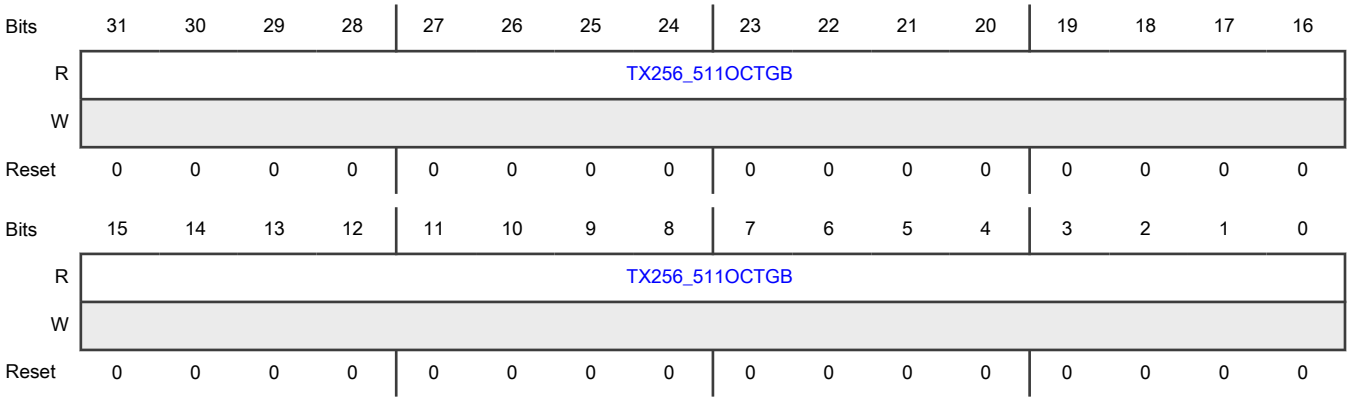
78.17.69 Transmit 256 To 511 Octet Packets Good Bad (Tx_256To511Octets_Packets_Good_Bad)

Offset

Register	Offset
Tx_256To511Octets_Packets_Good_Bad	730h

Function
Provides the number of good and bad packets that the module transmitted, having length between 256 to 511 (inclusive) bytes, exclusive of preamble and retried packets.

Diagram



Fields

Field	Function
31-0 TX256_511OCTGB	Transmit 256 To 511 Octet Packets Good Bad Indicates the number of good and bad packets transmitted, having length between 256 and 511 (inclusive) bytes, exclusive of preamble and retried packets.

78.17.70 Transmit 512 To 1023 Octet Packets Good Bad (Tx_512To1023Octets_Packets_Good_Bad)

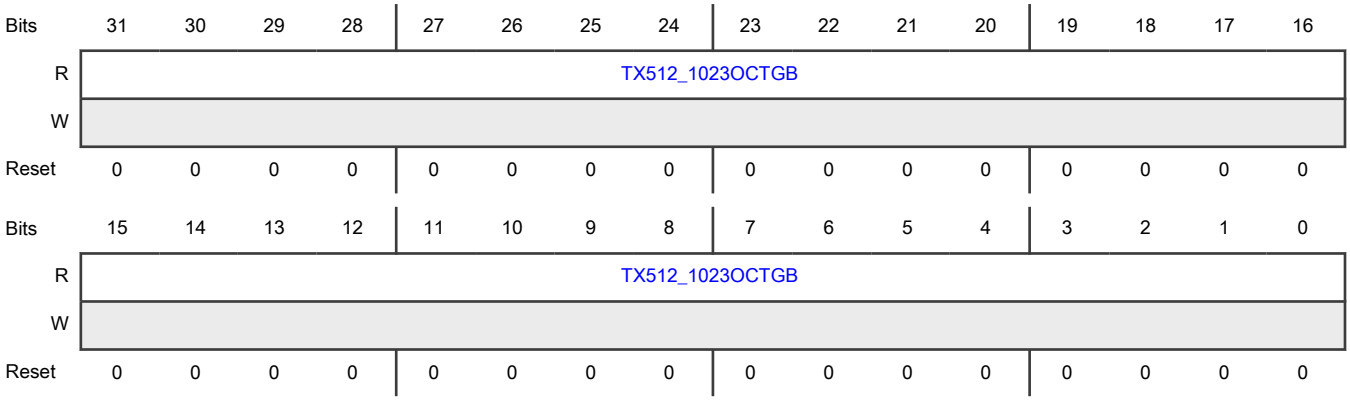
Offset

Register	Offset
Tx_512To1023Octets_Packets_Good_Bad	734h

Function

Provides the number of good and bad packets that the module transmitted, having length between 512 to 1023 (inclusive) bytes, exclusive of preamble and retried packets.

Diagram



Fields

Field	Function
31-0 TX512_1023OCTGB	Transmit 512 To 1023 Octet Packets Good Bad Indicates the number of good and bad packets transmitted, having length between 512 and 1023 (inclusive) bytes, exclusive of preamble and retried packets.

78.17.71 Transmit 1024 To Max Octet Packets Good Bad (Tx_1024ToMaxOctets_Packets_Good_Bad)

Offset

Register	Offset
Tx_1024ToMaxOctets_Packets_Good_Bad	738h

Function

Provides the number of good and bad packets that the module transmitted, having a length between 1024 bytes (inclusive) and the maximum size, exclusive of preamble and retried packets.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TX1024_MAXOCTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TX1024_MAXOCTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TX1024_MAXOCTGB	Transmit 1024 To Max Octet Packets Good Bad Indicates the number of good and bad packets transmitted, having a length between 1024 bytes (inclusive) and the maximum size, exclusive of preamble and retried packets.

78.17.72 Transmit Unicast Packets Good Bad (Tx_Unicast_Packets_Good_Bad)

Offset

Register	Offset
Tx_Unicast_Packets_Good_Bad	73Ch

Function

Provides the number of good and bad unicast packets that the module transmitted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXUCASTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXUCASTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXUCASTGB	Transmit Unicast Packets Good Bad Indicates the number of good and bad unicast packets transmitted.

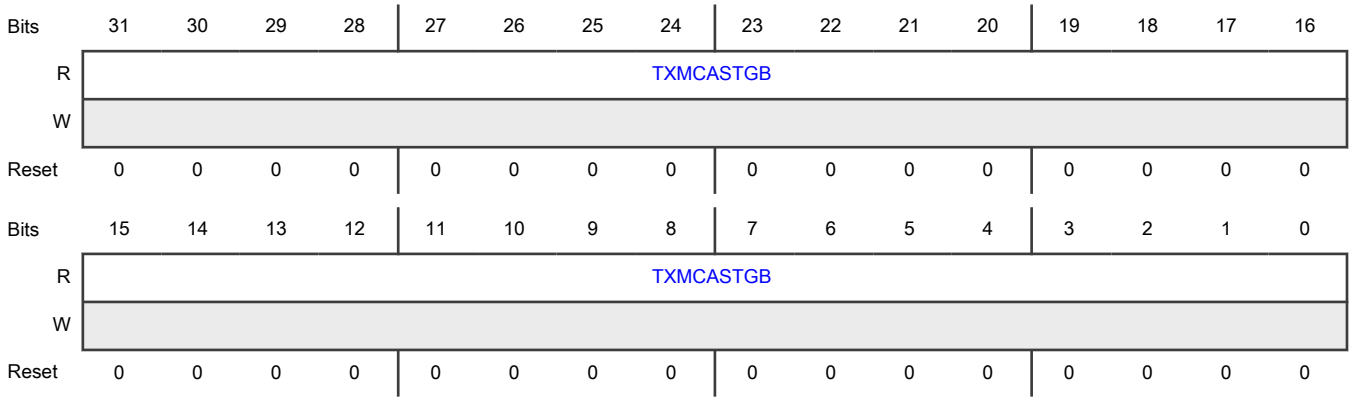
78.17.73 Transmit Multicast Packets Good Bad (Tx_Multicast_Packets_Good_Bad)

Offset

Register	Offset
Tx_Multicast_Packets_Good_Bad	740h

Function
Provides the number of good and bad multicast packets that the module transmitted.

Diagram



Fields

Field	Function
31-0 TXMCASTGB	Transmit Multicast Packets Good Bad Indicates the number of good and bad multicast packets transmitted.

78.17.74 Transmit Broadcast Packets Good Bad (Tx_Broadcast_Packets_Good_Bad)

Offset

Register	Offset
Tx_Broadcast_Packets_Good_Bad	744h

Function

Provides the number of good and bad broadcast packets that the module transmitted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXBCASTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXBCASTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXBCASTGB	Transmit Broadcast Packets Good Bad Indicates the number of good and bad broadcast packets transmitted.

78.17.75 Transmit Underflow Error Packets (Tx_Underflow_Error_Packets)

Offset

Register	Offset
Tx_Underflow_Error_Packets	748h

Function

Provides the number of packets that the module aborted because of a packet underflow error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXUNDRFLW															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXUNDRFLW															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXUNDRFLW	Transmit Underflow Error Packets Indicates the number of packets aborted because of a packet underflow error.

78.17.76 Transmit Single Collision Good Packets (Tx_Single_Collision_Good_Packets)

Offset

Register	Offset
Tx_Single_Collision_Good_Packets	74Ch

Function
Provides the number of packets that the module successfully transmitted after a single collision in Half-Duplex mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXSNGLCOLG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXSNGLCOLG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXSNGLCOLG	Transmit Single Collision Good Packets Indicates the number of successfully transmitted packets after a single collision in Half-Duplex mode.

78.17.77 Transmit Multiple Collision Good Packets (Tx_Multiple_Collision_Good_Packets)

Offset

Register	Offset
Tx_Multiple_Collision_Good_Packets	750h

Function

Provides the number of packets that the module successfully transmitted after multiple collisions in Half-Duplex mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXMULTCOLG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXMULTCOLG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXMULTCOLG	Transmit Multiple Collision Good Packets Indicates the number of successfully transmitted packets after multiple collisions in Half-Duplex mode.

78.17.78 Transmit Deferred Packets (Tx_Deferred_Packets)

Offset

Register	Offset
Tx_Deferred_Packets	754h

Function

Provides the number of packets that the module successfully transmitted after a deferral in Half-Duplex mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXDEFRD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXDEFRD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXDEFRD	Transmit Deferred Packets Indicates the number of successfully transmitted packets after a deferral in Half-Duplex mode.

78.17.79 Transmit Late Collision Packets (Tx_Late_Collision_Packets)

Offset

Register	Offset
Tx_Late_Collision_Packets	758h

Function
Provides the number of packets that the module aborted because of a late collision error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXLATECOL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXLATECOL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXLATECOL	Transmit Late Collision Packets Indicates the number of packets aborted because of a late collision error.

78.17.80 Transmit Excessive Collision Packets (Tx_Excessive_Collision_Packets)

Offset

Register	Offset
Tx_Excessive_Collision_Packets	75Ch

Function

Provides the number of packets that the module aborted because of excessive (16) collision errors.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXEXSCOL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXEXSCOL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXEXSCOL	Transmit Excessive Collision Packets Indicates the number of packets aborted because of excessive (16) collision errors.

78.17.81 Transmit Carrier Error Packets (Tx_Carrier_Error_Packets)

Offset

Register	Offset
Tx_Carrier_Error_Packets	760h

Function

Provides the number of packets that the module aborted because of a carrier sense error (such as no carrier or loss of carrier).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXCARR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXCARR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXCARR	Transmit Carrier Error Packets Indicates the number of packets aborted because of a carrier sense error (such as no carrier or loss of carrier).

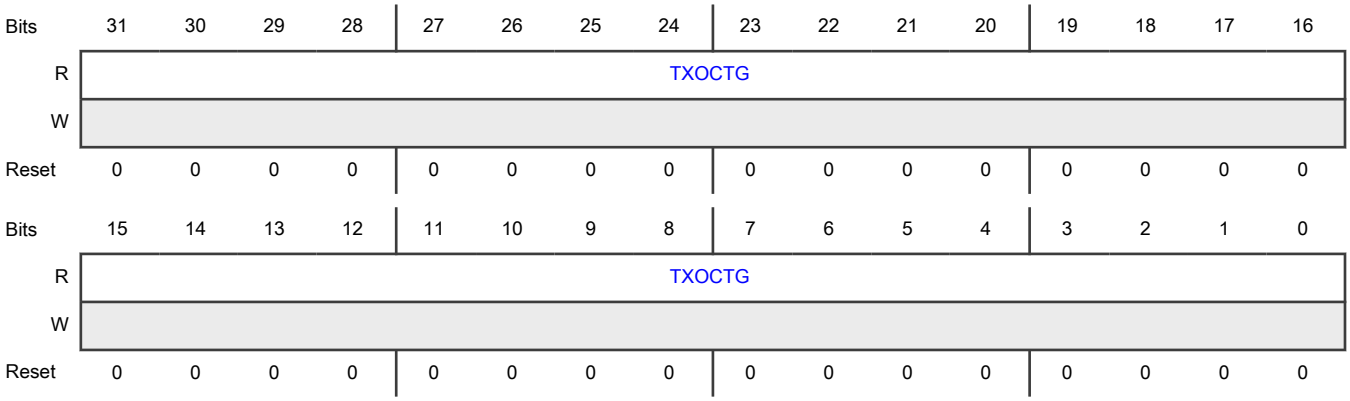
78.17.82 Transmit Octet Count Good (Tx_Octet_Count_Good)

Offset

Register	Offset
Tx_Octet_Count_Good	764h

Function
Provides the number of bytes that the module transmitted, exclusive of preamble, only in good packets.

Diagram



Fields

Field	Function
31-0 TXOCTG	Transmit Octet Count Good Indicates the number of bytes transmitted, exclusive of preamble, only in good packets.

78.17.83 Transmit Packet Count Good (Tx_Packet_Count_Good)

Offset

Register	Offset
Tx_Packet_Count_Good	768h

Function

Provides the number of good packets that the module transmitted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXPKTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXPKTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXPKTG	Transmit Packet Count Good Indicates the number of good packets transmitted.

78.17.84 Transmit Excessive Deferral Error (Tx_Excessive_Deferral_Error)

Offset

Register	Offset
Tx_Excessive_Deferral_Error	76Ch

Function

Provides the number of packets that the module aborted because of an excessive deferral error (deferred for more than two max-sized packet times).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXEXSDEF															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXEXSDEF															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXEXSDEF	Transmit Excessive Deferral Error Indicates the number of packets aborted because of excessive deferral error (deferred for more than two max-sized packet times).

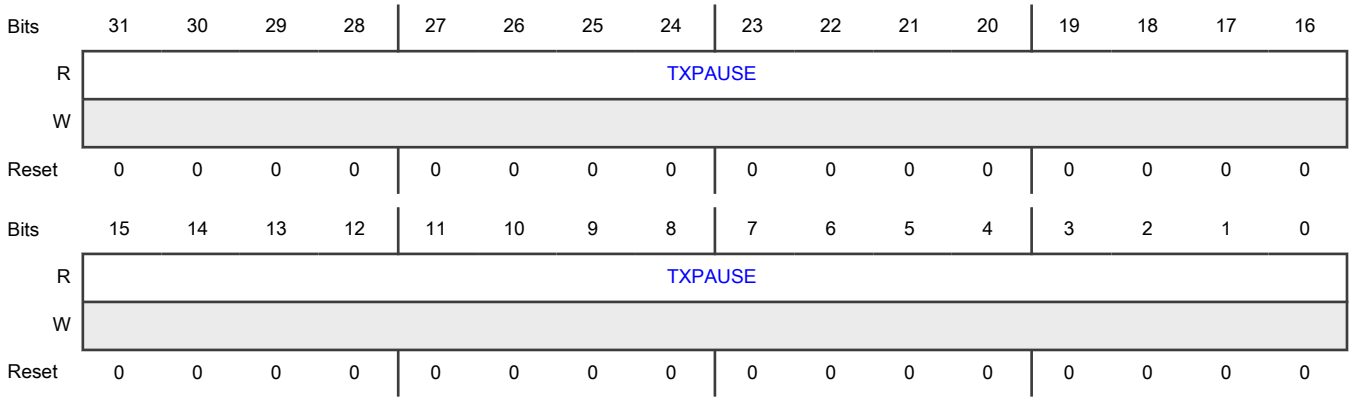
78.17.85 Transmit Pause Packets (Tx_Pause_Packets)

Offset

Register	Offset
Tx_Pause_Packets	770h

Function
Provides the number of good pause packets that the module transmitted.

Diagram



Fields

Field	Function
31-0 TXPAUSE	Transmit Pause Packets Indicates the number of good pause packets transmitted.

78.17.86 Transmit VLAN Packets Good (Tx_VLAN_Packets_Good)

Offset

Register	Offset
Tx_VLAN_Packets_Good	774h

Function

Provides the number of good VLAN packets that the module transmitted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXVLANG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXVLANG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXVLANG	Transmit VLAN Packets Good Provides the number of good VLAN packets transmitted.

78.17.87 Transmit O Size Packets Good (Tx_OSize_Packets_Good)

Offset

Register	Offset
Tx_OSize_Packets_Good	778h

Function

Provides the number of packets that the module transmitted without errors, and having a length greater than the maximum size, which is 1,518 or 1,522 bytes for VLAN-tagged packets. This size is 2000 bytes if MAC_Configuration[S2KP] = 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXOSIZG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXOSIZG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXOSIZG	Transmit O Size Packets Good Indicates the number of packets transmitted without errors, and having a length greater than the maximum size, which is 1,518 or 1,522 bytes for VLAN-tagged packets. This size is 2000 bytes if MAC_Configuration[S2KP] = 1.

78.17.88 Receive Packets Count Good Bad (Rx_Packets_Count_Good_Bad)

Offset

Register	Offset
Rx_Packets_Count_Good_Bad	780h

Function
Provides the number of good and bad packets that the module received.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXPKTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXPKTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXPKTGB	Receive Packets Count Good Bad Indicates the number of good and bad packets received.

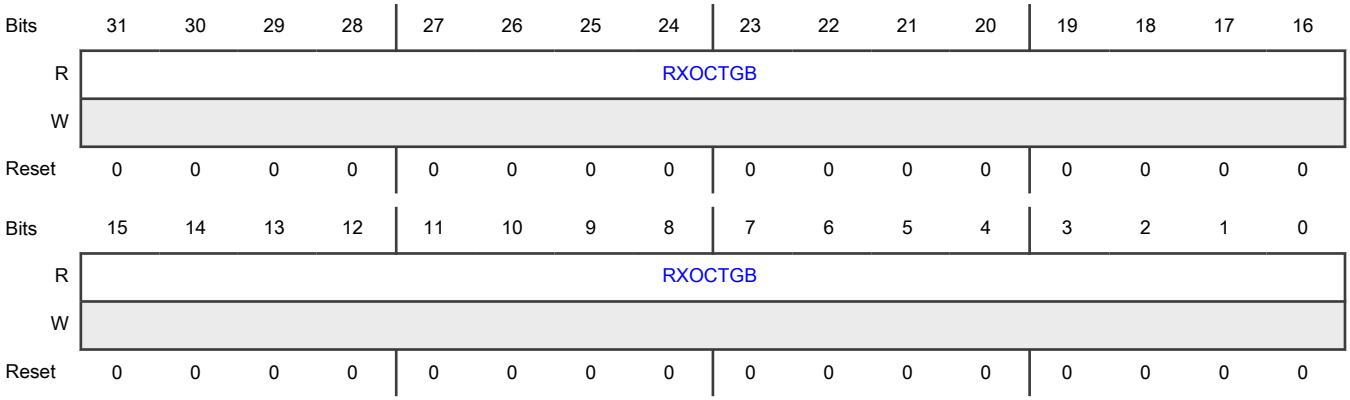
78.17.89 Receive Octet Count Good Bad (Rx_Octet_Count_Good_Bad)

Offset

Register	Offset
Rx_Octet_Count_Good_Bad	784h

Function
Provides the number of bytes that DWC_ther_qos received, exclusive of preamble, in good and bad packets.

Diagram



Fields

Field	Function
31-0 RXOCTGB	Receive Octet Count Good Bad Indicates the number of bytes received, exclusive of preamble, in good and bad packets.

78.17.90 Receive Octet Count Good (Rx_Octet_Count_Good)

Offset

Register	Offset
Rx_Octet_Count_Good	788h

Function
Provides the number of bytes that the module received, exclusive of preamble, only in good packets.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXOCTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXOCTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXOCTG	Receive Octet Count Good Indicates the number of bytes received, exclusive of preamble, only in good packets.

78.17.91 Receive Broadcast Packets Good (Rx_Broadcast_Packets_Good)

Offset

Register	Offset
Rx_Broadcast_Packets_Good	78Ch

Function

Provides the number of good broadcast packets that the module received.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXBCASTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXBCASTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXBCASTG	Receive Broadcast Packets Good Indicates the number of good broadcast packets received.

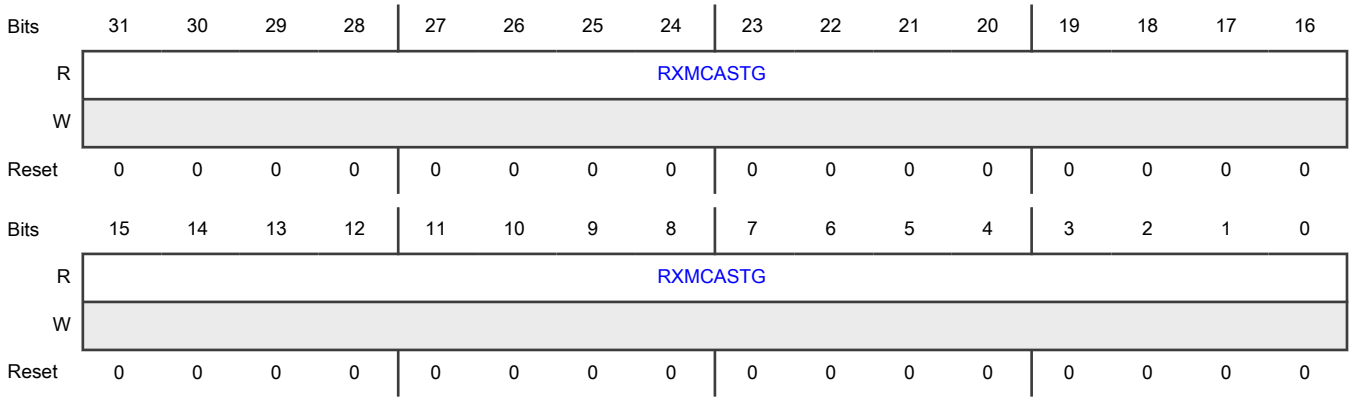
78.17.92 Receive Multicast Packets Good (Rx_Multicast_Packets_Good)

Offset

Register	Offset
Rx_Multicast_Packets_Good	790h

Function
Provides the number of good multicast packets that the module received.

Diagram



Fields

Field	Function
31-0 RXMCASTG	Receive Multicast Packets Good Indicates the number of good multicast packets received.

78.17.93 Receive CRC Error Packets (Rx_CRC_Error_Packets)

Offset

Register	Offset
Rx_CRC_Error_Packets	794h

Function

Provides the number of packets that the module received with a CRC error.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXCRCERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXCRCERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXCRCERR	Receive CRC Error Packets Indicates the number of packets received with a CRC error.

78.17.94 Receive Alignment Error Packets (Rx_Alignment_Error_Packets)

Offset

Register	Offset
Rx_Alignment_Error_Packets	798h

Function

Provides the number of packets that the module received with an alignment (dribble) error. It is valid only in 10/100 mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXALGNERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXALGNERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXALGNERR	Receive Alignment Error Packets Indicates the number of packets received with alignment (dribble) error. It is valid only in 10/100 mode.

78.17.95 Receive Runt Error Packets (Rx_Runt_Error_Packets)

Offset

Register	Offset
Rx_Runt_Error_Packets	79Ch

Function
Provides the number of runt packets, which have a length less than 64 bytes and a CRC error, that the module received.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXRUNTERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXRUNTERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXRUNTERR	Receive Runt Error Packets Indicates the number of runt packets received.

78.17.96 Receive Jabber Error Packets (Rx_Jabber_Error_Packets)

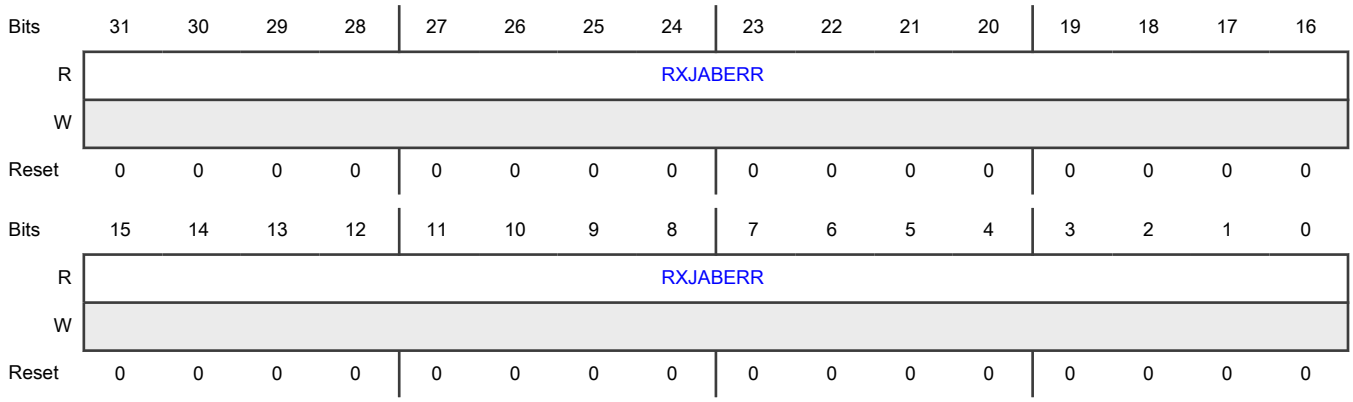
Offset

Register	Offset
Rx_Jabber_Error_Packets	7A0h

Function

Provides the number of giant packets that the module received, having a length (including CRC) greater than 1,518 bytes (1,522 bytes for VLAN-tagged packets), and with a CRC error. If Jumbo Packet mode is enabled, packets of length greater than 9,018 bytes (9,022 bytes for VLAN-tagged packets) are considered as giant packets.

Diagram



Fields

Field	Function
31-0 RXJABERR	Receive Jabber Error Packets Indicates the number of giant packets received, having a length (including CRC) greater than 1,518 bytes (1,522 bytes for VLAN-tagged packets), and with a CRC error. If Jumbo Packet mode is enabled, packets of length greater than 9,018 bytes (9,022 bytes for VLAN-tagged packets) are considered as giant packets.

78.17.97 Receive Undersize Packets Good (Rx_Undersize_Packets_Good)

Offset

Register	Offset
Rx_Undersize_Packets_Good	7A4h

Function

Provides the number of packets that the module received, having a length less than 64 bytes, but without any errors.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXUNDERSZG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXUNDERSZG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXUNDERSZG	Receive Undersize Packets Good Indicates the number of packets received, having a length less than 64 bytes, but without any errors.

78.17.98 Receive Oversize Packets Good (Rx_Oversize_Packets_Good)

Offset

Register	Offset
Rx_Oversize_Packets_Good	7A8h

Function

Provides the number of packets that the module received without any errors, having a length greater than the maximum size (1,518 bytes or 1,522 bytes for VLAN-tagged packets; 2000 bytes if MAC_Configuration[S2KP] = 1).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXOVERSZG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXOVERSZG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXOVERSZG	Receive Oversize Packets Good Indicates the number of packets received without errors, with a length greater than the maximum size (1,518 bytes or 1,522 bytes for VLAN-tagged packets; 2000 bytes if MAC_Configuration[S2KP] = 1).

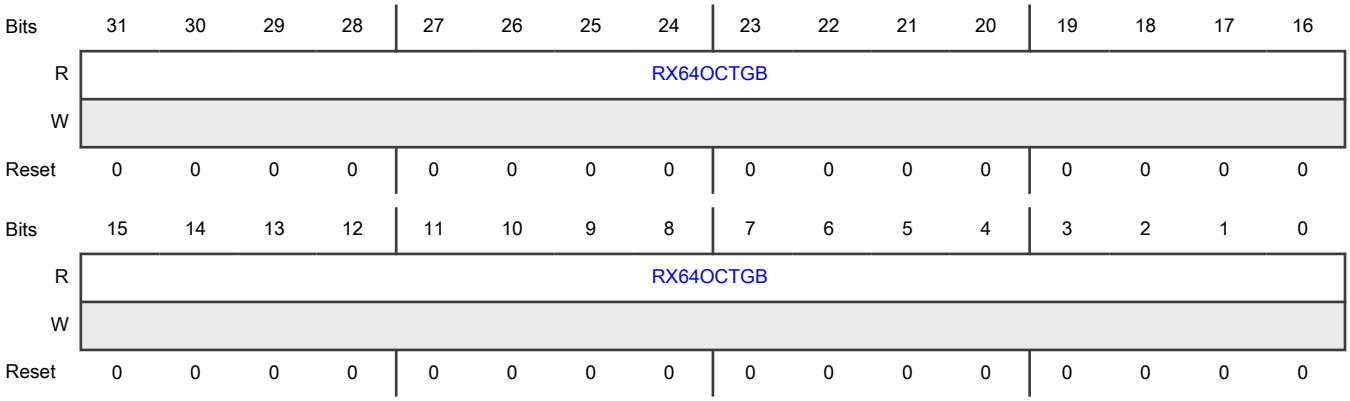
78.17.99 Receive 64 Octets Packets Good Bad (Rx_64Octets_Packets_Good_Bad)

Offset

Register	Offset
Rx_64Octets_Packets_Good_Bad	7ACh

Function
Provides the number of 64-byte good and bad packets that the module received, exclusive of the preamble.

Diagram



Fields

Field	Function
31-0 RX64OCTGB	Receive 64 Octets Packets Good Bad Provides the number of 64-byte good and bad packets that the module received, exclusive of the preamble.

78.17.100 Receive 65-127 Octets Packets Good Bad (Rx_65To127Octets_Packets_Good_Bad)

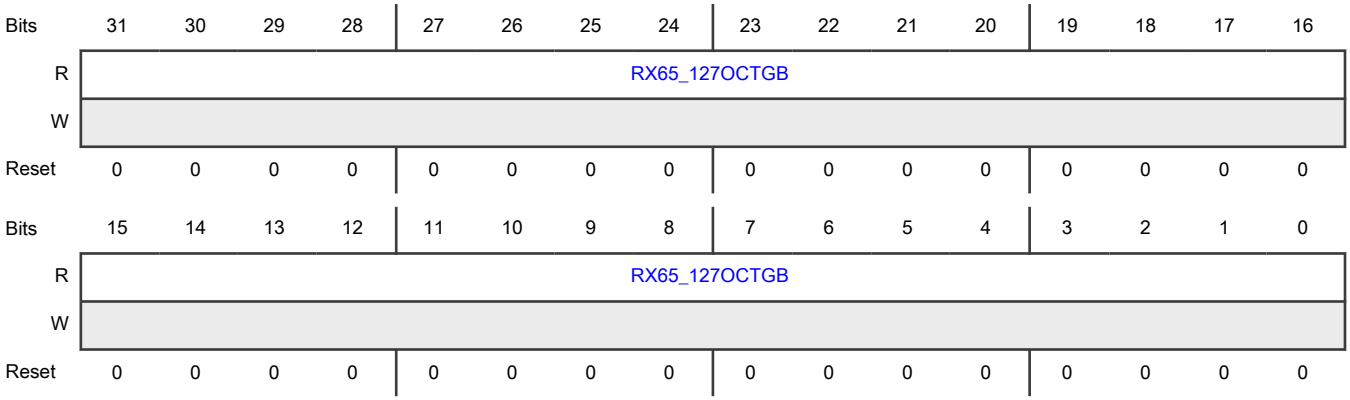
Offset

Register	Offset
Rx_65To127Octets_Packets_Good_Bad	7B0h

Function

Provides the number of good and bad packets that the module received, ranging between 65 and 127 (inclusive) bytes, exclusive of the preamble.

Diagram



Fields

Field	Function
31-0 RX65_127OCTGB	Receive 65-127 Octets Packets Good Bad Indicates the number of good and bad packets received, ranging between 65 and 127 (inclusive) bytes, exclusive of the preamble.

78.17.101 Receive 128-255 Octets Packets Good Bad (Rx_128To255Octets_Packets_Good_Bad)

Offset

Register	Offset
Rx_128To255Octets_Packets_Good_Bad	7B4h

Function

Provides the number of good and bad packets that the module received, with packet length between 128 and 255 (inclusive) bytes, exclusive of the preamble.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RX128_255OCTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RX128_255OCTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RX128_255OCTGB	Receive 128-255 Octets Packets Good Bad Indicates the number of good and bad packets received, with packet length between 128 and 255 (inclusive) bytes, exclusive of the preamble.

78.17.102 Receive 256-511 Octets Packets Good Bad (Rx_256To511Octets_Packets_Good_Bad)

Offset

Register	Offset
Rx_256To511Octets_Packets_Good_Bad	7B8h

Function

Provides the number of good and bad packets that the module received, having a packet length between 256 and 511 (inclusive) bytes, exclusive of the preamble.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RX256_511OCTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RX256_511OCTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RX256_511OCTGB	Receive 256-511 Octets Packets Good Bad Indicates the number of good and bad packets received, having a packet length between 256 and 511 (inclusive) bytes, exclusive of the preamble.

78.17.103 Receive 512-1023 Octets Packets Good Bad (Rx_512To1023Octets_Packets_Good_Bad)

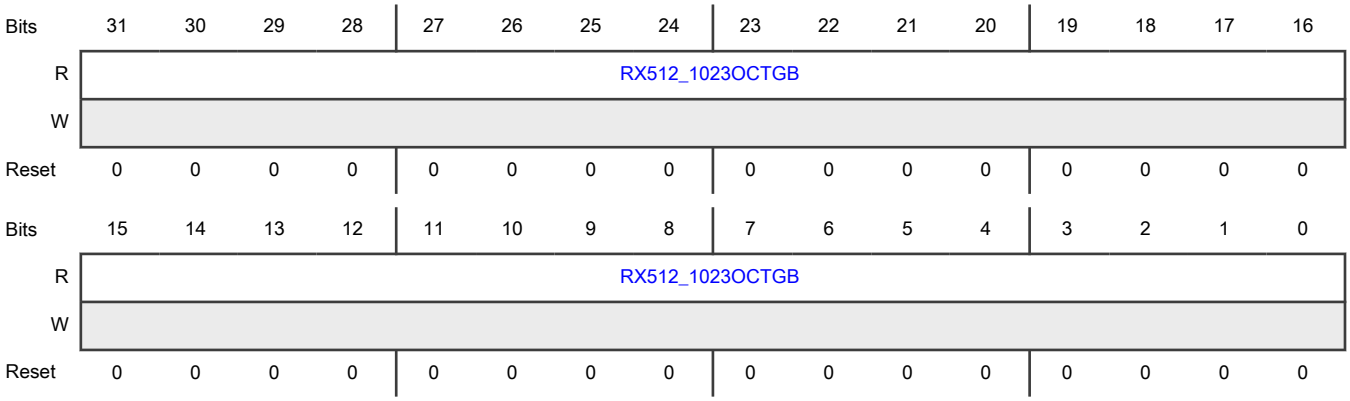
Offset

Register	Offset
Rx_512To1023Octets_Packets_Good_Bad	7BCh

Function

Provides the number of good and bad packets that the module received, having a packet length between 512 and 1023 (inclusive) bytes, exclusive of the preamble.

Diagram



Fields

Field	Function
31-0 RX512_1023OCTGB	Receive 512-1023 Octets Packets Good Bad Indicates the number of good and bad packets received, having a packet length between 512 and 1023 (inclusive) bytes, exclusive of the preamble.

78.17.104 Receive 1024 To Max Octets Good Bad (Rx_1024ToMaxOctets_Packets_Good_Bad)

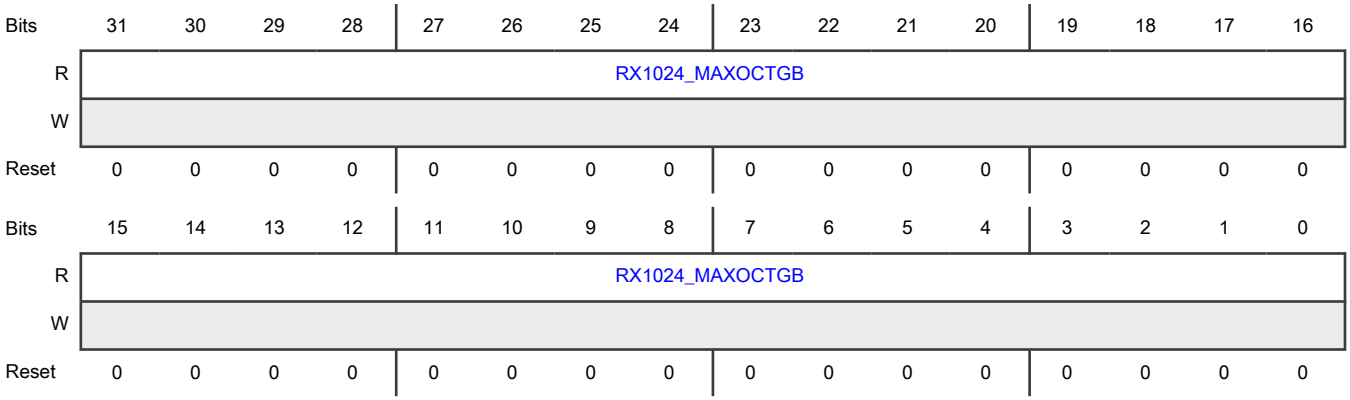
Offset

Register	Offset
Rx_1024ToMaxOctets_Packets_Good_Bad	7C0h

Function

Provides the number of good and bad packets that the module received, having an inclusive packet length between 1024 bytes and the maximum byte size, exclusive of the preamble.

Diagram



Fields

Field	Function
31-0 RX1024_MAXOCTGB	Receive 1024-Max Octets Good Bad Indicates the number of good and bad packets received with length between 1024 and the maximum size (inclusive) bytes, exclusive of the preamble.

78.17.105 Receive Unicast Packets Good (Rx_Unicast_Packets_Good)

Offset

Register	Offset
Rx_Unicast_Packets_Good	7C4h

Function

Provides the number of good unicast packets that the module received.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXUCASTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXUCASTG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXUCASTG	Receive Unicast Packets Good Indicates the number of good unicast packets received.

78.17.106 Receive Length Error Packets (Rx_Length_Error_Packets)

Offset

Register	Offset
Rx_Length_Error_Packets	7C8h

Function

Provides the number of packets that the module received with a length error (the Length/Type (LT) field of the RDES3 normal descriptor not equal to the packet size) for all the packets with a valid length field. For more information on the LT field, see the "RDES3 normal descriptor (write-back format)" section.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXLENERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXLENERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXLENERR	Receive Length Error Packets Indicates the number of packets received with a length error (the Length/Type (LT) field of the RDES3 normal descriptor not equal to the packet size) for all the packets with a valid length field. For more information on the LT field, see the "RDES3 normal descriptor (write-back format)" section.

78.17.107 Receive Out of Range Type Packet (Rx_Out_Of_Range_Type_Packets)

Offset

Register	Offset
Rx_Out_Of_Range_Type_Packets	7CCh

Function

Provides the number of packets that the module received, with the length field not equal to the valid packet size (greater than 1,500 but less than 1,536).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXOUTOFRNG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXOUTOFRNG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXOUTOFRNG	Receive Out of Range Type Packet Indicates the number of packets received with length field not equal to the valid packet size (greater than 1,500 but less than 1,536).

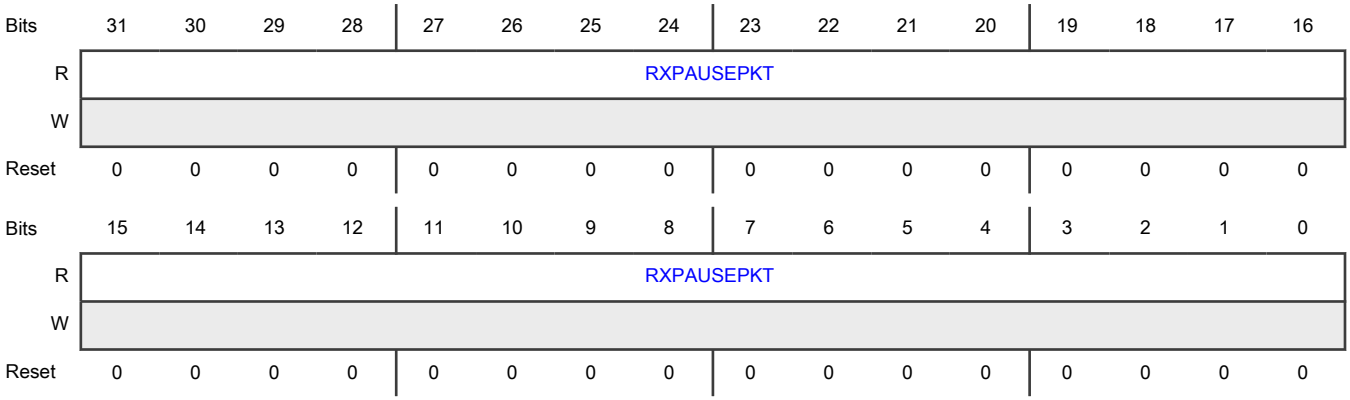
78.17.108 Receive Pause Packets (Rx_Pause_Packets)

Offset

Register	Offset
Rx_Pause_Packets	7D0h

Function
Provides the number of good and valid pause packets that the module received.

Diagram



Fields

Field	Function
31-0 RXPAUSEPKT	Receive Pause Packets Indicates the number of good and valid pause packets received.

78.17.109 Receive FIFO Overflow Packets (Rx_FIFO_Overflow_Packets)

Offset

Register	Offset
Rx_FIFO_Overflow_Packets	7D4h

Function
Provides the number of missed received packets because of FIFO overflow in the module.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXFIFOOVFL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXFIFOOVFL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXFIFOOVFL	Receive FIFO Overflow Packets Indicates the number of missed received packets because of FIFO overflow.

78.17.110 Receive VLAN Packets Good Bad (Rx_VLAN_Packets_Good_Bad)

Offset

Register	Offset
Rx_VLAN_Packets_Good_Bad	7D8h

Function

Provides the number of good and bad VLAN packets that the module received.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXVLANPKTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXVLANPKTGB															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXVLANPKTGB	Receive VLAN Packets Good Bad Indicates the number of good and bad VLAN packets received.

78.17.111 Receive Watchdog Error Packets (Rx_Watchdog_Error_Packets)

Offset

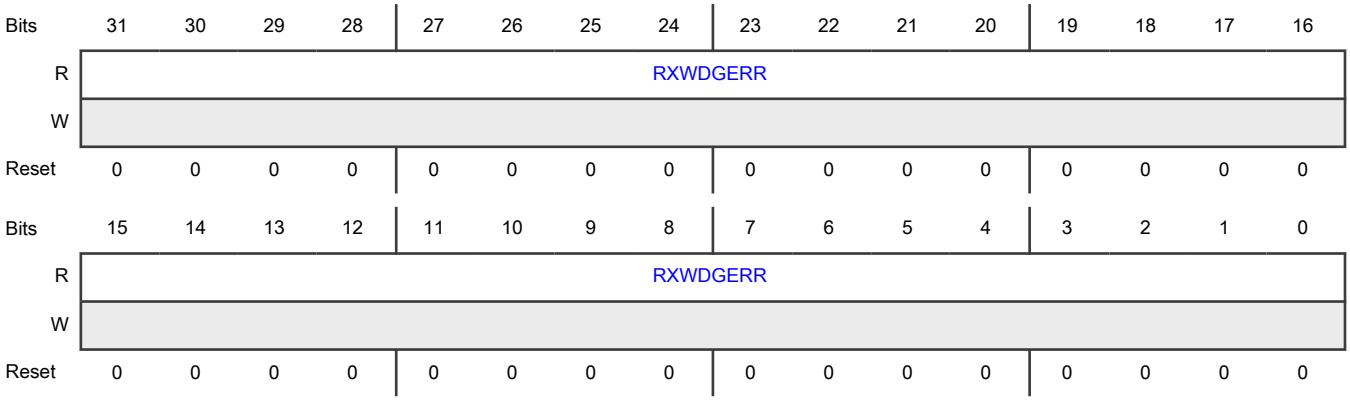
Register	Offset
Rx_Watchdog_Error_Packets	7DCh

Function

Provides the number of packets that the module received with a watchdog timeout error. Packets with a data load larger than the following are received:

- 2,048 bytes when MAC_Configuration[JE] = 0 and MAC_Configuration[WD] = 0
- 10,240 bytes when MAC_Configuration[JE] = 1 and MAC_Configuration[WD] = 0
- 16,384 bytes when MAC_Configuration[WD] = 1 or the value programmed in MAC Watchdog Timeout (MAC_Watchdog_Timeout)

Diagram



Fields

Field	Function
31-0 RXWDGERR	Receive Watchdog Error Packets Indicates the number of packets received with a watchdog timeout error. Packets with a data load larger than the following are received:

Table continues on the next page...

Field	Function
	• 2,048 bytes when MAC_Configuration[JE] = 0 and MAC_Configuration[WD] = 0 • 10,240 bytes when MAC_Configuration[JE] = 1 and MAC_Configuration[WD] = 0 • 16,384 bytes when MAC_Configuration[WD] = 1 or the value programmed in MAC Watchdog Timeout (MAC_Watchdog_Timeout)

78.17.112 Receive Error Packets (Rx_Receive_Error_Packets)

Offset

Register	Offset
Rx_Receive_Error_Packets	7E0h

Function
Provides the number of packets that the module received with a receive or packet extension error on GMII or MII.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXRCVERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXRCVERR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXRCVERR	Receive Error Packets Indicates the number of packets received with a receive or packet extension error on GMII or MII.

78.17.113 Receive Control Packets Good (Rx_Control_Packets_Good)

Offset

Register	Offset
Rx_Control_Packets_Good	7E4h

Function

Provides the number of good control packets that the module received.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RXCTRLG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	RXCTRLG															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 RXCTRLG	Receive Control Packets Good Indicates the number of good control packets received.

78.17.114 MMC Transmit FPE Fragment Counter Interrupt Status (MMC_FPE_Tx_Interrupt)

Offset

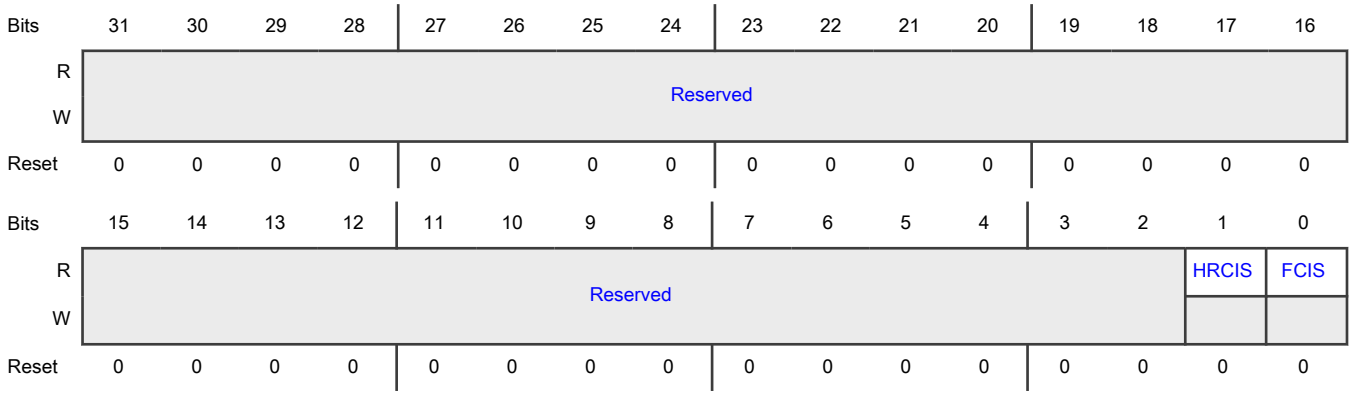
Register	Offset
MMC_FPE_Tx_Interrupt	8A0h

Function

Maintains the interrupts generated from all the FPE-related transmit statistic counters when they reach half of their maximum values (8000_0000h for a 32-bit counter and 8000h for a 16-bit counter), and when they cross their maximum values (FFFF_FFFFh for a 32-bit counter and FFFFh for a 16-bit counter). When MMC_Control[CNTSTOPRO] = 1, the interrupts are set but the counter remains at all-ones.

An interrupt bit of this register becomes 0 when the respective MMC counter that caused the interrupt is read. The least significant byte lane (bits [7:0]) of the respective counter must be read to clear the interrupt bit.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 HRCIS	MMC Transmit Hold Request Counter Interrupt Status Indicates whether the MMC Transmit hold request counter interrupt status is detected. This field: • Becomes 1 when the Tx_Hold_Req_Cntr counter reaches half of the maximum value or the maximum value. • Exists when any one of the receive or transmit MMC counters is enabled during FPE with AV_EST-enabled configuration. Access restrictions apply to this field that clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
0 FCIS	MMC Transmit FPE Fragment Counter Interrupt Status Indicates whether the MMC Transmit FPE fragment counter interrupt status is detected. This field: • Becomes 1 when the Tx_FPE_Fragment_Cntr counter reaches half of the maximum value or the maximum value. • Exists when any one of the receive or transmit MMC counters is enabled during FPE-enabled configuration. Access restrictions apply to this field that clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

78.17.115 MMC FPE Transmit Interrupt Mask (MMC_FPE_Tx_Interrupt_Mask)

Offset

Register	Offset
MMC_FPE_Tx_Interrupt_Mask	8A4h

Function

Maintains the masks for interrupts generated from all FPE-related transmit statistics counters. MMC Receive Interrupt Mask (MMC_Rx_Interrupt_Mask) maintains the masks for the interrupts generated when FPE-related receive statistic counters reach half of their maximum value or the maximum value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved														HRCIM	FCIM
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-2 —	Reserved
1 HRCIM	MMC Transmit Hold Request Counter Interrupt Mask Indicates the status of the MMC transmit hold request counter interrupt mask. Writing 1 to this field masks the interrupt when the Tx_Hold_Req_Cntr counter reaches half of its maximum value or the maximum value. The field exists when any one of the receive, transmit, or MMC counters is enabled during FPE with AV_EST-enabled configuration. 0b - Disabled 1b - Enabled
0 FCIM	MMC Transmit Fragment Counter Interrupt Mask Indicates the status of the MMC transmit fragment counter interrupt mask.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Writing 1 to this field masks the interrupt when the Tx_FPE_Fragment_Cntr counter reaches half of its maximum value or the maximum value. The field exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration. 0b - Disabled 1b - Enabled

78.17.116 Transmit FPE Fragment Counter (MMC_Tx_FPE_Fragment_Cntr)

Offset

Register	Offset
MMC_Tx_FPE_Fragment_Cntr	8A8h

Function

Provides the number of additional mPackets transmitted because of preemption.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TXFFC															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TXFFC															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXFFC	Transmit FPE Fragment Counter Indicates the number of additional mPackets transmitted because of preemption. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration.

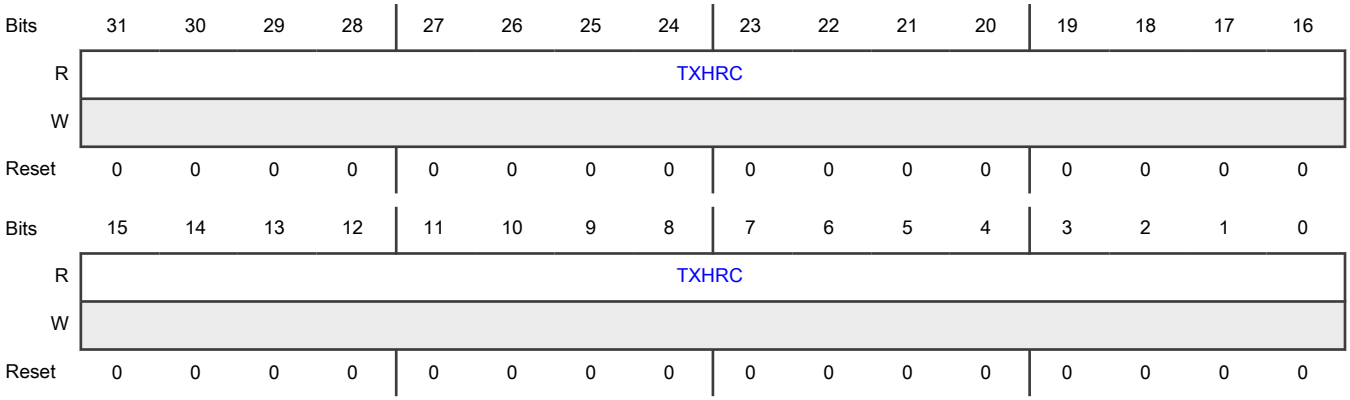
78.17.117 Transmit Hold Request Counter (MMC_Tx_Hold_Req_Cntr)

Offset

Register	Offset
MMC_Tx_Hold_Req_Cntr	8ACh

Function
Provides the count of times that a hold request is given to MAC.

Diagram



Fields

Field	Function
31-0 TXHRC	Transmit Hold Request Counter Indicates the count of times that a hold request is given to MAC. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE with AV_EST-enabled configuration.

78.17.118 MMC Receive Packet Assembly Error Counter Interrupt Status (MMC_FPE_Rx_Interrupt)

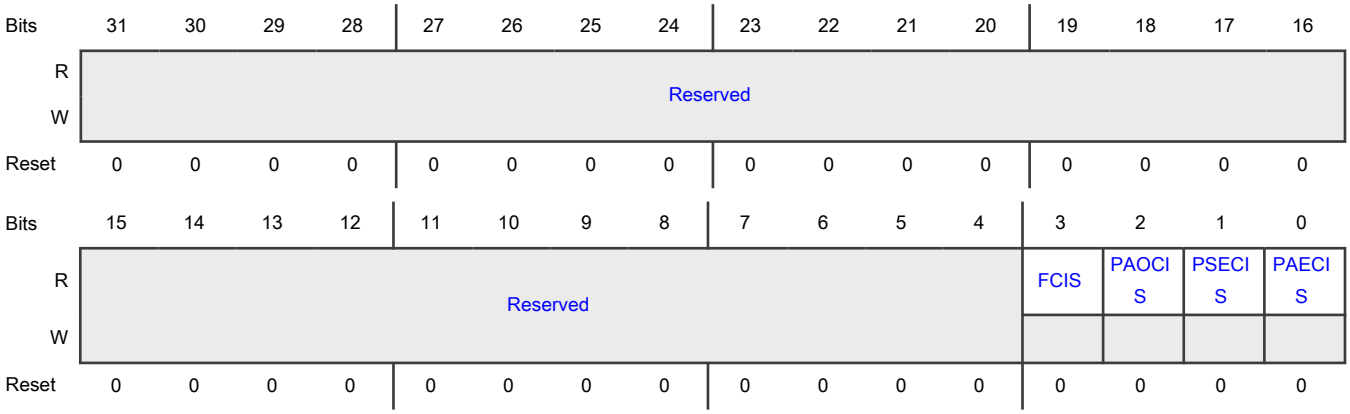
Offset

Register	Offset
MMC_FPE_Rx_Interrupt	8C0h

Function
Maintains the interrupts generated from all the FPE-related receive statistic counters, when these transmit statistic counters reach half of their maximum values (8000_0000h for a 32-bit counter and 8000h for a 16-bit counter), and when they cross their maximum values (FFFF_FFFFh for a 32-bit counter and FFFFh for 16-bit counter). When MMC_Control[CNTSTOPRO] = 1, the interrupts are set but the counter remains at all-ones. An interrupt bit of this register becomes 0 when the respective

MMC counter that caused the interrupt is read. The least significant byte lane (bits [7:0]) of the respective counter must be read to clear the interrupt bit.

Diagram



Fields

Field	Function
31-4 —	Reserved
3 FCIS	MMC Receive FPE Fragment Counter Interrupt Status Indicates whether the MMC receive FPE fragment counter interrupt status is detected. This field becomes 1 when the Rx_FPE_Fragment_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration. Access restrictions apply to this field that clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
2 PAOCIS	MMC Receive Packet Assembly OK Counter Interrupt Status Indicates whether the MMC receive packet assembly OK counter interrupt status is detected. This field becomes 1 when the Rx_Packet_Assemble_Ok_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration. Access restrictions apply to this field that clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

Table continues on the next page...

Table continued from the previous page...

Field	Function
1 PSECIS	MMC Receive, Transmit, Packet SMD Error Counter Interrupt Status Indicates whether the status of the MMC receive packet SMD error counter interrupt is detected. This field becomes 1 when the Rx_Packet_SMD_Err_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration. Access restrictions apply to this field that clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
0 PAECIS	MMC Receive, transmit, Packet Assembly Error Counter Interrupt Status Indicates whether the status of the MMC receive packet assembly error counter interrupt is detected. This field becomes 1 when the Rx_Packet_Assemble_Err_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during the FPE-enabled configuration. Access restrictions apply to this field that clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

78.17.119 MMC FPE Receive Interrupt Mask (MMC_FPE_Rx_Interrupt_Mask)

Offset

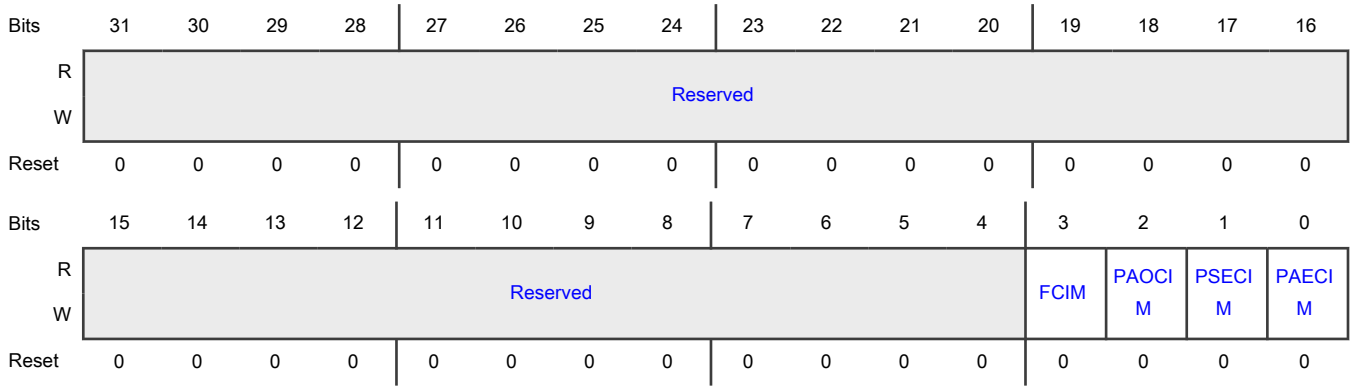
Register	Offset
MMC_FPE_Rx_Interrupt_Mask	8C4h

Function

Maintains the masks for interrupts generated from all FPE-related receive statistic counters.

This register maintains the masks for the interrupts generated when FPE-related receive statistic counters reach half of their maximum value or the maximum value.

Diagram



Fields

Field	Function
31-4 —	Reserved
3 FCIM	MMC Receive FPE Fragment Counter Interrupt Mask Indicates the status of the MMC receive FPE fragment counter interrupt mask. Writing 1 to this field masks the interrupt when the Tx_FPE_Fragment_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration. 0b - Disabled 1b - Enabled
2 PAOCIM	MMC Receive Packet Assembly OK Counter Interrupt Mask Indicates the status of the MMC receive packet assembly OK counter interrupt mask. Writing 1 to this field masks the interrupt when the Rx_Packet_Assemble_Ok_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration. 0b - Disabled 1b - Enabled
1 PSECIM	MMC Receive Packet SMD Error Counter Interrupt Mask Indicates the status of the MMC receive packet SMD error counter interrupt mask. Writing 1 to this field masks the interrupt when the Rx_Packet_SMD_Err_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled
0 PAECIM	MMC receive Packet Assembly Error Counter Interrupt Mask Indicates the status of the MMC receive packet assembly error counter interrupt mask. Writing 1 to this field masks the interrupt when the Rx_Packet_Assemble_Err_Cntr counter reaches half of its maximum value or the maximum value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration. 0b - Disabled 1b - Enabled

78.17.120 MMC Receive Packet Assembly Error Counter (MMC_Rx_Packet_Assembly_Err_Cntr)

Offset

Register	Offset
MMC_Rx_Packet_Assembly_Err_Cntr	8C8h

Function

Provides the number of MAC frames having reassembly errors on the receiver arising out of mismatch in the fragment count value.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	PAEC															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	PAEC															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PAEC	Packet Assembly Error Counter Indicates the number of MAC frames having reassembly errors on the receiver arising out of mismatch in the fragment count value. Exists when any one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration.

78.17.121 MMC Receive Packet SMD Error Counter (MMC_Rx_Packet_SMD_Err_Cntr)

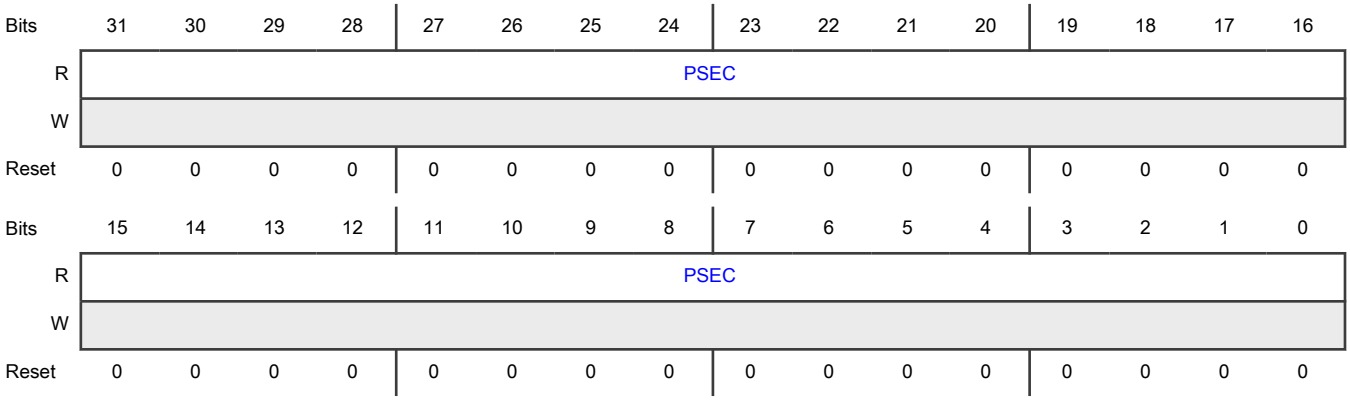
Offset

Register	Offset
MMC_Rx_Packet_SMD_Err_Cntr	8CCh

Function

Provides the number of received MAC frames rejected because of an unknown SMD value and MAC frame fragments rejected because of arriving with SMD-C when there was no preceding preempted frame.

Diagram



Fields

Field	Function
31-0 PSEC	Packet SMD Error Counter Indicates the number of MAC frames rejected because of an unknown SMD value and MAC frame fragments rejected because of arriving with SMD-C when there was no preceding preempted frame. Exists when at least one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration.

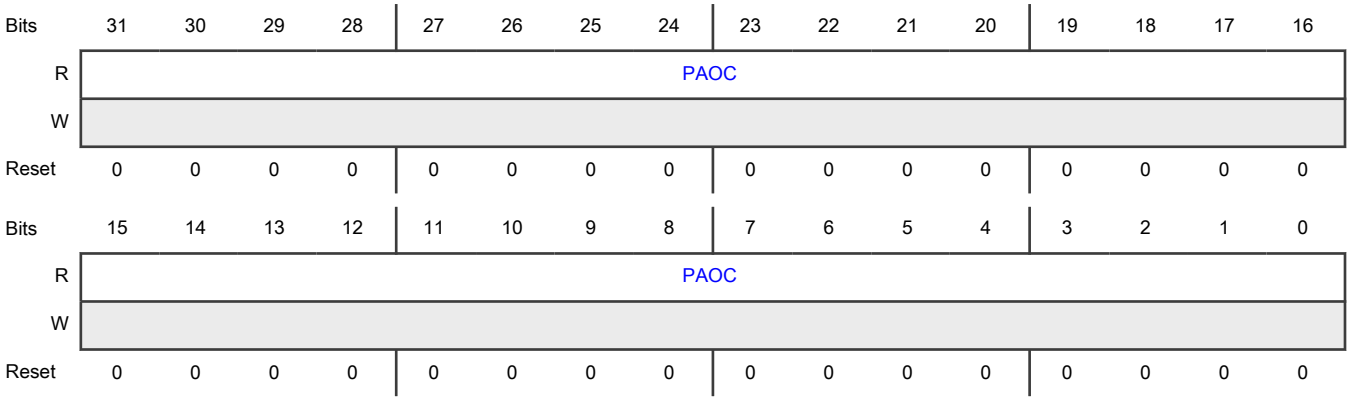
78.17.122 MMC Receive Packet Assembly OK Counter (MMC_Rx_Packet_Assembly_OK_Cntr)

Offset

Register	Offset
MMC_Rx_Packet_Assembly_OK_Cntr	8D0h

Function
Provides the number of MAC frames that were successfully reassembled and delivered to MAC.

Diagram



Fields

Field	Function
31-0 PAOC	Packet Assembly OK Counter Indicates the number of MAC frames that were successfully reassembled and delivered to MAC. Exists when at least one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration.

78.17.123 MMC Receive FPE Fragment Counter (MMC_Rx_FPE_Fragment_Cntr)

Offset

Register	Offset
MMC_Rx_FPE_Fragment_Cntr	8D4h

Function
Provides the number of additional mPackets received because of preemption.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	FFC															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	FFC															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 FFC	FPE Fragment Counter Indicates the number of additional mPackets received because of preemption. Exists when at least one of the receive, transmit, or MMC counters is enabled during FPE-enabled configuration.

78.17.124 MAC Layer 3 Layer 4 Control 0 (MAC_L3_L4_Control0)

Offset

Register	Offset
MAC_L3_L4_Control0	900h

Function
Controls the filter 0 operations of the layer 3 and layer 4 protocols.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved			DMCHEN0	Reserved			DMCHN0	Reserved		L4DPIM0	L4DPM0	L4SPIM0	L4SPM0	Reserved	L4PEN0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	L3HDBM0				L3HSBM0						L3DAIM0	L3DAM0	L3SAIM0	L3SAM0	Reserved	L3PEN0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved
28 DMCHEN0	DMA Channel Select Enable Indicates the status of the DMA channel number. • If this field is 1, it enables the selection of the DMA channel number for the packet that the L3_L4 filter passes. The DMCHN fields indicate the DMA channel number. • If this field is 0, the filter does not decide the DMA channel number. 0b - Disabled 1b - Enabled
27-25 —	Reserved
24 DMCHN0	DMA Channel Number Indicates the DMA channel number. If the value of the DMCHEN fields is 1, this field selects the DMA channel number to which the packet that this filter passes is routed. The width of this field depends on the number of the DMA channels present in your configuration.
23-22 —	Reserved
21 L4DPIM0	Layer 4 Destination Port Inverse Match Enable Indicates the status of layer 4 destination port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4DP0] is enabled for perfect matching. This field is valid and applicable only when the L4DPM0 field is 1. 0b - Disabled 1b - Enabled
20 L4DPM0	Layer 4 Destination Port Match Enable Indicates the status of layer 4 destination port matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4DP0] for matching. 0b - Disabled 1b - Enabled
19	Layer 4 Source Port Inverse Match Enable

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Field	Function
L4SPIM0	Indicates the status of layer 4 source port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4SP0] is enabled for perfect matching. This field is valid and applicable only when MAC_Layer4_Address0[L4SP0] = 1. 0b - Disabled 1b - Enabled
18 L4SPM0	Layer 4 Source Port Match Enable Indicates the status of layer 4 source port matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4SP0] for matching. 0b - Disabled 1b - Enabled
17 —	Reserved
16 L4PEN0	Layer 4 Protocol Enable Indicates the status of layer 4 protocol. • If this field is 1, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] are used for matching UDP packets. • If this field is 0, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] are used for matching TCP packets. Layer 4 matching is performed only when the L4SPM0 field or the L4DPM0 field is 1. 0b - Disabled 1b - Enabled
15-11 L3HDBM0	Layer 3 IP DA Higher Bits Match IPv4 packets: This field contains the number of higher bits of IP DA that are matched in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • - .. • 31: All bits except MSb are masked. IPv6 packets:

Table continues on the next page...

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Field	Function
	Bits [12:11] of this field correspond to bits [6:5] of the L3HSBM0 field, which indicates the number of lower bits of IP SA or DA that are masked in the IPv6 packets. The following list describes the concatenated values of the L3HDBM0[1:0] and L3HSBM0 fields: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 127: All bits except MSb are masked. This field is valid and applicable only when the L3DAM0 field or the L3SAM0 field is 1.
10-6 L3HSBM0	Layer 3 IP SA Higher Bits Match IPv4 packets: This field contains the number of lower bits of IP SA that are masked for matching in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 31: All bits except MSb are masked. IPv6 packets: This field contains bits [4:0] of L3HSBM0. These bits indicate the number of higher bits of IP SA or DA matched in the IPv6 packets. The field is valid and applicable only when the L3DAM0 field or the L3SAM0 field is 1.
5 L3DAIM0	Layer 3 IP DA Inverse Match Enable Indicates the status of layer 3 IP DA inverse matching. • If this field is 1, layer 3 IP DA is enabled for inverse matching. • If this field is 0, layer 3 IP DA is enabled for perfect matching. This field is valid and applicable only if L3DAM0 = 1. 0b - Disabled 1b - Enabled
4 L3DAM0	Layer 3 IP DA Match Enable Indicates the status of layer 3 IP DA matching. • If this field is 1, layer 3 IP DA is enabled for matching. • If this field is 0, MAC ignores layer 3 IP DA for matching.

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Field	Function
	NOTE If L3PEN0 = 1, you must write 1 to either this field or the L3SAM0 field because either the IPv6 DA or SA can be checked for filtering. 0b - Disabled 1b - Enabled
3 L3SAIM0	Layer 3 IP SA Inverse Match Enable Indicates the status of layer 3 IP SA inverse matching. • If this field is 1, layer 3 IP SA is enabled for inverse matching. • If this field is 0, layer 3 IP SA is enabled for perfect matching. This field is valid and applicable only if the L3SAM0 field is 1. 0b - Disabled 1b - Enabled
2 L3SAM0	Layer 3 IP SA Match Enable Indicates the status of layer 3 IP SA matching. • If this field is 1, layer 3 IP SA matching is enabled. • If this field is 0, MAC ignores layer 3 IP SA matching. **NOTE** If L3PEN0 = 1, you must write 1 to either this field or the L3DAM0 field because either IPv6 SA or DA can be checked for filtering. 0b - Disabled 1b - Enabled
1 —	Reserved
0 L3PEN0	Layer 3 Protocol Enable Indicates the status of layer 3 protocol. • If this field is 1, the layer 3 IP SA or DA matching is enabled for IPv6 packets. • If this field is 0, the layer 3 IP SA or DA matching is enabled for IPv4 packets. The layer 3 matching is performed only when either the L3SAM0 field or the L3DAM0 field is 1. 0b - Disabled 1b - Enabled

78.17.125 MAC Layer 4 Address 0 (MAC_Layer4_Address0)

Offset

Register	Offset
MAC_Layer4_Address0	904h

Function

Provides the layer 4 source and destination port numbers.

MAC Layer 4 Address 1 (MAC_Layer4_Address1), MAC L3 L4 Control 1 (MAC_L3_L4_Control1), MAC Layer 3 Address 0 Reg 1 (MAC_Layer3_Addr0_Reg1), MAC Layer 3 Address 1 Reg 1 (MAC_Layer3_Addr1_Reg1), MAC Layer 3 Address 2 Reg 1 (MAC_Layer3_Addr2_Reg1), and MAC Layer 3 Address 3 Reg 1 (MAC_Layer3_Addr3_Reg1) are reserved registers (RO with a default value) if MAC_Packet_Filter[IPFE] is 0 when configuring the core.

You can configure the layer 3 and layer 4 address registers to be double-synchronized by selecting the synchronize layer 3 and layer 4 address registers to the receive clock domain option while configuring the core. When you select this option, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of the layer 3 and layer 4 address registers are written to. For proper synchronization updates, you must perform consecutive writes to the same layer 3 and layer 4 address registers after a delay of at least four destination clock cycles.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	L4DP0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	L4SP0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 L4DP0	Layer 4 Destination Port Number Indicates layer 4 destination port number. If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4DPM0] = 1, this field contains the value to be matched with the TCP destination port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4DPM0] are 1, this field contains the value to be matched with the UDP destination port number field in the IPv4 or IPv6 packets.
15-0 L4SP0	Layer 4 Source Port Number Indicates layer 4 source port number.

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Field	Function
	If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4SPM0] = 1, this field contains the value to be matched with the TCP source port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4SPM0] are 1, this field contains the value to be matched with the UDP source port number field in the IPv4 or IPv6 packets.

78.17.126 MAC Layer 3 Address 0 Reg 0 (MAC_Layer3_Addr0_Reg0)

Offset

Register	Offset
MAC_Layer3_Addr0_Reg0	910h

Function

Contains the 32-bit IP source address field for IPv4 packets. For IPv6 packets, the field contains bits [31:0] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A00															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A00															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A00	Layer 3 Address 0 Indicates layer 3 address 0. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.127 MAC Layer 3 Address 1 Reg 0 (MAC_Layer3_Addr1_Reg0)

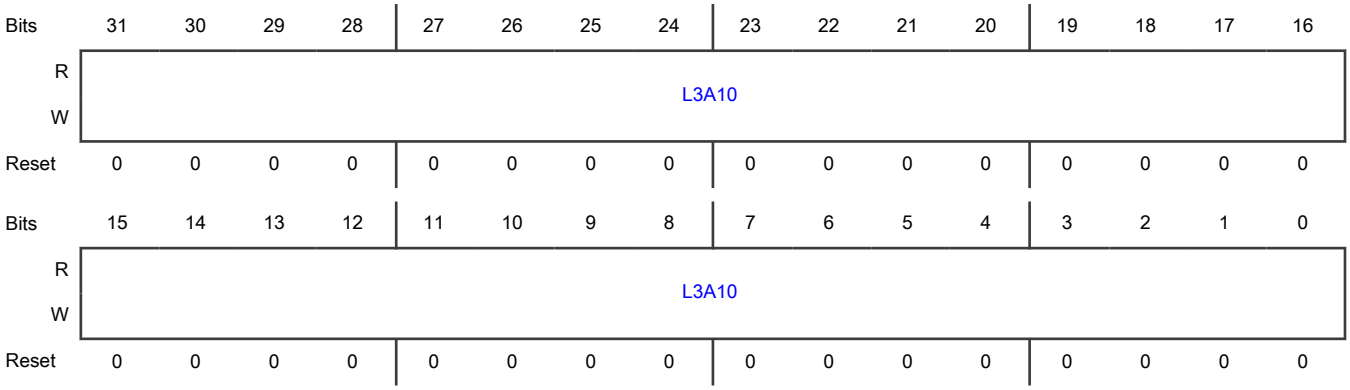
Offset

Register	Offset
MAC_Layer3_Addr1_Reg0	914h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [63:32] of the 128-bit IP source address or destination address field.

Diagram



Fields

Field	Function
31-0 L3A10	Layer 3 Address 1 Indicates layer 3 address 1. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.128 MAC Layer 3 Address 2 Reg 0 (MAC_Layer3_Addr2_Reg0)

Offset

Register	Offset
MAC_Layer3_Addr2_Reg0	918h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [95:64] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A20															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A20															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A20	Layer 3 Address 2 Indicates layer 3 address 2. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.129 MAC Layer 3 Address 3 Reg 0 (MAC_Layer3_Addr3_Reg0)

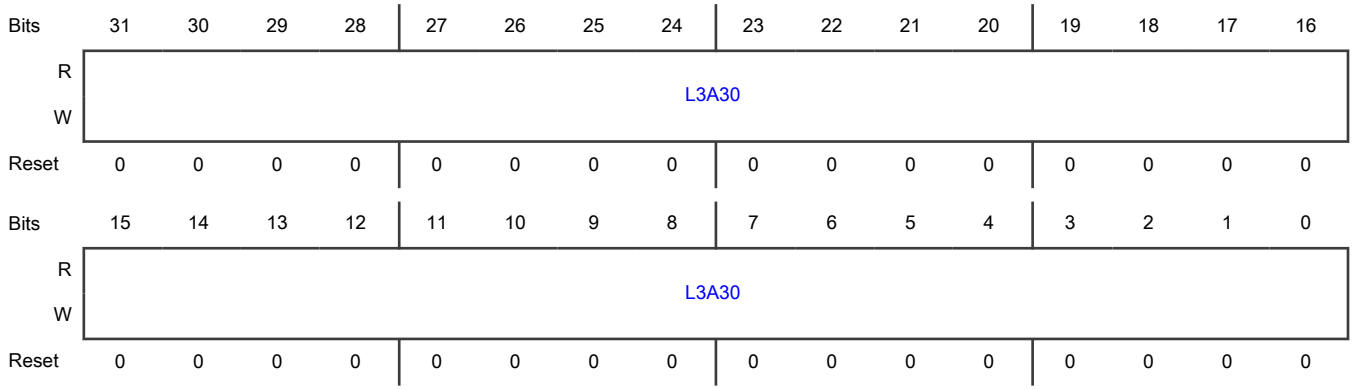
Offset

Register	Offset
MAC_Layer3_Addr3_Reg0	91Ch

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [127:96] of the 128-bit IP source address or destination address field.

Diagram



Fields

Field	Function
31-0 L3A30	Layer 3 Address 3 Indicates layer 3 address 3. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.130 MAC L3 L4 Control 1 (MAC_L3_L4_Control1)

Offset

Register	Offset
MAC_L3_L4_Control1	930h

Function

Controls the filter 0 operations of the layer 3 and layer 4 protocols.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved			DMCHEN1	Reserved			DMCHN1	Reserved		L4DPIM1	L4DPM1	L4SPIM1	L4SPM1	Reserved	L4PEN1
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3HDBM1				L3HSBM1						L3DAIM1	L3DAM1	L3SAIM1	L3SAM1	Reserved	L3PEN1
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved
28 DMCHEN1	DMA Channel Select Enable 1 Indicates the status of the DMA channel number. • If this field is 1, it enables the selection of the DMA channel number for the packet that the L3_L4 filter passes. The DMCHN fields indicate the DMA channel number. • If this field is 0, the filter does not decide the DMA channel number. 0b - Disabled 1b - Enabled
27-25 —	Reserved
24 DMCHN1	DMA Channel Number 1 Indicates the DMA channel number. If the value of the DMCHEN fields is 1, this field selects the DMA channel number to which the packet that this filter passes is routed. The width of this field depends on the number of the DMA channels present in your configuration.
23-22 —	Reserved
21 L4DPIM1	Layer 4 Destination Port Inverse Match Enable 1 Indicates the status of layer 4 destination port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4DP0] is enabled for perfect matching. This field is valid and applicable only when the L4DPM0 field is 1.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
20 L4DPM1	Layer 4 Destination Port Match Enable 1 Indicates the status of layer 4 destination port matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4DP0] for matching. 0b - Disabled 1b - Enabled
19 L4SPIM1	Layer 4 Source Port Inverse Match Enable 1 Indicates the status of layer 4 source port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4SP0] is enabled for perfect matching. This field is valid and applicable only when MAC_Layer4_Address0[L4SP0] = 1. 0b - Disabled 1b - Enabled
18 L4SPM1	Layer 4 Source Port Match Enable 1 Indicates the status of layer 4 source port matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4SP0] for matching. 0b - Disabled 1b - Enabled
17 —	Reserved
16 L4PEN1	Layer 4 Protocol Enable 1 Indicates the status of layer 4 protocol. • If this field is 1, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] of UDP packets are used for matching. • If this field is 0, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] of TCP packets are used for matching. Layer 4 matching is performed only when the L4SPM0 field or the L4DPM0 field is 1. 0b - Disabled 1b - Enabled

Table continues on the next page...

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Field	Function
15-11 L3HDBM1	Layer 3 IP DA Higher Bits Match 1 IPv4 Packets: This field contains the number of higher bits of IP DA that are matched in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 31: All bits except MSb are masked. IPv6 Packets: Bits [12:11] of this field correspond to bits [6:5] of MAC_L3_L4_Control0[L3HSBM0], which indicates the number of lower bits of IP SA or DA that are masked in the IPv6 packets. The following list describes the concatenated values of MAC_L3_L4_Control0[L3HDBM0][1:0] and MAC_L3_L4_Control0[L3HSBM0]: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked • .. • 127: All bits except MSb are masked. This field is valid and applicable only when MAC_L3_L4_Control0[L3DAM0] or MAC_L3_L4_Control0[L3SAM0] is 1.
10-6 L3HSBM1	Layer 3 IP SA Higher Bits Match 1 IPv4 packets: This field contains the number of lower bits of IP SA that are masked for matching in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 31: All bits except MSb are masked. IPv6 packets: This field contains bits [4:0] of MAC_L3_L4_Control0[L3HSBM0]. These bits indicate the number of higher bits of IP SA or DA matched in the IPv6 packets. The field is valid and applicable only when MAC_L3_L4_Control0[L3DAM0] or MAC_L3_L4_Control0[L3SAM0] is 1.
5 L3DAIM1	Layer 3 IP DA Inverse Match Enable 1 Indicates the status of layer 3 IP DA inverse matching.

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Field	Function
	• If this field is 1, layer 3 IP DA is enabled for inverse matching. • If this field is 0, layer 3 IP DA is enabled for perfect matching. This field is valid and applicable only if MAC_L3_L4_Control0[L3DAM0] = 1. 0b - Disabled 1b - Enabled
4 L3DAM1	Layer 3 IP DA Match Enable 1 Indicates the status of layer 3 IP DA matching. • If this field is 1, layer 3 IP DA is enabled for matching. • If this field is 0, MAC ignores layer 3 IP DA for matching. **NOTE** If MAC_L3_L4_Control0[L3PEN0] = 1, you must write 1 to either this field or to MAC_L3_L4_Control0[L3SAM0] because either the IPv6 DA or SA can be checked for filtering. 0b - Disabled 1b - Enabled
3 L3SAIM1	Layer 3 IP SA Inverse Match Enable 1 Indicates the status of layer 3 IP SA inverse matching. • If this field is 1, layer 3 IP SA is enabled for inverse matching. • If this field is 0, layer 3 IP SA is enabled for perfect matching. This field is valid and applicable only if MAC_L3_L4_Control0[L3SAM0] is 1. 0b - Disabled 1b - Enabled
2 L3SAM1	Layer 3 IP SA Match Enable 1 Indicates the status of layer 3 IP SA matching. • If this field is 1, layer 3 IP SA matching is enabled. • If this field is 0, MAC ignores layer 3 IP SA matching. **NOTE** If MAC_L3_L4_Control0[L3PEN0] = 1, you must write 1 to either this field or to MAC_L3_L4_Control0[L3DAM0] because either IPv6 SA or DA can be checked for filtering. 0b - Disabled 1b - Enabled
1 —	Reserved

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Field	Function
0 L3PEN1	Layer 3 Protocol Enable 1 Indicates the status of layer 3 protocol. • If this field is 1, the layer 3 IP SA or DA matching is enabled for IPv6 packets. • If this field is 0, the layer 3 IP SA or DA matching is enabled for IPv4 packets. The layer 3 matching is performed only when either MAC_L3_L4_Control0[L3SAM0] or MAC_L3_L4_Control0[L3DAM0] is 1. 0b - Disabled 1b - Enabled

78.17.131 MAC Layer 4 Address 1 (MAC_Layer4_Address1)

Offset

Register	Offset
MAC_Layer4_Address1	934h

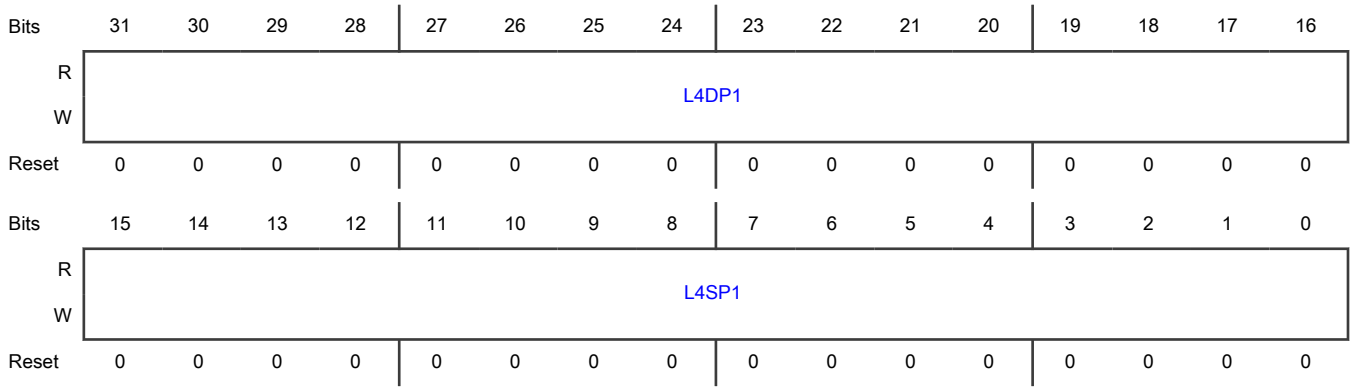
Function

Provides the layer 4 source and destination port numbers.

MAC Layer 4 Address 1 (MAC_Layer4_Address1), MAC L3 L4 Control 1 (MAC_L3_L4_Control1), MAC Layer 3 Address 0 Reg 1 (MAC_Layer3_Addr0_Reg1), MAC Layer 3 Address 1 Reg 1 (MAC_Layer3_Addr1_Reg1), MAC Layer 3 Address 2 Reg 1 (MAC_Layer3_Addr2_Reg1), and MAC Layer 3 Address 3 Reg 1 (MAC_Layer3_Addr3_Reg1) are reserved registers (RO with a default value) if the enable layer 3 and layer 4 packet filter option is not selected when configuring the core.

You can configure the layer 3 and layer 4 address registers to be double-synchronized by selecting the synchronize layer 3 and layer 4 address registers to the receive clock domain option while configuring the core. When you select this option, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of the layer 3 and layer 4 address registers are written to. For proper synchronization updates, you must perform consecutive writes to the same layer 3 and layer 4 address registers after a delay of at least four destination clock cycles.

Diagram



Fields

Field	Function
31-16 L4DP1	Layer 4 Destination Port Number 1 Indicates layer 4 destination port number. If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4DPM0] = 1, this field contains the value to be matched with the TCP destination port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4DPM0] are 1, this field contains the value to be matched with the UDP destination port number field in the IPv4 or IPv6 packets.
15-0 L4SP1	Layer 4 Source Port Number 1 Indicates layer 4 source port number. If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4SPM0] = 1, this field contains the value to be matched with the TCP source port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4SPM0] are 1, this field contains the value to be matched with the UDP source port number field in the IPv4 or IPv6 packets.

78.17.132 MAC Layer 3 Address 0 Reg 1 (MAC_Layer3_Addr0_Reg1)

Offset

Register	Offset
MAC_Layer3_Addr0_Reg1	940h

Function

Contains the 32-bit IP source address field for IPv4 packets. For IPv6 packets, the field contains bits [31:0] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A01															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A01															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A01	Layer 3 Address 0 Indicates layer 3 address 0. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.133 MAC Layer 3 Address 1 Reg 1 (MAC_Layer3_Addr1_Reg1)

Offset

Register	Offset
MAC_Layer3_Addr1_Reg1	944h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits[63:32] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A11															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A11															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A11	Layer 3 Address 1 Indicates layer 3 address 1.

Table continues on the next page...

Field	Function
	• If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.134 MAC Layer 3 Address 2 Reg 1 (MAC_Layer3_Addr2_Reg1)

Offset

Register	Offset
MAC_Layer3_Addr2_Reg1	948h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [95:64] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A21															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A21															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A21	Layer 3 Address 2 Indicates layer 3 address 2. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.135 MAC Layer 3 Address 3 Reg 1 (MAC_Layer3_Addr3_Reg1)

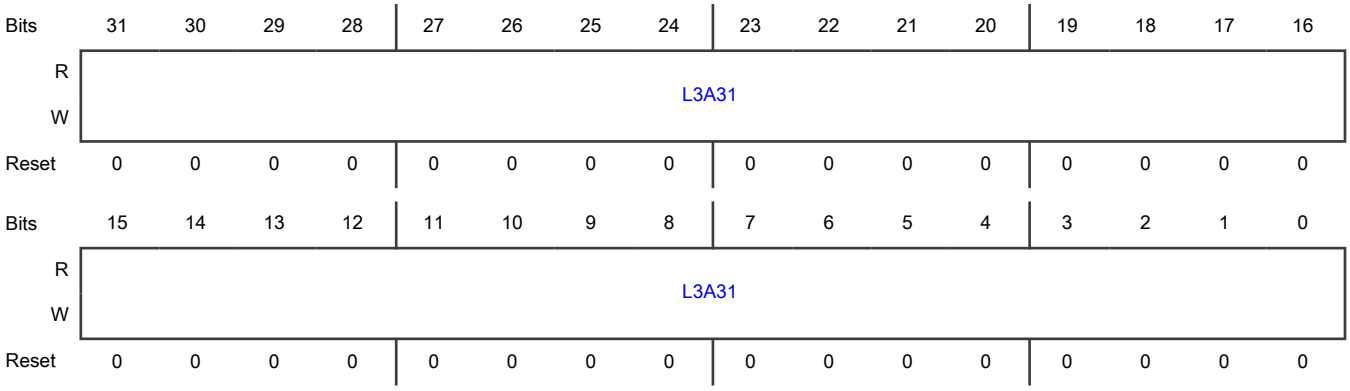
Offset

Register	Offset
MAC_Layer3_Addr3_Reg1	94Ch

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [127:96] of the 128-bit IP source address or destination address field.

Diagram



Fields

Field	Function
31-0 L3A31	Layer 3 Address 3 Indicates layer 3 address 3. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.136 MAC L3 L4 Control 2 (MAC_L3_L4_Control2)

Offset

Register	Offset
MAC_L3_L4_Control2	960h

Function

Controls the filter 0 operations of the layer 3 and layer 4 protocols.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved			DMCHEN2	Reserved			DMCHN2	Reserved		L4DPIM2	L4DPM2	L4SPIM2	L4SPM2	Reserved	L4PEN2
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3HDBM2				L3HSBM2						L3DAIM2	L3DAM2	L3SAIM2	L3SAM2	Reserved	L3PEN2
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved
28 DMCHEN2	DMA Channel Select Enable 2 Indicates the status of the DMA channel number. • If this field is 1, it enables the selection of the DMA channel number for the packet that the L3_L4 filter passes. The DMCHN fields indicate the DMA channel number. • If this field is 0, the filter does not decide the DMA channel number. 0b - Disabled 1b - Enabled
27-25 —	Reserved
24 DMCHN2	DMA Channel Number 2 Indicates the DMA channel number. If the value of the DMCHEN fields is 1, this field selects the DMA channel number to which the packet that this filter passes is routed. The width of this field depends on the number of the DMA channels present in your configuration.
23-22 —	Reserved
21 L4DPIM2	Layer 4 Destination Port Inverse Match Enable 2 Indicates the status of layer 4 destination port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4DP0] is enabled for perfect matching. This field is valid and applicable only when the L4DPM0 field is 1.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
20 L4DPM2	Layer 4 Destination Port Match Enable 2 Indicates the status of layer 4 destination port matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4DP0] for matching. 0b - Disabled 1b - Enabled
19 L4SPIM2	Layer 4 Source Port Inverse Match Enable 2 Indicates the status of layer 4 source port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4SP0] is enabled for perfect matching. This field is valid and applicable only when MAC_Layer4_Address0[L4SP0] = 1. 0b - Disabled 1b - Enabled
18 L4SPM2	Layer 4 Source Port Match Enable 2 Indicates the status of layer 4 source port matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4SP0] for matching. 0b - Disabled 1b - Enabled
17 —	Reserved
16 L4PEN2	Layer 4 Protocol Enable 2 Indicates the status of layer 4 protocol. • If this field is 1, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] of UDP packets are used for matching. • If this field is 0, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] of TCP packets are used for matching. Layer 4 matching is performed only when the L4SPM0 field or the L4DPM0 field is 1. 0b - Disabled 1b - Enabled

Table continues on the next page...

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Field	Function
15-11 L3HDBM2	Layer 3 IP DA Higher Bits Match 2 IPv4 Packets: This field contains the number of higher bits of IP DA that are matched in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 31: All bits except MSb are masked. IPv6 Packets: Bits [12:11] of this field correspond to bits [6:5] of MAC_L3_L4_Control0[L3HSBM0], which indicates the number of lower bits of IP SA or DA that are masked in the IPv6 packets. The following list describes the concatenated values of MAC_L3_L4_Control0[L3HDBM0][1:0] and MAC_L3_L4_Control0[L3HSBM0]: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked • .. • 127: All bits except MSb are masked. This field is valid and applicable only when MAC_L3_L4_Control0[L3DAM0] or MAC_L3_L4_Control0[L3SAM0] is 1.
10-6 L3HSBM2	Layer 3 IP SA Higher Bits Match 2 IPv4 packets: This field contains the number of lower bits of IP SA that are masked for matching in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 31: All bits except MSb are masked. IPv6 packets: This field contains bits [4:0] of MAC_L3_L4_Control0[L3HSBM0]. These bits indicate the number of higher bits of IP SA or DA matched in the IPv6 packets. The field is valid and applicable only when MAC_L3_L4_Control0[L3DAM0] or MAC_L3_L4_Control0[L3SAM0] is 1.
5 L3DAIM2	Layer 3 IP DA Inverse Match Enable 2 Indicates the status of layer 3 IP DA inverse matching.

Table continues on the next page...

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Field	Function
	• If this field is 1, layer 3 IP DA is enabled for inverse matching. • If this field is 0, layer 3 IP DA is enabled for perfect matching. This field is valid and applicable only if MAC_L3_L4_Control0[L3DAM0] = 1. 0b - Disabled 1b - Enabled
4 L3DAM2	Layer 3 IP DA Match Enable 2 Indicates the status of layer 3 IP DA matching. • If this field is 1, layer 3 IP DA is enabled for matching. • If this field is 0, MAC ignores layer 3 IP DA for matching. **NOTE** If MAC_L3_L4_Control0[L3PEN0] = 1, you must write 1 to either this field or to MAC_L3_L4_Control0[L3SAM0] because either the IPv6 DA or SA can be checked for filtering. 0b - Disabled 1b - Enabled
3 L3SAIM2	Layer 3 IP SA Inverse Match Enable 2 Indicates the status of layer 3 IP SA inverse matching. • If this field is 1, layer 3 IP SA is enabled for inverse matching. • If this field is 0, layer 3 IP SA is enabled for perfect matching. This field is valid and applicable only if MAC_L3_L4_Control0[L3SAM0] is 1. 0b - Disabled 1b - Enabled
2 L3SAM2	Layer 3 IP SA Match Enable 2 Indicates the status of layer 3 IP SA matching. • If this field is 1, layer 3 IP SA matching is enabled. • If this field is 0, MAC ignores layer 3 IP SA matching. **NOTE** If MAC_L3_L4_Control0[L3PEN0] = 1, you must write 1 to either this field or to MAC_L3_L4_Control0[L3DAM0] because either IPv6 SA or DA can be checked for filtering. 0b - Disabled 1b - Enabled
1 —	Reserved

Table continues on the next page...

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Field	Function
0 L3PEN2	Layer 3 Protocol Enable 2 Indicates the status of layer 3 protocol. • If this field is 1, the layer 3 IP SA or DA matching is enabled for IPv6 packets. • If this field is 0, the layer 3 IP SA or DA matching is enabled for IPv4 packets. The layer 3 matching is performed only when either MAC_L3_L4_Control0[L3SAM0] or MAC_L3_L4_Control0[L3DAM0] is 1. 0b - Disabled 1b - Enabled

78.17.137 MAC Layer 4 Address 2 (MAC_Layer4_Address2)

Offset

Register	Offset
MAC_Layer4_Address2	964h

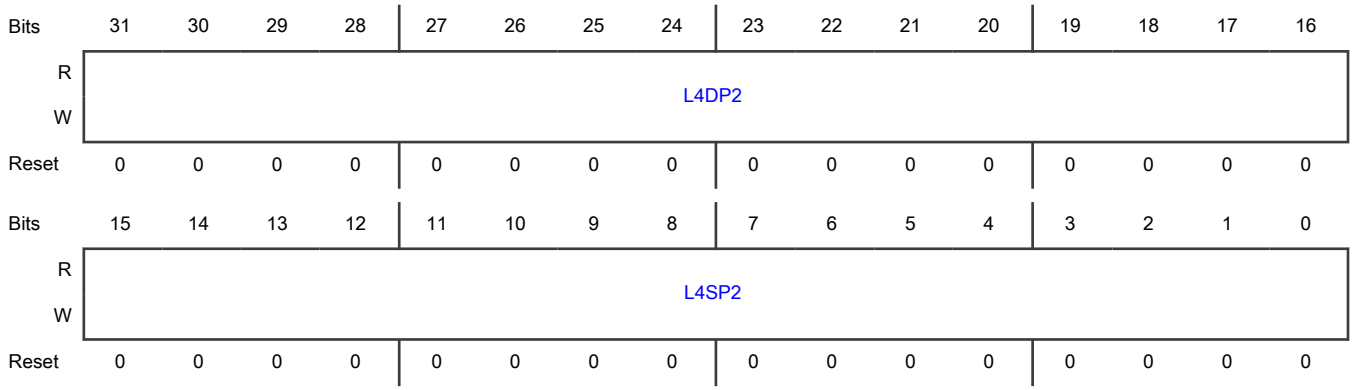
Function

Provides the layer 4 source and destination port numbers.

MAC Layer 4 Address 1 (MAC_Layer4_Address1), MAC L3 L4 Control 1 (MAC_L3_L4_Control1), MAC Layer 3 Address 0 Reg 1 (MAC_Layer3_Addr0_Reg1), MAC Layer 3 Address 1 Reg 1 (MAC_Layer3_Addr1_Reg1), MAC Layer 3 Address 2 Reg 1 (MAC_Layer3_Addr2_Reg1), and MAC Layer 3 Address 3 Reg 1 (MAC_Layer3_Addr3_Reg1) are reserved registers (RO with a default value) if the enable layer 3 and layer 4 packet filter option is not selected when configuring the core.

You can configure the layer 3 and layer 4 address registers to be double-synchronized by selecting the synchronize layer 3 and layer 4 address registers to the receive clock domain option while configuring the core. When you select this option, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of the layer 3 and layer 4 address registers are written to. For proper synchronization updates, you must perform consecutive writes to the same layer 3 and layer 4 address registers after a delay of at least four destination clock cycles.

Diagram



Fields

Field	Function
31-16 L4DP2	Layer 4 Destination Port Number 2 Indicates layer 4 destination port number. If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4DPM0] = 1, this field contains the value to be matched with the TCP destination port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4DPM0] are 1, this field contains the value to be matched with the UDP destination port number field in the IPv4 or IPv6 packets.
15-0 L4SP2	Layer 4 Source Port Number 2 Indicates layer 4 source port number. If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4SPM0] = 1, this field contains the value to be matched with the TCP source port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4SPM0] are 1, this field contains the value to be matched with the UDP source port number field in the IPv4 or IPv6 packets.

78.17.138 MAC Layer 3 Address 0 Reg 2 (MAC_Layer3_Addr0_Reg2)

Offset

Register	Offset
MAC_Layer3_Addr0_Reg2	970h

Function

Contains the 32-bit IP source address field for IPv4 packets. For IPv6 packets, the field contains bits [31:0] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A02															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A02															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A02	Layer 3 Address 0 Indicates layer 3 address 0. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.139 MAC Layer 3 Address 1 Reg 2 (MAC_Layer3_Addr1_Reg2)

Offset

Register	Offset
MAC_Layer3_Addr1_Reg2	974h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits[63:32] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A12															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A12															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A12	Layer 3 Address 1 Indicates layer 3 address 1.

Table continues on the next page...

Field	Function
	• If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.140 MAC Layer 3 Address 2 Reg 2 (MAC_Layer3_Addr2_Reg2)

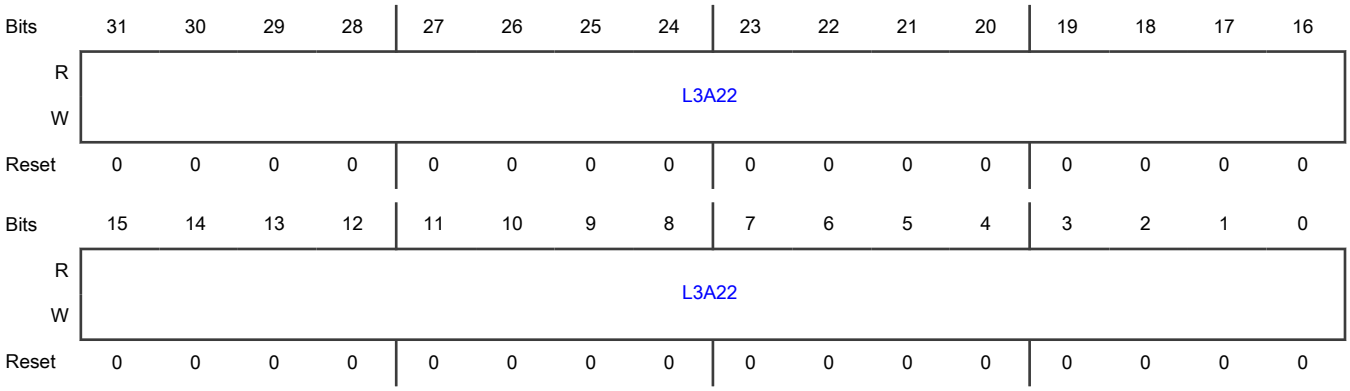
Offset

Register	Offset
MAC_Layer3_Addr2_Reg2	978h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [95:64] of the 128-bit IP source address or destination address field.

Diagram



Fields

Field	Function
31-0 L3A22	Layer 3 Address 2 Indicates layer 3 address 2. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.141 MAC Layer 3 Address 3 Reg 2 (MAC_Layer3_Addr3_Reg2)

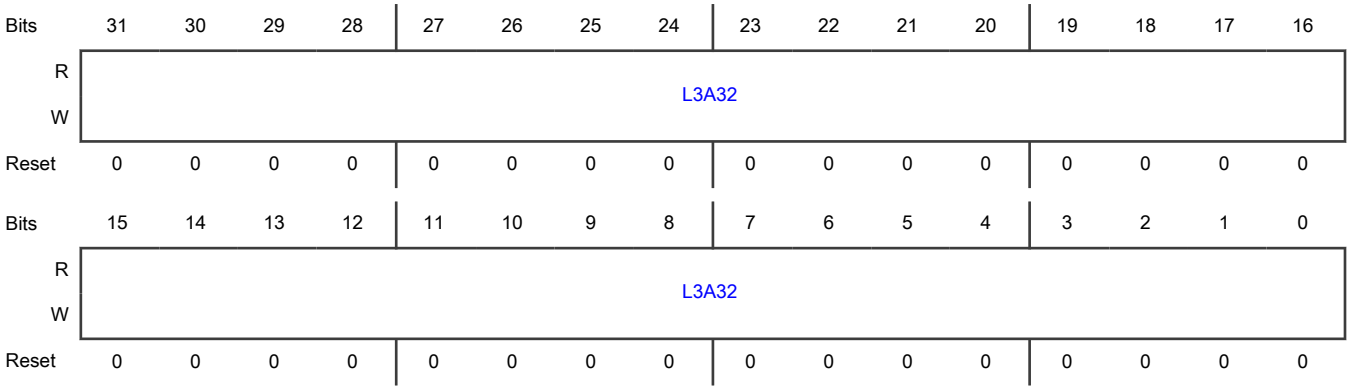
Offset

Register	Offset
MAC_Layer3_Addr3_Reg2	97Ch

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [127:96] of the 128-bit IP source address or destination address field.

Diagram



Fields

Field	Function
31-0 L3A32	Layer 3 Address 3 Indicates layer 3 address 3. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.142 MAC L3 L4 Control 3 (MAC_L3_L4_Control3)

Offset

Register	Offset
MAC_L3_L4_Control3	990h

Function

Controls the filter 0 operations of the layer 3 and layer 4 protocols.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved			DMCHEN3	Reserved			DMCHN3	Reserved		L4DPIM3	L4DPM3	L4SPIM3	L4SPM3	Reserved	L4PEN3
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3HDBM3				L3HSBM3						L3DAIM3	L3DAM3	L3SAIM3	L3SAM3	Reserved	L3PEN3
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved
28 DMCHEN3	DMA Channel Select Enable 3 Indicates the status of the DMA channel number. • If this field is 1, it enables the selection of the DMA channel number for the packet that the L3_L4 filter passes. The DMCHN fields indicate the DMA channel number. • If this field is 0, the filter does not decide the DMA channel number. 0b - Disabled 1b - Enabled
27-25 —	Reserved
24 DMCHN3	DMA Channel Number 2 Indicates the DMA channel number. If the value of the DMCHEN fields is 1, this field selects the DMA channel number to which the packet that this filter passes is routed. The width of this field depends on the number of the DMA channels present in your configuration.
23-22 —	Reserved
21 L4DPIM3	Layer 4 Destination Port Inverse Match Enable 3 Indicates the status of layer 4 destination port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4DP0] is enabled for perfect matching. This field is valid and applicable only when the L4DPM0 field is 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disabled 1b - Enabled
20 L4DPM3	Layer 4 Destination Port Match Enable 3 Indicates the status of layer 4 destination port matching. • If this field is 1, MAC_Layer4_Address0[L4DP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4DP0] for matching. 0b - Disabled 1b - Enabled
19 L4SPIM3	Layer 4 Source Port Inverse Match Enable 3 Indicates the status of layer 4 source port inverse matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for inverse matching. • If this field is 0, MAC_Layer4_Address0[L4SP0] is enabled for perfect matching. This field is valid and applicable only when MAC_Layer4_Address0[L4SP0] = 1. 0b - Disabled 1b - Enabled
18 L4SPM3	Layer 4 Source Port Match Enable 3 Indicates the status of layer 4 source port matching. • If this field is 1, MAC_Layer4_Address0[L4SP0] is enabled for matching. • If this field is 0, MAC ignores MAC_Layer4_Address0[L4SP0] for matching. 0b - Disabled 1b - Enabled
17 —	Reserved
16 L4PEN3	Layer 4 Protocol Enable 3 Indicates the status of layer 4 protocol. • If this field is 1, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] of UDP packets are used for matching. • If this field is 0, MAC_Layer4_Address0[L4SP0] and MAC_Layer4_Address0[L4DP0] of TCP packets are used for matching. Layer 4 matching is performed only when the L4SPM0 field or the L4DPM0 field is 1. 0b - Disabled 1b - Enabled

Table continues on the next page...

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Field	Function
15-11 L3HDBM3	Layer 3 IP DA Higher Bits Match 3 IPv4 Packets: This field contains the number of higher bits of IP DA that are matched in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 31: All bits except MSb are masked. IPv6 Packets: Bits [12:11] of this field correspond to bits [6:5] of MAC_L3_L4_Control0[L3HSBM0], which indicates the number of lower bits of IP SA or DA that are masked in the IPv6 packets. The following list describes the concatenated values of MAC_L3_L4_Control0[L3HDBM0][1:0] and MAC_L3_L4_Control0[L3HSBM0]: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked • .. • 127: All bits except MSb are masked. This field is valid and applicable only when MAC_L3_L4_Control0[L3DAM0] or MAC_L3_L4_Control0[L3SAM0] is 1. .
10-6 L3HSBM3	Layer 3 IP SA Higher Bits Match 3 IPv4 packets: This field contains the number of lower bits of IP SA that are masked for matching in the IPv4 packets. The following list describes the values of this field: • 0: No bits are masked. • 1: LSb[0] is masked. • 2: Two LSbs [1:0] are masked. • .. • 31: All bits except MSb are masked. IPv6 packets: This field contains bits [4:0] of MAC_L3_L4_Control0[L3HSBM0]. These bits indicate the number of higher bits of IP SA or DA matched in the IPv6 packets. The field is valid and applicable only when MAC_L3_L4_Control0[L3DAM0] or MAC_L3_L4_Control0[L3SAM0] is 1.
5	Layer 3 IP DA Inverse Match Enable 3

Table continues on the next page...

Table continued from the previous page...

Field	Function
L3DAIM3	Indicates the status of layer 3 IP DA inverse matching. • If this field is 1, layer 3 IP DA is enabled for inverse matching. • If this field is 0, layer 3 IP DA is enabled for perfect matching. This field is valid and applicable only if MAC_L3_L4_Control0[L3DAM0] = 1. 0b - Disabled 1b - Enabled
4 L3DAM3	Layer 3 IP DA Match Enable 3 Indicates the status of layer 3 IP DA matching. • If this field is 1, layer 3 IP DA is enabled for matching. • If this field is 0, MAC ignores layer 3 IP DA for matching. **NOTE** If MAC_L3_L4_Control0[L3PEN0] = 1, you must write 1 to either this field or to MAC_L3_L4_Control0[L3SAM0] because either the IPv6 DA or SA can be checked for filtering. 0b - Disabled 1b - Enabled
3 L3SAIM3	Layer 3 IP SA Inverse Match Enable 3 Indicates the status of layer 3 IP SA inverse matching. • If this field is 1, layer 3 IP SA is enabled for inverse matching. • If this field is 0, layer 3 IP SA is enabled for perfect matching. This field is valid and applicable only if MAC_L3_L4_Control0[L3SAM0] is 1. 0b - Disabled 1b - Enabled
2 L3SAM3	Layer 3 IP SA Match Enable 3 Indicates the status of layer 3 IP SA matching. • If this field is 1, layer 3 IP SA matching is enabled. • If this field is 0, MAC ignores layer 3 IP SA matching. **NOTE** If MAC_L3_L4_Control0[L3PEN0] = 1, you must write 1 to either this field or to MAC_L3_L4_Control0[L3DAM0] because either IPv6 SA or DA can be checked for filtering. 0b - Disabled 1b - Enabled
1	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
0 L3PEN3	Layer 3 Protocol Enable 3 Indicates the status of layer 3 protocol. • If this field is 1, the layer 3 IP SA or DA matching is enabled for IPv6 packets. • If this field is 0, the layer 3 IP SA or DA matching is enabled for IPv4 packets. The layer 3 matching is performed only when either MAC_L3_L4_Control0[L3SAM0] or MAC_L3_L4_Control0[L3DAM0] is 1. 0b - Disabled 1b - Enabled

78.17.143 MAC Layer 4 Address 3 (MAC_Layer4_Address3)

Offset

Register	Offset
MAC_Layer4_Address3	994h

Function

Provides the layer 4 source and destination port numbers.

MAC Layer 4 Address 1 (MAC_Layer4_Address1), MAC L3 L4 Control 1 (MAC_L3_L4_Control1), MAC Layer 3 Address 0 Reg 1 (MAC_Layer3_Addr0_Reg1), MAC Layer 3 Address 1 Reg 1 (MAC_Layer3_Addr1_Reg1), MAC Layer 3 Address 2 Reg 1 (MAC_Layer3_Addr2_Reg1), and MAC Layer 3 Address 3 Reg 1 (MAC_Layer3_Addr3_Reg1) are reserved registers (RO with a default value) if the enable layer 3 and layer 4 packet filter option is not selected when configuring the core.

You can configure the layer 3 and layer 4 address registers to be double-synchronized by selecting the synchronize layer 3 and layer 4 address registers to the receive clock domain option while configuring the core. When you select this option, the synchronization is triggered only when bits [31:24] (in Little-Endian mode) or bits [7:0] (in Big-Endian mode) of the layer 3 and layer 4 address registers are written to. For proper synchronization updates, you must perform consecutive writes to the same layer 3 and layer 4 address registers after a delay of at least four destination clock cycles.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L4DP3															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L4SP3															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 L4DP3	Layer 4 Destination Port Number 3 Indicates layer 4 destination port number. If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4DPM0] = 1, this field contains the value to be matched with the TCP destination port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4DPM0] are 1, this field contains the value to be matched with the UDP destination port number field in the IPv4 or IPv6 packets.
15-0 L4SP3	Layer 4 Source Port Number 3 Indicates layer 4 source port number. If MAC_L3_L4_Control0[L4PEN0] = 0 and MAC_L3_L4_Control0[L4SPM0] = 1, this field contains the value to be matched with the TCP source port number field in the IPv4 or IPv6 packets. If MAC_L3_L4_Control0[L4PEN0] and MAC_L3_L4_Control0[L4SPM0] are 1, this field contains the value to be matched with the UDP source port number field in the IPv4 or IPv6 packets.

78.17.144 MAC Layer 3 Address 0 Reg 3 (MAC_Layer3_Addr0_Reg3)

Offset

Register	Offset
MAC_Layer3_Addr0_Reg3	9A0h

Function

Contains the 32-bit IP source address field for IPv4 packets. For IPv6 packets, the field contains bits [31:0] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A03															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A03															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A03	Layer 3 Address 0 Indicates layer 3 address 0. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [31:0] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.145 MAC Layer 3 Address 1 Reg 3 (MAC_Layer3_Addr1_Reg3)

Offset

Register	Offset
MAC_Layer3_Addr1_Reg3	9A4h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [63:32] of the 128-bit IP source address or destination address field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	L3A13															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	L3A13															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 L3A13	Layer 3 Address 1 Indicates layer 3 address 1.

Table continues on the next page...

Field	Function
	• If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [63:32] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, and MAC_L3_L4_Control0[L3SAM0] = 1, this field contains the value to be matched with the IP source address field in the IPv4 packets.

78.17.146 MAC Layer 3 Address 2 Reg 3 (MAC_Layer3_Addr2_Reg3)

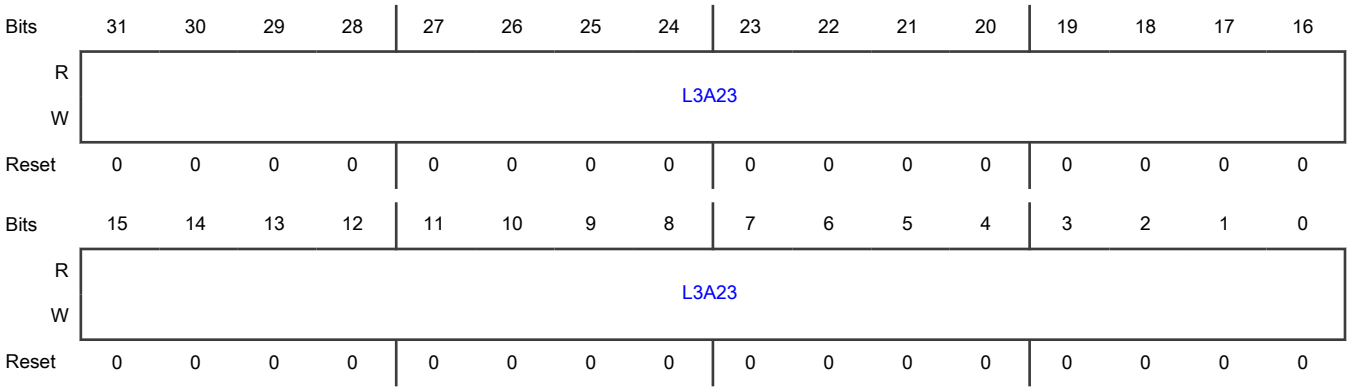
Offset

Register	Offset
MAC_Layer3_Addr2_Reg3	9A8h

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [95:64] of the 128-bit IP source address or destination address field.

Diagram



Fields

Field	Function
31-0 L3A23	Layer 3 Address 2 Indicates layer 3 address 2. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [95:64] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.147 MAC Layer 3 Address 3 Reg 3 (MAC_Layer3_Addr3_Reg3)

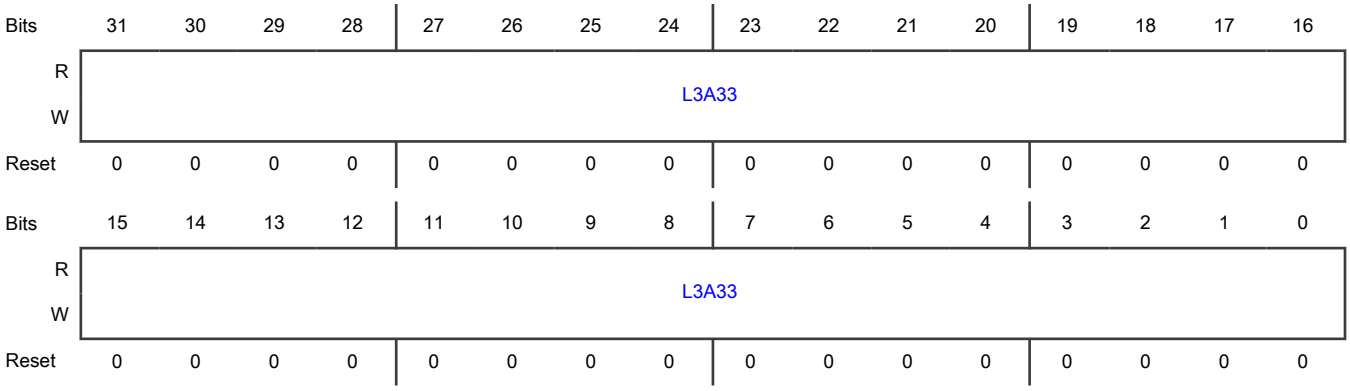
Offset

Register	Offset
MAC_Layer3_Addr3_Reg3	9ACh

Function

Contains the 32-bit IP destination address field for IPv4 packets. For IPv6 packets, the field contains bits [127:96] of the 128-bit IP source address or destination address field.

Diagram



Fields

Field	Function
31-0 L3A33	Layer 3 Address 3 Indicates layer 3 address 3. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3SAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP source address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] and MAC_L3_L4_Control0[L3DAM0] are 1, this field contains the value to be matched with bits [127:96] of the IP destination address field in the IPv6 packets. • If MAC_L3_L4_Control0[L3PEN0] = 0, this field is not used.

78.17.148 MAC Timestamp Control (MAC_Timestamp_Control)

Offset

Register	Offset
MAC_Timestamp_Control	B00h

Function

Controls the operation of the system time generator and processing of PTP packets for timestamping in the receiver.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved			AV8021A...	Reserved			TXTSSTSM	Reserved			ESTI	Reserved	TSENMAC...	SNAPTYPSEL	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSMSTRE...	TSEVNTE...	TSIPV4E...	TSIPV6E...	TSIPENA	TSVER2E...	TSCTRLS...	TSENALL	Reserved	PTGE	TSADDREG	Reserved	TSUPDT	TSINIT	TSCFUPDT	TSENA
Reset	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved
28 AV8021ASMEN	AV 802.1AS Mode Enable Indicates the status of AV 802.1AS mode. If this field is 1, MAC processes only untagged PTP over Ethernet packets for providing PTP status and capturing timestamp snapshots, which means using the IEEE 802.1AS mode of operation. If MAC_HW_Feature1[PTOEN] = 1, for the purpose of PTP offload, the transport-specific field in the PTP header is generated and checked based on the value of the AV8021ASMEN field. 0b - Disabled 1b - Enabled
27-25 —	Reserved
24 TXTSSTSM	Transmit Timestamp Status Mode Indicates the status of transmit timestamp status mode. • If this field is 1, MAC overwrites the previous transmit timestamp status even if the software does not read it. MAC indicates this by writing 1 to MAC_Tx_Timestamp_Status_Nanoseconds[TXTSSMIS]. • If this field is 0, MAC ignores the timestamp status of the current packet if the software does not read the timestamp status of the previous packet. MAC indicates this by writing 1 to MAC_Tx_Timestamp_Status_Nanoseconds[TXTSSMIS]. 0b - Disabled 1b - Enabled

Table continues on the next page...

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Field	Function
23-21 —	Reserved
20 ESTI	External System Time Input Indicates the status of external system time input. If this field is 1, MAC uses the external 64-bit reference system time input for these functions: • To consider the timestamp provided as status • To insert the timestamp in transmit PTP packets if the one-step timestamp or the timestamp offload feature is enabled If this field is 1, MAC uses the internal reference system time. 0b - Disabled 1b - Enabled
19 —	Reserved
18 TSENMACADDR	Enable MAC Address For PTP Packet Filtering Indicates whether the MAC address for PTP packet filtering is enabled. If this field is 1, the DA MAC address, which matches any MAC Address register, is used to filter the PTP packets when PTP is directly sent over Ethernet. If this field is 1, received PTP packets with DA containing a special multicast or unicast address that matches the one programmed in the MAC address registers are considered for processing when PTP is directly sent over Ethernet. • For a normal time stamping operation, MAC address registers 0 to 31 are considered for unicast destination address matching. • For PTP offload, only MAC address register 0 is considered for unicast destination address matching. 0b - Disabled 1b - Enabled
17-16 SNAPTYPSEL	Select PTP Packets For Taking Snapshots Determines the set of PTP packet types for which a snapshot needs to be taken. This field, along with the TSEVNTENA and TSMSTRENA fields, determines the set of PTP packet types for which a snapshot needs to be taken. See Receive path functions for encoding.
15 TSMSTRENA	Enable Snapshot For Messages Relevant To Master Indicates whether the snapshot for messages relevant to master is enabled. If this field is 1, the snapshot is taken only for the messages that are relevant to the master node. Otherwise, the snapshot is taken for the messages relevant to the slave node.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
14 TSEVNTENA	Enable Timestamp Snapshot For Event Messages Enables or disables timestamp snapshot for event messages. If this field is 1, the timestamp snapshot is taken only for event messages (SYNC, Delay_Req, Pdelay_Req, or Pdelay_Resp). When the field becomes 0, the snapshot is taken for all the messages except Announce, Management, and Signaling. For more information on timestamp snapshot dependency on register bits, see Receive path functions. 0b - Disabled 1b - Enabled
13 TSIPV4ENA	Enable Processing Of PTP Packets Sent Over IPv4-UDP Indicates whether the processing of PTP packets sent over IPv4-UDP is enabled. If this field is 1, the MAC receiver processes the PTP packets encapsulated in the IPv4-UDP packets. When this field becomes 0, MAC ignores the PTP transported over the IPv4-UDP packets. The default value of this field is 1. 0b - Disabled 1b - Enabled
12 TSIPV6ENA	Enable Processing Of PTP Packets Sent Over IPv6-UDP Indicates whether the processing of PTP packets sent over IPv6-UDP is enabled. If this field is 1, the MAC receiver processes the PTP packets encapsulated in the IPv6-UDP packets. If the value is 0, MAC ignores the PTP transported over IPv6-UDP packets. 0b - Disabled 1b - Enabled
11 TSIPENA	Enable Processing Of PTP Over Ethernet Packets Indicates the status of PTP processing over Ethernet packets. If this field is 1, the MAC receiver processes the PTP packets encapsulated directly in the Ethernet packets. When the field becomes 0, MAC ignores the PTP over Ethernet packets. 0b - Disabled 1b - Enabled
10 TSVER2ENA	Enable PTP Packet Processing For Version 2 Format Indicates the status of PTP packet processing for version 2 format. If this field is 1, the IEEE 1588 version 2 format is used to process the PTP packets. When this field becomes 0, the IEEE 1588 version 1 format is used to process the PTP packets. See PTP processing and control for more information on the IEEE 1588 formats.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
9 TSCTRLSSR	Timestamp Digital Or Binary Rollover Control Indicates the status of timestamp digital or binary rollover control. • If this field is 1, the Timestamp Low register rolls over after the 3B9A_C9FFh value (that is, 1 nanosecond accuracy) and increments the timestamp (high) seconds. • If this field is 0, the rollover value of the Subsecond register is 7FFF_FFFFh. The sub-second increment must be programmed correctly depending on the PTP reference clock frequency and the value of this field. 0b - Disabled 1b - Enabled
8 TSENALL	Enable Timestamp For All Packets Indicates the status of timestamp snapshot for all packets. If this field is 1, the timestamp snapshot is enabled for all packets that MAC receives. 0b - Disabled 1b - Enabled
7 —	Reserved
6 PTGE	Presentation Time Generation Enable Indicates the status of presentation time generation. If this field is 1, the presentation time generation is enabled. 0b - Disabled 1b - Enabled
5 TSADDREG	Update Addend Register Indicates whether MAC Timestamp Addend (MAC_Timestamp_Addend) is updated. If this field is 1, the contents of MAC Timestamp Addend (MAC_Timestamp_Addend) are updated in the PTP block for fine correction. The field becomes 0 after the update completes. The value of the field must also be 0 before you write 1 to it. Access restrictions apply to this field that clears automatically. Writing 0 has no effect. 0b - Not updated 1b - Updated
4 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 TSUPDT	Update Timestamp Indicates whether the timestamp is updated. If this field is 1, the system time is updated (added or subtracted) with the value specified in MAC System Time Seconds Update (MAC_System_Time_Seconds_Update) and MAC System Time Nanoseconds Update (MAC_System_Time_Nanoseconds_Update). The value of this field must be 0 before you update it. It resets after the update is complete in hardware. MAC_System_Time_Higher_Word_Seconds[TSHWR], if enabled during core configuration, is not updated. When media clock generation and recovery is configured (DWC_EQOS_FLEXI_PPS_OUT_EN) and enabled, MAC Presentation Time Update (MAC_Presn_Time_Updt) must also be updated before you write 1 to this field. Access restrictions apply to this field that clears automatically. Writing 0 has no effect. 0b - Not updated 1b - Updated
2 TSINIT	Initialize Timestamp Indicates whether the timestamp is initialized. If this field is 1, the system time is initialized (overwritten) with the value specified in MAC System Time Seconds Update (MAC_System_Time_Seconds_Update) and MAC System Time Nanoseconds Update (MAC_System_Time_Nanoseconds_Update). The value of this field must be 0 before you update it, and the field is reset after the initialization is complete. MAC_System_Time_Higher_Word_Seconds[TSHWR], if enabled during core configuration, can only be initialized. When media clock generation and recovery is configured (DWC_EQOS_FLEXI_PPS_OUT_EN) and enabled, MAC Presentation Time Update (MAC_Presn_Time_Updt) must also be updated before you write 1 to this field. Access restrictions apply to this field that clears automatically. Writing 0 has no effect. 0b - Not initialized 1b - Initialized
1 TSCFUPDT	Fine Or Coarse Timestamp Update Indicates the method used to update system timestamp. • If this field is 1, the fine method is used to update system timestamp. • If this field is 0, the coarse method is used to update the system timestamp. 0b - Coarse method 1b - Fine method
0 TSENA	Timestamp Enable Enables or disables timestamp for transmit and receive packets.

Table continues on the next page...

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Field	Function
	• If this field is 1, the timestamp is added for transmit and receive packets. • If this field is 0, timestamp is not added for transmit and receive packets and the timestamp generator is also suspended. You need to initialize the timestamp (system time) after enabling this mode. On the receive side, MAC processes the 1588 packets only if this field is 1. 0b - Disabled 1b - Enabled

78.17.149 MAC Sub Second Increment (MAC_Sub_Second_Increment)

Offset

Register	Offset
MAC_Sub_Second_Increment	B04h

Function

Specifies the value to be added to the internal system time register at every cycle of the CLK_PTP_REF_I clock.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved								SSINC							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	SNSINC								Reserved							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23-16 SSINC	Sub-Second Increment Value

Table continues on the next page...

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Field	Function
	Contains the sub-second increment value, which accumulates every clock cycle (of clk_ptp_i) with the contents of the Subsecond register. For example, if the PTP clock is 50 MHz (period is 20 ns), you must program 20 (14h) when MAC System Time In Nanoseconds (MAC_System_Time_Nanoseconds) has an accuracy of 1 ns (MAC_Timestamp_Control[TSCTRLSSR] = 1). When TSCTRLSSR = 0, the Nanoseconds register has a resolution of ~0.465 ns. In this case, you must program a value of 43 (2Bh), which is derived by 20 ns/0.465.
15-8 SNSINC	Sub-Nanosecond Increment Value Contains the sub-nanosecond increment value, represented in nanoseconds multiplied by 2^8. This value is accumulated in the sub-nanoseconds field of the Subsecond register. For example, if MAC_Timestamp_Control[TSCTRLSSR] = 1, and if the required increment is 5.3 ns, then this field must be 4Ch and the SSINC field must be 05h.
7-0 —	Reserved

78.17.150 MAC System Time In Seconds (MAC_System_Time_Seconds)

Offset

Register	Offset
MAC_System_Time_Seconds	B08h

Function

Indicates, along with MAC System Time In Nanoseconds (MAC_System_Time_Nanoseconds), the current value of the system time that MAC maintains. Although it is updated on a continuous basis, there is some delay from the actual time because of clock domain transfer latencies (from CLK_PTP_REF_I to the CSR clock).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TSS															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TSS															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSS	Timestamp Second Indicates the current value, in seconds, of the system time that MAC maintains.

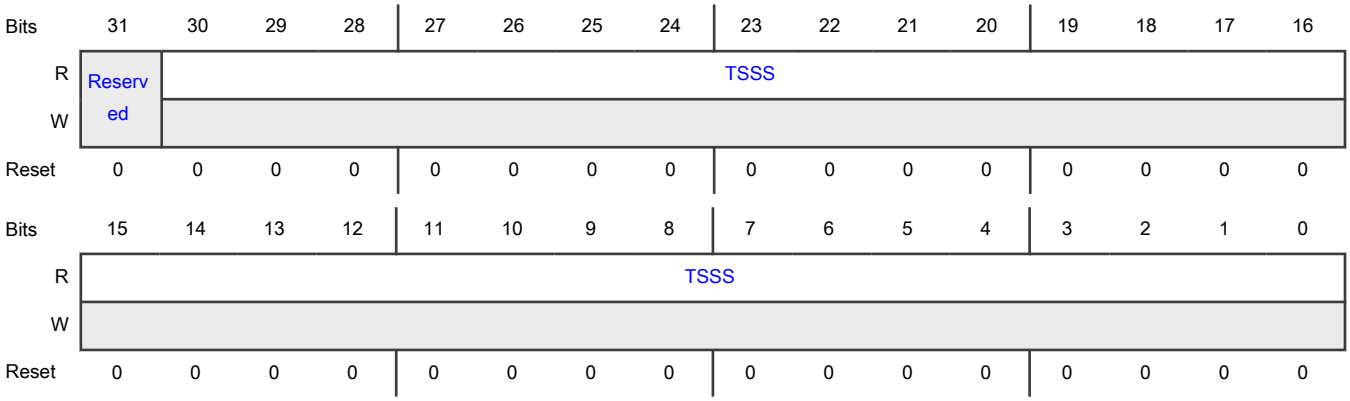
78.17.151 MAC System Time In Nanoseconds (MAC_System_Time_Nanoseconds)

Offset

Register	Offset
MAC_System_Time_Nanoseconds	B0Ch

Function
Indicates, along with MAC System Time In Seconds (MAC_System_Time_Seconds), the current value of the system time that MAC maintains.

Diagram



Fields

Field	Function
31 —	Reserved
30-0 TSSS	Timestamp Sub Seconds Indicates the sub-second representation of time, with an accuracy of 0.46 ns. When MAC_Timestamp_Control[TSCTRLSSR] = 1, each bit represents 1 ns. The maximum value is 3B9A_C9FFh after which it rolls over to 0.

78.17.152 MAC System Time Seconds Update (MAC_System_Time_Seconds_Update)

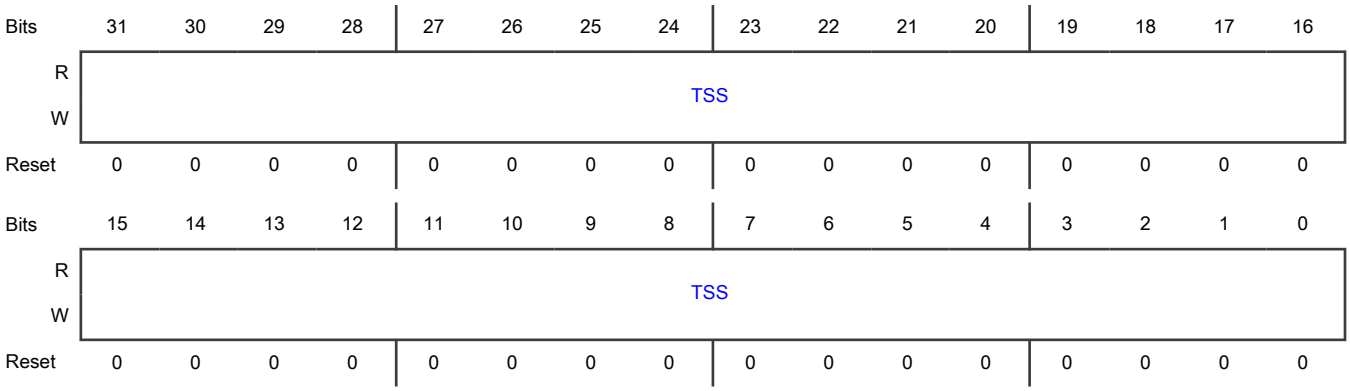
Offset

Register	Offset
MAC_System_Time_Seconds_Update	B10h

Function

Initializes or updates, along with MAC System Time Nanoseconds Update (MAC_System_Time_Nanoseconds_Update), the system time that MAC maintains. You must write both to this register and the MAC System Time Nanoseconds Update register before writing 1 to MAC_Timestamp_Control[TSINIT] and MAC_Timestamp_Control[TSUPDT].

Diagram



Fields

Field	Function
31-0 TSS	Timestamp Seconds Indicates the timestamp seconds value. The value in this field is the seconds part of the update. • If MAC_System_Time_Nanoseconds_Update[ADDSUB] = 0, this field must be programmed with the seconds part of the update value. • If MAC_System_Time_Nanoseconds_Update[ADDSUB] = 1, this field must be programmed with the complement of the seconds part of the update value. For example, if 2.000000001 seconds need to be subtracted from the system time, MAC_System_Time_Seconds[TSS] must be FFFF_FFFEh (that is, 2^32 - 2).

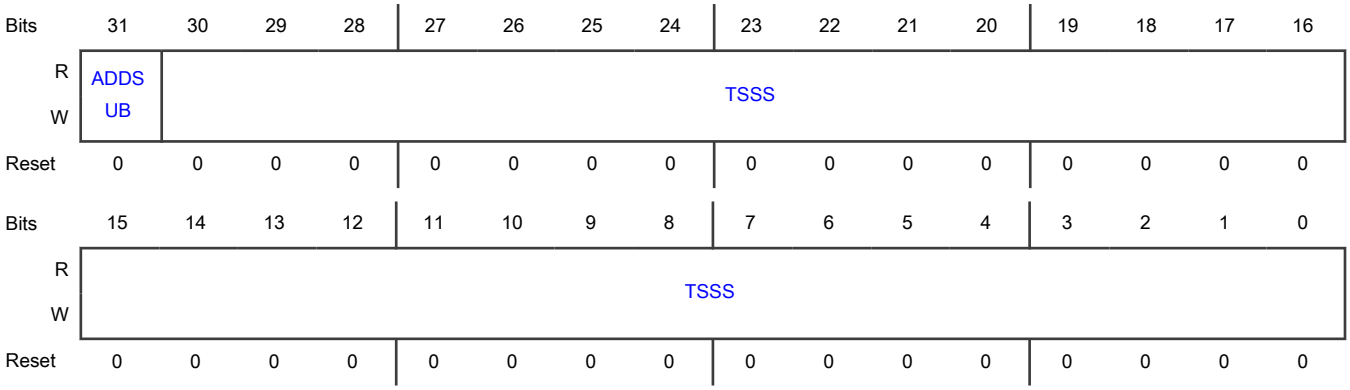
78.17.153 MAC System Time Nanoseconds Update (MAC_System_Time_Nanoseconds_Update)

Offset

Register	Offset
MAC_System_Time_Nanoseconds_Update	B14h

Function
Indicates system time nanoseconds update.

Diagram



Fields

Field	Function
31 ADDSUB	Add Or Subtract Time Indicates whether the time value is added or subtracted from the contents of the update register. • If this field is 1, the time value is subtracted from the contents of the update register. • If this field is 0, the time value is added to the contents of the update register. 0b - Add time 1b - Subtract time
30-0 TSSS	Timestamp Subseconds Indicates the sub-second part of the update. • If ADDSUB = 0, this field must be programmed with the sub-second part of the update value, with an accuracy based on MAC_Timestamp_Control[TSCTRLSSR]. • If ADDSUB = 0, this field must be programmed with the complement of the sub-second part of the update value as described below. • If MAC_Timestamp_Control[TSCTRLSSR] = 1, the programmed value must be 10^9 - <sub-second value>, and if MAC_Timestamp_Control[TSCTRLSSR] = 0, the programmed value must be 2^31 - <sub-second_value>.

Table continues on the next page...

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Field	Function
	• If MAC_Timestamp_Control[TSCTRLSSR] = 0, each bit of it represents an accuracy of 0.46 ns, and if MAC_Timestamp_Control[TSCTRLSSR] = 1, each bit represents 1 ns and the programmed value must not exceed 3B9A_C9FFh. For example, if 2.000000001 seconds need to be subtracted from the system time, this field must be 7FFF_FFFFh (that is, 2^31 - 1) if MAC_Timestamp_Control[TSCTRLSSR] = 0. This field must be 3B9A_C9FFh (that is, 10^9 - 1) if MAC_Timestamp_Control[TSCTRLSSR] = 1.

78.17.154 MAC Timestamp Addend (MAC_Timestamp_Addend)

Offset

Register	Offset
MAC_Timestamp_Addend	B18h

Function

Is used only when the system time is configured for Fine Update mode (MAC_Timestamp_Control[TSINIT] = 1). The contents of this register are added to a 32-bit accumulator in every clock cycle (of CLK_PTP_REF_I), and the system time is updated whenever the accumulator overflows.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSAR	Timestamp Addend Register Indicates the 32-bit time value to be added to the Accumulator register to achieve time synchronization.

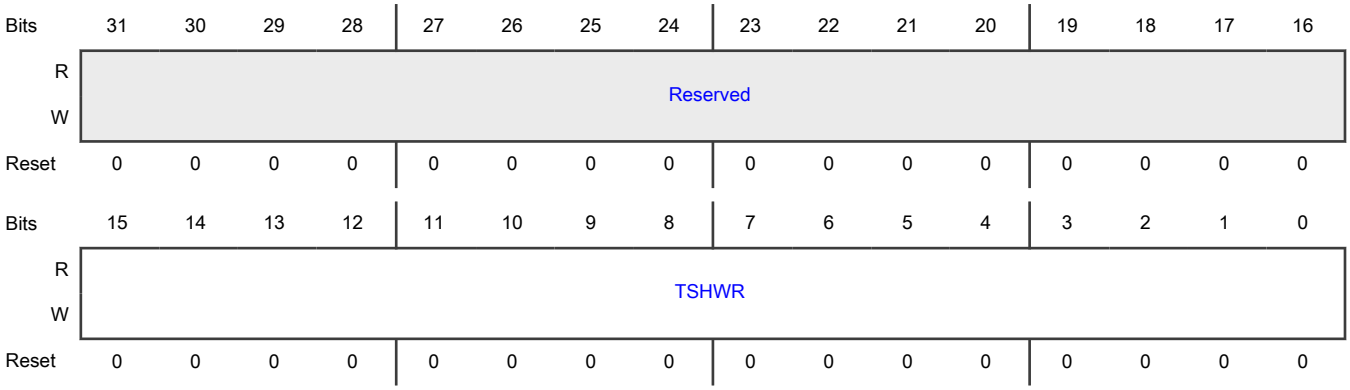
78.17.155 MAC System Time Higher Word In Seconds (MAC_System_Time_Higher_Word_Seconds)

Offset

Register	Offset
MAC_System_Time_Higher_Word_Seconds	B1Ch

Function
Indicates system time - higher word in seconds.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 TSHWR	Timestamp Higher Word Register Contains the most-significant 16 bits of the timestamp seconds value. This register is optional, and you can add it if you select the IEEE 1588 higher-word register option. You write to this register directly to initialize the value, which increments when there is an overflow from the 32 bits of MAC System Time In Seconds (MAC_System_Time_Seconds). Access restrictions apply to this field, which updates based on an event occurrence.

78.17.156 MAC Timestamp Status (MAC_Timestamp_Status)

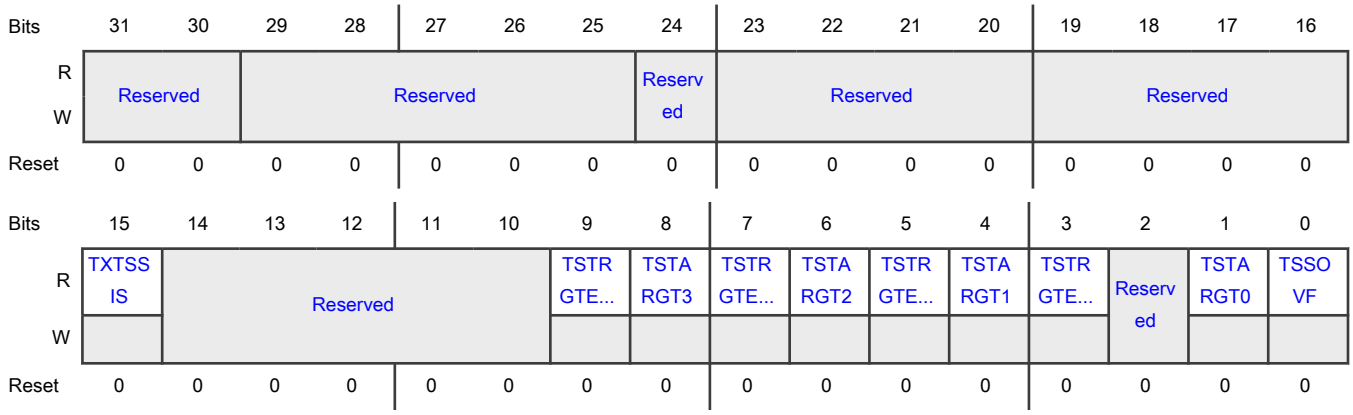
Offset

Register	Offset
MAC_Timestamp_Status	B20h

Function

Indicates timestamp status. All the bits except [27:25] are cleared when the application reads this register.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-25 —	Reserved
24 —	Reserved
23-20 —	Reserved
19-16 —	Reserved
15 TXTSSIS	Transmit Timestamp Status Interrupt Status Indicates whether the transmit timestamp interrupt status is detected. In non-EQOS_CORE configurations, if the drop transmit status is enabled in MTL, this field becomes 1 when the captured transmit timestamp is updated in MAC Transmit Timestamp Status In Seconds (MAC_Tx_Timestamp_Status_Seconds) and MAC Transmit Timestamp Status In Nanoseconds (MAC_Tx_Timestamp_Status_Nanoseconds). If MAC_HW_Feature1[PTOEN] = 1, TXTSSIS becomes 1 when the captured transmit timestamp is updated in MAC Transmit Timestamp Status In Seconds (MAC_Tx_Timestamp_Status_Seconds) and MAC Transmit Timestamp Status In Nanoseconds (MAC_Tx_Timestamp_Status_Nanoseconds) for PTO-generated delay request and Pdelay request packets.

Table continues on the next page...

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Field	Function
	This field becomes 0 if you read or write to MAC Transmit Timestamp Status In Seconds (MAC_Tx_Timestamp_Status_Seconds) when MAC_CSR_SW_Ctrl[RCWE] = 1. 0b - Not detected 1b - Detected
14-10 —	Reserved
9 TSTRGTERR3	Timestamp Target Time Error Indicates whether the timestamp target time error status is detected. This field becomes 1 if the latest target time programmed in MAC PPS3 Target Time In Seconds (MAC_PPS3_Target_Time_Seconds) and MAC PPS3 Target Time In Nanoseconds (MAC_PPS3_Target_Time_Nanoseconds) elapses. The field becomes 0 when the application reads it. Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
8 TSTARGT3	Timestamp Target Time Reached For Target Time PPS3 Indicates whether the timestamp target time reached for target time PPS3 status is detected. If this field is 1, it indicates that the value of the system time is greater than or equal to the value specified in MAC PPS3 Target Time In Seconds (MAC_PPS3_Target_Time_Seconds) and MAC PPS3 Target Time In Nanoseconds (MAC_PPS3_Target_Time_Nanoseconds). Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
7 TSTRGTERR2	Timestamp Target Time Error Indicates whether the timestamp target time error status is detected. This field becomes 1 when the latest target time programmed in MAC PPS2 Target Time In Seconds (MAC_PPS2_Target_Time_Seconds) and MAC PPS2 Target Time In Nanoseconds (MAC_PPS2_Target_Time_Nanoseconds) elapses. The field becomes 0 when the application reads it. Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
6 TSTARGT2	Timestamp Target Time Reached For Target Time PPS2 Indicates whether the timestamp target time reached for the target time PPS2 status is detected.

Table continues on the next page...

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Field	Function
	If this field is 1, it indicates that the value of system time is greater than or equal to the value specified in MAC PPS2 Target Time In Seconds (MAC_PPS2_Target_Time_Seconds) and MAC PPS2 Target Time In Nanoseconds (MAC_PPS2_Target_Time_Nanoseconds). Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
5 TSTRGTERR1	Timestamp Target Time Error Indicates whether the timestamp target time error status is detected. This field becomes 1 when the latest target time programmed in MAC PPS1 Target Time In Seconds (MAC_PPS1_Target_Time_Seconds) and MAC PPS1 Target Time In Nanoseconds (MAC_PPS1_Target_Time_Nanoseconds) elapses. The field becomes 0 when the application reads it. Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
4 TSTARGT1	Timestamp Target Time Reached For Target Time PPS1 Indicates whether the timestamp target time reached for target time PPS1 status is detected. If this field is 1, it indicates that the value of system time is greater than or equal to the value specified in MAC PPS1 Target Time In Seconds (MAC_PPS1_Target_Time_Seconds) and MAC PPS1 Target Time In Nanoseconds (MAC_PPS1_Target_Time_Nanoseconds) Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
3 TSTRGTERR0	Timestamp Target Time Error Indicates whether the timestamp target time error status is detected. This field becomes 1 when the latest target time programmed in MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds) and MAC PPS0 Target Time In Nanoseconds (MAC_PPS0_Target_Time_Nanoseconds) elapses. The field becomes 0 when the application reads it. Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
2 —	Reserved

Table continues on the next page...

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Field	Function
1 TSTARGT0	Timestamp Target Time Reached Indicates whether the timestamp target time reached status is detected. If this field is 1, it indicates that the value of the system time is greater than or equal to the value specified in MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds) and MAC PPS0 Target Time In Nanoseconds (MAC_PPS0_Target_Time_Nanoseconds) Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
0 TSSOVF	Timestamp Seconds Overflow Indicates whether the timestamp seconds overflow status is detected. If this field is 1, it indicates that the seconds value of the timestamp (when supporting version 2 format) has overflowed beyond 32'hFFFF_FFFF. Access restrictions apply to this field that clears when read (or when this field is written to 1 if MAC_CSR_SW_Ctrl[RCWE] = 1). Also, the field automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected

78.17.157 MAC Transmit Timestamp Status In Nanoseconds (MAC_Tx_Timestamp_Status_Nanoseconds)

Offset

Register	Offset
MAC_Tx_Timestamp_Status_Nanoseconds	B30h

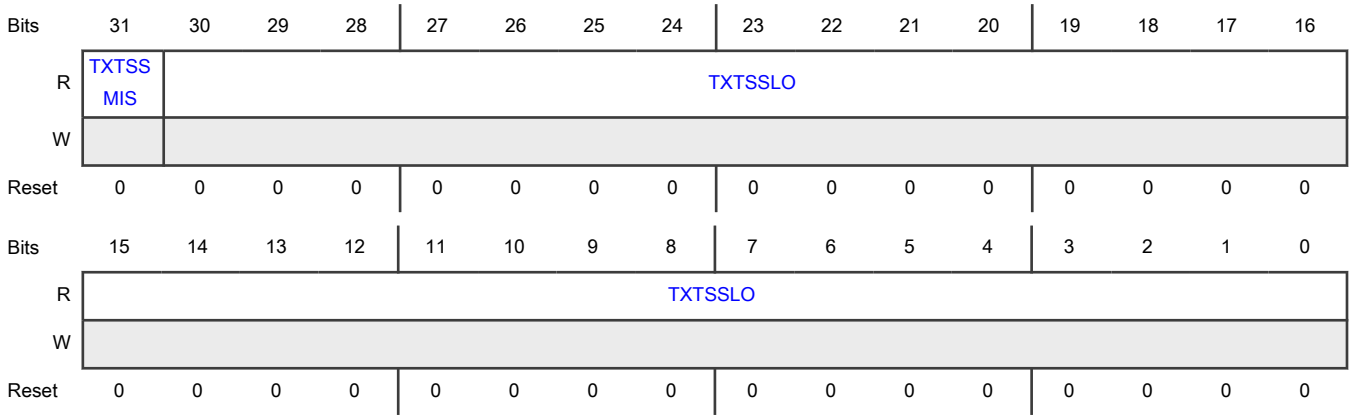
Function

Contains the nanosecond part of the timestamp captured for tansmit packets when the transmit status is disabled.

This register, along with MAC Transmit Timestamp Status In Seconds (MAC_Tx_Timestamp_Status_Seconds), gives the 64-bit timestamp captured for the PTP packet that MAC successfully transmits. The application considers reading this value after the last byte of this register is read. In Little-Endian mode, this means when bits [31:24] are read, and in Big-Endian mode, this means when bits [7:0] are read.

If the application does not read these registers and the timestamp of another packet is captured, then either the current timestamp is lost (overwritten) or the new timestamp is lost (dropped), depending on the settings specified in MAC_Timestamp_Control[TXTSSTSM]. The status bit TXTSC bit [15] in the MAC_Timestamp_Status register is set whenever the MAC transmitter captures the timestamp.

Diagram



Fields

Field	Function
31 TXTSSMIS	Transmit Timestamp Status Missed Indicates whether the transmit timestamp missed status is detected. If this field is 1, it indicates one of these conditions: • The timestamp of the current packet is ignored if MAC_Timestamp_Control[TXTSSTSM] = 0. • The timestamp of the previous packet is overwritten with the timestamp of the current packet if MAC_Timestamp_Control[TXTSSTSM] = 1. Access restrictions apply to this field that cleas on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
30-0 TXTSSLO	Transmit Timestamp Status Low Contains 31 bits of the Nanoseconds field of the transmit packet's captured timestamp.

78.17.158 MAC Transmit Timestamp Status In Seconds (MAC_Tx_Timestamp_Status_Seconds)

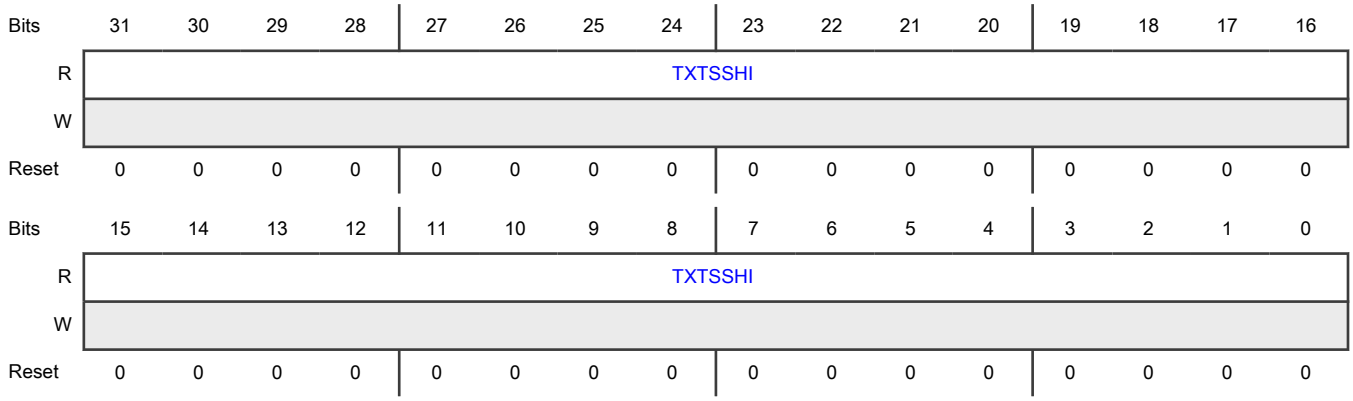
Offset

Register	Offset
MAC_Tx_Timestamp_Status_Seconds	B34h

Function

Contains the higher 32 bits of the timestamp (in seconds) captured when a PTP packet is transmitted.

Diagram



Fields

Field	Function
31-0 TXTSSHI	Transmit Timestamp Status High Contains the lower 32 bits of the Seconds field of the transmitted packet's captured timestamp.

78.17.159 MAC Timestamp Ingress Asymmetry Correction (MAC_Timestamp_Ingress_Asym_Corr)

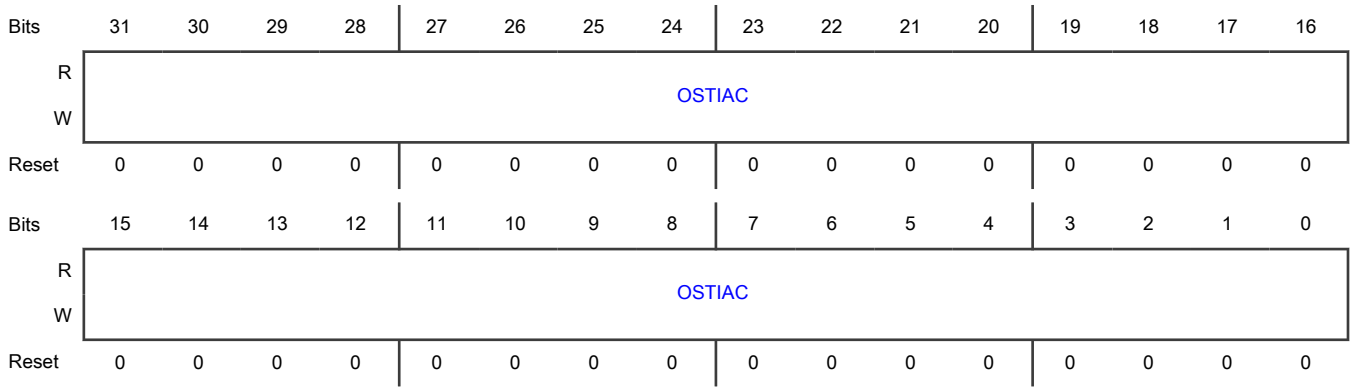
Offset

Register	Offset
MAC_Timestamp_Ingress_Asym_Corr	B50h

Function

Contains the ingress asymmetry correction value to be used when updating the correction field in the PDelay_Resp PTP messages.

Diagram



Fields

Field	Function
31-0 OSTIAC	One-Step Timestamp Ingress Asymmetry Correction Contains the ingress path asymmetry value to be added to the correctionField of the Pdelay_Resp PTP packet. The programmed value must be expressed in units of nanoseconds and multiplied by 2^16. For example, 2.5 ns is represented as 00028000h. This value can also be negative, which is represented in the two's-complement form with bit 31 representing the sign bit.

78.17.160 MAC Timestamp Egress Asymmetry Correction (MAC_Timestamp_Egress_Asym_Corr)

Offset

Register	Offset
MAC_Timestamp_Egress_Asym_Corr	B54h

Function

Contains the egress asymmetry correction value to be used when updating the correction field in the PDelay_Req PTP messages.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	OSTEAC															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	OSTEAC															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 OSTEAC	One-Step Timestamp Egress Asymmetry Correction Contains the egress path asymmetry value to be subtracted from the correctionField of the Pdelay_Resp PTP packet. The programmed value must be the negated value in units of nanoseconds multiplied by 2^16. For example, if the required correction is +2.5 ns, the programmed value must be FFFD_8000h, which is the two's-complement of 0002_8000h (2.5 * 216). Similarly, if the required correction is -3.3 ns, the programmed value is 0003_4CCCh (3.3 * 216).

78.17.161 MAC Timestamp Ingress Correction In Nanoseconds (MAC_Timestamp_Ingress_Corr_Nanosecond)

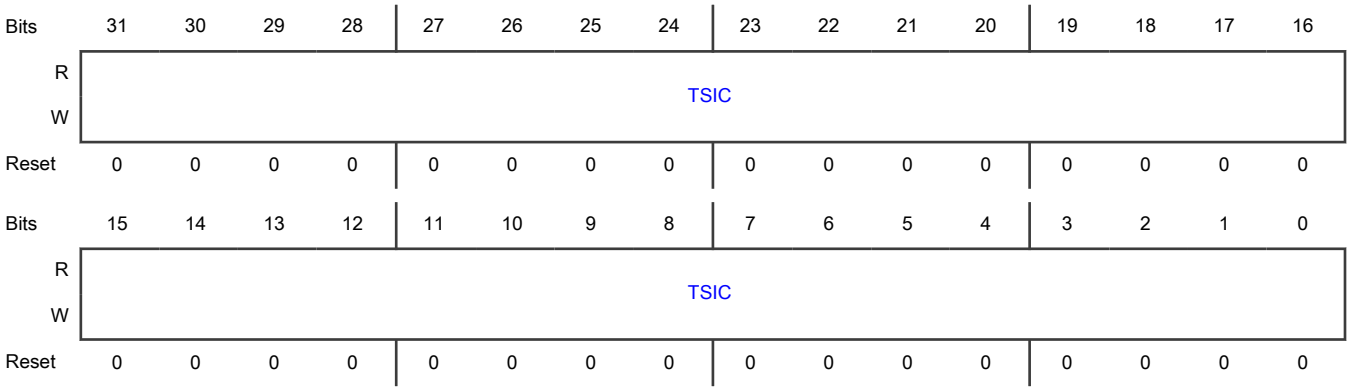
Offset

Register	Offset
MAC_Timestamp_Ingress_Corr_Nanosecond	B58h

Function

Contains the correction value, in nanoseconds, to be used with the captured timestamp value in the ingress path.

Diagram



Fields

Field	Function
31-0 TSIC	Timestamp Ingress Correction Contains the ingress path correction value as defined by the ingress correction expression.

78.17.162 MAC Timestamp Egress Correction In Nanoseconds (MAC_Timestamp_Egress_Corr_Nanosecond)

Offset

Register	Offset
MAC_Timestamp_Egress_Corr_Nanosecond	B5Ch

Function

Contains the correction value, in nanoseconds, to be used with the captured timestamp value in the egress path.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSEC															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSEC															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSEC	Timestamp Egress Correction Contains the nanoseconds part of the egress path correction value as defined by the egress correction expression.

78.17.163 MAC Timestamp Ingress Correction In Subnanoseconds (MAC_Timestamp_Ingress_Corr_Subnanosec)

Offset

Register	Offset
MAC_Timestamp_Ingress_Corr_Subnanosec	B60h

Function

Contains the sub-nanosecond part of the correction value to be used with the captured timestamp value for ingress direction.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSICSNS								Reserved							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-8 TSICSNS	Timestamp Ingress Correction In Sub-Nanoseconds Contains the sub-nanoseconds part of the ingress path correction value as defined by the Ingress Correction expression.
7-0 —	Reserved

78.17.164 MAC Timestamp Engress Correction In Subnanoseconds (MAC_Timestamp_Egress_Corr_Subnanosec)

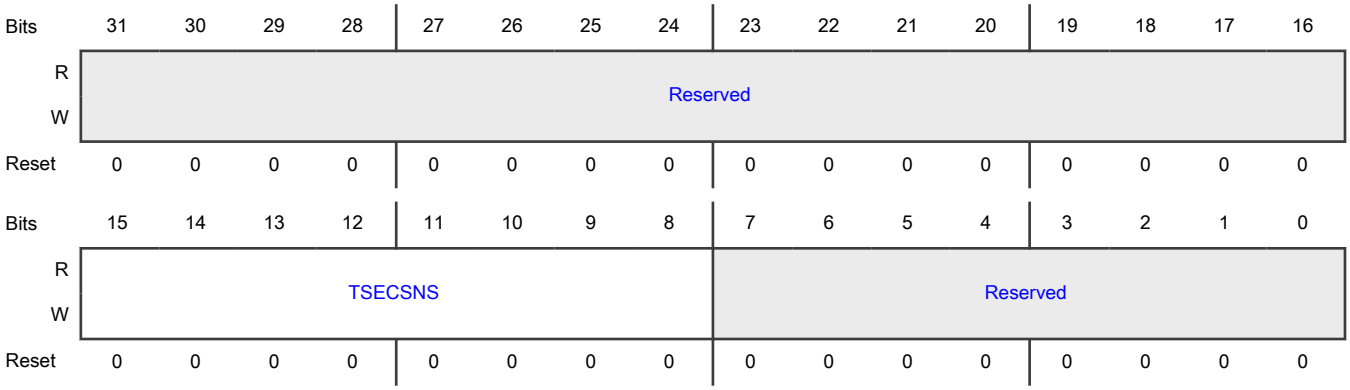
Offset

Register	Offset
MAC_Timestamp_Egress_Corr_Subnanosec	B64h

Function

Contains the sub-nanosecond part of the correction value to be used with the captured timestamp value for the egress direction.

Diagram



Fields

Field	Function
31-16	Reserved

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Field	Function
—	
15-8 TSECSNS	Timestamp Egress Correction In Sub-Nanoseconds Contains the sub-nanoseconds part of the egress path correction value, as defined by the Egress Correction expression.
7-0 —	Reserved

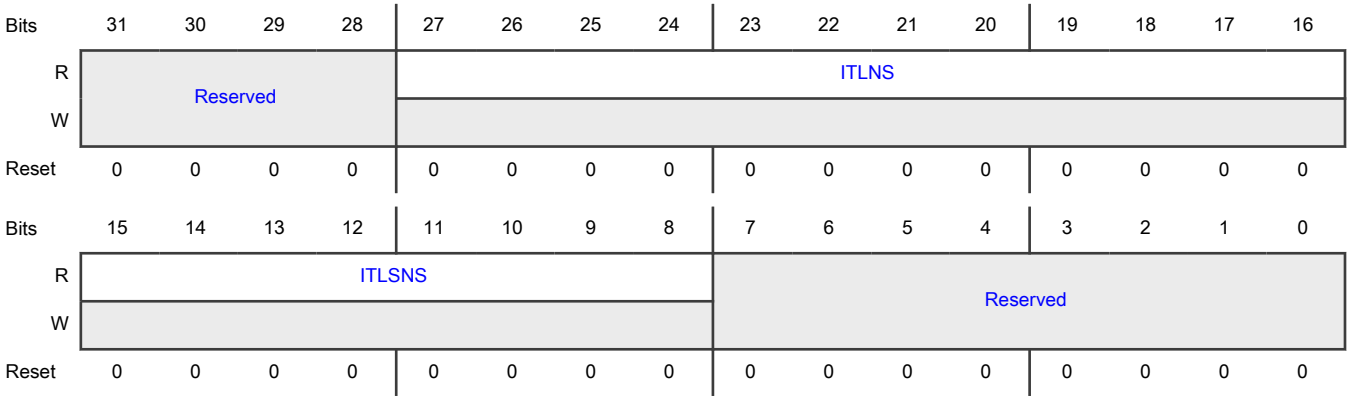
78.17.165 MAC Timestamp Ingress Latency (MAC_Timestamp_Ingress_Latency)

Offset

Register	Offset
MAC_Timestamp_Ingress_Latency	B68h

Function
Holds the ingress MAC latency.

Diagram



Fields

Field	Function
31-28 —	Reserved
27-16	Ingress Timestamp Latency In Sub-Nanoseconds

Table continues on the next page...

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Field	Function
ITLNS	Holds the average latency, in sub-nanoseconds, between the MAC input ports (PHY_RXD_I) and the actual point (GMII/MII), where the ingress timestamp is taken. The ingress correction value is computed as described in section 7.1.2.4.1 of QoS Databook.
15-8 ITLSNS	Ingress Timestamp Latency In Nanoseconds Holds the average latency, in nanoseconds, between the MAC input ports (PHY_RXD_I) and the actual point (GMII/MII), where the ingress timestamp is taken. The ingress correction value is computed as described in section 7.1.2.4.1 of QoS Databook.
7-0 —	Reserved

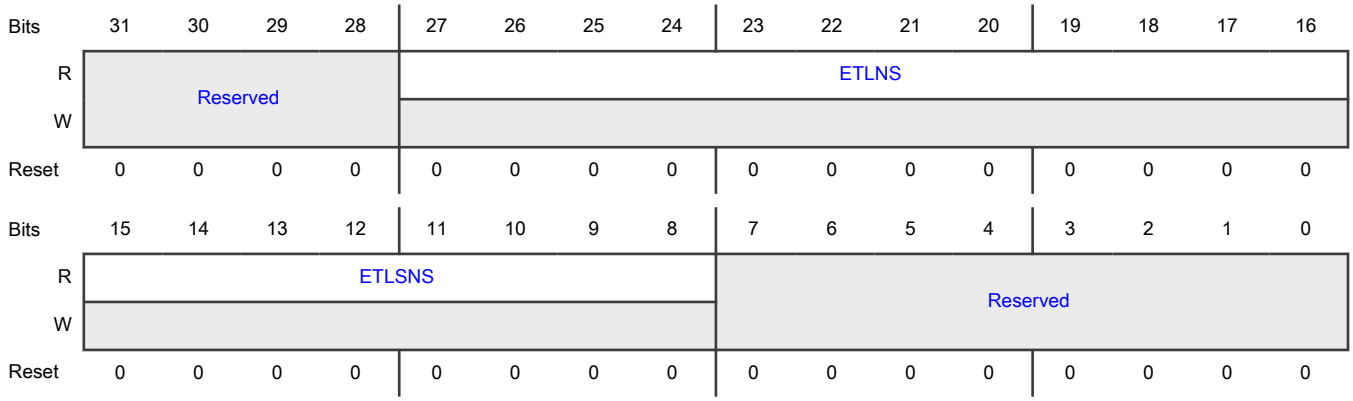
78.17.166 MAC Timestamp Egress Latency (MAC_Timestamp_Egress_Latency)

Offset

Register	Offset
MAC_Timestamp_Egress_Latency	B6Ch

Function
Holds the egress MAC latency.

Diagram



Fields

Field	Function
31-28 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
27-16 ETLNS	Egress Timestamp Latency In Nanoseconds Holds the average latency, in nanoseconds, between the actual point (GMII/MII) where the egress timestamp is taken and the MAC output ports (PHY_TXD_O). The ingress correction value is computed as described in section 7.1.2.4.2 of QoS Databook.
15-8 ETLSNS	Egress Timestamp Latency In Sub-Nanoseconds Holds the average latency, in sub-nanoseconds, between the actual point (GMII/MII) where the egress timestamp is taken and the MAC output ports (PHY_TXD_O). The ingress correction value is computed as described in section 7.1.2.4.2 of QoS Databook.
7-0 —	Reserved

78.17.167 MAC PPS Control (MAC_PPS_Control)

Offset

Register	Offset
MAC_PPS_Control	B70h

Function

Indicates PPS control.

In this register:

- Bits [30:24] are valid only when four flexible PPS outputs are selected.
- Bits [22:16] are valid only when three or more flexible PPS outputs are selected.
- Bits [14:8] are valid only when two or more flexible PPS outputs are selected.
- Bits [6:4] are valid only when the flexible PPS feature is selected.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	MCGREN3	TRGTMODSEL3		Reserved	PPSCMD3				MCGREN2	TRGTMODSEL2		Reserved	PPSCMD2			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	MCGREN1	TRGTMODSEL1		Reserved	PPSCMD1				MCGREN0	TRGTMODSEL0		PPSEN0	PPSCTRL_PPSCMD			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 MCGREN3	MCGR Mode Enable For PPS3 Output Enables the third PPS instance to operate in PPS or MCGR mode. If this field is 1, it operates in MCGR mode, and if the value is 0, it operates in PPS mode.
30-29 TRGTMODSEL3	Target Time Register Mode For PPS3 Output Indicates MAC PPS3 Target Time In Seconds (MAC_PPS3_Target_Time_Seconds) and MAC PPS3 Target Time In Nanoseconds (MAC_PPS3_Target_Time_Nanoseconds) mode for the PPS3 output signal. 00b - Target Time registers are programmed only for generating the interrupt event. The flexible PPS function must not be enabled in this mode, otherwise spurious transitions may be observed on the corresponding PTP_PPS_O output port. 01b - Reserved 10b - Target Time registers are programmed for generating the interrupt event and starting or stopping the PPS0 output signal generation. 11b - Target Time registers are programmed only for starting or stopping the PPS0 output signal generation. No interrupt is asserted.
28 —	Reserved
27-24 PPSCMD3	Flexible PPS3 Output Control Controls the flexible PPS3 output (PTP_PPS_O[3]) signal. The functioning of this field is similar to that of PPSCMD0[2:0] (presentation time control bits). If MCGREN3 = 1, PPSCMD3 that includes bits [27:24] are considered as presentation time control bits for media clock generation and recovery for comparator instance 3. If MCGREN3 is not 1, only three bits [26:24] are considered as PPSCMD3 and the fourth bit becomes 0. Access restrictions apply to this field that clears automatically. Writing 0 to it has no effect.
23 MCGREN2	MCGR Mode Enable For PPS2 Output Enables or disables the second PPS instance to operate in PPS or MCGR mode. If this field is 1, it operates in MCGR mode, and if the value is 0, it operates in PPS mode. 0b - Disabled 1b - Enabled
22-21 TRGTMODSEL2	Target Time Register Mode For PPS2 Output Indicates MAC PPS2 Target Time In Seconds (MAC_PPS2_Target_Time_Seconds) and MAC PPS2 Target Time In Nanoseconds (MAC_PPS2_Target_Time_Nanoseconds) mode for the PPS2 output signal. 00b - Target Time registers are programmed only for generating the interrupt event. The flexible PPS function must not be enabled in this mode, otherwise spurious transitions may be observed on the corresponding PTP_PPS_O output port. 01b - Reserved

Table continues on the next page...

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Field	Function
	10b - Target Time registers are programmed for generating the interrupt event and starting or stopping the PPS0 output signal generation. 11b - Target Time registers are programmed only for starting or stopping the PPS0 output signal generation. No interrupt is asserted.
20 —	Reserved
19-16 PPSCMD2	Flexible PPS2 Output Control Controls the flexible PPS2 output (PTP_PPS_O[2]) signal. The functioning of this field is similar to that of the PPSCMD0 (presentation time control bits). If MCGREN2 = 1, the bits included in PPSCMD2 [19:16] are considered as presentation time control bits for media clock generation and recovery for comparator instance 2. If MCGREN2 is not 1, only three bits [18:16] are used as PPSCMD2 and the fourth bit becomes 0. Access restrictions apply to this field that clears automatically. Writing 0 to it has no effect.
15 MCGREN1	MCGR Mode Enable For PPS1 Output Enables or disables the first PPS instance to operate in PPS or MCGR mode. If this field is 1, it operates in MCGR mode, and if the value is 0, it operates in PPS mode. 0b - Disabled 1b - Enabled
14-13 TRGTMODSEL1	Target Time Register Mode For PPS1 Output Indicates MAC PPS1 Target Time In Seconds (MAC_PPS1_Target_Time_Seconds) and MAC PPS1 Target Time In Nanoseconds (MAC_PPS1_Target_Time_Nanoseconds) mode for the PPS1 output signal. 00b - Target Time registers are programmed only for generating the interrupt event. The flexible PPS function must not be 1 in this mode, otherwise spurious transitions may be observed on the corresponding PTP_PPS_O output port. 01b - Reserved 10b - Target Time registers are programmed for generating the interrupt event and starting or stopping the PPS0 output signal generation. 11b - Target Time registers are programmed only for starting or stopping the PPS0 output signal generation. No interrupt is asserted.
12 —	Reserved
11-8 PPSCMD1	Flexible PPS1 Output Control Controls the flexible PPS1 output (PTP_PPS_O[1]) signal. The functioning of this field is similar to that of the PPSCMD0 field.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	If MCGREN1 = 1, the bits included in PPSCMD1 [11:8] are considered as presentation time control bits for media clock generation and recovery for comparator instance 1. The functioning of PPSCMD1 is similar to that of the PPSCMD0 presentation time control bits. If MCGREN1 is not 1, only three bits [10:8] are used as PPSCMD1 and the fourth bit becomes 0. Access restrictions apply to this field that clears automatically. Writing 0 to it has no effect.
7 MCGREN0	MCGR Mode Enable For PPS0 Output Indicates whether the 0th PPS instance is enabled to operate in PPS or MCGR mode. If this field is 1, it operates in MCGR mode, and if the value is 0, it operates in PPS mode. 0b - PPS mode 1b - MCGR mode
6-5 TRGTMODSEL0	Target Time Register Mode For PPS0 Output Indicates MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds) and MAC PPS0 Target Time In Nanoseconds (MAC_PPS0_Target_Time_Nanoseconds) mode for the PPS0 output signal. 00b - Target Time registers are programmed only for generating the interrupt event. The flexible PPS function must not be 1 in this mode, otherwise spurious transitions may be observed on the corresponding PTP_PPS_O output port. 01b - Reserved 10b - Target Time registers are programmed for generating the interrupt event and starting or stopping the PPS0 output signal generation. 11b - Target Time registers are programmed only for starting or stopping the PPS0 output signal generation. No interrupt is asserted.
4 PPSEN0	Flexible PPS Output Mode Enable 0 Indicates the status of Flexible PPS Output mode. • If this field is 1, the PPSCTRL_PPSCMD field functions as PPSCMD. • If this field is 0, the PPSCTRL_PPSCMD field functions as PPSCTRL (fixed PPS mode). 0b - Disabled 1b - Enabled
3-0 PPSCTRL_PPSCMD	PPS Output Frequency Control Controls the frequency of the PPS0 output (PTP_PPS_O[0] signal). The default value of this field is 0, and the PPS output is 1 pulse (of width clk_ptp_i) every second. For the other values of PPSCTRL, the PPS output becomes a generated clock having these frequencies: • 0001: The binary rollover is 2 Hz, and the digital rollover is 1 Hz. • 0010: The binary rollover is 4 Hz, and the digital rollover is 2 Hz. • 0011: The binary rollover is 8 Hz, and the digital rollover is 4 Hz. • 0100: The binary rollover is 16 Hz, and the digital rollover is 8 Hz.

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Field	Function
	• .. • 1111: The binary rollover is 32.768 kHz and the digital rollover is 16.384 kHz. **NOTE** In Binary Rollover mode, the PPS output (PTP_PPS_O) has a duty cycle of 50 percent with these frequencies. In Digital Rollover mode, the PPS output frequency is an average number. The actual clock has a different frequency that is synchronized every second. For example, • If PPSCTRL = 0001, PPS (1 Hz) has a low period of 537 ms and a high period of 463 ms. • If PPSCTRL = 0010, PPS (2 Hz) is a sequence of one clock of 50 percent duty cycle and a 537 ms period. The second clock has a period of 463 ms (268 ms low and 195 ms high). • If PPSCTRL = 0011, PPS (4 Hz) is a sequence of three clocks of 50 percent duty cycle and a 268 ms period, and the fourth clock of 195 ms period (134 ms low and 61 ms high). This behavior is a result of the non-linear toggling of bits in Digital Rollover mode in MAC System Time In Nanoseconds (MAC_System_Time_Nanoseconds) or flexible PPS output (PTP_PPS_O[0]) control. Programming these bits with a non-zero value instructs MAC to initiate an event. When the command is transferred or synchronized with the PTP clock domain, these bits automatically become 0. You must ensure that these bits are programmed only when they are "all-zero." The following list describes the values of PPSCMD0. • 0000: No command • 0001: Start a single pulse. This command generates a single pulse rising at the start point defined in MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds) and MAC PPS0 Target Time In Nanoseconds (MAC_PPS0_Target_Time_Nanoseconds), for a duration defined in MAC PPS0 Width (MAC_PPS0_Width). • 0010: Start pulse train. This command generates the train of pulses rising at the start point defined in the Target Time registers and for a duration defined in MAC PPS0 Width (MAC_PPS0_Width), repeated at an interval defined in the PPS Interval registers. By default, the PPS pulse train runs freely unless the "stop pulse train at time" or "stop pulse train immediately" command stops it. • 0011: Cancel start. This command cancels the start single pulse and start pulse train commands if the system time has not crossed the programmed start time. • 0100: Stop pulse train at time. This command stops the train of pulses that the start pulse train command (PPSCMD = 0010) initiates after the time programmed in the Target Time registers elapses. • 0101: Stop pulse train immediately. This command immediately stops the train of pulses that the start pulse train command (PPSCMD = 0010) initiates. • 110: Cancel stop pulse train. This command cancels the stop pulse train at the time command if the programmed stop time has not elapsed. The PPS pulse train runs freely if the command executes successfully. • 0111-1111: Reserved or presentation time control. If MAC_PPS_Control[MCGREN0] = 0, then these are treated as presentation time control bits. This list describes the values of PPSCMD0:

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Field	Function
	• 0000: The MCGR operation is not carried out. If set to this value in the mid of clock recovery or generation, all the processing inputs are flushed. • 0001: Captures the presentation time at the rising edge of MCG_PST_TRIG_I[0] in MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds) • 0010: Captures the presentation time at the falling edge of MCG_PST_TRIG_I[0] in MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds) • 0011: Captures the presentation time at both the edges of MCG_PST_TRIG_I[0] in MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds) • 0100-1000: Reserved • 1001: Toggle output on compare • 1010: Pulse output low on compare for one PTP-clock cycle • 1011: Pulse output high on compare for one PTP-clock cycle • 1100-1111: Reserved

78.17.168 MAC PPS0 Target Time In Seconds (MAC_PPS0_Target_Time_Seconds)

Offset

Register	Offset
MAC_PPS0_Target_Time_Seconds	B80h

Function

Is used, along with the PPS Target Time Nanoseconds register, to schedule an interrupt event (MAC_Timestamp_Status[TSTARGT0]) when the system time exceeds the value programmed in these registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSTRH0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSTRH0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSTRH0	PPS Target Time In Seconds Register Stores the target time in seconds. When the timestamp value matches or exceeds both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt (if enabled), based on Target Time mode selected for the corresponding PPS output in MAC PPS Control (MAC_PPS_Control). If DWC_EQOS_FLEXI_PPS_OUT_EN is enabled in the configuration and MAC_Timestamp_Control[PTGE] = 1, with the presentation time control set in Recovery mode, these fields indicate that the application programs the TPT. In Generation mode, it indicates that CPT is generated at the sampled trigger.

78.17.169 MAC PPS0 Target Time In Nanoseconds (MAC_PPS0_Target_Time_Nanoseconds)

Offset

Register	Offset
MAC_PPS0_Target_Time_Nanoseconds	B84h

Function
Indicates the target time in nanoseconds for PPS0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	TRGTBUS...				TTSL0											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TTSL0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 TRGTBUSY0	PPS Target Time Busy Status 0 Indicates whether the PPS target time busy status 0 is detected.

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Field	Function
	• MAC writes 1 to this field when MAC_PPS_Control[PPSCTRL_PPSCMD] is programmed to 010 or 011. This instructs MAC to synchronize the Target Time registers with the PTP clock domain. • MAC writes 0 to this field after synchronizing the Target Time registers with the PTP clock domain. The application must not update the Target Time registers when this field is read as 1. Otherwise, the synchronization of the previously programmed time is corrupted. 0b - Not detected 1b - Detected
30-0 TTSL0	Target Time Low For PPS0 Stores the time in (signed) nanoseconds. If the value of the timestamp matches the value in both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt, if enabled, based on MAC_PPS_Control[TRGTMODSEL0]. • If MAC_Timestamp_Control[TSCTRLSSR] = 0, this value must be calculated as (time in ns / 0.465). The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. • If MAC_Timestamp_Control[TSCTRLSSR] = 1, this value must not exceed 3B9A_C9FFh. The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. Access restriction apply to this field that clears automatically. Writing 0 to it has no effect.

78.17.170 MAC PPS0 Interval (MAC_PPS0_Interval)

Offset

Register	Offset
MAC_PPS0_Interval	B88h

Function

Contains the number of units of the sub-second increment value between the rising edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PPSINT0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PPSINT0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PPSINT0	PPS Output Signal Interval 0 Stores the interval between the rising edges of the PPS0 signal output. The interval is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock is 50 MHz (period of 20 ns), and the desired interval between the rising edges of the PPS0 signal output is 100 ns (that is, five units of the sub-second increment value), you must program value 4 (5-1) in this register.

78.17.171 MAC PPS0 Width (MAC_PPS0_Width)

Offset

Register	Offset
MAC_PPS0_Width	B8Ch

Function

Contains the number of units of the sub-second increment value between the rising and corresponding falling edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PPSWIDTH0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PPSWIDTH0															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PPSWIDTH0	PPS Output Signal Width 0 Stores the width between the rising and corresponding falling edges of the PPS0 signal output. The width is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock has a frequency of 50 MHz (period of 20 ns), and a width between the rising and corresponding falling edges of the PPS0 signal output is 80 ns (that is, four units of the sub-second increment value), you should program value 3 (4-1) in this register. **NOTE** The value programmed in this register must be lesser than the value programmed in MAC PPS0 Interval (MAC_PPS0_Interval).

78.17.172 MAC PPS1 Target Time In Seconds (MAC_PPS1_Target_Time_Seconds)

Offset

Register	Offset
MAC_PPS1_Target_Time_Seconds	B90h

Function
Is used to schedule an interrupt event (MAC_Timestamp_Status[TSTARGT0]), along with the PPS Target Time Nanoseconds register, when the system time exceeds the value programmed in these registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSTRH1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSTRH1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0	PPS Target Time In Seconds 1

Table continues on the next page...

Field	Function
TSTRH1	Stores the target time in seconds. When the timestamp value matches or exceeds both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt, if enabled, based on Target Time mode selected for the corresponding PPS output in MAC PPS Control (MAC_PPS_Control). If DWC_EQOS_FLEXI_PPS_OUT_EN is enabled in the configuration and MAC_Timestamp_Control[PTGE] = 1, with the presentation time control set in Recovery mode, these fields indicate that the application programs the TPT. In Generation mode, it indicates that CPT is generated at the sampled trigger.

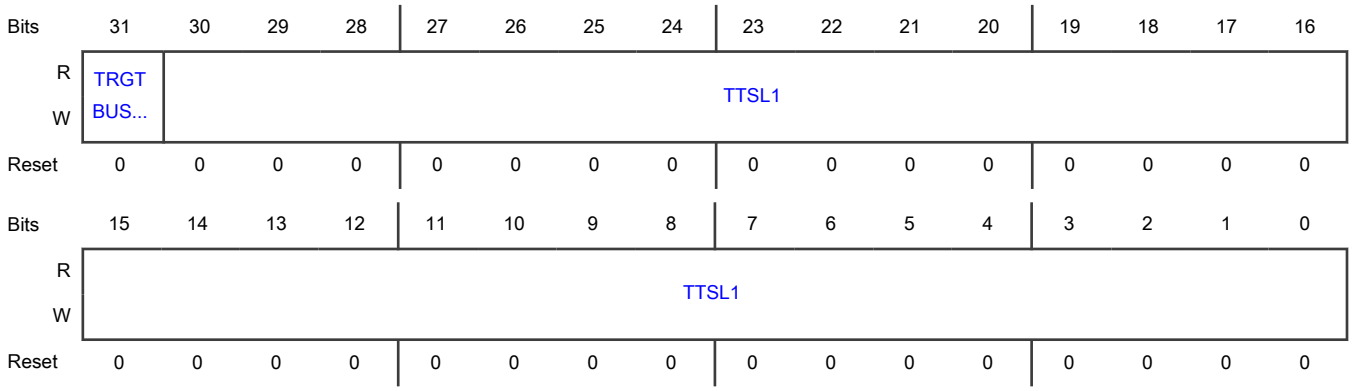
78.17.173 MAC PPS1 Target Time In Nanoseconds (MAC_PPS1_Target_Time_Nanoseconds)

Offset

Register	Offset
MAC_PPS1_Target_Time_Nanoseconds	B94h

Function
Indicates the target time in nanoseconds for PPS1.

Diagram



Fields

Field	Function
31 TRGTBUSY1	PPS Target Time Busy Status 1 Indicates whether the PPS target time busy status 1 is detected. • MAC writes 1 to this field when MAC_PPS_Control[PPSCTRL_PPSCMD] is programmed to 010 or 011. Programming the PPSCMD0 field as 010 or 011 instructs MAC to synchronize the Target Time registers with the PTP clock domain.

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Field	Function
	• MAC writes 0 to this field after synchronizing the Target Time registers with the PTP clock domain. The application must not update the Target Time registers when this field is read as 1. Otherwise, the synchronization of the previously programmed time is corrupted. 0b - Not detected 1b - Detected
30-0 TTSL1	Target Time Low For PPS1 Stores the time in (signed) nanoseconds. If the value of the timestamp matches the value in both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt, if enabled, based on MAC_PPS_Control[TRGTMODSEL0]. • If MAC_Timestamp_Control[TSCTRLSSR] = 0, this value must be defined as (time in ns / 0.465). The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. • If MAC_Timestamp_Control[TSCTRLSSR] = 1, this value must not exceed 3B9A_C9FFh. The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. Access restriction apply to this field that clears automatically. Writing 0 to it has no effect.

78.17.174 MAC PPS1 Interval (MAC_PPS1_Interval)

Offset

Register	Offset
MAC_PPS1_Interval	B98h

Function

Contains the number of units of the sub-second increment value between the rising edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PPSINT1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PPSINT1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PPSINT1	PPS Output Signal Interval 1 Stores the interval between the rising edges of the PPS0 signal output. The interval is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock is 50 MHz (period of 20 ns), and the desired interval between the rising edges of the PPS0 signal output is 100 ns (that is, five units of the sub-second increment value), you must program value 4 (5-1) in this register.

78.17.175 MAC PPS1 Width (MAC_PPS1_Width)

Offset

Register	Offset
MAC_PPS1_Width	B9Ch

Function

Contains the number of units of the sub-second increment value between the rising and corresponding falling edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PPSWIDTH1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PPSWIDTH1															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PPSWIDTH1	PPS Output Signal Width 1 Stores the width between the rising and corresponding falling edges of the PPS0 signal output. The width is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock has a frequency of 50 MHz (period of 20 ns), and a width between the rising and corresponding falling edges of the PPS0 signal output is 80 ns (that is, four units of the sub-second increment value), you should program value 3 (4-1) in this register.

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Field	Function
	NOTE The value programmed in this register must be lesser than the value programmed in MAC PPS0 Interval (MAC_PPS0_Interval).

78.17.176 MAC PPS2 Target Time In Seconds (MAC_PPS2_Target_Time_Seconds)

Offset

Register	Offset
MAC_PPS2_Target_Time_Seconds	BA0h

Function
Is used to schedule an interrupt event (MAC_Timestamp_Status[TSTARGT0]), along with the PPS Target Time Nanoseconds register, when the system time exceeds the value programmed in these registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSTRH2															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSTRH2															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSTRH2	PPS Target Time In Seconds 2 Stores the target time in seconds. When the timestamp value matches or exceeds both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt, if enabled, based on Target Time mode selected for the corresponding PPS output in MAC PPS Control (MAC_PPS_Control). If DWC_EQOS_FLEXI_PPS_OUT_EN is enabled in the configuration and MAC_Timestamp_Control[PTGE] = 1, with the presentation time control set in Recovery mode, these fields indicate that the application programs the TPT. In Generation mode, it indicates that CPT is generated at the sampled trigger.

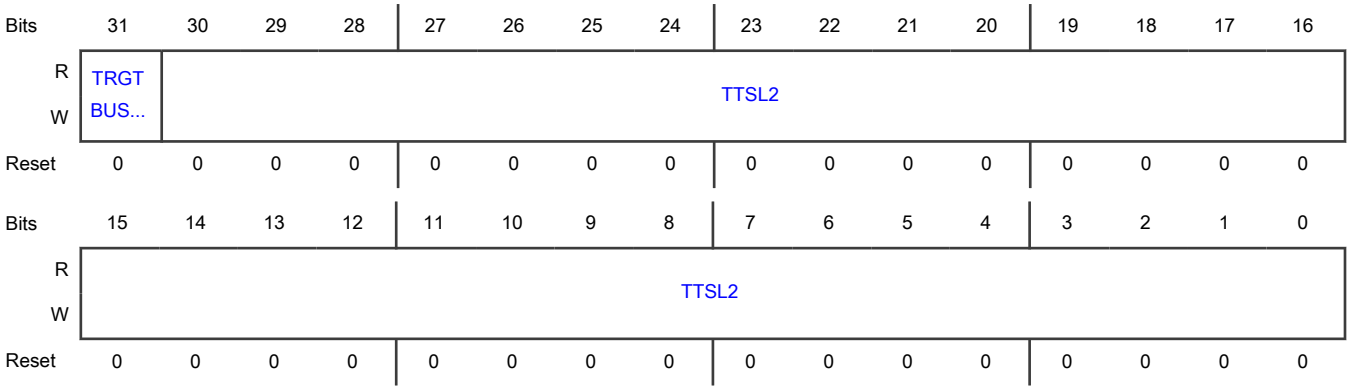
78.17.177 MAC PPS2 Target Time In Nanoseconds (MAC_PPS2_Target_Time_Nanoseconds)

Offset

Register	Offset
MAC_PPS2_Target_Time_Nanoseconds	BA4h

Function
Indicates the target time in nanoseconds for PPS2.

Diagram



Fields

Field	Function
31 TRGTBUSY2	PPS Target Time Busy Status 2 Indicates whether the PPS target time busy status 2 is detected. • MAC writes 1 to this field when MAC_PPS_Control[PPSCTRL_PPSCMD] is programmed to 010 or 011. This instructs MAC to synchronize the Target Time registers with the PTP clock domain. • MAC writes 0 to this field after synchronizing the Target Time registers with the PTP clock domain. The application must not update the Target Time registers when this field is read as 1. Otherwise, the synchronization of the previously programmed time is corrupted. 0b - Not detected 1b - Detected
30-0 TTSL2	Target Time Low For PPS2 Stores the time in (signed) nanoseconds. If the value of the timestamp matches the value in both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt, if enabled, based on MAC_PPS_Control[TRGTMODSEL0].

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Field	Function
	• If MAC_Timestamp_Control[TSCTRLSSR] = 0, this value must be defined as (time in ns / 0.465). The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. • If MAC_Timestamp_Control[TSCTRLSSR] = 1, this value must not exceed 3B9A_C9FFh. The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. Access restriction apply to this field that clears automatically. Writing 0 to it has no effect.

78.17.178 MAC PPS2 Interval (MAC_PPS2_Interval)

Offset

Register	Offset
MAC_PPS2_Interval	BA8h

Function

Contains the number of units of the sub-second increment value between the rising edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	PPSINT2															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	PPSINT2															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 PPSINT2	PPS Output Signal Interval 2 Stores the interval between the rising edges of the PPS0 signal output. The interval is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock is 50 MHz (period of 20 ns), and the desired interval between the rising edges of the PPS0 signal output is 100 ns (that is, five units of the sub-second increment value), you must program value 4 (5-1) in this register.

78.17.179 MAC PPS2 Width (MAC_PPS2_Width)

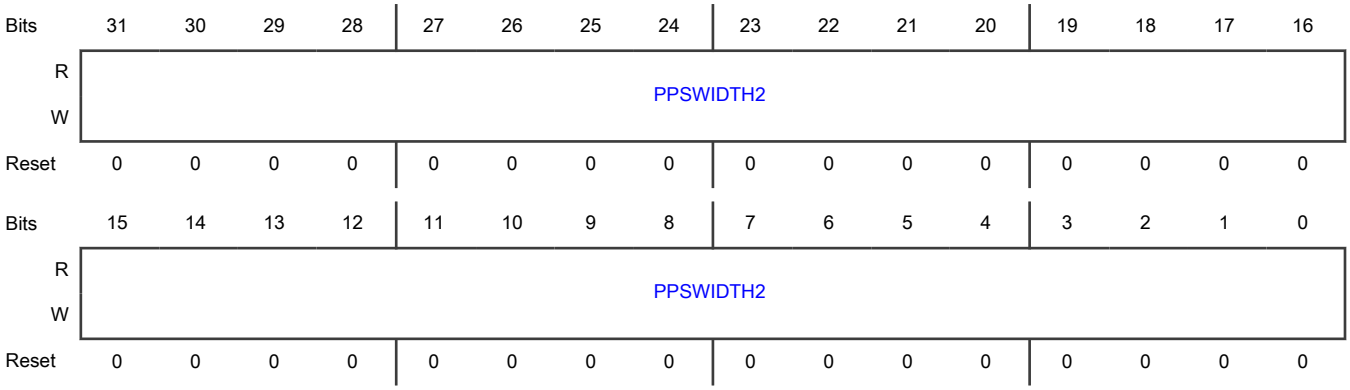
Offset

Register	Offset
MAC_PPS2_Width	BACh

Function

Contains the number of units of the sub-second increment value between the rising and corresponding falling edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram



Fields

Field	Function
31-0 PPSWIDTH2	PPS Output Signal Width 2 Stores the width between the rising and corresponding falling edges of the PPS0 signal output. The width is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock has a frequency of 50 MHz (period of 20 ns), and a width between the rising and corresponding falling edges of the PPS0 signal output is 80 ns (that is, four units of the sub-second increment value), you should program value 3 (4-1) in this register. **NOTE** The value programmed in this register must be lesser than the value programmed in MAC PPS0 Interval (MAC_PPS0_Interval).

78.17.180 MAC PPS3 Target Time In Seconds (MAC_PPS3_Target_Time_Seconds)

Offset

Register	Offset
MAC_PPS3_Target_Time_Seconds	BB0h

Function

Is used to schedule an interrupt event (MAC_Timestamp_Status[TSTARGT0]), along with the PPS Target Time Nanoseconds register, when the system time exceeds the value programmed in these registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TSTRH3															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TSTRH3															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TSTRH3	PPS Target Time In Seconds 3 Stores the target time in seconds. When the timestamp value matches or exceeds both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt, if enabled, based on Target Time mode selected for the corresponding PPS output in MAC PPS Control (MAC_PPS_Control). If DWC_EQOS_FLEXI_PPS_OUT_EN is enabled in the configuration and MAC_Timestamp_Control[PTGE] = 1, with the presentation time control set in Recovery mode, these fields indicate that the application programs the TPT. In Generation mode, it indicates that CPT is generated at the sampled trigger.

78.17.181 MAC PPS3 Target Time In Nanoseconds (MAC_PPS3_Target_Time_Nanoseconds)

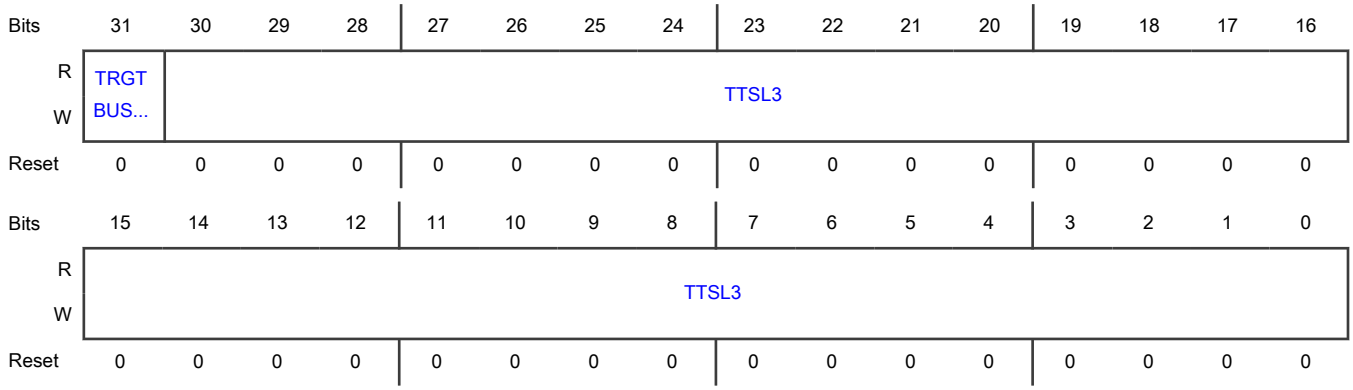
Offset

Register	Offset
MAC_PPS3_Target_Time_Nanoseconds	BB4h

Function

Indicates the target time in nanoseconds for PPS3.

Diagram



Fields

Field	Function
31 TRGTBUSY3	PPS Target Time Register Busy 3 Indicates whether the PPS target time register busy status is detected. MAC writes 1 to this field when MAC_PPS_Control[PPSCTRL_PPSCMD] is programmed to 010 or 011. This instructs MAC to synchronize the Target Time registers with the PTP clock domain. MAC writes 0 to this field after synchronizing the Target Time registers with the PTP clock domain. The application must not update the Target Time registers when this field is read as 1. Otherwise, the synchronization of the previously programmed time is corrupted. 0b - Not detected 1b - Detected
30-0 TTSL3	Target Time Low For PPS3 Stores the time in (signed) nanoseconds. If the value of the timestamp matches the value in both the Target Timestamp registers, MAC starts or stops the PPS signal output and generates an interrupt, if enabled, based on MAC_PPS_Control[TRGTMODSEL0]. • If MAC_Timestamp_Control[TSCTRLSSR] = 0, this value must be defined as (time in ns / 0.465). The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. • If MAC_Timestamp_Control[TSCTRLSSR] = 1, this value must not exceed 3B9A_C9FFh. The actual start or stop time of the PPS signal output might have an error margin up to one unit of the sub-second increment value. Access restriction apply to this field that clears automatically. Writing 0 to it has no effect.

78.17.182 MAC PPS3 Interval (MAC_PPS3_Interval)

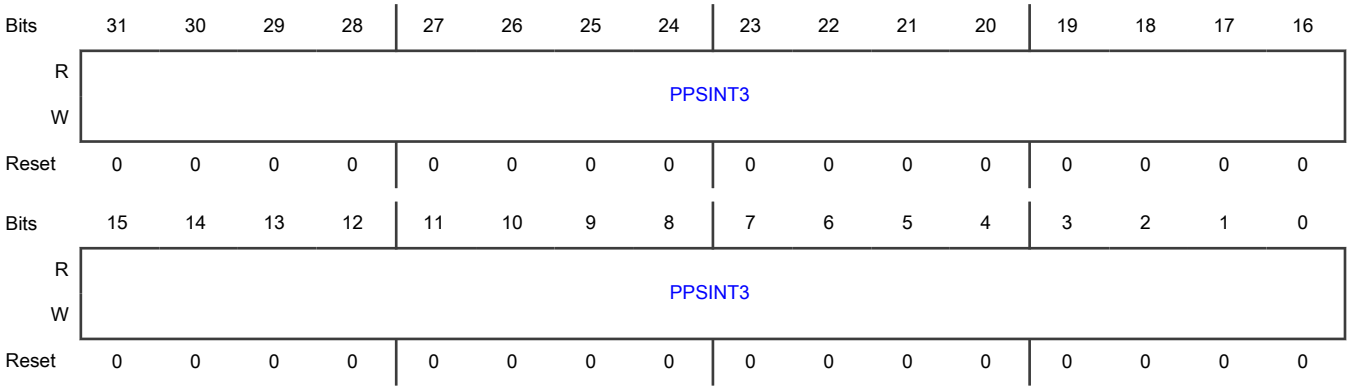
Offset

Register	Offset
MAC_PPS3_Interval	BB8h

Function

Contains the number of units of the sub-second increment value between the rising edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram



Fields

Field	Function
31-0 PPSINT3	PPS Output Signal Interval Stores the interval between the rising edges of the PPS0 signal output. The interval is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock is 50 MHz (period of 20 ns), and the desired interval between the rising edges of the PPS0 signal output is 100 ns (that is, five units of the sub-second increment value), you must program value 4 (5-1) in this register.

78.17.183 MAC PPS3 Width (MAC_PPS3_Width)

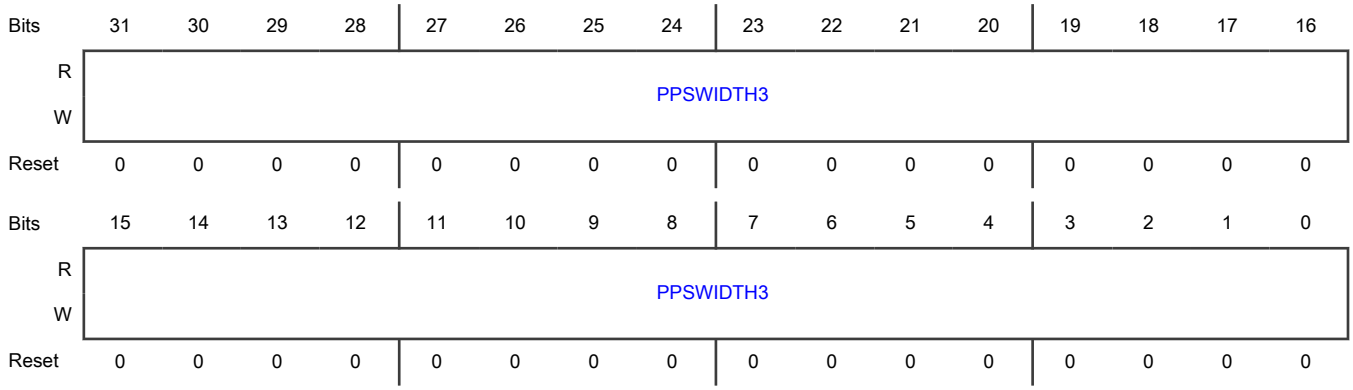
Offset

Register	Offset
MAC_PPS3_Width	BBCh

Function

Contains the number of units of the sub-second increment value between the rising and corresponding falling edges of the PPS0 signal output (PTP_PPS_O[0]).

Diagram



Fields

Field	Function
31-0 PPSWIDTH3	PPS Output Signal Width 3 Stores the width between the rising and corresponding falling edges of the PPS0 signal output. The width is stored in terms of the number of units of the sub-second increment value. You must program one value less than the required interval. For example, if the PTP reference clock has a frequency of 50 MHz (period of 20 ns), and a width between the rising and corresponding falling edges of the PPS0 signal output is 80 ns (that is, four units of the sub-second increment value), you should program value 3 (4-1) in this register. **NOTE** The value programmed in this register must be lesser than the value programmed in MAC PPS0 Interval (MAC_PPS0_Interval).

78.17.184 MTL Operation Mode (MTL_Operation_Mode)

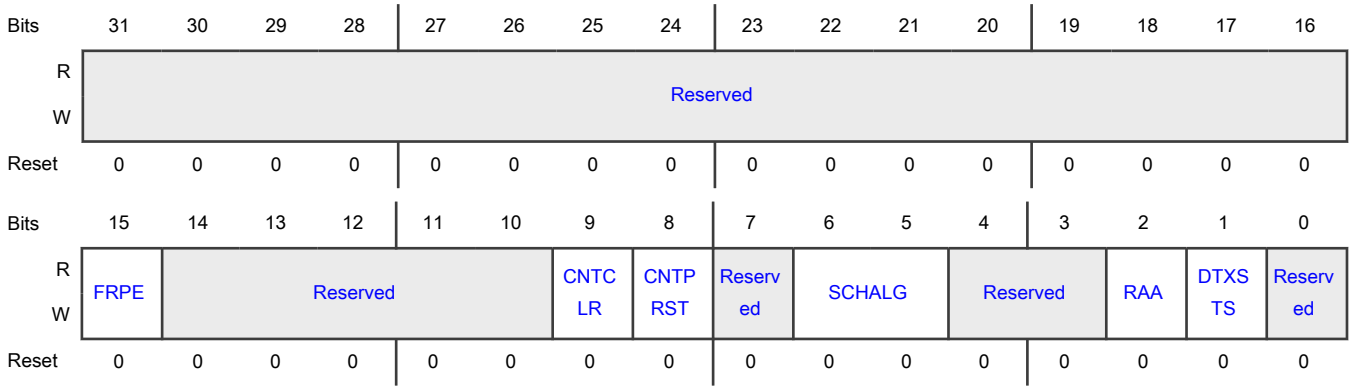
Offset

Register	Offset
MTL_Operation_Mode	C00h

Function

Establishes the transmit and receive operating modes and commands.

Diagram



Fields

Field	Function
31-16 —	Reserved
15 FRPE	Flexible Receive Parser Enable Indicates the status of the flexible receive parser. • If this field is 1, the programmable receive parser functionality is enabled. • If the receive parser is disabled and is in the middle of parsing, the receive parser functionality is disabled only after completing the current packet parsing. When the receive parser is enabled from the disabled state, the receive parser is activated for the next immediate packet. 0b - Disabled 1b - Enabled
14-10 —	Reserved
9 CNTCLR	Counters Reset Indicates whether the counters are reset. • If this field is 1, all the counters are reset. The field clears automatically after one clock cycle. • If you write 1 to this field along with the CNTPRST field, the CNT_PRESET field takes precedence. Access restrictions apply to this field that clears automatically. Writing 0 to it has no effect. 0b - Not reset 1b - Reset
8 CNTPRST	Counters Preset Indicates the status of preset counters. If this field is 1,

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Field	Function
	• MTL Tx Queue 0 Underflow (MTL_TxQ0_Underflow)[bits 0-7] is initialized or preset to 12'h7F0. • Missed packet and overflow packet counters in MTL Rx Queue Missed Packet Overflow Count (MTL_RxQ0_Missed_Packet_Overflow_Cnt)[bits 0-7] are initialized or preset to 12'h7F0. Access restrictions apply to this field that clears automatically. Writing 0 to it has no effect. 0b - Disabled 1b - Enabled
7 —	Reserved
6-5 SCHALG	Transmit Scheduling Algorithm Indicates the algorithm for transmit scheduling. 00b - WRR algorithm 01b - WFQ algorithm when DCB feature selected; otherwise, reserved 10b - DWRR algorithm when DCB feature selected; otherwise, reserved 11b - Strict priority algorithm
4-3 —	Reserved
2 RAA	Receive Arbitration Algorithm Is used to select the arbitration algorithm for the receive side. Queue 0 has the lowest priority and the last queue has the highest priority. 0b - Strict priority (SP) 1b - Weighted strict priority (WSP)
1 DTXSTS	Drop Transmit Status Indicates whether the drop transmit status is enabled. • If this field is 1, the transmit packet status received from MAC is dropped in MTL. • If this field is 0, the transmit packet status received from MAC is forwarded to the application. 0b - Disabled 1b - Enabled
0 —	Reserved

78.17.185 MTL Debug Control (MTL_DBG_CTL)

Offset

Register	Offset
MTL_DBG_CTL	C08h

Function

Controls, along with MTL Debug Status (MTL_DBG_STS), the operation mode of FIFO debug access.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved													EIEC		EIEE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	STSIE	PKTIE	FIFOSEL		FIFOWREN	FIFORDEN	RSTSEL	RSTALL	Reserved	PKTSTATE		Reserved	BYTEEN		DBGMOD	FDBGEN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18-17 EIEC	ECC Inject Error Control Indicates the status of the ECC inject error control feature for transmit, receive, and TSO memories. If EIEE = 1, following are the errors inserted based on the value encoded in this field. 00b - 1-bit error 01b - 2-bit errors 10b - 3-bit errors 11b - 1-bit error in the address field
16 EIEE	ECC Inject Error Enable Indicates the status of the ECC error injection feature for transmit, receive, and TSO memories. • If the value if this field is 1, it enables the ECC error injection feature. • If the value if this field is 0, it disables the ECC error injection feature. 0b - Disabled

Table continues on the next page...

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Field	Function
	1b - Enabled
15 STSIE	Transmit Status Available Interrupt Status Enable Indicates whether the transmit packet available interrupt status is enabled. If this field is 1, an interrupt is generated when transmit status is available in Slave mode. 0b - Disabled 1b - Enabled
14 PKTIE	Receive Packet Available Interrupt Status Enable Indicates whether the receive packet available interrupt status is enabled. If this field is 1, an interrupt is generated when EOP of the received packet is written to the receive FIFO. 0b - Disabled 1b - Enabled
13-12 FIFOSEL	FIFO Selected for Access Indicates the FIFO selected for debug access. 00b - Transmit FIFO 01b - Transmit status FIFO (only read access when SLVMOD is set) 10b - TSO FIFO (cannot be accessed when SLVMOD is set) 11b - Receive FIFO
11 FIFOWREN	FIFO Write Enable Indicates the status of FIFO write. If this field is 1, it enables the write operation on the selected FIFO when FIFO debug access is enabled. This field must not be written to 1 when FIFO debug access is disabled, that is, when FDBGEN = 0. Access restrictions apply to this field that clears automatically. Also, writing 0 to the field clears it and writing 1 sets it. 0b - Disabled 1b - Enabled
10 FIFORDEN	FIFO Read Enable Indicates the status of FIFO read. If this field is 1, it enables the read operation on the selected FIFO when FIFO debug access is enabled. This field must not be written to 1 when FIFO debug access is disabled, that is, when FDBGEN = 0. Access restrictions apply to this field that clears automatically. Also, writing 0 to the field clears it and writing 1 sets it. 0b - Disabled

Table continues on the next page...

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Field	Function
	1b - Enabled
9 RSTSEL	Reset Pointers Of Selected FIFO Indicates whether the resetting of pointers for the selected FIFO is enabled. If this field is 1, the pointers of the currently selected FIFO are reset when FIFO debug access is enabled. This field must not be written to 1 when FIFO debug access is disabled, that is, when FDBGEN = 0. Access restrictions apply to this field that clears automatically. Also, writing 0 to the field clears it and writing 1 sets it. 0b - Disabled 1b - Enabled
8 RSTALL	Reset All Pointers Indicates whether the resetting of all the pointers is enabled. If this field is 1, the pointers of all the FIFOs are reset when the FIFO debug access is enabled. This field must not be written to 1 when FIFO debug access is disabled, that is, when FDBGEN = 0. Access restrictions apply to this field that clears automatically. Also, writing 0 to the field clears it and writing 1 sets it. 0b - Disabled 1b - Enabled
7 —	Reserved
6-5 PKTSTATE	Encoded Packet State Is used to write the control information to the transmit FIFO or receive FIFO. These are the values related to the transmit FIFO: • 00: Packet data • 01: Control word • 10: SOP data • 11: EOP data These are the values related to the receive FIFO: • 00: Packet data • 01: Normal status • 10: Last status • 11: EOP 00b - Packet data

Table continues on the next page...

Table continued from the previous page...

Field	Function
	01b - Control word/normal status 10b - SOP data/last status 11b - EOP data/EOP
4 —	Reserved
3-2 BYTEEN	Byte Enables Indicates the number of data bytes valid in the data register during a write operation. This is valid only when MTL_DBG_STS[PKTSTATE] is 2'b10 (EOP), and the transmit FIFO or receive FIFO is selected. 00b - Byte 0 valid 01b - Byte 0 and byte 1 valid 10b - Byte 0, byte 1, and byte 2 valid 11b - All four bytes valid
1 DBGMOD	Debug Mode Access to FIFO Indicates the status of Debug mode access to FIFO. If this field is 1, it indicates that the current access to FIFO is read, write, and debug. In this mode, the following access types are allowed: • Read and write access to transmit FIFO, TSO FIFO, and receive FIFO • Read access to transmit status FIFO If this field is 0, it indicates that the current access to FIFO is slave access bypassing DMA. In this mode, the following access types are allowed: • Write access to transmit FIFO • Read access to receive FIFO and transmit status FIFO 0b - Disabled 1b - Enabled
0 FDBGEN	FIFO Debug Access Enable Indicates the status of FIFO debug access. • If this field is 1, it indicates that the FIFO debug mode access is enabled. • If the value of the field is 0, it indicates that FIFO can be accessed only through a master interface. 0b - Disabled 1b - Enabled

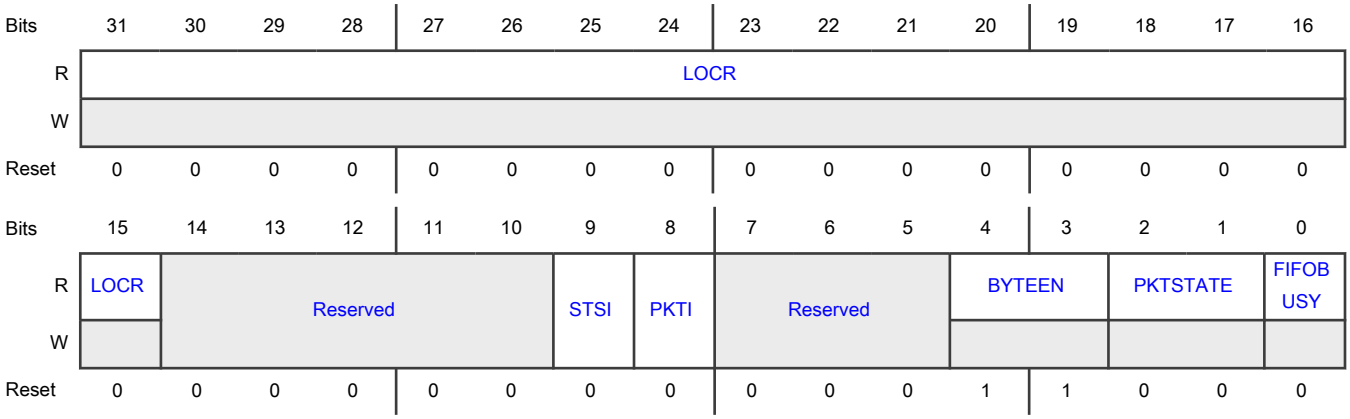
78.17.186 MTL Debug Status (MTL_DBG_STS)

Offset

Register	Offset
MTL_DBG_STS	C0Ch

Function
Contains the status of FIFO debug access.

Diagram



Fields

Field	Function
31-15 LOCR	Remaining Locations In FIFO Indicates the remaining locations in FIFO. For Slave Access mode, the field indicates the space available in the selected FIFO, and for Debug Access mode, this field contains the write or read pointer value of the selected FIFO during the write or read operation, respectively. Reset: In single transmit queue configurations, (DWC_EQOS_TXFIFO_SIZE/(DWC_EQOS_DATAWIDTH/8)), otherwise 0000h.
14-10 —	Reserved
9 STSI	Transmit Status Available Interrupt Status Indicates whether the transmit status available interrupt status is detected. If this field is 1, it indicates that Slave mode transmit packet is transmitted, and the status is available in transmit status FIFO. The field resets when you write 1 to it. 0b - Not detected 1b - Detected
8	Receive Packet Available Interrupt Status

Table continues on the next page...

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Field	Function
PKTI	Indicates whether the receive packet available interrupt status is detected. If this field is 1, it indicates that the MAC layer has written the EOP of the received packet to the receive FIFO. The field resets when you write 1 to it. 0b - Not detected 1b - Detected
7-5 —	Reserved
4-3 BYTEEN	Byte Enables Indicates the number of data bytes valid in the data register during a read operation. This is valid only when MTL_DBG_STS[PKTSTATE] is 2'b10 (EOP), and the transmit FIFO or receive FIFO is selected. 00b - Byte 0 valid 01b - Byte 0 and byte 1 valid 10b - Byte 0, byte 1, and byte 2 valid 11b - All four bytes valid
2-1 PKTSTATE	Encoded Packet State Is used to get the control or status information of the selected FIFO. These are the values related to the transmit FIFO. • 00: Packet data • 01: Control word • 10: SOP data • 11: EOP data These are the values related to the receive FIFO. • 00: Packet data • 01: Normal status • 10: Last status • 11: EOP This field is applicable only for transmit and receive FIFOs during a read operation. 00b - Packet data 01b - Control word/normal status 10b - SOP data/last status 11b - EOP data/EOP
0 FIFOBUSY	FIFO Busy Indicates whether the FIFO busy status is detected.

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Field	Function
	If this field is 1, it indicates that a FIFO operation is in progress in MAC and the content of the following is invalid: • All other fields of this register • All the fields of MTL FIFO Debug Data (MTL_FIFO_Debug_Data) 0b - Not detected 1b - Detected

78.17.187 MTL FIFO Debug Data (MTL_FIFO_Debug_Data)

Offset

Register	Offset
MTL_FIFO_Debug_Data	C10h

Function
Contains the data to be written to or read from the FIFOs.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	FDBGDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	FDBGDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 FDBGDATA	FIFO Debug Data Contains the data to be written to the transmit FIFO, receive FIFO, or TSO FIFO during a debug or slave access write operations. The field contains the data read from the transmit FIFO, receive FIFO, TSO FIFO, or transmit status FIFO during debug or slave access read operations.

78.17.188 MTL Interrupt Status (MTL_Interrupt_Status)

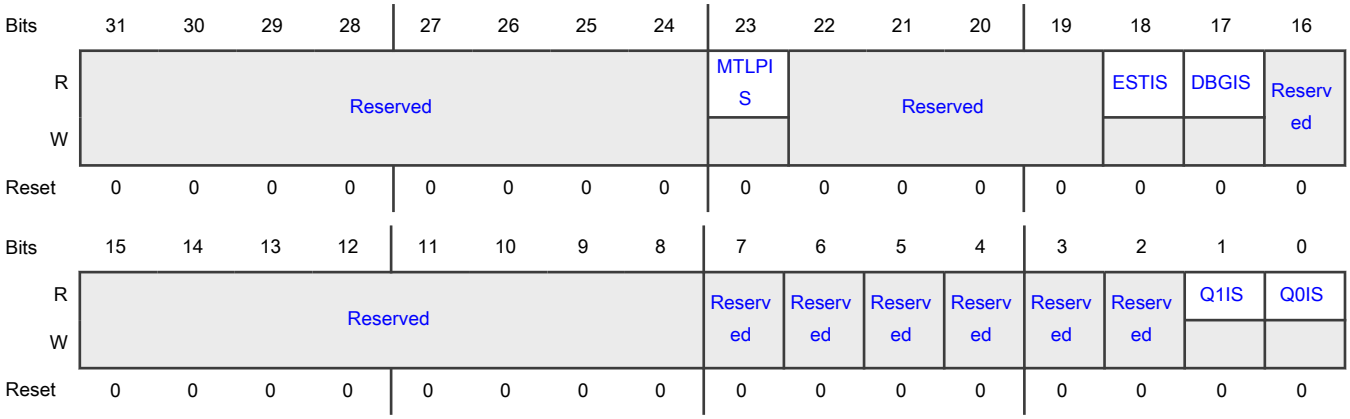
Offset

Register	Offset
MTL_Interrupt_Status	C20h

Function

Determines the interrupt status of MAC and MTL queues. The software driver (application) reads this register during an interrupt service routine or polling to perform this function.

Diagram



Fields

Field	Function
31-24 —	Reserved
23 MTLPIS	MTL Receive Parser Interrupt Status Indicates whether the MTL receive parser interrupt status is detected. This field indicates an interrupt from the receive parser block. To reset this field, the application must read MTL Rx Parser Interrupt Control Status (MTL_RXP_Interrupt_Control_Status) to get the exact cause of the interrupt and clear its source. 0b - Not detected 1b - Detected
22-19 —	Reserved
18 ESTIS	EST (TAS- 802.1Qbv) Interrupt Status Indicates whether the EST (TAS- 802.1Qbv) interrupt status is detected.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field indicates an interrupt event during the operation of 802.1Qbv. To reset the field, the application must clear the error or event that caused the interrupt. 0b - Not detected 1b - Detected
17 DBGIS	Debug Interrupt Status Indicates whether the debug interrupt status is detected. This field indicates an interrupt event during the slave access. To reset the field, the application must read MTL Debug Status (MTL_DBG_STS) to get the exact cause of the interrupt and clear its source. 0b - Not detected 1b - Detected
16 —	Reserved
15-8 —	Reserved
7 —	Reserved
6 —	Reserved
5 —	Reserved
4 —	Reserved
3 —	Reserved
2 —	Reserved
1 Q1IS	Queue 1 Interrupt Status Indicates whether the queue 1 interrupt status is detected. To reset this field, the application must read MTL Queue 1 Interrupt Control Status (MTL_Q1_Interrupt_Control_Status) to get the exact cause of the interrupt and clear its source. 0b - Not detected

Table continues on the next page...

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Field	Function
	1b - Detected
0 Q0IS	Queue 0 Interrupt Status Indicates whether the queue 0 interrupt status is detected. To reset this field, the application must read MTL Queue 0 Interrupt Control Status (MTL_Q0_Interrupt_Control_Status) to get the exact cause of the interrupt and clear its source. 0b - Not detected 1b - Detected

78.17.189 MTL Receive Queue DMA Map 0 (MTL_RxQ_DMA_Map0)

Offset

Register	Offset
MTL_RxQ_DMA_Map0	C30h

Function
Reserves in EQOS-CORE and EQOS-MTL configurations.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved			Reserved	Reserved			Reserved	Reserved			Reserved	Reserved			Reserved
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved			Q1DDMACH	Reserved			Q1MDMACH	Reserved			Q0DDMACH	Reserved			Q0MDMACH
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved.
28 —	Reserved.

Table continues on the next page...

Table continued from the previous page...

Field	Function
27-25 —	Reserved.
24 —	Reserved.
23-21 —	Reserved.
20 —	Reserved.
19-17 —	Reserved.
16 —	Reserved.
15-13 —	Reserved.
12 Q1DDMACH	Queue 1 Enabled for DA-based DMA Channel Selection Enables or disables queue 1 for DA-based DMA channel selection. If this field is 1, it indicates that the packets received in queue 1 are routed to a particular DMA channel as decided in the MAC receiver based on the DMA channel number programmed in the L3-L4 filter registers, or the Ethernet DA address. When this field becomes 0, it indicates that the packets received in queue 1 are routed to the DMA Channel programmed in the MTL_RxQ_DMA_Map0[Q1MDMACH] (bits [10:8]). 0b - Disabled 1b - Enabled
11-9 —	Reserved.
8 Q1MDMACH	Queue 1 Mapped to DMA Channel Controls the routing of the received packet in Queue 1 to the DMA channel: 000b - DMA Channel 0 001b - DMA Channel 1 010b - DMA Channel 2 011b - DMA Channel 3

Table continues on the next page...

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Field	Function
	100b - DMA Channel 4 101b - DMA Channel 5 110b - DMA Channel 6 111b - DMA Channel 7 This field is valid when the MTL_RxQ_DMA_Map0[Q1DDMACH] resets. The field's width depends on the number of RX DMA channels and in some configurations all the values may not be valid . For example, if two RX DMA channels are selected, then only 000b and 001b are valid, the other bits are reserved.
7-5 —	Reserved.
4 Q0DDMACH	Queue 0 Enabled for DA-based DMA Channel Selection Enables or disables queue 0 for DA-based DMA channel selection. If this field is 1, it indicates that the packets received in queue 0 are routed to a particular DMA channel as decided in the MAC Receiver based on the DMA channel number programmed in the L3-L4 filter registers, or the Ethernet DA address. When this field becomes 0, it indicate that the packets received in queue 0 are routed to the DMA Channel programmed in the MTL_RxQ_DMA_Map0[Q0MDMACH]. 0b - Disable 1b - Enable
3-1 —	Reserved.
0 Q0MDMACH	Queue 0 Mapped to DMA Channel Controls the routing of the packet received in queue 0 to the DMA channel: 000b - DMA channel 0 001b - DMA channel 1 010b - DMA channel 2 011b - DMA channel 3 100b - DMA channel 4 101b - DMA channel 5 110b - DMA channel 6 111b - DMA channel 7 This field is valid when the MTL_RxQ_DMA_Map0[Q0DDMACH] resets.

Table continues on the next page...

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Field	Function
	The field's width depends on the number of RX DMA channels in some configurations all the values may not be valid. For example, if the number of RX DMA channels selected is 2, only 000 and 001 bits are valid, the other bits are reserved.

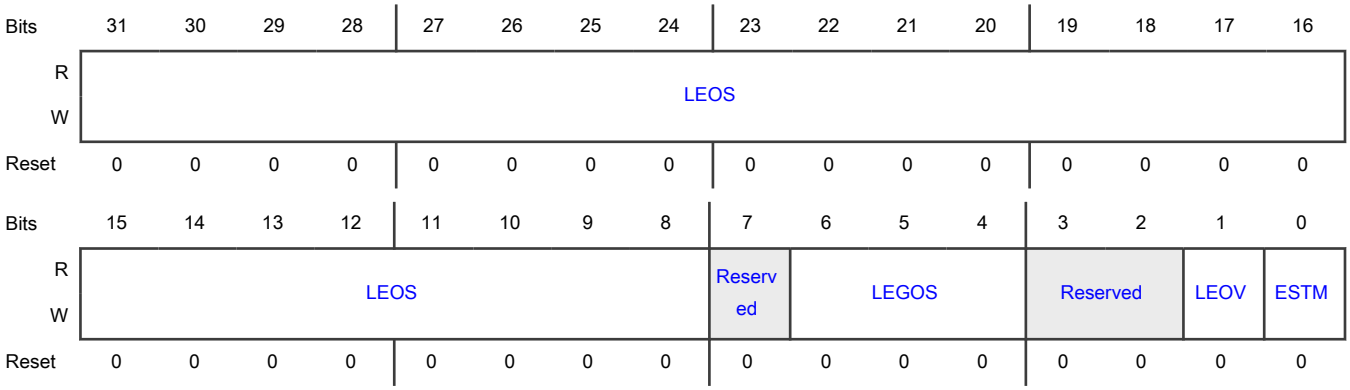
78.17.190 MTL TBS Control (MTL_TBS_CTRL)

Offset

Register	Offset
MTL_TBS_CTRL	C40h

Function
Controls the operation of time based scheduling.

Diagram



Fields

Field	Function
31-8 LEOS	Launch Expiry Offset Computes the launch expiry time. To compute the launch expiry time the value in units of 256 nanoseconds is added to the launch time. The field value is valid only if MTL_TBS_CTRL[LEOV] is 1. Max value: 999,999,999 nanosecond should be smaller than CTR-1 value when ESTM mode = 1, because this value is a modulo CTR value.
7 —	Reserved.
6-4	Launch Expiry GSN Offset

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Field	Function
LEGOS	Computes the Launch expiry time. To compute the launch expiry time the number of GSN slots is to be added to the launch GSN. The field value is valid only if MTL_TBS_CTRL[LEOV] is 1.
3-2 —	Reserved.
1 LEOV	Launch Expiry Offset Valid Indicates if MTL_TBS_CTRL[LEOS] is valid or invalid. When this field is 1, it indicates that MTL_TBS_CTRL[LEOS] is valid. When not 1, it indicates that the launch expiry Offset is not valid and the MTL must not check for launch expiry time. 0b - Invalid 1b - Valid
0 ESTM	EST offset Mode Enables or disables EST Offset mode. If this field is 1, the launch time value used in Time Based Scheduling is interpreted as an EST offset value and is added to the BTR of the current list. When this field becomes 0, the launch time value is used as an absolute value that must be compared with the system time [39:8]. 0b - Disabled 1b - Enabled

78.17.191 MTL EST Control (MTL_EST_Control)

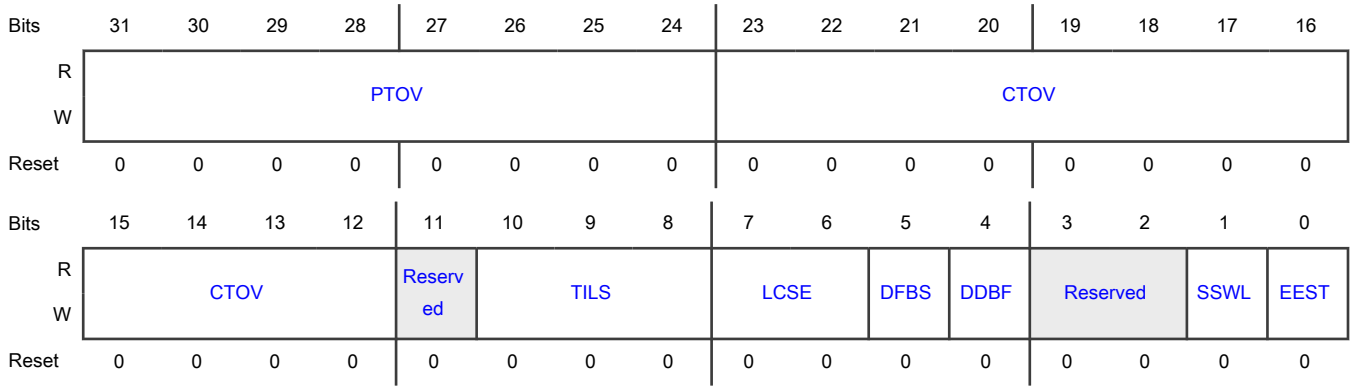
Offset

Register	Offset
MTL_EST_Control	C50h

Function

Controls the operation of enhancements to scheduled transmission (IEEE802.1Qbv).

Diagram



Fields

Field	Function
31-24 PTOV	PTP Time Offset Value Indicates the PTP time offset value. You must multiply 6 to the value of PTP clock period in nanoseconds. At the beginning of the installation of a new GCL this value avoid transmission overruns.
23-12 CTOV	Current Time Offset Value Provides a 12 bit time offset value in nano second which is added to the current time to compensate for all the implementation pipeline delays such as the CDC sync delay, buffering delays, data path delays and so on. This offset ensures that the impact of gate controls is visible on the line exactly at the pre-determined schedule (or as close to the schedule as possible).
11 —	Reserved.
10-8 TILS	Time Interval Left Shift Amount Provides the left shift amount for the programmed time interval values used in the gate control lists. 000b - No left shift needed (equal to x1ns) 001b - Left shift TI by 1 bit (equal to x2ns) 010b - Left shift TI by 2 bits (equal to x4ns) - - 100b - Left shift TI by 7 bits (equal to x128ns) On the basis of configuration you must consider one or more bits of this field as reserved or read-only.
7-6 LCSE	Loop Count to Report Scheduling Error Provides programmable number of GCL list iterations before reporting an HLBS error which is defined in MTL_EST_Status.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	00b - 4 iterations 01b - 8 iterations 10b - 16 iterations 11b - 32 iterations
5 DFBS	Drop Frames Causing Scheduling Error Provides the status of the frames causing scheduling error. If this field is 1 then the frames report to cause an HOL blocking because the MTL_EST_Status[HLBS] is not scheduled after 4,8,16,and 32 (on the basis of MTL_EST_Control[LCSE]) GCL iterations are dropped. 0b - Do not drop frames 1b - Drop frames
4 DDBF	Do not Drop Frames during Frame Size Error Provides status of frames during Frame Size Error. If this field is 1, it indicates that the frames are not dropped during head-of-line blocking because of the frame size error (MTL_EST_Status[HLBF]). 0b - Drop frames during frame size error 1b - Do not Drop frames during frame size error
3-2 —	Reserved.
1 SSWL	Switch to Software Owned List If this field is 1, it indicates that the software has programmed that list that it currently owns (SWOL) and the hardware should switch to the new list based on the new BTR. Hardware clears this bit when the switch to the SWOL happens to indicate the completion of the switch or when an BTR error (BTRE in Status register) is set. When BTRE is set this bit is cleared but SWOL is not updated as the switch was not successful. Access restriction apply to this field that clears on read and automatically becomes 1 on an internal event occurrence. Enables or disables the switch to the software owned list. 0b - Disabled 1b - Enabled
0 EEST	Enable EST Enables or disables EST. If the field becomes 0, it indicate that the gate control list processing is halted and all gates are assumed to be in open state. The field must be 1 for the hardware to start processing the gate control lists. During the toggle from 0 to 1, when the MTL_EST_Control[SSWL] is 1, the gate control list processing starts. During the configuration when DWC_EQOS_ASP_ECC is selected, the hardware resets this field and disables the EST function if any uncorrectable error is detected in the EST memory .

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled

78.17.192 MTL EST Status (MTL_EST_Status)

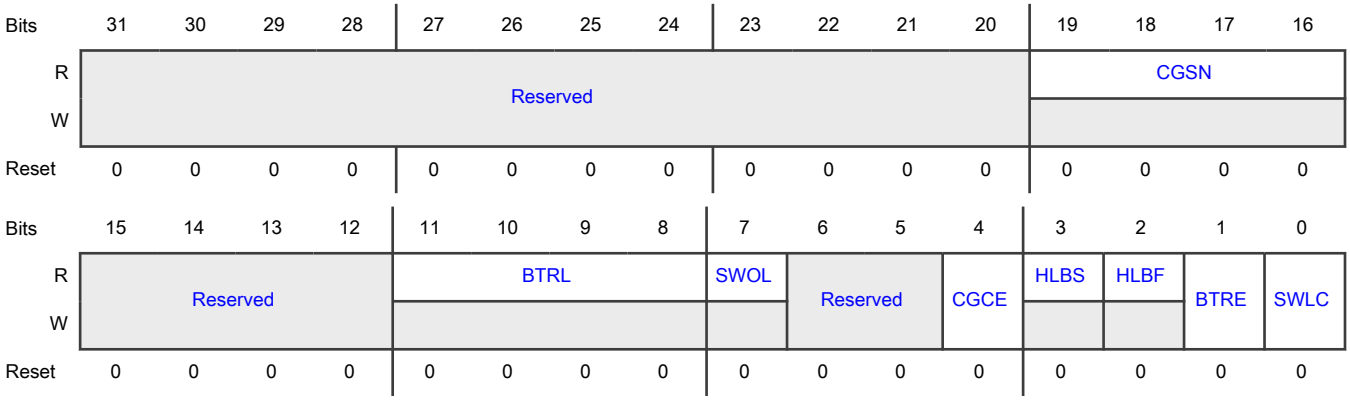
Offset

Register	Offset
MTL_EST_Status	C58h

Function

Provides status of enhancements to scheduled transmission (IEEE802.1Qbv).

Diagram



Fields

Field	Function
31-20 —	Reserved.
19-16 CGSN	Current GCL Slot Number Indicates the slot number of the GCL list. Slot number is a modulo 16 count of the GCL List loops executed so far. Even if a new GCL list is installed, the count is incremental.
15-12 —	Reserved.

Table continues on the next page...

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Field	Function
11-8 BTRL	BTR Error Loop Count Provides the minimum count (N) for which the equation Current Time =< New BTR + (N * New Cycle Time) becomes true. N = "1111" indicates the iterations exceeded the value of 8 and the hardware was not able to update New BTR to be equal to or greater than Current Time. Software intervention is needed to update the New BTR. Value cleared when BTRE field of this register is cleared.
7 SWOL	S/W owned list When '0' indicates Gate control list number "0" is owned by software and when "1" indicates the Gate Control list "1" is owned by the software. Any reads/writes by the software (using indirect access via GCL_Control) is directed to the list indicated by this value by default. The inverse of this value is treated as HWOL. R/W operations performed by hardware are directed to the list pointed by HWOL by default. 0b - Gate control list number "0" is owned by software 1b - Gate control list number "1" is owned by software
6-5 —	Reserved.
4 CGCE	Constant Gate Control Error This error occurs when the list length (LLR) is 1 and the Cycle Time (CTR) is less than or equal to the programmed Time Interval (TI) value after the optional Left Shifting. The above programming implies Gates are either always Closed or always Open based on the Gate Control values; the same effect can be achieved by other simpler (non TSN) programming mechanisms. Since the implementation does not support such a programming an error is reported. Access restriction applies. Self-set to 1 on internal event. Setting 1 clears. Setting 0 has no effect. 0b - Constant Gate Control Error not detected 1b - Constant Gate Control Error detected
3 HLBS	Head-Of-Line Blocking due to Scheduling Set when the frame is not able to win arbitration and get scheduled even after 4 iterations of the GCL. Indicates to software a potential programming error. The one hot encoded values of the Queue Numbers that are not able to make progress are indicated in the MTL_EST_Sch_Error register. Bit cleared when MTL_EST_Sch_Error register is all zeros. 0b - Head-Of-Line Blocking due to Scheduling not detected 1b - Head-Of-Line Blocking due to Scheduling detected
2 HLBF	Head-Of-Line Blocking due to Frame Size Set when HOL Blocking is noticed on one or more Queues as a result of none of the Time Intervals of gate open in the GCL being greater than or equal to the duration needed for frame size (or frame fragment size when preemption is enabled) transmission. The one hot encoded Queue numbers that are experiencing HLBF are indicated in the MTL_EST_Frm_Size_Error register. Additionally, the first Queue number that experienced HLBF along with the frame size is captured in MTL_EST_Frm_Size_Capture register. Bit cleared when MTL_EST_Frame_Size_ Error register is all zeros.

Table continues on the next page...

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Field	Function
	0b - Head-Of-Line Blocking due to Frame Size not detected 1b - Head-Of-Line Blocking due to Frame Size detected
1 BTRE	BTR Error Indicates whether the BTR error is detected. When this field is 1, it indicates a programming error in the BTR of SWOL where the programmed value is less than the current time. If the BTRL = "1111", SWOL is not updated and software must reprogram the BTR to a value greater than current time and then set SSWL to reinitiate the switch to SWOL. Else if the value of BTRL < "1111", SWOL is updated and this field indicates the number of iterations (of + CycleTime) taken by hardware to update the BTR to a value greater than Current Time. Access restrictions apply to this field. It sets automatically to 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - BTR Error not detected 1b - BTR Error detected
0 SWLC	Switch to Software Owned List Complete Indicates whether the switch to software owned list complete is detected. When the field is 1, it indicates that the hardware has successfully switched to the SWOL, and updated the MTL_EST_Status[SWOL] to that effect. This field is 0 when MTL_EST_Control[SSWL] transitions from 0 to 1, or on a software write. Access restrictions apply to this field. It clears automatically and writing 0 to it has no effect. 0b - Not detected 1b - Detected

78.17.193 MTL EST Scheduling Error (MTL_EST_Sch_Error)

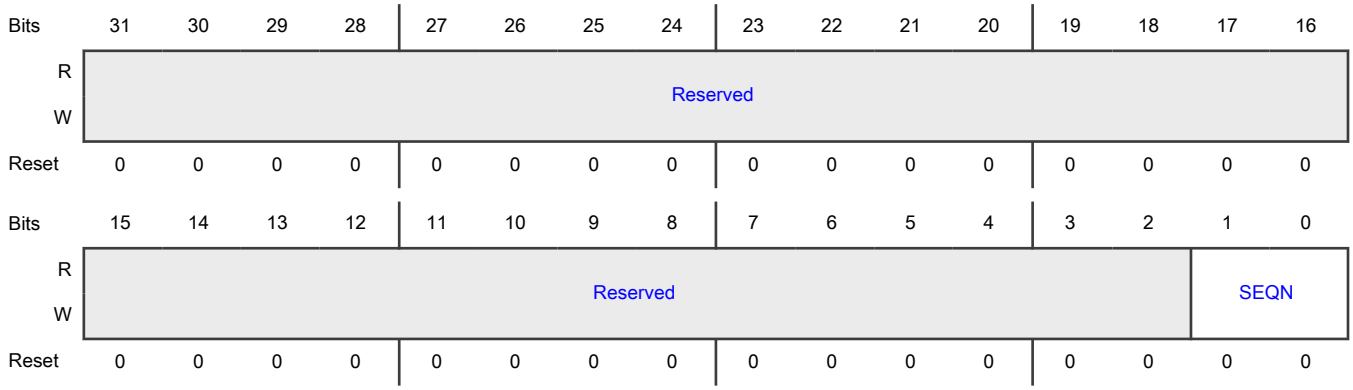
Offset

Register	Offset
MTL_EST_Sch_Error	C60h

Function

Provides the one hot encoded queue numbers that have the scheduling related error (timeout).

Diagram



Fields

Field	Function
31-2 —	Reserved.
1-0 SEQN	Schedule Error Queue Number Provides the one hot encoded queue numbers that have experienced error or timeout described in MTL_EST_Status[HLBS]. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 to it has no effect.

78.17.194 MTL EST Frame Size Error (MTL_EST_Frm_Size_Error)

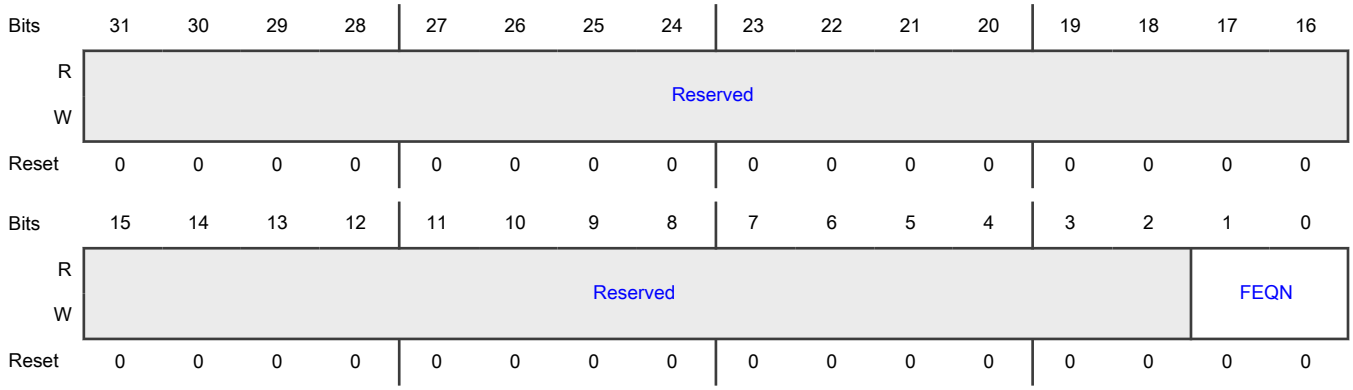
Offset

Register	Offset
MTL_EST_Frm_Size_Error	C64h

Function

Provides the one hot encoded queue numbers that have the frame Size related error.

Diagram



Fields

Field	Function
31-2 —	Reserved.
1-0 FEQN	Frame Size Error Queue Number Provides the one hot encoded queue Nnumbers that have experienced error described in MTL_EST_Status[HLBF]. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 to it has no effect.

78.17.195 MTL EST Frame Size Capture (MTL_EST_Frm_Size_Capture)

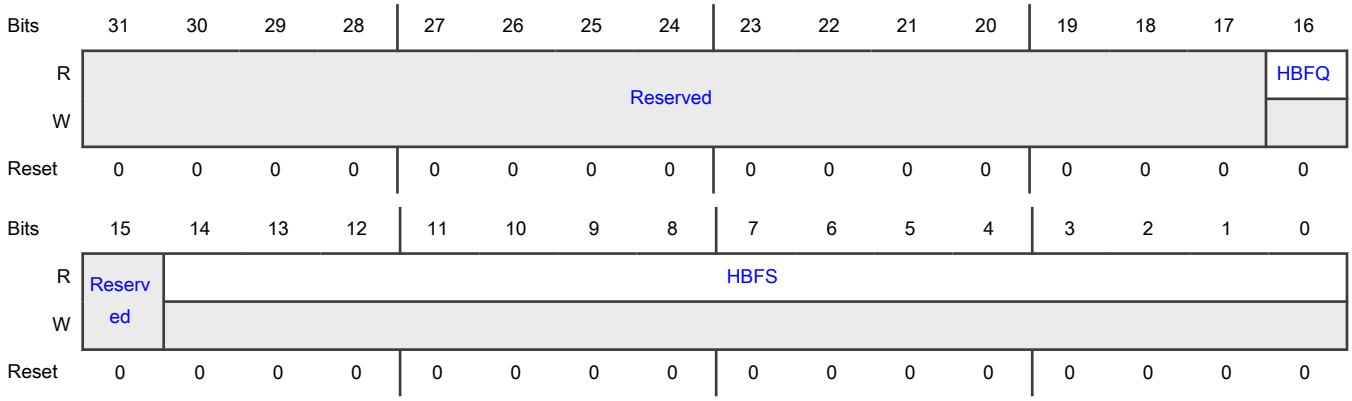
Offset

Register	Offset
MTL_EST_Frm_Size_Capture	C68h

Function

Captures the frame Size and queue number of the first occurrence of the frame Size related error. When you write 0, it captures the data of immediate next occurrence of a similar error.

Diagram



Fields

Field	Function
31-17 —	Reserved.
16 HBFQ	Queue Number of HLBF Captures the binary value of the first queue (number) which experiences the HLBF error (see MTL_EST_Status[HLBF]). Any subsequent queue errors similar to HLBF errors does not alter the value after it is written. After this field is 0, it captures the queue number of the next occurring HLBF error. Field's width is based on the number of transit queues configured; remaining fields are read-only. This field clears when MTL_EST_Frm_Size_Error is all zeros.
15 —	Reserved.
14-0 HBFS	Frame Size of HLBF Captures the frame Size of the dropped frame related to queue number indicated in MTL_EST_Frm_Size_Capture[HBFQ]. If this field is zero, then this register must be considered invalid. This field clears when MTL_EST_Frm_Size_Error is all zeros.

78.17.196 MTL EST Interrupt Enable (MTL_EST_Intr_Enable)

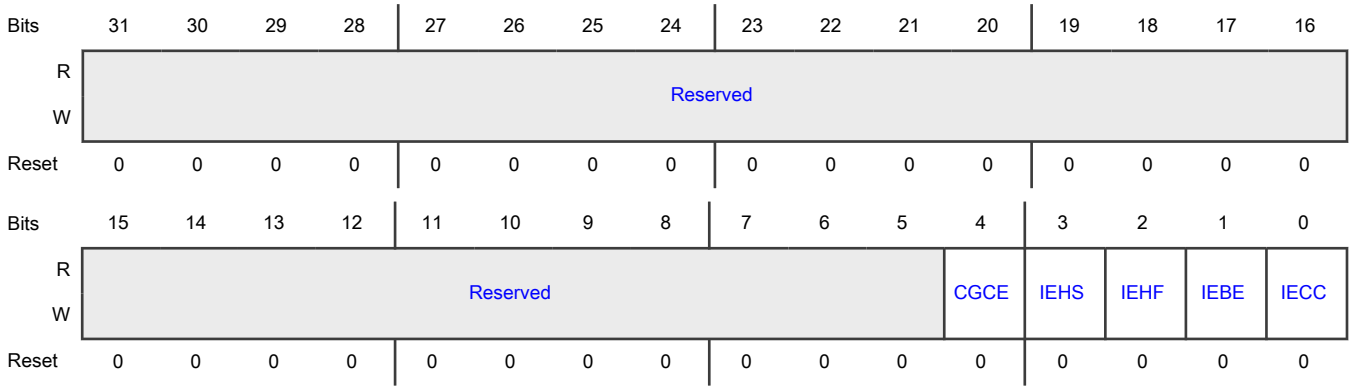
Offset

Register	Offset
MTL_EST_Intr_Enable	C70h

Function

Implements the interrupt enable fields for the various events that generate an interrupt. Bit positions have a 1 to 1 correlation with the status bit positions in MTL_ETS_Status register.

Diagram



Fields

Field	Function
31-5 —	Reserved.
4 CGCE	Interrupt Enable for CGCE Indicates whether an interrupt for MTL_EST_Intr_Enable[CGCE] is enabled. When this field is 1, it generates an interrupt when the constant gate control error occurs and is indicated in the status. When this field becomes 0, this event does not generate an interrupt 0b - Disabled 1b - Enabled
3 IEHS	Interrupt Enable for HLBS Indicates whether an interrupt for MTL_EST_Status[HLBS] is enabled. When this field is 1, it generates an interrupt when the head-of-line blocking due to scheduling issue occurs and is indicated in the status. When this field becomes 0, this event does not generate an interrupt. 0b - Disabled 1b - Enabled
2 IEHF	Interrupt Enable for HLBF Indicates whether an interrupt for MTL_EST_Status[HLBF] is enabled. When this field is 1, it generates an interrupt when the head-of-line blocking due to frame size error occurs and is indicated in the status. When this field becomes 0, this event does not generate an interrupt. 0b - Disabled 1b - Enabled
1 IEBE	Interrupt Enable for BTR Error Indicates whether an interrupt for BTR error is enabled.

Table continues on the next page...

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Field	Function
	When this field is 1, it generates an interrupt when the BTR error occurs and is indicated in the status. When this field becomes 0, this event does not generate an interrupt. 0b - Disabled 1b - Enabled
0 IECC	Interrupt Enable for Switch List Indicates whether the interrupt for switch list is enabled. When this field is 1, it generates an interrupt when the configuration change is successful and the hardware switches to the new list. When this field becomes 0, this event does not generate an interrupt. 0b - Disabled 1b - Enabled

78.17.197 MTL EST GCL Control (MTL_EST_GCL_Control)

Offset

Register	Offset
MTL_EST_GCL_Control	C80h

Function

Provides the control information for reading and writing to the gate control lists.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved								ESTEIEC		ESTEIEE	ERR0	Reserved			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ADDR								Reserved		DBGB	DBGM	Reserved	GCRR	R1W0	SRWO
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24	Reserved.

Table continues on the next page...

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Field	Function
—	
23-22 ESTEIEC	ECC Inject Error Control for EST Memory Provides the status of inject error control for EST memory. When MTL_EST_GCL_Control[ESTEIEE] = 1, it indicates that on the basis of the value encoded in this field following errors are inserted. This field is valid only if you select DWC_EQOS_ASP_ECC feature during the configuration, otherwise it is reserved. 00b - Insert 1 bit error 01b - Insert 2 bit errors 10b - Insert 3 bit errors 11b - Insert 1 bit error in address field
21 ESTEIEE	EST ECC Inject Error Enable Indicates whether the EST ECC inject error is enabled. If this field along with MTL_EST_Control[EEST] = 1, it enables the ECC error injection feature. When this field becomes 0, it disables the ECC error injection feature. 0b - Disabled 1b - Enabled
20 ERR0	If this field is 1, it indicates that when the software writes to GCL the last write operation was aborted and when MTL_EST_Control[SSWL] is 1, GCL registers are prohibited. Access restriction apply to this field and automatically becomes 1 on an internal event occurrence. Writing 1 to this field clears it and writing 0 to this field has no effect. 0b - ERR0 is disabled 1b - ERR1 is enabled
19-16 —	Reserved.
15-8 ADDR	Gate Control List Address: (GCLA when GCRR is "0"). Provides the address (row number) of the gate control list at which the R/W operation has to be performed. By default the gate control list to which MTL_EST_Status[SWOL] points is selected for read and write. If MTL_EST_GCL_Control[DBGM] is 1, it indicates that MTL_EST_GCL_Control[DBGB] gives Debug mode access to read and write. The field's width depends on DWC_EQOS_EST_DEP and the unused bits must be treated as read only. Gate Control list Related Registers Address: (GCRA when GCRR is "1"). By default the GCL related register set pointed by MTL_EST_Status[SWOL] is selected for read or write. If MTL_EST_GCL_Control[DBGM], it indicates that MTL_EST_GCL_Control[DBGB] gives Debug mode access to read write. Lower 3 bits are only used in this mode, higher order bits are treated as don't cares.

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Field	Function
	000b - BTR Low (31:0) 001b - BTR High (63:31) 010b - CTR Low (31:0) 011b - CTR High (39:32) 100b - TER (31:0) 101b - LLR (n:0) (where n is (log{DWC_EQOS_EST_DEP} / log2)) Others - Reserved
7-6 —	Reserved.
5 DBGB	Debug Mode Bank Select Indicates whether the read and write in Debug mode is directed to bank 0 or bank 1. When this field is 0, it indicates that read or write in Debug mode must be directed to bank 0 (GCL0 and corresponding Time related registers). When this field is 1, it indicates that read or write in Debug mode should be directed to bank 1 (GCL1 and corresponding Time related registers). When MTL_EST_GCL_Control[DBGM] is 1 you can use this value and overrides with the MTL_EST_Status[SWOL] value. 0b - Directed to bank 0 1b - Directed to bank 1
4 DBGM	Debug Mode Enables or disables Debug mode. When this field is 1, it indicates that the read and write is in Debug mode where the MTL_EST_GCL_Control[DBGB] value explicitly provides the memory bank (for GCL and time related registers). When this field is 0, it indicates that MTL_EST_Status[SWOL] determines which bank to use. 0b - Disabled 1b - Enabled
3 —	Reserved.
2 GCRR	Gate Control Related Registers Enables or disables gate control related registers. When this field is 1, it indicates that the read or write access is for the GCL related registers (BTR, CTR, TER, LLR) for which GCRA provides the address. When this field is 0, it indicates that read and write must be directed to GCL from the address which GCLA provides. 0b - Disabled 1b - Enabled

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Field	Function
1 R1W0	Read '1', Write '0' Indicates whether this field performs read operation or write operation. When this field is 1 it indicates that it performs a read operation. When this field is 0 it indicates that it performs a write operation. 0b - Write operation 1b - Read operation
0 SRWO	Start Read/Write Operation Indicates whether the read/write operation is enabled. When this field is 1, it indicates that a read/write operation has started and is in progress. When hardware resets this field and MTL_EST_GCL_Control[ERR0] = 1 , it indicates that the read/write operation has completed or an error has occurred. Reads: When this field becomes 0, it indicates that MTL_EST_GCL_Data reads data. Writes: Before writing 1 to this field, you must program MTL_EST_GCL_Data with write data. Access restrictions apply to this field. It clears automatically. Writing 1 sets this field and writing 0 to it has no effect. 0b - Disabled 1b - Enabled

78.17.198 MTL EST GCL Data (MTL_EST_GCL_Data)

Offset

Register	Offset
MTL_EST_GCL_Data	C84h

Function

Holds the read data or write data in case of reads and writes respectively.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	GCD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	GCD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 GCD	Gate Control Data Provides the data corresponding to the address selected in the MTL_EST_GCL_Control. This field is used for both read and write operations.

78.17.199 MTL FPE Control Status (MTL_FPE_CTRL_STS)

Offset

Register	Offset
MTL_FPE_CTRL_STS	C90h

Function

Controls the operation of, and provides status for frame preemption (IEEE802.1Qbu/802.3br).

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved			HRS	Reserved											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved						PEC		Reserved						AFSZ	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved.
28 HRS	Hold/Release Status Indicates whether a set-and-release-MAC operation which was last executed and the pMAC is in release state or in hold state. 0b - Release state 1b - Hold state
27-16 —	Reserved.
15-10 —	Reserved.
9-8 PEC	Preemption Classification When this field is 1, it indicates that you must classify the corresponding queue as preemptable. When this field is 0, it indicates that you must classify the queue as express. When set indicates the corresponding Queue must be classified as preemptable, when '0' Queue is classified as express. When both EST (Qbv) and Preemption are enabled, Queue-0 is always assumed to be preemptable. When you enables EST (Qbv), the preemptable queues are always assumed to be in open state in gate control list.
7-2 —	Reserved.
1-0 AFSZ	Additional Fragment Size Indicates that, in units of 64 bytes, the minimum number of bytes over 64 bytes required in non-final fragments of preempted frames. The minimum non-final fragment size is (AFSZ +1) * 64 bytes.

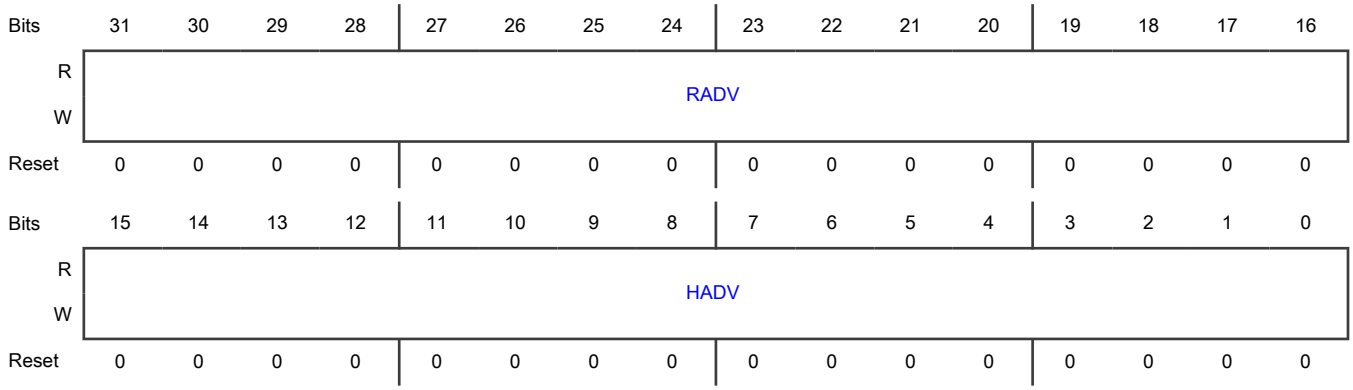
78.17.200 MTL FPE Advance (MTL_FPE_Advance)

Offset

Register	Offset
MTL_FPE_Advance	C94h

Function
Holds the hold and release advance time.

Diagram



Fields

Field	Function
31-16 RADV	Release Advance Provides the maximum time in nanoseconds that can elapse between issuing a release to the MAC and the MAC being ready to resume transmission of preemptable frames, in the absence of there being any express frames available for transmission.
15-0 HADV	Hold Advance Provides the maximum time in nanoseconds that can elapse between issuing a hold to the MAC and the MAC ceasing to transmit any preemptable frame that is in the process of transmission or any preemptable frames that are queued for transmission.

78.17.201 MTL Rx Parser Control Status (MTL_RXP_Control_Status)

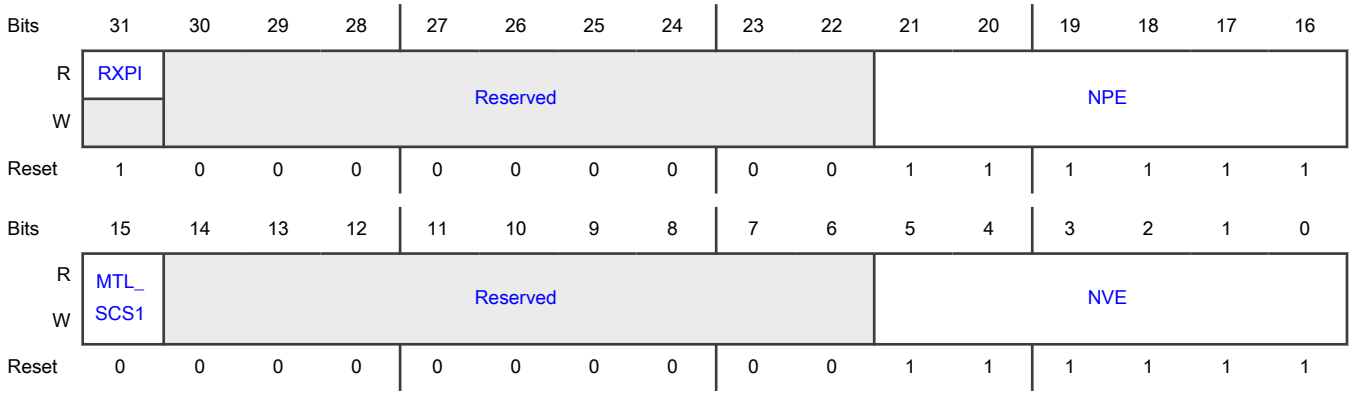
Offset

Register	Offset
MTL_RXP_Control_Status	CA0h

Function

Establishes the operating mode of receive parser and provides some status.

Diagram



Fields

Field	Function
31 RXPI	RX Parser in Idle State Indicates whether the receive parser is in idle state. When this field is 1, it indicates that the receive parser is in idle state and waiting for the processing of a new packet. When parser disables, you can use this field as a handshake with software and also the software can update the receive parser instruction table when you write 1 to this field. 0b - Not in Idle state 1b - Idle state
30-22 —	Reserved.
21-16 NPE	Number of parsable entries in the Instruction table Indicates the number of parsable entries in the instruction memory. This is used in receive parser logic to detect programming error. MTL_RXP_Interrupt_Control_Status[NPEOVIS] = 1, if the number of parsed entries for a packet is more than this entry.
15 MTL_SCS1	MTL_SCS1 Is reserved for NXP internal use. The value of this field must always be 0 unless NXP instructs you otherwise. Writing 1 to any of the bits of this field might cause unexpected behavior in th IP.
14-6 —	Reserved.
5-0 NVE	Number Of Valid Entry Address Or Index In The Instruction Table Indicates the number of valid entry address or index in the instruction memory.

Table continues on the next page...

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Field	Function
	The maximum valid entry address is = NVE + 1 and the addresses or indices range from 0 to 32. Therefore, if the value of this field is 32, the number of valid entry address is 33. This value is used in receive parser logic to detect if any programming errors exist. When parsing, the module writes 1 to NVEOVIS if the number of the memory address is found to be more than the defined maximum valid entry address number. **NOTE** The minimum value of this field must be two.

78.17.202 MTL Rx Parser Interrupt Control Status (MTL_RXP_Interrupt_Control_Status)

Offset

Register	Offset
MTL_RXP_Interrupt_Control_Status	CA4h

Function
Provides enable control for the interrupts and also provides interrupt status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved												PDRFIE	FOOVIE	NPEOVIE	NVEOVIE
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved												PDRFIS	FOOVIS	NPEOVIS	NVEOVIS
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-20 —	Reserved.
19 PDRFIE	Packet Drop due to RF Interrupt Enable Indicates whether the packet drop due to RF interrupt is enabled. If this field is 1, it enables the PDRFIS interrupt. When this field becomes 0, it disables the PDRFIS interrupt.

Table continues on the next page...

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Field	Function
	0b - Disabled 1b - Enabled
18 FOOVIE	Frame Offset Overflow Interrupt Enable Indicates whether the frame offset overflow interrupt is enabled. If this field is 1, it enables the FOOVIS interrupt. When this field becomes 0, it disables the FOOVIS interrupt. 0b - Disabled 1b - Enabled
17 NPEOVIE	Number of Parsable Entries Overflow Interrupt Enable Enables or disables the number of parsable entries overflow interrupt. If this field is 1, it enables the NPEOVIS interrupt. When this field becomes 0, it disables the NPEOVIS interrupt. 0b - Disable 1b - Enable
16 NVEOVIE	Number of Valid Entries Overflow Interrupt Enable Enables or disables the number of valid entries overflow interrupt. If this field is 1, it enables the NVEOVIS interrupt. When this field becomes 0, it disables the NVEOVIS interrupt. 0b - Disable 1b - Enable
15-4 —	Reserved.
3 PDRFIS	Packet Dropped due to RF Interrupt Status Indicates whether the packet dropped due to RF interrupt status is detected. If the Rx Parser result says to drop the packet by setting RF=1 in the instruction memory, then this bit is set to 1. This field clears when the application writes 1 to this field. Access apply to this field. It automatically sets to 1 on an internal event occurrence. Writing 1 clears this field and writing 0 to it has no effect. 0b - Not detected 1b - Detected
2	Frame Offset Overflow Interrupt Status

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Field	Function
FOOVIS	Indicates whether the frame offset overflow interrupt status is detected. If this field is 1, it indicates that when parsing, the instruction table entry's frame offset is more than the EOF offset. This field clears when the application writes 1 to this field. Access apply to this field. It automatically sets to 1 on an internal event occurrence. Writing 1 clears this field and writing 0 to it has no effect. 0b - Not detected 1b - Detected
1 NPEOVIS	Number of Parsable Entries Overflow Interrupt Status Indicates whether the number of parsable entries overflow interrupt status is detected. If this field is 1, it indicates that when parsing a packet the number of parsed entries are more than NPE[] (MTL_RXP_Control_Status[NPE]). This field clears when the application writes 1 to this field. Access apply to this field. It automatically sets to 1 on an internal event occurrence. Writing 1 clears this field and writing 0 to it has no effect. 0b - Not detected 1b - Detected
0 NVEOVIS	Number of Valid Entry Address/Index Overflow Interrupt Status Indicates whether the number of valid entry address or index overflow interrupt status is detected. If this field is 1, it indicates that when parsing, the instruction address is more than MTL_RXP_Control_Status[NVE]. For example, when MTL_RXP_Control_Status[NVE] = 31, the maximum valid entry address/index is NVE+1 that is 32 (addresses/indices = 0 to 32, or 33 entries). MTL_RXP_Interrupt_Control_Status[NVEOVIS] = 1 when currently processed entry indicates that the next address is 33 or more, that is 34th or later entries. This field clears when the application writes 1 to this field. Access apply to this field. It automatically sets to 1 on an internal event occurrence. Writing 1 clears this field and writing 0 to it has no effect. 0b - Not detected 1b - Detected

78.17.203 MTL Rx Parser Drop Count (MTL_RXP_Drop_Cnt)

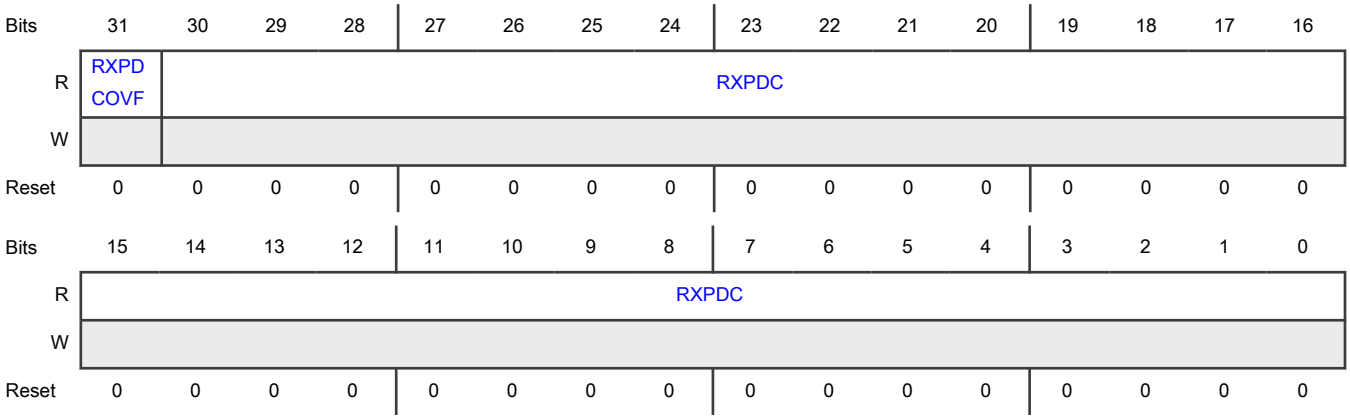
Offset

Register	Offset
MTL_RXP_Drop_Cnt	CA8h

Function

Provides the drop count of receive parser initiated drops.

Diagram



Fields

Field	Function
31 RXPDCOVF	Rx Parser Drop Counter Overflow Bit Indicates whether the receive parser drop count overflow has occurred. When this field is 1, it indicates that the MTL_RXP_Drop_Cnt[RXPDC] counter field has crossed the maximum limit. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not occurred 1b - Occurred
30-0 RXPDC	Rx Parser Drop Count Provides the receive parser drop count. This 31-bit counter is implemented whenever a receive parser drops a packet due to RF = 1. The counter clears when you read the register.

78.17.204 MTL Rx Parser Error Count (MTL_RXP_Error_Cnt)

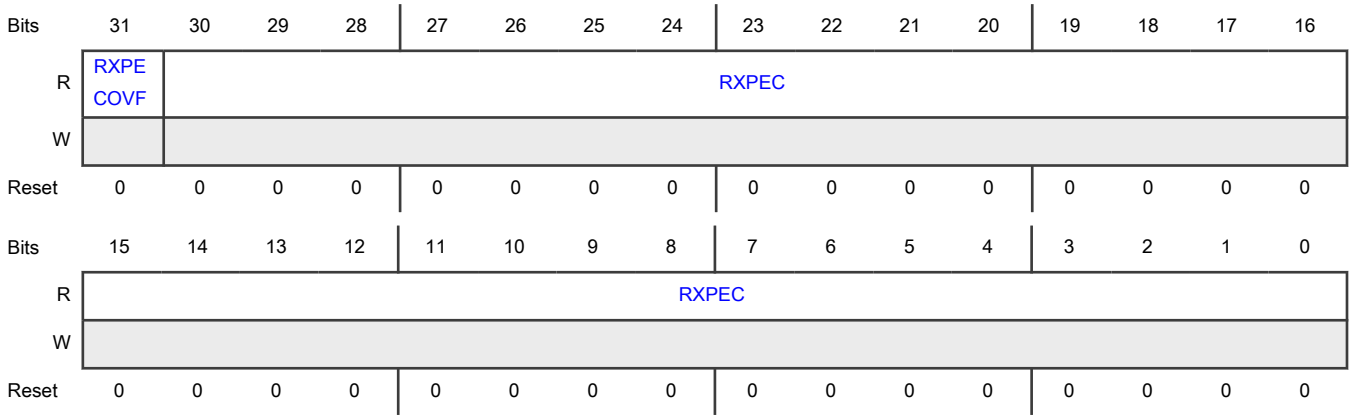
Offset

Register	Offset
MTL_RXP_Error_Cnt	CACh

Function

Provides the receive parser related error occurrence count.

Diagram



Fields

Field	Function
31 RXPECOVF	Rx Parser Error Counter Overflow Bit Indicates whether the receive parser error counter overflow has occurred. When this field is 1, it indicates that MTL_RXP_Error_Cnt[RXPEC] counter field has crossed the maximum limit. Access restrictions apply to this field, which clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not occurred 1b - Occurred
30-0 RXPEC	Rx Parser Error Count Provides the receive parser error count. This 31-bit counter is implemented whenever a receive parser encounters following error scenarios: Entry address >= NVE[] Number parsed entries >= NPE[] Entry address > EOF data entry address The counter clears when you read the register.

78.17.205 MTL Rx Parser Indirect Access Control Status (MTL_RXP_Indirect_Acc_Control_Status)

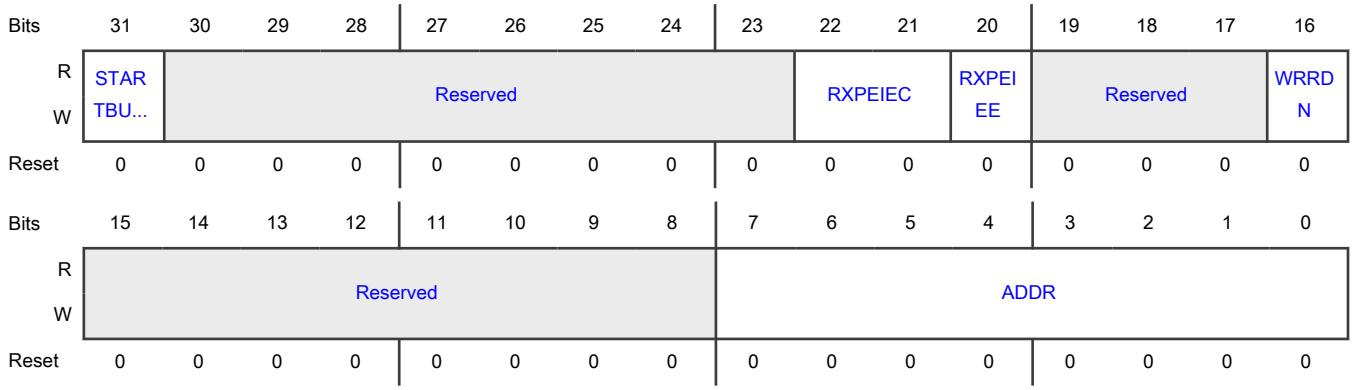
Offset

Register	Offset
MTL_RXP_Indirect_Acc_Control_Status	CB0h

Function

Provides the indirect access control and status for receive parser memory.

Diagram



Fields

Field	Function
31 STARTBUSY	FRP Instruction Table Access Busy When this bit is set to 1 by the software then it indicates to start the Read/Write operation from/to the Rx Parser Memory. Software should read this bit as 0 before issuing read or write request to access the Parser Memory Instructions. This bit when set to 1 indicates that hardware is busy until its gets cleared by hardware and software should not issue any read or write operation. 0b - hardware not busy 1b - hardware is busy (Read/Write operation from/to the Rx Parser Memory)
30-23 —	Reserved.
22-21 RXPEIEC	ECC Inject Error Control for Rx Parser Memory Controls the ECC inject error for receive parser memory. When MTL_RXP_Indirect_Acc_Control_Status[RXPEIEE] = 1, it indicates that on the basis of the value encoded in this field following errors are inserted: 00b - Insert 1 bit error 01b - Insert 2 bit errors 10b - Insert 3 bit errors 11b - Insert 1 bit error in address field
20 RXPEIEE	ECC Inject Error Enable for Rx Parser Memory Indicates whether the ECC inject error for receive parser memory is enabled. If this field is 1, it enables the ECC error injection feature. When this field becomes 0, it disables the ECC error injection feature.

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Field	Function
	0b - Disabled 1b - Enabled
19-17 —	Reserved.
16 WRRDN	Read Write Control Controls the read and write operation to the receive parser memory. If this field is 1, it indicates the write operation to the receive parser memory. When this field is 0, it indicates the read operation to the receive parser memory. 0b - Read operation to the receive parser memory 1b - Write operation to the receive parser memory
15-8 —	Reserved.
7-0 ADDR	FRP Instruction Table Offset Address Indicates the ADDR of the 32-bit entry in receive parser instruction table. Each entry has 128-bit (4x32-bit words). The X depends on the configurable DWC_EQOS_FRP_ENTRIES. If DWC_EQOS_FRP_ENTRIES = 256 , then X = 9 If DWC_EQOS_FRP_ENTRIES = 128 , then X = 8 If DWC_EQOS_FRP_ENTRIES = 64, then X = 7

78.17.206 MTL Rx Parser Indirect Access Data (MTL_RXP_Indirect_Acc_Data)

Offset

Register	Offset
MTL_RXP_Indirect_Acc_Data	CB4h

Function
Provides the data associated to indirect access to receive parser memory.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DATA															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 DATA	FRP Instruction Table Write/Read Data You must write this register before issuing any write command. After read command, when MTL_RXP_Indirect_Acc_Control_Status[STARTBUSY] = 0, the hardware provides the read data from the receive parser memory for read operation.

78.17.207 MTL ECC Control (MTL_ECC_Control)

Offset

Register	Offset
MTL_ECC_Control	CC0h

Function

Establishes the operating mode of ECC related to MTL memories.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved							MEEAO	Reserved			Reserved	MRXPEE	MESTEE	MRXEE	MTXEE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

Fields

Field	Function
31-9 —	Reserved.
8 MEEAO	MTL ECC Error Address Status Over-ride Enables or disables the MTL ECC error address status over-ride. When this field is 1, it indicates that MTL_ECC_Err_Addr_Status[EUEAS] and MTL_ECC_Err_Addr_Status[ECEAS] hold the last valid address where the error is detected. When this field becomes 0, it indicates that MTL_ECC_Err_Addr_Status[EUEAS] and MTL_ECC_Err_Addr_Status[ECEAS] hold the first address where the error is detected. 0b - Disable 1b - Enable
7-5 —	Reserved.
4 —	Reserved.
3 MRXPEE	MTL Rx Parser ECC Enable Indicates whether the MTL receive parser ECC is enabled. If this field is 1, it enables the ECC feature for receive parser memory. When this field is 0, it disables the ECC feature for receive parser memory. 0b - Disabled 1b - Enabled
2 MESTEE	MTL EST ECC Enable Indicates whether the MTL EST ECC is enabled. If this field is 1, it enables the ECC feature for EST memory. When this field is 0, it disables the ECC feature for EST memory. 0b - Disabled 1b - Enabled
1 MRXEE	MTL Rx FIFO ECC Enable Indicates whether the MTL Rx FIFO ECC is enabled. If this field is 1, it enables the ECC feature for MTL receive FIFO memory. When this field is 0, it disables the ECC feature for MTL receive FIFO memory. 0b - Disabled 1b - Enabled
0	MTL Tx FIFO ECC Enable

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Field	Function
MTXEE	Indicates whether the MTL Tx FIFO ECC is enabled. If this field is 1, it enables the ECC feature for MTL Tx FIFO memory. When field is 0, it disables the ECC feature for MTL Tx FIFO memory. 0b - Disabled 1b - Enabled

78.17.208 MTL Safety Interrupt Status (MTL_Safety_Interrupt_Status)

Offset

Register	Offset
MTL_Safety_Interrupt_Status	CC4h

Function

Provides safety interrupt status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	Reserved														
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved														MEUIS	MECIS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved Indicates whether the MAC safety uncorrectable interrupt status is detected. 0b - Not detected 1b - Detected
30-2	Reserved.

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Field	Function
—	
1 MEUIS	MTL ECC Uncorrectable Error Interrupt Status Indicates whether the MTL ECC uncorrectable error interrupt status is detected. Indicates that an uncorrectable error interrupt event in the MTL ECC safety feature. The application must read MTL_ECC_Interrupt_Status to get the exact cause of the interrupt. 0b - Not detected 1b - Detected
0 MECIS	MTL ECC Correctable Error Interrupt Status Indicates whether the MTL ECC correctable error interrupt status is detected. Indicates that a correctable error interrupt event in the MTL ECC safety feature. The application must read MTL_ECC_Interrupt_Status to get the exact cause of the interrupt . 0b - MTL ECC Correctable error Interrupt Status not detected 1b - MTL ECC Correctable error Interrupt Status detected

78.17.209 MTL ECC Interrupt Enable (MTL_ECC_Interrupt_Enable)

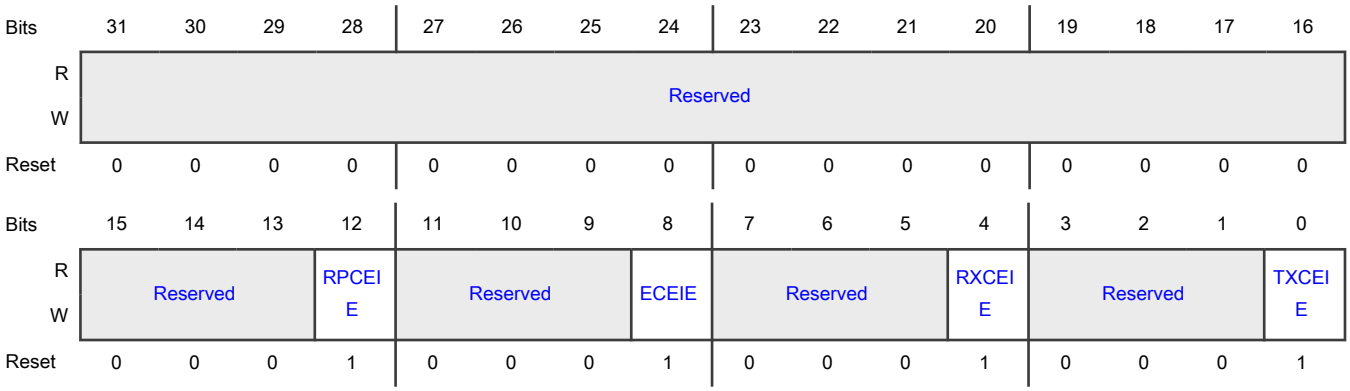
Offset

Register	Offset
MTL_ECC_Interrupt_Enable	CC8h

Function

Provides enable bits for the ECC interrupts.

Diagram



Fields

Field	Function
31-13 —	Reserved.
12 RPCEIE	Rx Parser Memory Correctable Error Interrupt Enable Indicates whether the Rx parser memory correctable error interrupt is enabled. When this field is 1, it generates an interrupt when an uncorrectable error is detected at the Rx parser memory interface. It is indicated in MTL_ECC_Interrupt_Status[RPCES]. When this field becomes 0, it indicates that this event does not generates an interrupt. 0b - Disabled 1b - Enabled
11-9 —	Reserved.
8 ECEIE	EST Memory Correctable Error Interrupt Enable Indicates whether the EST memory correctable error interrupt is enabled. When this field is 1, it generates an interrupt when a correctable error is detected at the MTL EST memory interface. It is indicated in MTL_ECC_Interrupt_Status[ECES]. When this field becomes 0, it indicates that this event does not generates an interrupt. 0b - Disabled 1b - Enabled
7-5 —	Reserved.
4 RXCEIE	Rx Memory Correctable Error Interrupt Enable Indicates whether the Rx memory correctable error interrupt is enabled. When this field is 1, it generates an interrupt when a correctable error is detected at the MTL Rx memory interface. It is indicated in MTL_ECC_Interrupt_Status[RXCES]. When this field becomes 0, it indicates that this event does not generates an interrupt. 0b - Disabled 1b - Enabled
3-1 —	Reserved.
0 TXCEIE	Tx Memory Correctable Error Interrupt Enable Indicates whether the Tx memory correctable error interrupt is enabled.

Table continues on the next page...

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Field	Function
	When this field is 1, it generates an interrupt when a correctable error is detected at the MTL Tx memory interface. It is indicated in MTL_ECC_Interrupt_Status[TXCES]. When this field becomes 0, it indicates that this event does not generates an interrupt. 0b - Disabled 1b - Enabled

78.17.210 MTL ECC Interrupt Status (MTL_ECC_Interrupt_Status)

Offset

Register	Offset
MTL_ECC_Interrupt_Status	CCCh

Function

Provides MTL ECC Interrupt Status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	RPUES	RPAMS	RPCES	Reserved	EUES	EAMS	ECES	Reserved	RXUES	RXAMS	RXCES	Reserved	TXUES	TXAMS	TXCES
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-15 —	Reserved.
14 RPUES	Rx Parser Memory Uncorrectable Error Status Indicates whether the Rx parser memory uncorrectable error status is detected. When this field is 1, it indicates that an uncorrectable error is detected at Rx parser memory interface.

Table continues on the next page...

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Field	Function
	0b - Not detected 1b - Detected
13 RPAMS	MTL Rx Parser Memory Address Mismatch Status Indicates whether the MTL Rx parser memory address mismatch status is detected. When this field is 1, it indicates that an address mismatch is found for Rx parser memory's address bus. 0b - Not detected 1b - Detected
12 RPCES	MTL Rx Parser Memory Correctable Error Status Indicates whether the MTL Rx parser memory correctable error status is detected. When this field is 1, it indicates that a correctable error is detected at RX parser memory interface. 0b - Not detected 1b - Detected
11 —	Reserved.
10 EUES	MTL EST Memory Uncorrectable Error Status Indicates whether the MTL EST memory uncorrectable error status is detected. When this field is 1, it indicates that an uncorrectable error is detected at MTL EST memory interface. 0b - Not detected 1b - Detected
9 EAMS	MTL EST Memory Address Mismatch Status Indicates whether the MTL EST memory address mismatch status is detected. When this field is 1, it indicates that an address mismatch is found for MTL EST memory's address bus. 0b - Not detected 1b - Detected
8 ECES	MTL EST Memory Correctable Error Status Indicates whether the MTL EST memory correctable error status is detected. When this field is 1, it indicates that a correctable error is detected at the MTL EST memory. 0b - Not detected 1b - Detected
7 —	Reserved.

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Field	Function
6 RXUES	MTL Rx Memory Uncorrectable Error Status Indicates whether the MTL Rx memory uncorrectable error status is detected. When this field is 1, it indicates that an uncorrectable error is detected at the MTL Rx memory interface. 0b - Not detected 1b - Detected
5 RXAMS	MTL Rx Memory Address Mismatch Status Indicates whether the MTL Rx memory address mismatch status is detected. When this field is 1, it indicates that an address mismatch is found for MTL Rx memory's address bus. 0b - Not detected 1b - Detected
4 RXCES	MTL Rx memory Correctable Error Status Indicates whether the MTL Rx memory correctable error status is detected. When this field is 1, it indicates that a correctable error is detected at the MTL Rx memory. 0b - Not detected 1b - Detected
3 —	Reserved.
2 TXUES	MTL Tx Memory Uncorrectable Error Status Indicates whether the MTL Tx memory uncorrectable error status is detected. When this field is 1, it indicates that an uncorrectable error is detected at the MTL TX memory interface. 0b - Not detected 1b - Detected
1 TXAMS	MTL Tx Memory Address Mismatch Status Indicates whether the MTL Tx memory address mismatch status is detected. When this field is 1, it indicates that an address mismatch is found for MTL Tx memory's address bus. 0b - Not detected 1b - Detected
0 TXCES	MTL Tx Memory Correctable Error Status Indicates whether the MTL Tx memory correctable error status is detected. When this field is 1, it indicates that a correctable error is detected at the MTL Tx memory. 0b - Not detected

Table continues on the next page...

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Field	Function
	1b - Detected

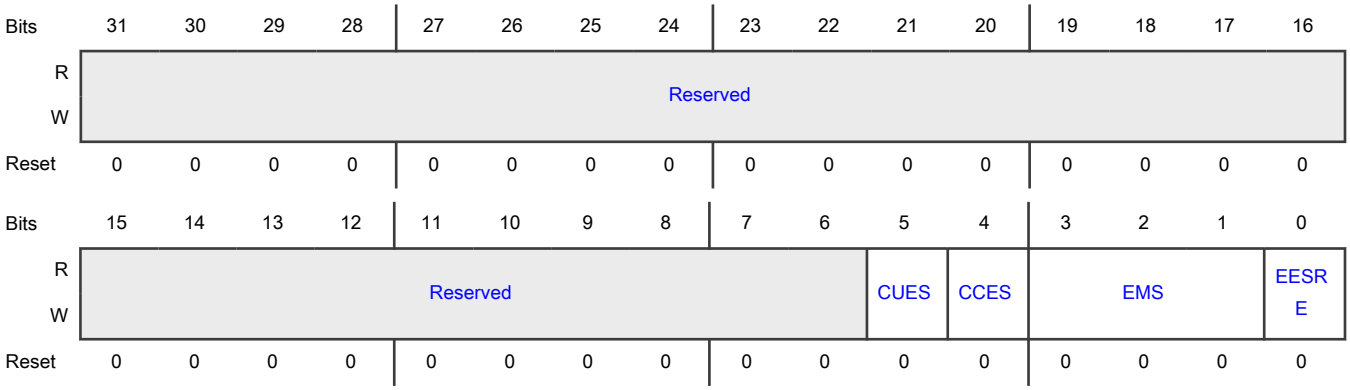
78.17.211 MTL ECC Error Status (MTL_ECC_Err_Sts_Rctl)

Offset

Register	Offset
MTL_ECC_Err_Sts_Rctl	CD0h

Function
Establishes the control for ECC error status capture.

Diagram



Fields

Field	Function
31-6 —	Reserved.
5 CUES	Clear Uncorrectable Error Status Indicates whether the clear uncorrectable error status is detected. When this field and MTL_ECC_Err_Sts_Rctl[EESRE] is 1, it indicates that based on the MTL_ECC_Err_Sts_Rctl[EMS], the respective memory's uncorrectable error address and uncorrectable error count values are cleared upon reading. When all the error status values are cleared hardware resets this field. 0b - Not detected 1b - Detected

Table continues on the next page...

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Field	Function
4 CCES	Clear Correctable Error Status Indicates whether the clear correctable error status is detected. When this field and MTL_ECC_Err_Sts_Rctl[EESRE] is 1, it indicates that based on the MTL_ECC_Err_Sts_Rctl[EMS],, the respective memory's correctable error address and correctable error count values are cleared upon reading. When all the error status values are cleared, hardware resets this field. 0b - Not detected 1b - Detected
3-1 EMS	MTL ECC Memory Selection Provides the memory selection encoding. When MTL_ECC_Err_Sts_Rctl[EESRE] is 1, this field indicates which memory's error status value to be read. The memory selection encoding is as described below. 000b - MTL Tx memory 001b - MTL Rx memory 010b - MTL EST memory 011b - MTL Rx Parser memory 100b - DMA TSO memory
0 EESRE	MTL ECC Error Status Read Enable Indicates whether the MTL ECC error status read is enabled. When this field is 1, it indicates that based on MTL_ECC_Err_Sts_Rctl[EMS], the respective memory's error status values are captured as described below: • The correctable and uncorrectable error count values are captured into MTL_ECC_Err_Cnt_Status. • The address location of correctable and uncorrectable errors are captured into MTL_ECC_Err_Addr_Status. When all the status values are captured into MTL_ECC_Err_Cnt_Status and MTL_ECC_Err_Addr_Status, hardware resets this field. 0b - Disabled 1b - Enabled

78.17.212 MTL ECC Error Address Status (MTL_ECC_Err_Addr_Status)

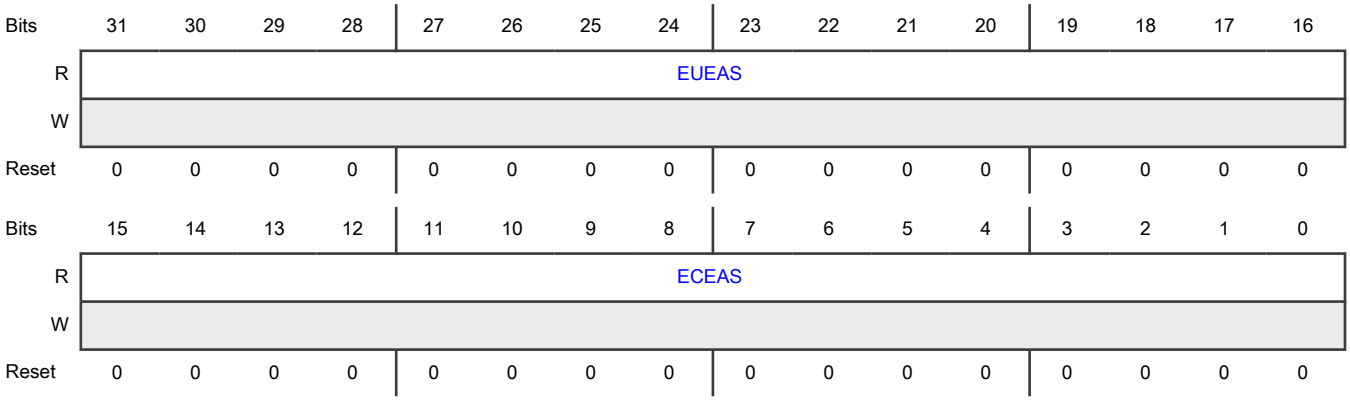
Offset

Register	Offset
MTL_ECC_Err_Addr_Status	CD4h

Function

Provides the memory addresses for the correctable and uncorrectable errors.

Diagram



Fields

Field	Function
31-16 EUEAS	MTL ECC Uncorrectable Error Address Status Based on the MTL_ECC_Err_Sts_Rctl[EMS], this field holds the respective memory's address locations for which an uncorrectable error or address mismatch is detected. When MTL_ECC_Control[MEEAO] = 1, this field holds the last valid address of memory for which either an uncorrectable error or an address mismatch is detected. When MTL_ECC_Control[MEEAO] = 0, this field holds the first address of the memory for which either an uncorrectable error or address mismatch is detected.
15-0 ECEAS	MTL ECC Correctable Error Address Status Based on the MTL_ECC_Err_Sts_Rctl[EMS], this field holds the respective memory's address locations for which a correctable error is detected. When MTL_ECC_Control[MEEAO] = 1, this field holds the last valid address of memory for which the correctable error or address mismatch is detected. When MTL_ECC_Control[MEEAO] = 0, this field holds the first address of the memory for which correctable error is detected.

78.17.213 MTL ECC Error Control Status (MTL_ECC_Err_Cntr_Status)

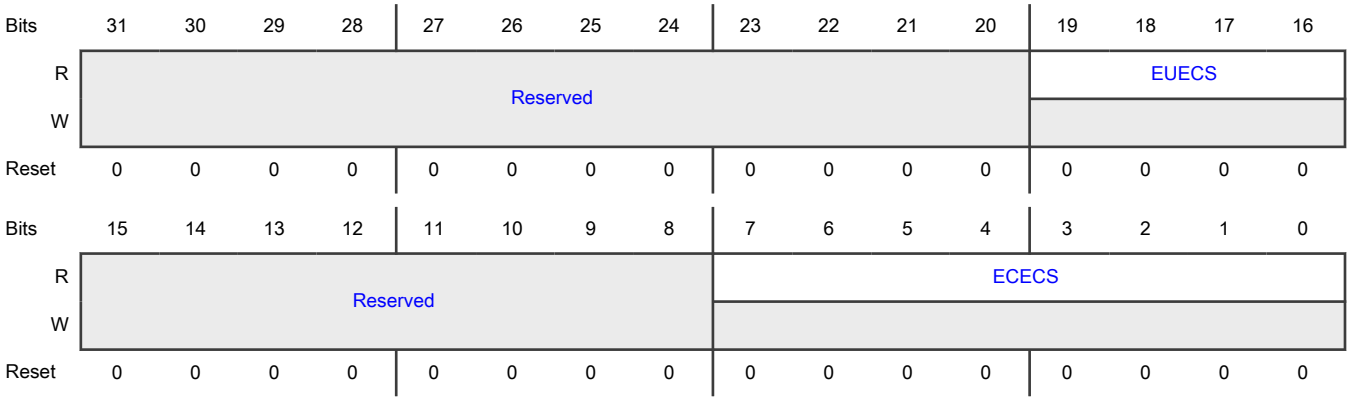
Offset

Register	Offset
MTL_ECC_Err_Cntr_Status	CD8h

Function

Provides ECC Error count for correctable and uncorrectable errors.

Diagram



Fields

Field	Function
31-20 —	Reserved.
19-16 EUECS	MTL ECC Uncorrectable Error Counter Status Based on the EMS field of MTL_ECC_Err_Cntr_Rctl register, this field holds the respective memory's uncorrectable error count value.
15-8 —	Reserved.
7-0 ECECS	MTL ECC Correctable Error Counter Status Based on the EMS field of MTL_ECC_Err_Cntr_Rctl register, this field holds the respective memory's correctable error count value.

78.17.214 MTL DPP Control (MTL_DPP_Control)

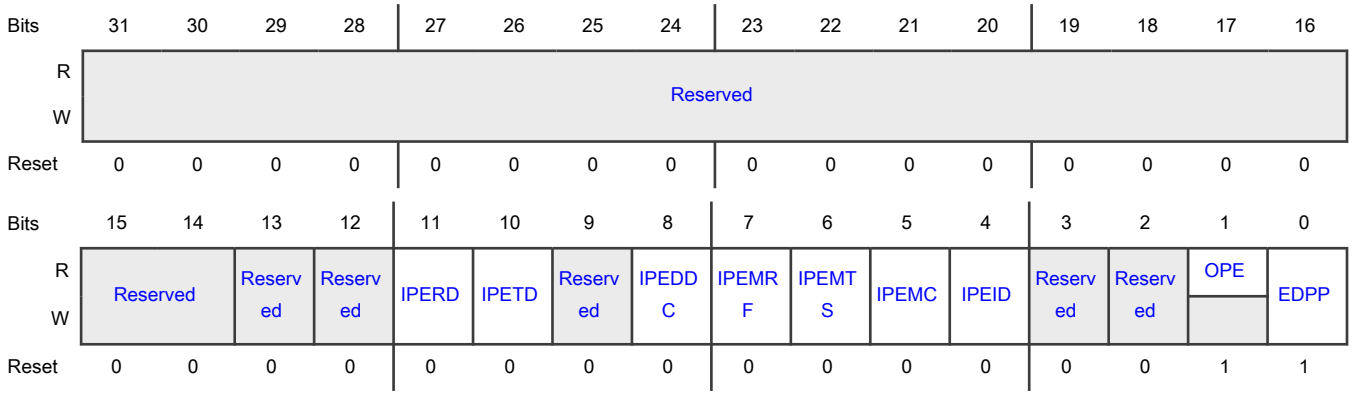
Offset

Register	Offset
MTL_DPP_Control	CE0h

Function

Establishes the operating mode of data parity protection and error injection.

Diagram



Fields

Field	Function
31-14 —	Reserved.
13 —	Reserved.
12 —	Reserved.
11 IPERD	Insert Parity error in Rx write-back Descriptor parity generator Indicates whether the insert parity error in receive write-back descriptor parity generator is enabled. When this field is 1, it flips the parity bit of first valid data to which the DMA Rx write-back descriptor parity generator(or at PG8 as shown in Receive data path parity protection diagram) generates. 0b - Disabled 1b - Enabled
10 IPETD	Insert Parity error in Tx write-back Descriptor parity generator Indicates whether the insert parity error in transit write-back descriptor parity generator is enabled. When this field is 1, it flips the parity bit of first valid data to which the DMA Tx write-back descriptor parity generator(or at PG4 as shown in Transmit data path parity protection diagram) generates. Hardware clears this field, when the respective parity bit flips. 0b - Disabled 1b - Enabled
9 —	Reserved.
8	Insert Parity Error in DMA DTX Control Word Parity Generator

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Field	Function
IPEDDC	Indicates whether the insert parity error in DMA DTX control word parity generator is enabled. When this field is 1, it flips the parity bit of first valid data to which the DMA DTX Control word parity generator (or at PG2 as shown in Transmit data path parity protection diagram) generates. Hardware clears this field, when the respective parity bit flips. 0b - Disabled 1b - Enabled
7 IPEMRF	Insert Parity Error in MTL Rx FIFO Read Control Parity Generator Inserts parity Error in MTL receive FIFO read control parity generator. When this field is 1, it flips the parity bit of first valid data to which the MTL Rx FIFO read control parity generator (or at PG7 as shown in Receive data path parity protection diagram) generates. Hardware clears this field, when the respective parity bit flips. 0b - Disabled 1b - Enabled
6 IPEMTS	Insert Parity Error in MTL Tx Status Parity Generator Indicates whether the insert parity error in MTL transit status parity generator is enabled. When this field is 1, it flips the parity bit of first valid data to which the MTL Tx Status parity generator (or at PG6 as shown in Transmit data path parity protection diagram) generates. Hardware clears this field, when the respective parity bit flips. 0b - Disabled 1b - Enabled
5 IPEMC	Insert Parity Error in MTL Checksum Parity Generator Indicates whether the insert parity error in MTL checksum parity generator is enabled. When this field is 1, it flips the parity bit of first valid data to which the MTL checksum parity generator (or at PG5 as shown in Transmit data path parity protection diagram) generates. Hardware clears this field, when the respective parity bit flips. 0b - Disabled 1b - Enabled
4 IPEID	Insert Parity Error in Interface Data Parity Generator Indicates whether the insert parity error in interface data parity generator is enabled. When this field is 1, it flips the parity bit of first valid input data to which the interface data parity generator (or at PG1 as shown in Transmit data path parity protection diagram) generates. Following are the input data bus on which parity bits are generated on the basis of configuration selected. In AHB Config, hrdata_i In AXI config, rdata_m_i

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Field	Function
	In DMA Config, mdc_rdata_i In MTL Config, ati_data_i Hardware clears this field, when the respective parity bit flips. 0b - Disabled 1b - Enabled
3 —	Reserved.
2 —	Reserved.
1 OPE	Odd Parity Enable Indicates whether an odd parity protection is enabled. When this field is 1, it enables an odd parity protection on all the external interfaces and when this field is 0, it enables an even parity protection on all the external interfaces. 0b - Disabled 1b - Enabled
0 EDPP	Enable Data path Parity Protection Enables or disables the data path parity protection. When this field is 1, it indicates that by generating and checking the parity on EQOS datapath it enables the parity protection for EQOS datapath . When this field is 0, it disables the parity protection for EQOS datapath. 0b - Disable 1b - Enable

78.17.215 MTL Tx Queue 0 Operation Mode (MTL_TxQ0_Operation_Mode)

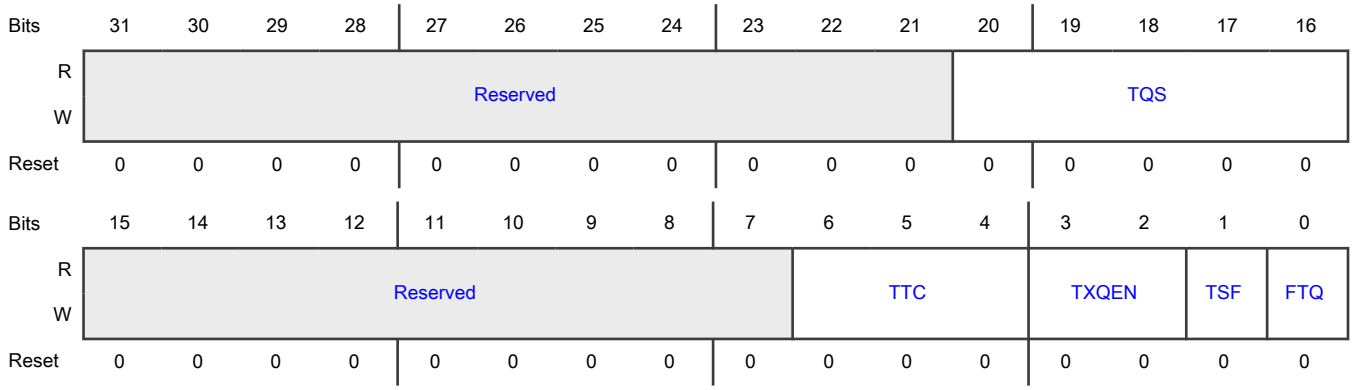
Offset

Register	Offset
MTL_TxQ0_Operation_Mode	D00h

Function

Establishes the transmit queue operating modes and commands.

Diagram



Fields

Field	Function
31-21 —	Reserved.
20-16 TQS	Transmit Queue Size Indicates the size of the allocated transmit queues in blocks of 256 bytes. This field is read-write only if the number of transit queues are more than one, the reset value is 0x0 and indicates 256 bytes size. This means that value of 0x0 = 256 bytes, 0x1 = 512 bytes and so on. You must program TQS [5:0] = 6'b001111 to allocate queue size of 4096 (4K) bytes . In general, the size of the Queue = (TQS+1)*256 bytes. When the number of transit queue is one, the field is read-only and the reset value reflects the configured TX FIFO size in blocks of 256 bytes. The field's width depends on the transit memory size selected in your configuration. For example, if the memory size is 2048, the field's width is 3 bits: LOG2(2048/256) = LOG2(8) = 3 bits
15-7 —	Reserved.
6-4 TTC	Transmit Threshold Control Controls the threshold level of the MTL transit queue. The transmission starts when the packet size within the MTL transit queue is larger than the threshold, also transmits full packets with length less than the threshold. These fields are used only when MTL_TxQ0_Operation_Mode[TSF] resets. 000b - 32 001b - 64 010b - 96 011b - 128 100b - 192 101b - 256

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Field	Function
	110b - 384 111b - 512
3-2 TXQEN	Transmit Queue Enable Enables or disables the transmit queue 0. 2'b00 - Not enabled 2'b01 - Reserved 2'b10 - Enabled 2'b11 - Reserved This field is read only in single queue configurations and read write in multiple queue configurations. **NOTE** In multiple transit queue configuration, all the queues disables by default and programming this field enables the transit queue. 00b - Not enabled 01b - Enable in AV mode (Reserved in non-AV) 10b - Enabled 11b - Reserved
1 TSF	Transmit Store and Forward Indicates whether the transmit store and forward is enabled. When this field is 1, it indicates that the transmission starts when a full packet resides in the MTL transit queue and the TTC values specified in Bits[6:4] of this register are ignored. This field must be changed only when you stop the transmission. 0b - Disabled 1b - Enabled
0 FTQ	Flush Transmit Queue Indicates whether the flush transmit queue is enabled. When this field is 1, it indicates that the transit queue controller logic resets to its default values. Therefore, all the data in the transit queue is lost or flushed. After the flushing operation completes this field resets internally. You must not write to the MTL_TxQ1_Operation_Mode until this field resets. The data to which the MAC transmitter has already accepted is not flushed. It is scheduled for transmission and results in underflow and runt packet transmission. **NOTE** The flush operation completes only when the transit queue is empty and the application accepts the pending transit status of all the transmitted packets. To complete the flush operation, the PHY Tx clock (CLK_TX_I) must be active.

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Field	Function
	Access restriction apply to this field. It clears automatically. Writing 1 sets this field and writing 0 has no effect. 0b - Disabled 1b - Enabled

78.17.216 MTL Tx Queue 0 Underflow (MTL_TxQ0_Underflow)

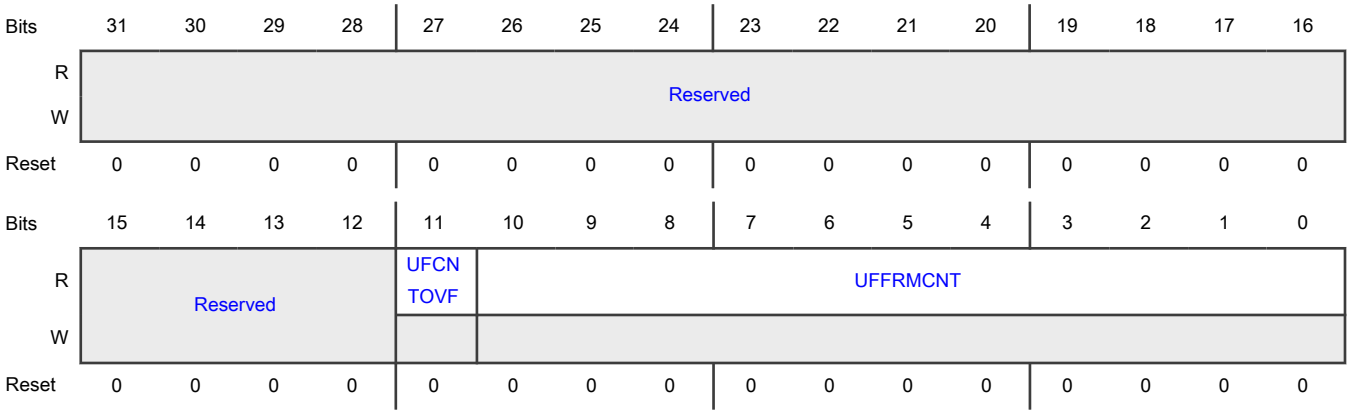
Offset

Register	Offset
MTL_TxQ0_Underflow	D04h

Function

Contains the counter for packets aborted because of transmit queue underflow and packets missed because of receive queue packet flush.

Diagram



Fields

Field	Function
31-12 —	Reserved.
11 UFCNTOVF	Overflow Bit for Underflow Packet Counter Indicates whether the overflow is detected for underflow packet counter.

Table continues on the next page...

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Field	Function
	This field is 1, when the transit queue underflow packet counter field overflows, that is, it has crossed the maximum count. In such a scenario, the overflow packet counter resets to all-zeros and this field indicates that the rollover occurred. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
10-0 UFFRMCNT	Underflow Packet Counter Indicates the number of packets aborted by the controller because of transit queue underflow. This counter increments each time the MAC aborts outgoing packet because of underflow. The counter clears when this register is read with mci_be_i[0] at 1'b1. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.

78.17.217 MTL Tx Queue 0 Debug (MTL_TxQ0_Debug)

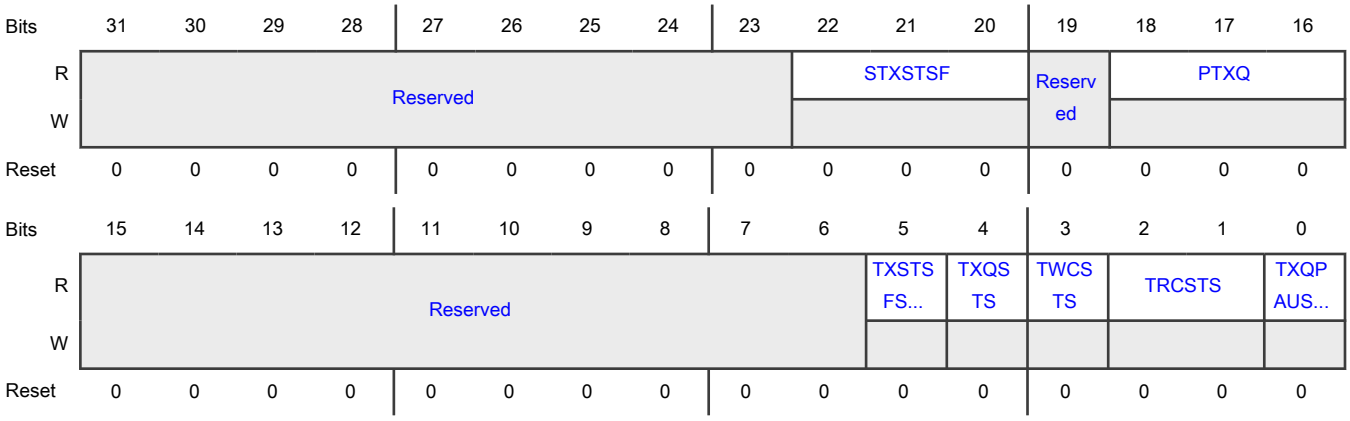
Offset

Register	Offset
MTL_TxQ0_Debug	D08h

Function

Provides the debug status of various blocks related to the transmit queue.

Diagram



Fields

Field	Function
31-23 —	Reserved.
22-20 STXSTSF	Number of Status Words in Tx Status FIFO of Queue Indicates the current number of status in the transit status FIFO of this queue. This field does not reflect the number of status words in transit status FIFO, when MTL_Operation_Mode[DTXSTS] = 1.
19 —	Reserved.
18-16 PTXQ	Number of Packets in the Transmit Queue Indicates the current number of packets in the transit queue. This field does not reflect the number of packets in the transmit queue, when MTL_Operation_Mode[DTXSTS] = 1.
15-6 —	Reserved.
5 TXSTSFSTS	MTL Tx Status FIFO Full Status Indicates whether the MTL transit status and FIFO full status is detected. When this field is 1, it indicates that the MTL transit status FIFO is full. Therefore, MTL cannot accept any more packets for transmission. 0b - Not detected 1b - Detected
4 TXQSTS	MTL Tx Queue Not Empty Status Indicates whether the MTL transit queue not empty status is detected. When this field is high, it indicates that the MTL transit queue is not empty and some data is left for transmission. 0b - Not detected 1b - Detected
3 TWCSTS	MTL Tx Queue Write Controller Status Indicates whether the MTL transit queue write controller status is detected. When high, this field indicates that the MTL transit queue write controller is active, and transfers the data to the transit queue. 0b - Not detected 1b - Detected

Table continues on the next page...

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Field	Function
2-1 TRCSTS	MTL Tx Queue Read Controller Status Indicates the state of the transit queue read controller. 00b - Idle state 01b - Read state (transferring data to the MAC transmitter) 10b - Waiting for pending transit status from the MAC transmitter 11b - Flushing the transit queue because of the packet abort request from the MAC
0 TXQPAUSED	Transmit Queue in Pause Indicates whether the transmit queue in pause is detected. When this field is 1 and the receive flow control is enabled, it indicates that the transit queue is in the pause condition (in the full-duplex only mode) because of the following scenario: • Receives PFC packet with the priorities assigned to the transit queue when PFC is enabled. • Receives 802.3x pause packet when PFC is disabled. 0b - Not detected 1b - Detected

78.17.218 MTL Tx Queue 0 ETS Status (MTL_TxQ0_ETS_Status)

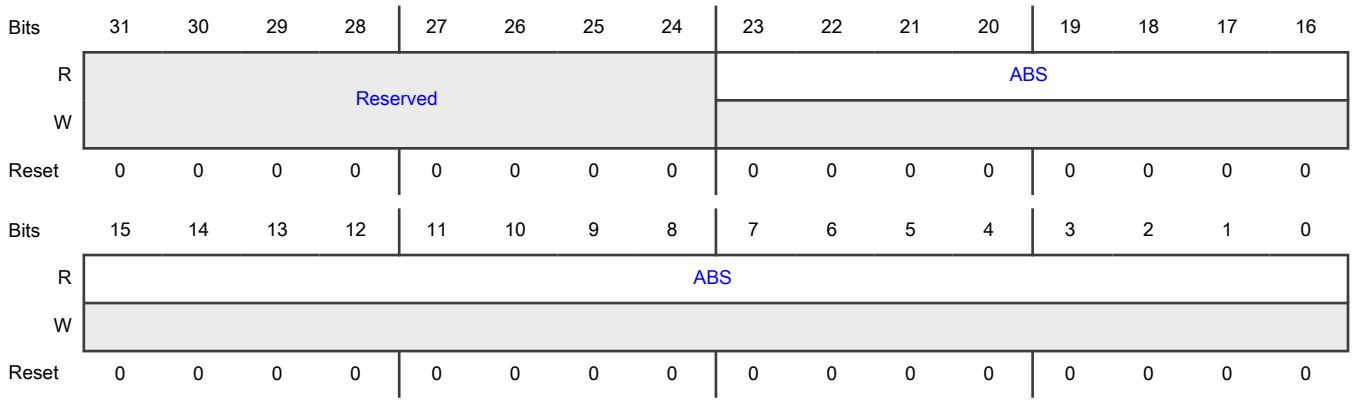
Offset

Register	Offset
MTL_TxQ0_ETS_Status	D14h

Function

Provides the average traffic transmitted in queue 0.

Diagram



Fields

Field	Function
31-24 —	Reserved.
23-0 ABS	Average Bits per Slot Contains the average transmitted bits per slot. Computes over every 10 million bit times slot (4 ms in 2500 Mbit/s; 10 ms in 1000 Mbit/s; 100 ms in 100 Mbit/s), when the DCB operation enables for queue 0. The maximum value is 0x989680.

78.17.219 MTL Tx Queue Quantum Weight (MTL_TxQ0_Quantum_Weight)

Offset

Register	Offset
MTL_TxQ0_Quantum_Weight	D18h

Function
Contains the quantum value for Deficit Weighted Round Robin (DWRR), weights for the Weighted Round Robin (WRR), and Weighted Fair Queuing (WFQ) for queue 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved												ISCQW			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ISCQW															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-21 —	Reserved.
20-0	Quantum or Weights

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Field	Function
ISCQW	Contains the quantum value in bytes which is added to credit during every queue scanning cycle, when DCB operation enables with DWRR algorithm for queue 0 traffic. The maximum value is 0x1312D0 bytes. Contains the weight for this queue, when DCB operation enables with WFQ algorithm for queue 0 traffic. The maximum value is 0x3FFF where weight of 0 indicates 100% bandwidth. Write 0 to bits[20:14]. The higher the programmed weights, the lesser is the bandwidth that is allocated for the particular transmit queue. This is because the weights compute the packet finish time (weights*packet_size). The lesser the finish time, the higher is the probability of the packet getting scheduled first and consuming more bandwidth. Contains the weight for this queue, when DCB operation or generic queuing operation enables with WRR algorithm for queue 0 traffic. The maximum value is 0x64. Write 0 to bits [20:7].

78.17.220 MTL Queue 0 Interrupt Control Status (MTL_Q0_Interrupt_Control_Status)

Offset

Register	Offset
MTL_Q0_Interrupt_Control_Status	D2Ch

Function
Contains the interrupt enable and status bits for the queue 0 interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved							RXOIE	Reserved							RXOVFIS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved						ABPSIE	TXUIE	Reserved						ABPSIS	TXUNFIS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-25 —	Reserved.

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Field	Function
24 RXOIE	Receive Queue Overflow Interrupt Enable Enables or disables the receive queue overflow interrupt. When this field is 1, it enables the receive queue overflow interrupt. When this field becomes 0, it disables the receive queue overflow interrupt. 0b - Disabled 1b - Enabled
23-17 —	Reserved.
16 RXOVFIS	Receive Queue Overflow Interrupt Status Indicates whether the status of receive queue overflow interrupt is detected. This bit indicates that the receive queue had an overflow when you receive the packet. If you transfer a partial packet to the application, the overflow status sets in RDES3[21]. This field is 0 when the application writes 1 to it. Access restriction apply to this field. It becomes 0 automatically on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
15-10 —	Reserved.
9 ABPSIE	Average Bits Per Slot Interrupt Enable Enables or disables the average bits per slot interrupt. When this field is 1, it indicates that when you update the average bits per slot status, the MAC asserts the sbd_intr_o or mci_intr_o interrupt. When this field is 0, it indicates that the interrupt do not assert for such an event. 0b - Disabled 1b - Enabled
8 TXUIE	Transmit Queue Underflow Interrupt Enable Enables or disables transmit queue underflow interrupt. When this field is 1, it enables the transmit queue underflow interrupt. When this field becomes 0, it disables the transmit queue underflow interrupt. 0b - Disabled 1b - Enabled
7-2	Reserved.

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Field	Function
—	
1 ABPSIS	Average Bits Per Slot Interrupt Status Indicates whether the status of average bits per slot interrupt is detected. When this field is 1, it indicates that the MAC has updated the ABS value. This field is 0 when the application writes 1 it. Access restriction apply to this field. It becomes 0 automatically on an internal event occurrence. Writing 1 sets this field and writing 0 has no effect. 0b - Not detected 1b - Detected
0 TXUNFIS	Transmit Queue Underflow Interrupt Status Indicates whether the status of transmit queue underflow interrupt is detected. This field indicates that, when you transmit the packet,the transmit queue had an underflow. Suspend the transmission and write 1 to an underflow error TDES3[2]. This field is 0, when the application writes 1 to it. Access restriction apply to this field. It becomes 0 automatically on an internal event occurrence. Writing 1 sets this field and writing 0 has no effect. 0b - Not detected 1b - Detected

78.17.221 MTL Rx Queue 0 Operation Mode (MTL_RxQ0_Operation_Mode)

Offset

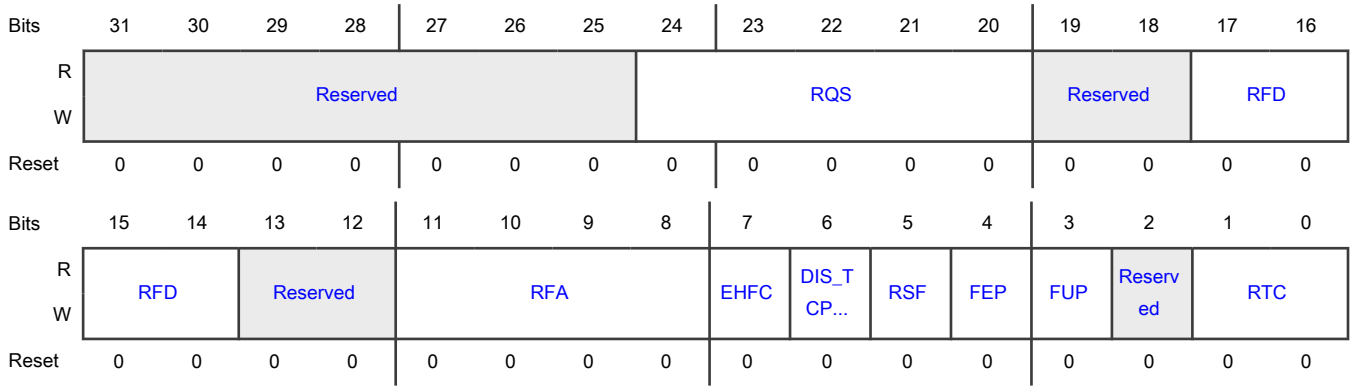
Register	Offset
MTL_RxQ0_Operation_Mode	D30h

Function

Establishes the receive queue operating modes and command.

The RFA and RFD fields are not backward compatible with the RFA and RFD fields of 4.00a release

Diagram



Fields

Field	Function
31-25 —	Reserved.
24-20 RQS	Receive Queue Size Indicates the size of the allocated receive queues in blocks of 256 bytes. The MTL_RxQ0_Operation_Mode[RQS] is read-write only if the number of receive queues are more than one, the reset value is 0x0 and indicates size of 256 bytes. This means that value of 0x0 = 256 bytes, 0x1 = 512 bytes and so on. You must program RQS [5:0] = 6'b001111 to allocate queue size of 4096 (4K) bytes. In general, the size of the Queue = (RQS+1)*256 bytes. When the number of receive queues is one, the field is read-only and the configured receive FIFO size in blocks of 256 bytes is reflected in the reset value. The field width depends on the receive memory size selected in your configuration. For example, if the memory size is 2048, the field width is 3 bits: LOG2(2048/256) = LOG2(8) = 3 bits
19-18 —	Reserved.
17-14 RFD	Threshold for Deactivating Flow Control (in half-duplex and full-duplex modes) Controls the threshold (fill-level of Rx queue) at which the flow control is de-asserts after activation. 0 - Full minus 1 KB, that is, FULL 1 KB 1 - Full minus 1.5 KB, that is, FULL 1.5 KB 2 - Full minus 2 KB, that is, FULL 2 KB 3 - Full minus 2.5 KB, that is, FULL 2.5 KB ... 14 - Full minus 8 KB, that is, FULL 8 KB 15 - Full minus 8.5 KB, that is, FULL 8.5 KB

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Field	Function
	De-assertion is effective only after flow control is asserted. **NOTE** You must program the value in such a way that the threshold is a positive number. When MTL_RxQ0_Operation_Mode[EHFC] = 1, these values are applicable only when the receive queue size which the MTL_RxQ0_Operation_Mode[RQS] determines is equal to or greater than 4 KB. For a given queue size, the values ranges between 0 and the encoding for FULL minus (QSIZE - 0.5 KB) and all other values are illegal. Here the term FULL and QSIZE refers to the queue size which the MTL_RxQ0_Operation_Mode[RQS] determines. The field width depends on RX FIFO size selected during the configuration. Remaining bits are reserved and read only.
13-12 —	Reserved.
11-8 RFA	Threshold for Activating Flow Control (in half-duplex and full-duplex) Controls the threshold (fill-level of receive queue) at which the flow control is activated. See MTL_RxQ0_Operation_Mode[RFD] for more information on encoding for this field.
7 EHFC	Enable Hardware Flow Control Enables or disables hardware flow control. If this field is 1, it enables the flow control signal operation, on the basis of the fill-level of receive queue. When this field becomes 0, it disables the flow control operation. 0b - Disable 1b - Enable
6 DIS_TCP_EF	Disable Dropping of TCP/IP Checksum Error Packets Enables or disable dropping of TCP or IP checksum error packets. When this field is 1, it indicates that the MAC does not drop the packets which only have the errors which the receive checksum offload engine detects. Such packets have errors only in the encapsulated payload. There are no errors (including FCS error) in the Ethernet packet received by the MAC. When this field becomes 0, it indicates that all error packets are dropped if MTL_RxQ0_Operation_Mode[FEP] resets. 0b - Enable 1b - Disable
5 RSF	Receive Queue Store and Forward Indicates whether the receive queue store and forward is enabled. When this field is 1, it indicates that the module reads a packet from the receive queue only after the complete packet has been written to it, ignores the MTL_RxQ0_Operation_Mode[RTC].

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Field	Function
	When this field becomes 0, it indicates that the receive queue operates in the Threshold (cut-through) mode, subject to the threshold which the MTL_RxQ0_Operation_Mode[RTC] specifies. 0b - Disabled 1b - Enabled
4 FEP	Forward Error Packets Indicates whether the forward error packets are enabled. When this field becomes 0, it indicates that the receive queue drop packets with an error status (CRC error, GMII_ER, watchdog timeout, or overflow). However, the packet does not drop if the start byte (write) pointer of a packet is already transferred to the read controller side (in Threshold mode). When this field is 1, it indicates that all packets except the runt error packets are forwarded to the application or DMA. The packet is dropped irrespective of the setting of this field, if MTL_RxQ0_Operation_Mode[RSF] is 1 and the receive queue overflows when a partial packet is written. However, if MTL_RxQ0_Operation_Mode[RSF] becomes 0 and the receive queue overflows when a partial packet is written, a partial packet might be forwarded to the application or DMA. 0b - Disabled 1b - Enabled
3 FUP	Forward Undersized Good Packets Indicates whether the forward undersized good packets are enabled. When this field is 1, it indicates that the receive queue forwards the undersized good packets (packets with no error and length less than 64 bytes), including pad-bytes and CRC. When this field becomes 0, it indicates that the receive queue drops all packets of less than 64 bytes, unless a packet is already transferred because of the lower value of receive threshold, for example, MTL_RxQ0_Operation_Mode[RTC] = 01. 0b - Disabled 1b - Enabled
2 —	Reserved.
1-0 RTC	Receive Queue Threshold Control Controls the threshold level of the MTL receive queue (in bytes). The received packet is transferred to the application or DMA when the packet size within the MTL receive queue is larger than the threshold. In addition, automatically transfer full packets with length less than the threshold. This field is valid only when MTL_RxQ0_Operation_Mode[RSF] = 0. This field is ignored when MTL_RxQ0_Operation_Mode[RSF] = 1. 00b - 64

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Field	Function
	01b - 32 10b - 96 11b - 128

78.17.222 MTL Rx Queue Missed Packet Overflow Count (MTL_RxQ0_Missed_Packet_Overflow_Cnt)

Offset

Register	Offset
MTL_RxQ0_Missed_Packet_Overflow_Cnt	D34h

Function

Contains the counter for packets missed because of receive queue packet flush and packets discarded because of receive queue overflow.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved				MISCNTO...	MISPKTCNT										
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved				OVFCNTO...	OVFPKTCNT										
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved.
27 MISCNTOVF	Missed Packet Counter Overflow Bit Indicates whether the missed packet counter overflow is detected. When this field is 1, it indicates that the receive queue missed packet counter has crossed the maximum limit.

Table continues on the next page...

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Field	Function
	Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
26-16 MISPKTCNT	Missed Packet Counter Indicates the number of packets this module has missed because the application asserts ari_pkt_flush_i[] for this queue. This counter resets when this register reads with mci_be_i[0] at 1b1. This counter increments by 1 when the DMA discards the packet because of buffer unavailability. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.
15-12 —	Reserved.
11 OVFCNTOVF	Overflow Counter Overflow Bit Indicates whether the counter overflow is detected. When this field is 1, it indicates that the receive queue overflow packet counter field has crossed the maximum limit. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
10-0 OVFPKTCNT	Overflow Packet Counter Indicates the number of packets which this module discards because of receive queue overflow. This counter increments each time the module discards an incoming packet because of overflow. This counter resets when this register reads with mci_be_i[0] at 1'b1. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.

78.17.223 MTL Rx Queue 0 Debug (MTL_RxQ0_Debug)

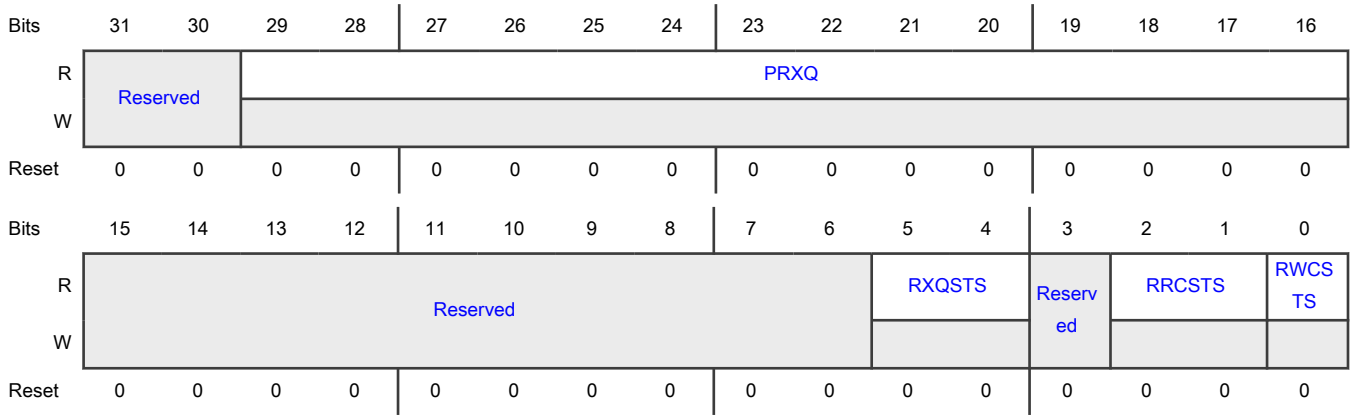
Offset

Register	Offset
MTL_RxQ0_Debug	D38h

Function

Provides the debug status of various blocks related to the receive queue.

Diagram



Fields

Field	Function
31-30 —	Reserved.
29-16 PRXQ	Number of Packets in Receive Queue Indicates the current number of packets in the receive queue. The theoretical maximum value for this field is 256KB/16B = 16K packets, that is, Max_Queue_Size/Min_Packet_Size.
15-6 —	Reserved.
5-4 RXQSTS	MTL Rx Queue Fill-Level Status Provides the status of the receive queue fill-level. 00b - Rx Queue empty 01b - Rx Queue fill-level below flow-control deactivate threshold 10b - Rx Queue fill-level above flow-control activate threshold 11b - Rx Queue full
3 —	Reserved.
2-1 RRCSTS	MTL Rx Queue Read Controller State Provides the state of the receive queue read controller. 00b - Idle state 01b - Reading packet data 10b - Reading packet status (or timestamp) 11b - Flushing the packet data and status

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Field	Function
0 RWCSTS	MTL Rx Queue Write Controller Active Status Indicates whether the MTL receive queue write controller active status is detected. When high, this bit indicates that the MTL receive queue write controller is active, and it is transferring a received packet to the receive queue. 0b - Not detected 1b - Detected

78.17.224 MTL Rx Queue 0 Control 0 (MTL_RxQ0_Control)

Offset

Register	Offset
MTL_RxQ0_Control	D3Ch

Function

Controls the receive arbitration and passing of received packets to the application.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved												RXQ_FRM...	RXQ_WEGT		
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-4 —	Reserved.
3 RXQ_FRM_ARBIT	Receive Queue Packet Arbitration Indicates whether the receive queue packet arbitration is enabled.

Table continues on the next page...

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Field	Function
	When this field is 1, it indicates that the module drives the packet data to the ARI interface such that the entire packet data of currently-selected queue transmits before switching to other queue. When this field becomes 0, it indicates that the module drives the packet data to the ARI interface such that the following amount of data of currently-selected queue transmits before switching to other queue: • PBL amount of data (indicated by ari_qN_pbl_i[]), or • Complete data of a packet The status and the timestamp are not a part of the PBL data. Therefore, the module drives the complete status (including timestamp status) during first PBL request for the packet (in store-and-forward mode) or the last PBL request for the packet (in Threshold mode). 0b - Disabled 1b - Enabled
2-0 RXQ_WEGT	Receive Queue Weight Indicates the weight assigned to receive queue 0. You must write a value to this field that is 1 less than the required queue weight. Therefore, if this field is 0, it indicates that the queue weight is 1, if this field is 1, it indicates that the queue weight is 2, and so on. You must use this weight to calculate the number of continuous PBL or packet requests, depending on the value of RXQ_FRM_ARBIT, allocated to the queue in an arbitration cycle. The field's value changes when the current service round completes or when there is a change from RAA=SP to RAA=WSP algorithm. This approach is required for a smooth transition. You must configure MTL Rx Queue 0 Control 0 (MTL_RxQ0_Control) before MTL Operation Mode (MTL_Operation_Mode) if you want to change the field's value before either of these two processes completes.

78.17.225 MTL Tx Queue 1 Operation Mode (MTL_TxQ1_Operation_Mode)

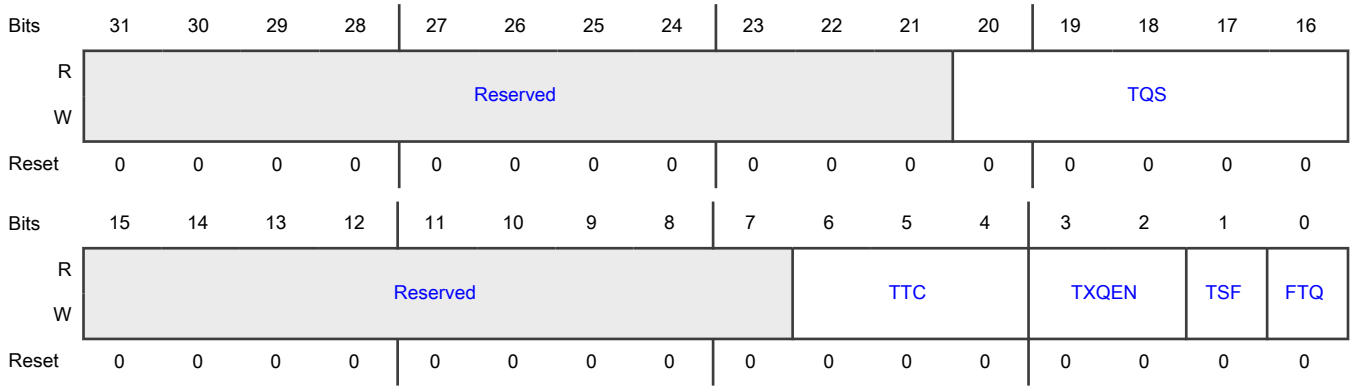
Offset

Register	Offset
MTL_TxQ1_Operation_Mode	D40h

Function

Establishes the transmit queue operating modes and commands.

Diagram



Fields

Field	Function
31-21 —	Reserved.
20-16 TQS	Transmit Queue Size Indicates the size of the allocated transmit queues in blocks of 256 bytes. This field is read-write only if the number of transit queues is more than one, the reset value is 0x0 and indicates size of 256 bytes. This means that value of 0x0 = 256 bytes, 0x1 = 512 bytes and so on. You must program TQS [5:0] = 6'b001111 to allocate queue size of 4096 (4K) bytes. In general, the size of the queue = (TQS+1)*256 bytes. When the number of transit queues is one, the field is read-only and the reset value reflects the configured TX FIFO size in blocks of 256 bytes. The field width depends on the transit memory size selected in your configuration. For example, if the memory size is 2048, the field width is 3 bits: LOG2(2048/256) = LOG2(8) = 3 bits
15-7 —	Reserved.
6-4 TTC	Transmit Threshold Control Controls the threshold level of the MTL Tx Queue. The transmission starts when the packet size within the MTL Tx Queue is larger than the threshold. In addition, it also transmit full packets with length less than the threshold. These fields are used only when the MTL_TxQ1_Operation_Mode[TSF] resets. 000b - 32 001b - 64 010b - 96 011b - 128 100b - 192 101b - 256

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Field	Function
	110b - 384 111b - 512
3-2 TXQEN	Transmit Queue Enable Enables or disables the transmit queue 0. 2'b00 - Not enabled 2'b01 - Enable in AV mode 2'b10 - Enabled 2'b11 - Reserved **NOTE** All the queues disables by default, in multiple transit queues configuration. You must program this field to enable the transit queue. 00b - Not enabled 01b - Enable in AV mode (Reserved in non-AV) 10b - Enabled 11b - Reserved
1 TSF	Transmit Store and Forward Indicates whether the transmit store and forward is enabled. When this field is 1, it indicates that the transmission starts when full packet resides in the MTL transit queue and the TTC values specified in MTL_TxQ1_Operation_Mode[TTC] are ignored. This field must change only when the transmission stops. 0b - Transmit Store and Forward is disabled 1b - Transmit Store and Forward is enabled
0 FTQ	Flush Transmit Queue Indicates whether the flush transmit queue is enabled. When this field is 1, it indicates that the transmit queue controller logic resets to its default values. Therefore, all the data in the transit queue is lost or flushed. This field resets internally when the flushing operation completes. Until this field becomes 0, you must not write to MTL_TxQ1_Operation_Mode. The data which the MAC transmitter has already accepted is not flushed. It is scheduled for transmission and results in an underflow and runt packet transmission. **NOTE** The flush operation completes only when the transit queue is empty and the application has accepted the pending transit status of all transmitted packets. To complete this flush operation, the PHY Tx clock (CLK_TX_I) must be active. Access restriction apply to this field. Writing 1 sets this field and it clears automatically. Writing 0 has no effect.

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Field	Function
	0b - Disabled 1b - Enabled

78.17.226 MTL Tx Queue 1 Underflow (MTL_TxQ1_Underflow)

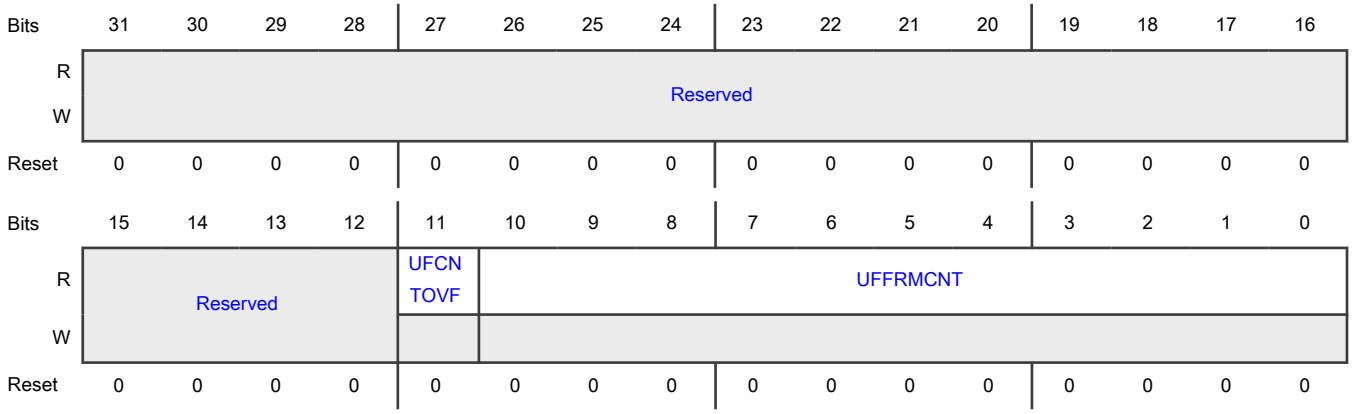
Offset

Register	Offset
MTL_TxQ1_Underflow	D44h

Function

Contains the counter for packets aborted because of transmit queue underflow and packets missed because of receive queue packet flush.

Diagram



Fields

Field	Function
31-12 —	Reserved.
11 UFCNTOVF	Overflow Bit for Underflow Packet Counter Indicates whether the overflow is detected for underflow packet counter. When this field is 1, it indicates that every time the transit queue underflow packet counter field overflows, that is, it has crossed the maximum count. In such case, the overflow packet counter resets to all-zeros and this field indicates that the rollover have occurred.

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Field	Function
	Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
10-0 UFFRMCNT	Underflow Packet Counter Indicates the number of packets which the controller abort because of transit queue underflow. This counter increments each time the MAC aborts outgoing packet because of underflow. The counter clears when this register is read with mci_be_i[0] at 1'b1. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.

78.17.227 MTL Tx Queue 1 Debug (MTL_TxQ1_Debug)

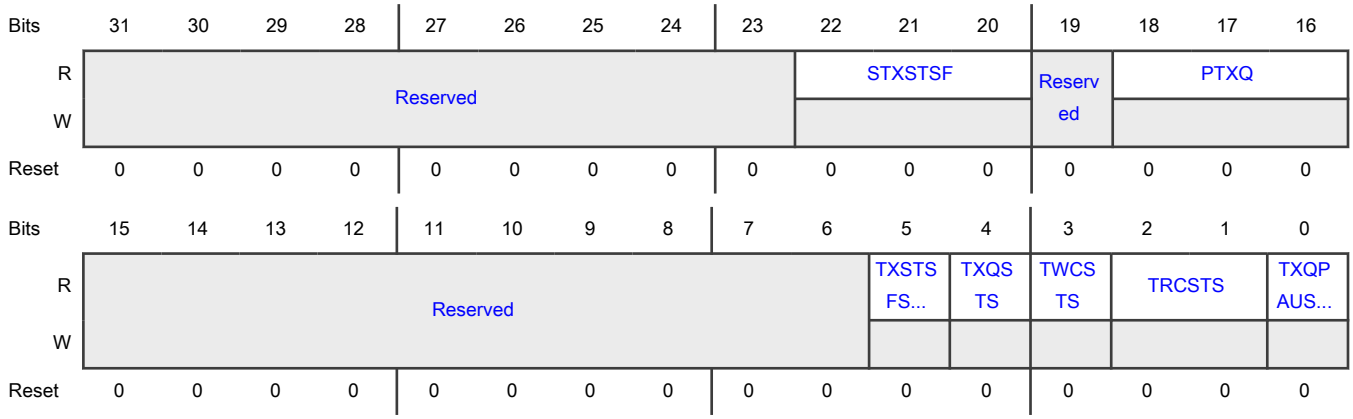
Offset

Register	Offset
MTL_TxQ1_Debug	D48h

Function

Provides the debug status of various blocks related to the transmit queue.

Diagram



Fields

Field	Function
31-23	Reserved.

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Field	Function
—	
22-20 STXSTSF	Number of Status Words in Tx Status FIFO of Queue Indicates the current number of status in the transit status FIFO of this queue. When MTL_Operation_Mode[DTXSTS] = 1, this field does not reflect the number of status words in transit status FIFO.
19 —	Reserved.
18-16 PTXQ	Number of Packets in the Transmit Queue Indicates the current number of packets in the transit queue. When MTL_Operation_Mode[DTXSTS] = 1, this field does not reflect the number of packets in the transmit queue.
15-6 —	Reserved.
5 TXSTSFSTS	MTL Tx Status FIFO Full Status Indicates whether the MTL transit status FIFO full status is detected. When this field is 1, it indicates that the MTL transit status FIFO is full. Therefore, the MTL cannot accept any more packets for transmission. 0b - Not detected 1b - Detected
4 TXQSTS	MTL Tx Queue Not Empty Status Indicates whether the MTL transit queue not empty status is detected. When this field is 1, it indicates that the MTL transit queue is not empty and some data is left for transmission. 0b - Not detected 1b - Detected
3 TWCSTS	MTL Tx Queue Write Controller Status Indicates whether the MTL transit queue write controller status is detected. When this field is 1, it indicates that the MTL transit queue write controller is active, and it is transferring the data to the transit queue. 0b - Not detected 1b - Detected
2-1 TRCSTS	MTL Tx Queue Read Controller Status Indicates the state of the transit queue read controller.

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Field	Function
	00b - Idle state 01b - Read state (transferring data to the MAC transmitter) 10b - Waiting for pending transit status from the MAC transmitter 11b - Flushing the transit queue because of the packet abort request from the MAC
0 TXQPAUSED	Transmit Queue in Pause Indicates whether the transmit queue in pause status is detected. When this field is 1 and the receive flow control is enabled, it indicates that the transit queue is in the pause condition (in the full-duplex only mode) because of these scenarios: • Reception of the PFC packet for the priorities assigned to the transit queue when PFC is enabled. • Reception of 802.3x pause packet when PFC is disabled. 0b - Not detected 1b - Detected

78.17.228 MTL Tx Queue 1 ETS Control (MTL_TxQ1_ETS_Control)

Offset

Register	Offset
MTL_TxQ1_ETS_Control	D50h

Function

Controls the enhanced transmission selection operation.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved								SLC				CC	AVALG	Reserved	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-7 —	Reserved.
6-4 SLC	Slot Count If the credit-based shaper algorithm is enabled, then you can program the number of slots (of duration programmed in DMA_CH(#i)_Slot_Interval register) over which the average transmitted bits per slot, provided in the MTL_TxQ(#i)_ETS_Status register, is computed for queue. The encoding is as follows: 000b - 1 slot 001b - 2 slots 010b - 4 slots 011b - 8 slots 100b - 16 slots 101b - Reserved
3 CC	Credit Control Indicates whether the credit control is enabled. When this field is 1, it indicates that the accumulated credit parameter in the credit-based shaper algorithm logic is not reset to zero, when there is positive credit and no packet to transmit in channel 1. The credit accumulates even when no packet is waiting in channel 1 and another channel is transmitting. When this field becomes 0, it indicates that the accumulated credit parameter in the credit-based shaper algorithm logic sets to zero, when there is positive credit and no packet to transmit in channel 1. No credit accumulates when no packet is waiting in channel 1 and other channel is transmitting. 0b - Disabled 1b - Enabled
2 AVALG	AV Algorithm Indicates whether the CBS algorithm is enabled. If you program queue 1 for AV, this field configures the scheduling algorithm for this queue. When this field is 1, it indicates that the credit based shaper algorithm (CBS) is selected for queue 1 traffic. If this field becomes 0, strict priority is selected. 0b - Disabled 1b - Enabled
1-0 —	Reserved.

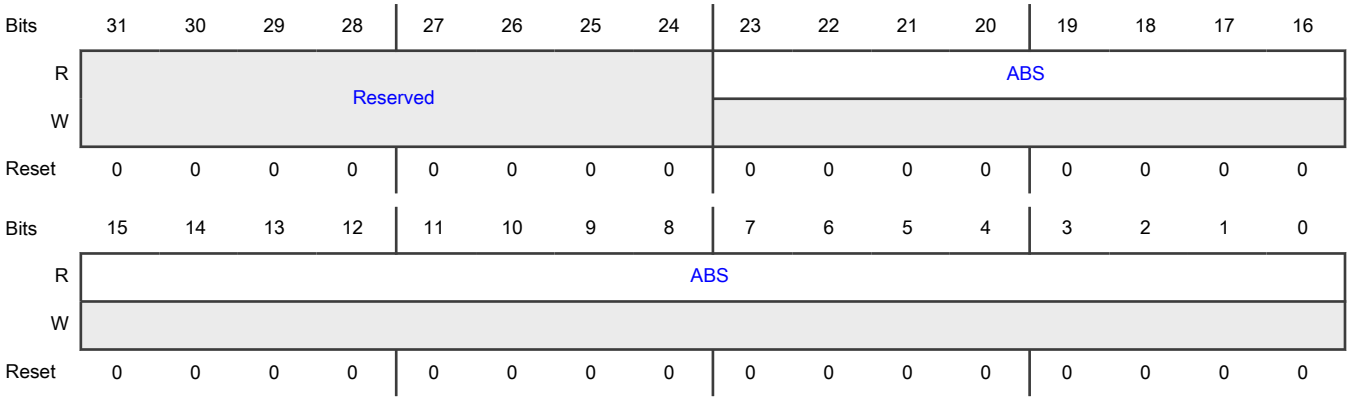
78.17.229 MTL Tx Queue 1 ETS Status (MTL_TxQ1_ETS_Status)

Offset

Register	Offset
MTL_TxQ1_ETS_Status	D54h

Function
Provides the average traffic transmitted in queue 1.

Diagram



Fields

Field	Function
31-24 —	Reserved.
23-0 ABS	Average Bits per Slot Contains the average transmitted bits per slot. Computes this field over number of slots programmed in the MTL_TxQ(#i)_ETS_CONTROL register's SLC field of, if you enables AV operation. This field's maximum value is 0x6_4000 in 100 Mbit/s, 0x3E_8000 in 1000 Mbit/s and 9C_4000 in 2500 Mbit/s mode respectively. Computes this field over every 10 million bit times slot (4 ms in 2500 Mbit/s; 10 ms in 1000 Mbit/s; 100 ms in 100 Mbit/s) when you enables DCB operation for queue. The maximum value is 0x989680.

78.17.230 MTL Tx Queue 1 Quantum Weight (MTL_TxQ1_Quantum_Weight)

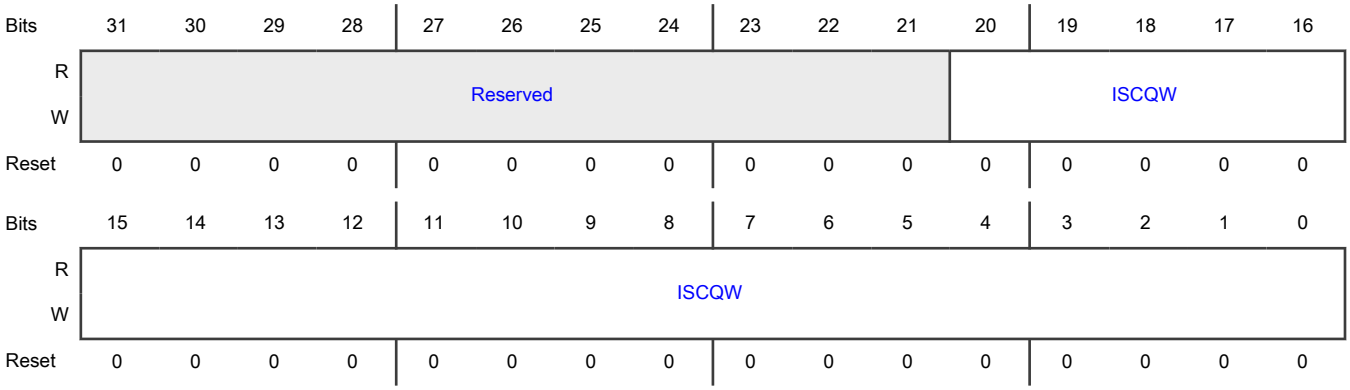
Offset

Register	Offset
MTL_TxQ1_Quantum_Weight	D58h

Function

Provides the average traffic transmitted in queue 1.

Diagram



Fields

Field	Function
31-21 —	Reserved.
20-0 ISCQW	idleSlopeCredit, Quantum or Weights idleSlopeCredit Contains the idleSlopeCredit value required for the credit-based shaper algorithm for queue 1, when you enables the AV feature. This is the rate of change of credit in bits per cycle (40 ns for 100 Mbit/s; 8 ns for 1000 Mbit/s; 3.2 ns for 2500 Mbit/s) when the credit is increasing. You must program this field with computed credit in bits per cycle scaled by 1,024. The maximum value is portTransmitRate, that is, 0x2000 in 1000/2500 Mbit/s mode and 0x1000 in 100 Mbit/s mode. Bits[20:14] must be written to zero. Quantum Contains the quantum value in bytes to be added to credit during every queue scanning cycle, when you enables the DCB operation with DWRR algorithm for queue 1 traffic. The maximum value is 0x1312D0 bytes. Weights Contains the weight for this queue, when you enables the DCB operation with WFQ algorithm for queue 1 traffic. The maximum value is 0x3FFF where weight of 0 indicates 100% bandwidth. Bits[20:14] must be written to zero. Contains the weight for this queue, when you enables the DCB operation or generic queuing operation with WRR algorithm for queue 1 traffic. The maximum value is 0x64. Bits [20:7] must be written to zero.

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Field	Function
	NOTE In multiple Queue configuration you must program this field in respective per queue register to some non-zero value when multiple queues are enabled or single queue other than Q0 is enabled. You must not program this field when only Q0 is enabled. In general, you must program a non-zero value on both receive and transmit when WRR algorithm is selected. In receive, the register is MTL_Operation_Mode register. **NOTE** For WFQ algorithm, higher the programmed weights lesser the bandwidth allocated for that transmit queue. The finish time is not a function of particular packet alone but it is according to the formula: (previous_finish_time of particular Transmit Queue + (weights*packet_size)) **NOTE** The programmed weights do not correspond to the number of packets but the fraction of bandwidth or time allocated for particular queue w.r.t. total BW or time.

78.17.231 MTL Tx Queue 1 Sendslope Credit (MTL_TxQ1_SendSlopeCredit)

Offset

Register	Offset
MTL_TxQ1_SendSlopeCredit	D5Ch

Function

Contains the sendSlope credit value required for the credit-based shaper algorithm for the queue.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved		SSC													
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-14 —	Reserved.
13-0 SSC	sendSlopeCredit Value Contains the sendSlopeCredit value required for credit-based shaper algorithm for Queue 1, when you enables the AV operation. This is the rate of change of credit in bits per cycle (40 ns, 8 ns and 3.2 ns for 100 Mbit/s, 1000 Mbit/s and 2500 Mbit/s respectively) when the credit is decreasing. You must program this field with computed credit in bits per cycle scaled by 1,024. The maximum value is portTransmitRate, that is, 0x2000 in 1000/2500 Mbit/s mode and 0x1000 in 100 Mbit/s mode. You must program this field with absolute sendSlopeCredit value. The credit-based shaper logic subtracts it from the accumulated credit when channel 1 is selected for transmission.

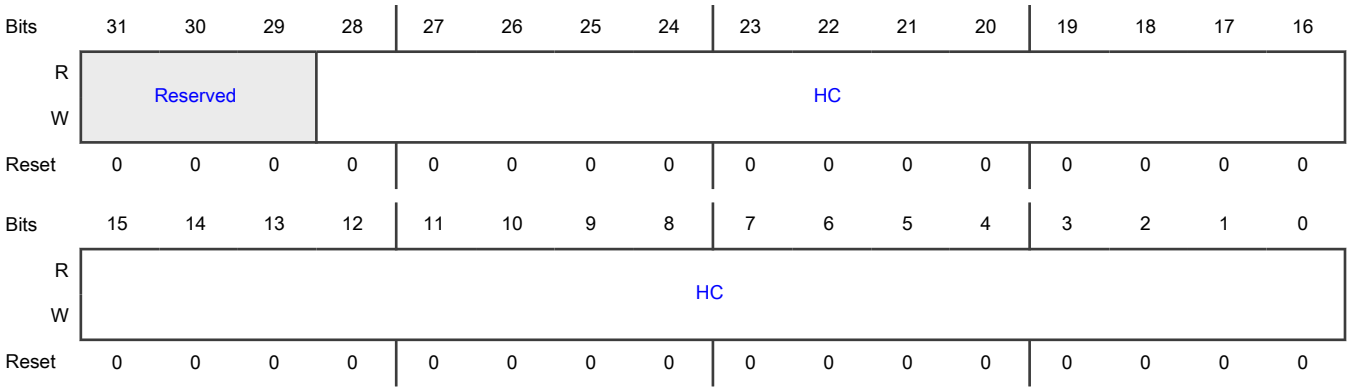
78.17.232 MTL Tx Queue 1 HiCredit (MTL_TxQ1_HiCredit)

Offset

Register	Offset
MTL_TxQ1_HiCredit	D60h

Function
Contains the hiCredit value required for the credit-based shaper algorithm for the queue.

Diagram



Fields

Field	Function
31-29 —	Reserved.

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Field	Function
28-0 HC	hiCredit Value Contains the hiCredit value required for the credit-based shaper algorithm, when you enables the AV feature. This is the maximum value that you can accumulate in the credit parameter. This is specified in bits scaled by 1,024. The maximum value is maxInterferenceSize, that is, best-effort maximum packet size (16,384 bytes or 131,072 bits). The specified value is 131,072 * 1,024 = 134,217,728 or 0x0800_0000.

78.17.233 MTL Tx Queue 1 LoCredit (MTL_TxQ1_LoCredit)

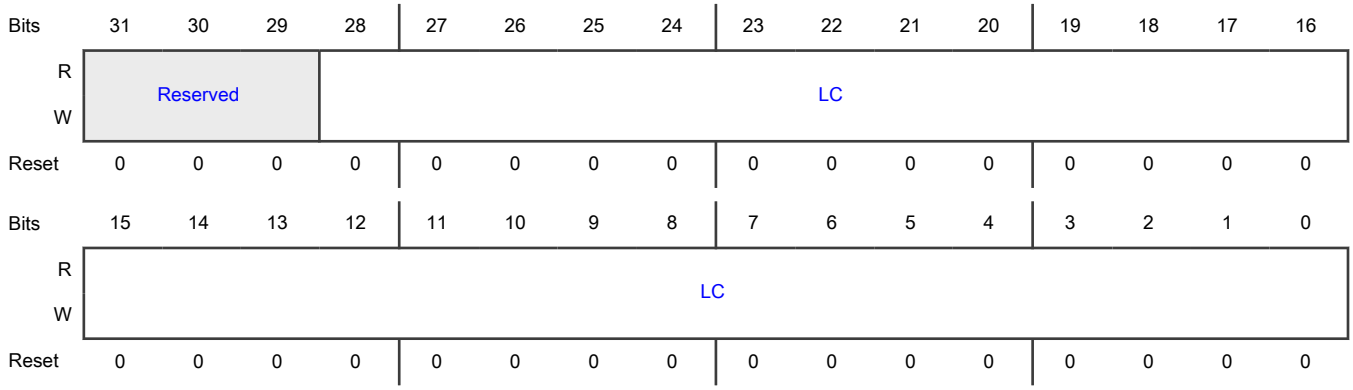
Offset

Register	Offset
MTL_TxQ1_LoCredit	D64h

Function

Contains the loCredit value required for the credit-based shaper algorithm for the queue.

Diagram



Fields

Field	Function
31-29 —	Reserved.
28-0 LC	loCredit Value Contains the loCredit value required for the credit-based shaper algorithm, when you enables the AV operation. This is the minimum value that you can accumulate in the credit parameter. This is specified in bits scaled by 1,024. The maximum value you can program corresponds to twice the maxFrameSize this queue transmits. If the maxFrameSize is 8192 bytes, then (8192*2) * 8 * 1024 = 134,217,728 or 0x0800_0000. The programmed value is 2's complement of the value, that is, 0x1800_0000 because it is a negative value.

78.17.234 MTL Queue 1 Interrupt Control Status (MTL_Q1_Interrupt_Control_Status)

Offset

Register	Offset
MTL_Q1_Interrupt_Control_Status	D6Ch

Function

Contains the interrupt enable and status bits for the queue 1 interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved							RXOIE	Reserved							RXOVFIS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved						ABPSIE	TXUIE	Reserved						ABPSIS	TXUNFIS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-25 —	Reserved.
24 RXOIE	Receive Queue Overflow Interrupt Enable Enables or disables the receive queue overflow interrupt. When this field is 1, it enables the receive queue overflow interrupt. When this field becomes 0, it disables the receive queue overflow interrupt. 0b - Disable 1b - Enable
23-17 —	Reserved.
16 RXOVFIS	Receive Queue Overflow Interrupt Status Indicates whether the status of receive queue overflow interrupt is detected. Indicates that the receive queue had an overflow when it receives the packet. If you transfers a partial packet to the application, the overflow status sets in RDES3[21]. This field is 0 when the application writes 1 to it.

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Field	Function
	Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
15-10 —	Reserved.
9 ABPSIE	Average Bits Per Slot Interrupt Enable Indicates whether an average bits per slot interrupt is enabled. When this field is 1, it indicates that the MAC asserts the sbd_intr_o or mci_intr_o interrupt when you update the average bits per slot status. When this field is 0, it indicates that the interrupt is not asserted for such an event. 0b - Disabled 1b - Enabled
8 TXUIE	Transmit Queue Underflow Interrupt Enable Enables or disables the transmit queue underflow interrupt. When this field is 1, it enables the transmit queue underflow interrupt. When this field becomes 0, it disables the transmit queue underflow interrupt. 0b - Disabled 1b - Enabled
7-2 —	Reserved.
1 ABPSIS	Average Bits Per Slot Interrupt Status Indicates whether the average bits per slot interrupt status is detected. When this field is 1, it indicates that the MAC has updated the ABS value. This field is 0 when the application writes 1 to it. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
0 TXUNFIS	Transmit Queue Underflow Interrupt Status Indicates whether the transmit queue underflow interrupt status is detected. Indicates that the transmit queue had an underflow when you transmits the packet. Suspends the transmission and sets an underflow error TDES3[2]. This field is 0 when the application writes 1 to this field.

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Field	Function
	Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected

78.17.235 MTL Rx Queue 1 Operation Mode (MTL_RxQ1_Operation_Mode)

Offset

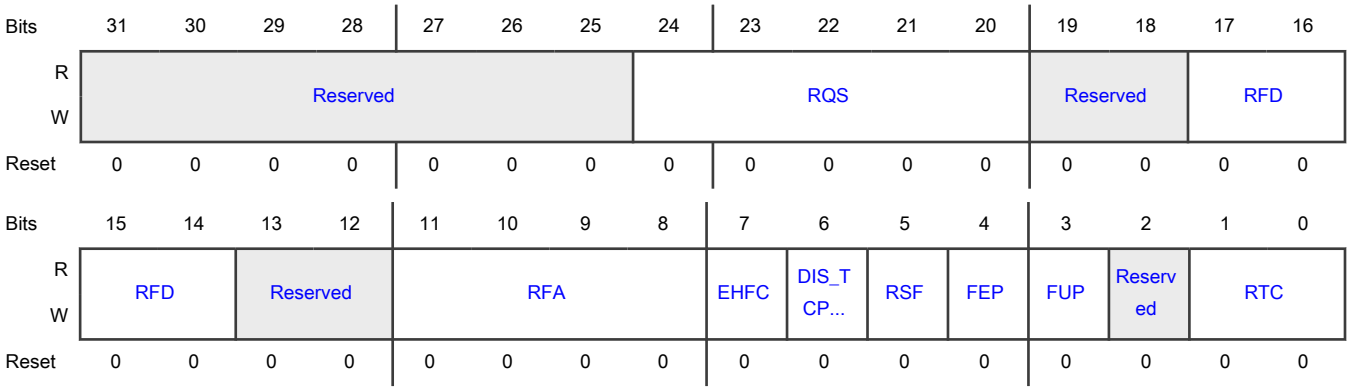
Register	Offset
MTL_RxQ1_Operation_Mode	D70h

Function

Establishes the receive queue operating modes and command.

The MTL_RxQ1_Operation_Mode[RFA] and MTL_RxQ1_Operation_Mode[RFD] are not backward compatible with the RFA and RFD fields of 4.00a release.

Diagram



Fields

Field	Function
31-25 —	Reserved.
24-20 RQS	Receive Queue Size Indicates the size of the allocated receive queues in blocks of 256 bytes. MTL_RxQ1_Operation_Mode[RQS] is read-write only if the number of receive queues is more than one, the

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Field	Function
	reset value is 0x0 and indicates 256 bytes size. This means that value of 0x0 = 256 bytes, 0x1 = 512 bytes and so on. You must program RQS [5:0] = 6'b001111 to allocate queue size of 4096 (4K) bytes. In general, the size of the Queue = (RQS+1)*256 bytes. When the number of receive queues is one, the field is read-only and the reset value reflects the configured RX FIFO size in blocks of 256 bytes. The field width depends on the receive memory size selected in your configuration. For example, if the memory size is 2048, the field width is 3 bits: LOG2(2048/256) = LOG2(8) = 3 bits
19-18 —	Reserved.
17-14 RFD	Threshold for Deactivating Flow Control (in half-duplex and full-duplex modes) Controls the threshold (fill-level of Rx queue) at which the flow control de-asserts after activation 0 - Full minus 1 KB, that is, FULL 1 KB 1 - Full minus 1.5 KB, that is, FULL 1.5 KB 2 - Full minus 2 KB, that is, FULL 2 KB 3 -Full minus 2.5 KB, that is, FULL 2.5 KB ... 14 - Full minus 8 KB, that is, FULL 8 KB 15 - Full minus 8.5 KB, that is, FULL 8.5 KB The de-assertion is effective only when flow control asserts. **NOTE** Program the value in such a way that the threshold is a positive number. When MTL_RxQ1_Operation_Mode[EHFC] = 1, these values are applicable only when the receive queue size which MTL_RxQ1_Operation_Mode[RQS] determines, is equal to or greater than 4 KB. For a given queue size, the values ranges between 0 and the encoding for FULL minus (QSIZE - 0.5 KB) and all other values are illegal. Here the term FULL and QSIZE refers to the queue size which MTL_RxQ1_Operation_Mode[RQS] determines. The field width depends on RX FIFO size selected during the configuration. Remaining bits are reserved and read only.
13-12 —	Reserved.
11-8 RFA	Threshold for Activating Flow Control (in half-duplex and full-duplex Controls the threshold (fill-level of Rx queue) at which the flow control activates. See MTL_RxQ1_Operation_Mode[RFD], for more information on encoding for this field.

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Field	Function
7 EHFC	Enable Hardware Flow Control Enables or disables hardware flow control. If this field is 1, it enables the flow control signal operation, based on the receive queue's fill-level. When this field becomes 0, it disables the flow control operation. 0b - Disable 1b - Enable
6 DIS_TCP_EF	Disable Dropping of TCP or IP Checksum Error Packets Indicates whether the dropping of TCP or IP checksum error packets is enabled. When this field is 1, it indicates that the MAC does not drop the packets which only have the errors that the receive checksum offload engine detects. Such packets have errors only in the encapsulated payload. MAC receives an Ethernet packet in which there are no errors (including FCS error). When this field becomes 0, it indicates that all the error packets drop if MTL_RxQ1_Operation_Mode[FEP] resets. 0b - Enabled 1b - Disabled
5 RSF	Receive Queue Store and Forward Indicates whether the receive queue store and forward is enabled. When this field is 1, it indicates that the module reads a packet from the receive queue only after the complete packet is written to it and ignores MTL_RxQ1_Operation_Mode[RTC]. When this field becomes 0, it indicates that the receive queue operates in the Threshold (cut-through) mode, subject to the threshold which MTL_RxQ1_Operation_Mode[RTC] specifies. 0b - Disabled 1b - Enabled
4 FEP	Forward Error Packets Indicates whether the forward error packets are enabled. If this field becomes 0, it indicates that the receive queue drops the packets with an error status (CRC error, GMII_ER, watchdog timeout, or overflow). However, the packet does not drops, if the start byte (write) pointer of a packet is already transferred to the read controller side in Threshold mode. When this field is 1, it indicates that all the packets except the runt error packets forward to the application or DMA. If MTL_RxQ1_Operation_Mode[RSF] is 1 and the receive queue overflows when a partial packet is written, the packet drops irrespective of the setting of this field. However, if MTL_RxQ1_Operation_Mode[RSF] resets and the receive queue overflows when a partial packet is written, you may forward a partial packet to the application or DMA. 0b - Disabled 1b - Enabled
3	Forward Undersized Good Packets

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Field	Function
FUP	Indicates whether the forward undersized good packets are enabled. When this field is 1, it indicates that the receive queue forwards the undersized good packets (packets with no error and length less than 64 bytes), including pad-bytes and CRC. When this field becomes 0, it indicates that the receive queue drops all the packets of less than 64 bytes, unless a packet is already transferred because of the lower value of Rx Threshold, for example, RTC = 01. 0b - Disabled 1b - Enabled
2 —	Reserved.
1-0 RTC	Receive Queue Threshold Control Controls the threshold level of the MTL Rx queue (in bytes): The received packet is transferred to the application or DMA when the packet size within the MTL receive queue is larger than the threshold. Also, the full packets with length less than the threshold are automatically transferred. This field is valid only when MTL_RxQ1_Operation_Mode[RSF] = 0. This field is ignored when MTL_RxQ1_Operation_Mode[RSF] = 1. 00b - 64 01b - 32 10b - 96 11b - 128

78.17.236 MTL Rx Queue 1 Missed Packet Overflow Counter (MTL_RxQ1_Missed_Packet_Overflow_Cnt)

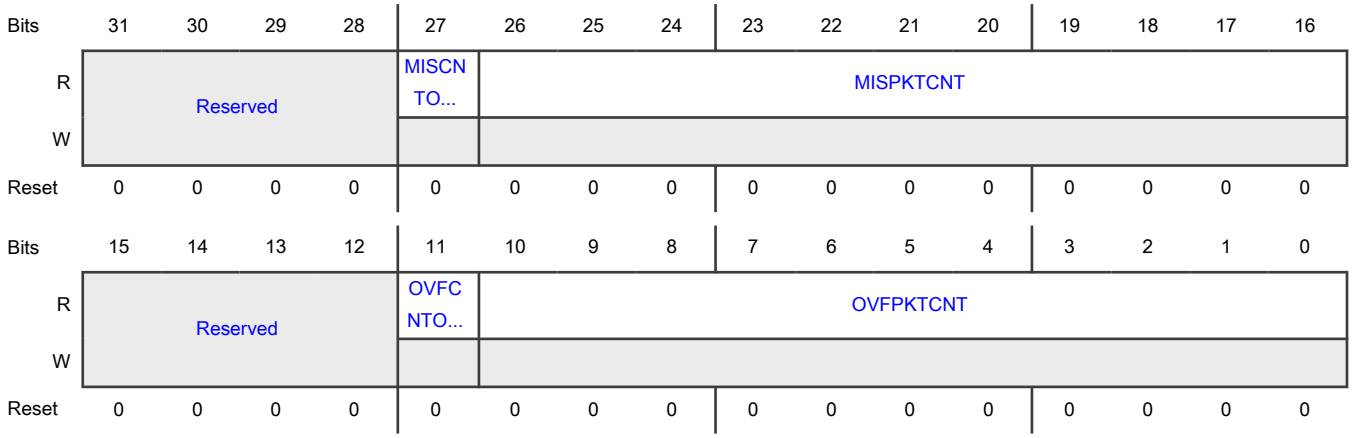
Offset

Register	Offset
MTL_RxQ1_Missed_Packet_Overflow_Cnt	D74h

Function

Contains the counter for packets missed because of receive queue packet flush and packets discarded because of receive queue overflow.

Diagram



Fields

Field	Function
31-28 —	Reserved.
27 MISCNTOVF	Missed Packet Counter Overflow Bit Indicates whether the missed packet counter overflow is detected. When this field is 1, it indicates that the receive queue missed packet counter has crossed the maximum limit. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
26-16 MISPKTCNT	Missed Packet Counter Indicates the number of packets the module has missed because the application asserted ari_pkt_flush_i[] for this queue. This counter resets when this register is read with mci_be_i[0] at 1b1. This counter increases by 1 when the DMA discards the packet because of buffer unavailability. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.
15-12 —	Reserved.
11 OVFCNTOVF	Overflow Counter Overflow Bit Indicates whether the counter overflow status is detected. When this field is 1, it indicates that the receive queue overflow packet counter field has crossed the maximum limit.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not detected 1b - Detected
10-0 OVFPKTCNT	Overflow Packet Counter Indicates the number of packets which the module discards because of receive queue overflow. This counter increments each time the module discards an incoming packet because of overflow. It resets when this register is read with mci_be_i[0] at 1'b1. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.

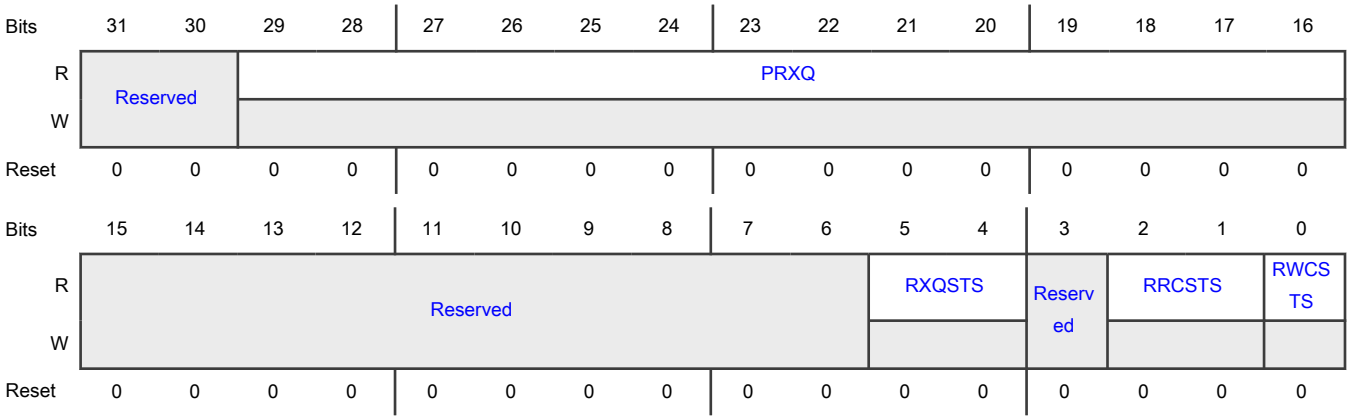
78.17.237 MTL Rx Queue 1 Debug (MTL_RxQ1_Debug)

Offset

Register	Offset
MTL_RxQ1_Debug	D78h

Function
Provides the debug status of various blocks related to the receive queue.

Diagram



Fields

Field	Function
31-30	Reserved.

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Field	Function
—	
29-16 PRXQ	Number of Packets in Receive Queue Indicates the current number of packets in the receive queue. The theoretical maximum field value is 256KB/16B = 16K packets, that is, Max_Queue_Size/Min_Packet_Size.
15-6 —	Reserved.
5-4 RXQSTS	MTL Rx Queue Fill-Level Status Provides the status of the receive queue fill-level. 00b - Rx Queue empty 01b - Rx Queue fill-level below flow-control deactivate threshold 10b - Rx Queue fill-level above flow-control activate threshold 11b - Rx Queue full
3 —	Reserved.
2-1 RRCSTS	MTL Rx Queue Read Controller State Provides the state of the receive queue read controller. 00b - Idle state 01b - Reading packet data 10b - Reading packet status (or timestamp) 11b - Flushing the packet data and status
0 RWCSTS	MTL Rx Queue Write Controller Active Status Indicates whether the MTL receive queue write controller active status is detected. When this field is 1, it indicates that the MTL receive queue write controller is active, and it is transferring a received packet to the receive queue. 0b - Not detected 1b - Detected

78.17.238 MTL Rx Queue 1 Control (MTL_RxQ1_Control)

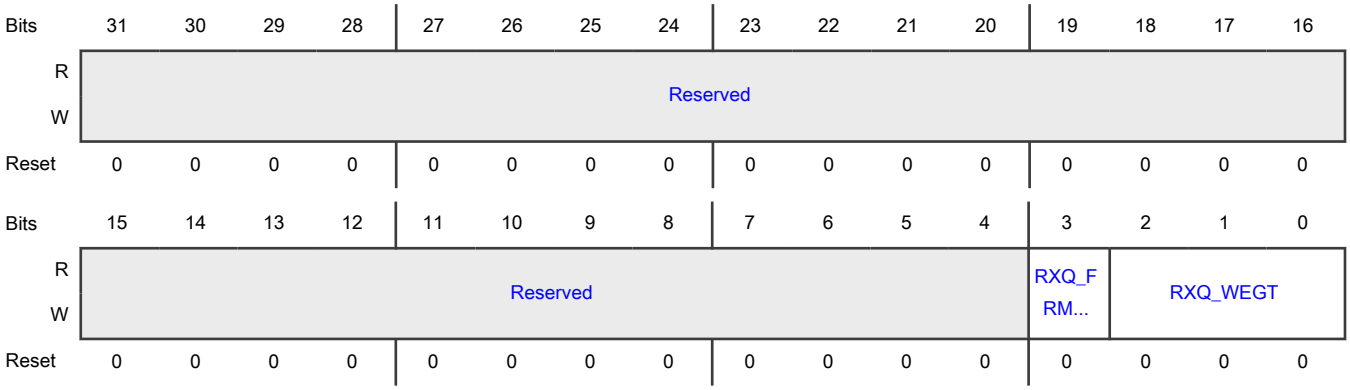
Offset

Register	Offset
MTL_RxQ1_Control	D7Ch

Function

Controls the receive arbitration and passing of received packets to the application.

Diagram



Fields

Field	Function
31-4 —	Reserved.
3 RXQ_FRM_ARBIT	Receive Queue Packet Arbitration Indicates whether the receive queue packet arbitration is enabled. When this field is 1, it indicates that the module drives the packet data to the ARI interface such that the entire packet data of currently-selected queue transmits before switching to other queue. When this field becomes 0, it indicates that the module drives the packet data to the ARI interface such that the following amount of data of currently-selected queue transmits before switching to other queue: • PBL amount of data (indicated by ari_qN_pbl_i[]), or • Complete data of a packet The status and the timestamp are not a part of the PBL data. Therefore, the module drives the complete status (including timestamp status) during the packet's first PBL request (in store-and-forward mode) or the last PBL request (in Threshold mode). 0b - Disabled 1b - Enabled
2-0 RXQ_WEGT	Receive Queue Weight Indicates the weight assigned to the receive queue 0. Program this field with one value less than the required weight, that is reset value of 0 indicates weight of 1, value of 1 indicates weight of 2, and so on. The weight is used as the number of continuous PBL or packets requests (depending on the RXQ_FRM_ARBIT) allocated to the queue in one arbitration cycle. Note: The change in value of RXQ_WEGT takes effect only after the completion of current service round or when there is change from RAA=SP to RAA=WSP algorithm. This approach is taken so that there is smooth transition. For the RXQ_WEGT value to take effect at the start, the MTL_RxQ(#i)_Control registers must be programmed before the MTL_Operation_Mode register.

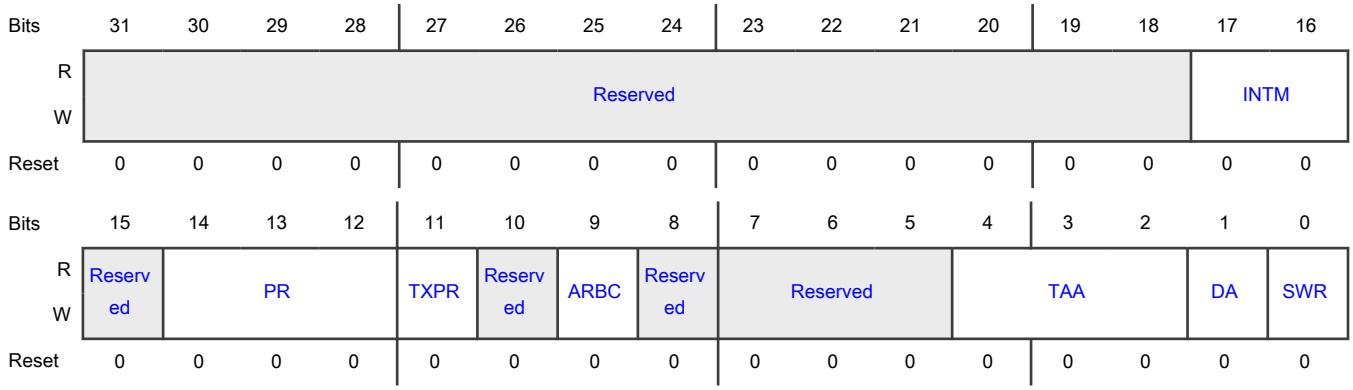
78.17.239 DMA Mode (DMA_Mode)

Offset

Register	Offset
DMA_Mode	1000h

Function
Establishes the bus operating modes for the DMA.

Diagram



Fields

Field	Function
31-18 —	Reserved.
17-16 INTM	Interrupt Mode Defines the interrupt mode of module. The behavior of the following outputs changes depending on these settings: sbd_perch_tx_intr_o[] (Transmit per channel interrupt) sbd_perch_rx_intr_o[] (Receive per channel interrupt) sbd_intr_o (Common interrupt) It also changes the behavior of the RI/TI bits in DMA_CH0_Status. 00 - sbd_perch_* are pulse signals for each TX/RX packet transfer completion events (irrespective of whether corresponding interrupts are enabled) for which IOC bits are enabled in descriptor. sbd_intr_o is also asserted when corresponding interrupts are enabled and cleared only when software clears the corresponding RI/TI status bits. 01 - sbd_perch_* are level signals asserted on TX/RX packet transfer completion event when corresponding interrupts are enabled and de-asserted when the software clears the corresponding RI/TI status bits. The sbd_intr_o is not asserted for these TX/RX packet transfer completion events.

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Field	Function
	10 - sbd_perch_* are level signals asserted on TX/RX packet transfer completion event when corresponding interrupts are enabled and de-asserted when the software clears the corresponding RI/TI status bits. However, the signal is asserted again if the same event occurred again before it was cleared. The sbd_intr_o is not asserted for these TX/RX packet transfer completion events. 11 - Reserved See table "Transfer Complete Interrupt Behavior" for more information. 00b - See above description 01b - See above description 10b - See above description 11b - Reserved
15 —	Reserved.
14-12 PR	Priority Ratio Controls the priority ratio in weighted round-robin arbitration between the Rx DMA and Tx DMA. These fields are valid only when DMA_Mode[DA] resets. The priority ratio is Rx:Tx or Tx:Rx depending on whether DMA_Mode[TXPR] = 1 or it resets. 000b - The priority ratio is 1:1 001b - The priority ratio is 2:1 010b - The priority ratio is 3:1 011b - The priority ratio is 4:1 100b - The priority ratio is 5:1 101b - The priority ratio is 6:1 110b - The priority ratio is 7:1 111b - The priority ratio is 8:1
11 TXPR	Transmit Priority Indicates whether the transmit priority is enabled. When this field is 1, it indicates that the Tx DMA has higher priority than the Rx DMA during arbitration for the system-side bus. 0b - Disabled 1b - Enabled
10 —	Reserved.
9 ARBC	Is reserved for NXP internal use. This field must always be 0 unless instructed by NXP. Writing 1 to this field may cause unexpected behavior.

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Field	Function
	0b - NXP reserved field disabled 1b - NXP reserved field enabled up on NXP request
8 —	Reserved.
7-5 —	Reserved.
4-2 TAA	Transmit Arbitration Algorithm Selects the arbitration algorithm for the transmit side when you select multiple transit DMAs. 000b - Fixed priority (Channel 0 has the lowest priority and the last channel has the highest priority) 001b - Weighted Strict Priority (WSP) 010b - Weighted Round-Robin (WRR) 011b - Reserved (for 3'b011 to 3'b111)
1 DA	DMA Tx or Rx Arbitration Scheme Specifies the arbitration scheme between the transmit and receive paths of all channels. 0 - Weighted round-robin with Rx:Tx or Tx:Rx The priority between the paths is according to the priority specified in bits[14:12] and the priority weight is specified in DMA_Mode[TXPR]. 1 - Fixed Priority The transit path has priority over the receive path when DMA_Mode[TXPR] = 1. Otherwise, the receive path has priority over the transit path. 0b - Weighted Round-Robin with Rx:Tx or Tx:Rx 1b - Fixed Priority
0 SWR	Software Reset Indicates whether the software reset is enabled. When this field is 1, it indicates that the MAC and the DMA controller resets the logic and all internal registers of the DMA, MTL, and MAC. This field automatically clears after the reset operation completes in all module clock domains. A value of zero should be read in this field before reprogramming any module register. When this field is 1, it indicates that this field must read at least 4 CSR clock cycles. **NOTE** The reset operation completes only when all resets in all active clock domains de-assert. Therefore, to complete software reset, it is essential that all PHY input clocks (applicable for the selected PHY interface) are present. The time to complete the software reset operation depends on the frequency of the slowest active clock.

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Field	Function
	Access restriction apply to this field. It clears automatically. Writing 1 sets this field and writing 0 has no effect. 0b - Disabled 1b - Enabled

78.17.240 DMA System Bus Mode (DMA_SysBus_Mode)

Offset

Register	Offset
DMA_SysBus_Mode	1004h

Function

Controls the behavior of the AHB or AXI master. It mainly controls burst splitting and the number of outstanding requests.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved	Reserved	Reserved				Reserved		Reserved						Reserved	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	RB	MB	Reserved	AAL	Reserved	Reserved	Reserved		Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	FB
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 —	Reserved.
30 —	Reserved.
29-26 —	Reserved.

Table continues on the next page...

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Field	Function
25-24 —	Reserved.
23-18 —	Reserved.
17-16 —	Reserved.
15 RB	Rebuild INCRx Burst Indicates whether the rebuild INCRx burst is enabled. When this field is 1 and the AHB master gets SPLIT, RETRY, or Early Burst Termination (EBT) response, it indicates that the AHB master interface rebuilds the pending beats of any initiated burst transfer with INCRx and SINGLE transfers. By default, the AHB master interface rebuilds pending beats of an EBT with an unspecified (INCR) burst. 0b - Disabled 1b - Enabled
14 MB	Mixed Burst Indicates whether the mixed burst is enabled. When this field is 1 and DMA_SysBus_Mode[FB] is 0, it indicates that the AHB master performs an undefined bursts transfers (INCR) for burst length of 16 or more. The AHB master performs fixed burst transfers (INCRx and SINGLE), for burst length of 16 or less. 0b - Disabled 1b - Enabled
13 —	Reserved.
12 AAL	Address-Aligned Beats Indicates whether the address-aligned beats are enabled. When this field is 1, it indicates that the EQOS-AXI or EQOS-AHB master performs address-aligned burst transfers on read and write channels. 0b - Disabled 1b - Enabled
11 —	Reserved.
10 —	Reserved.

Table continues on the next page...

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Field	Function
9-8 —	Reserved.
7 —	Reserved.
6 —	Reserved.
5 —	Reserved.
4 —	Reserved.
3 —	Reserved.
2 —	Reserved.
1 —	Reserved.
0 FB	Fixed Burst Length Indicates whether the fixed burst length is enabled. When this field is 1, it indicates that the AHB master initiates burst transfers of specified length (INCRx or SINGLE). When this field is 0, it indicates that the AHB master initiates transfers of unspecified length (INCR) or SINGLE transfers. 0b - Disabled 1b - Enabled

78.17.241 DMA Interrupt Status (DMA_Interrupt_Status)

Offset

Register	Offset
DMA_Interrupt_Status	1008h

Function

The application reads this Interrupt Status register during interrupt service routine or polling to determine the interrupt status of DMA channels, MTL queues, and the MAC.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved														MACIS	MTLIS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved								Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	DC1IS	DC0IS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-18 —	Reserved.
17 MACIS	MAC Interrupt Status Indicates whether the MAC interrupt status is detected. You must read the corresponding register in the MAC to get the exact cause of the interrupt and clear its source, to reset this field to 1'b0. 0b - Not detected 1b - Detected
16 MTLIS	MTL Interrupt Status Indicates whether the MTL interrupt status is detected. You must read the corresponding register in the MTL to get the exact cause of the interrupt and clear its source, to reset this field to 1'b0. 0b - Not detected 1b - Detected
15-8 —	Reserved.
7 —	Reserved.
6	Reserved.

Table continues on the next page...

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Field	Function
—	
5 —	Reserved.
4 —	Reserved.
3 —	Reserved.
2 —	Reserved.
1 DC1IS	DMA Channel 1 Interrupt Status Indicates whether the DMA channel 1 interrupt status is detected. You must read the corresponding register in DMA channel 1 to get the exact cause of the interrupt and clear its source, to reset this field to 1'b0. 0b - Not detected 1b - Detected
0 DC0IS	DMA Channel 0 Interrupt Status Indicates whether the DMA channel 0 interrupt status is detected. You must read the corresponding register in DMA channel 0 to get the exact cause of the interrupt and clear its source, to reset this field to 1'b0. 0b - Not detected 1b - Detected

78.17.242 DMA Debug Status 0 (DMA_Debug_Status0)

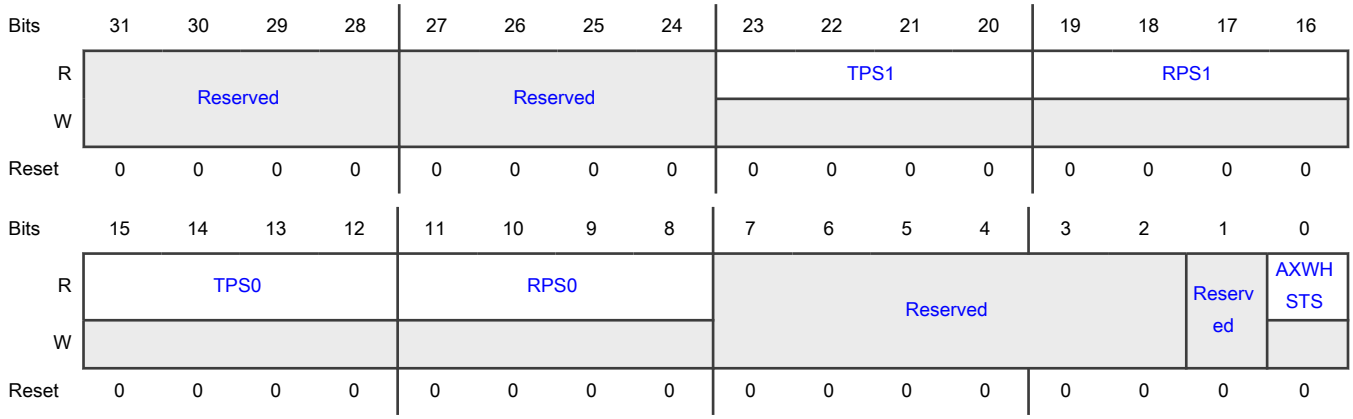
Offset

Register	Offset
DMA_Debug_Status0	100Ch

Function

Provides the receive and transmit process status for DMA Channel 0-Channel 2 for debugging purpose.

Diagram



Fields

Field	Function
31-28 —	Reserved.
27-24 —	Reserved.
23-20 TPS1	DMA Channel 1 Transmit Process State Indicates the transmit DMA FSM state for channel 1. The MSB of this field always returns 0. This field does not generate an interrupt. 0000b - Stopped (Reset or stop transmit command issued) 0001b - Running (Fetching transmit transfer descriptor) 0010b - Running (Waiting for status) 0011b - Running (Reading data from system memory buffer and queuing it to the transmit buffer (Tx FIFO)) 0100b - Timestamp write state 0101b - Reserved for future use 0110b - Suspended (Transmit descriptor unavailable or transmit buffer underflow) 0111b - Running (Closing transmit descriptor)
19-16 RPS1	DMA Channel 1 Receive Process State Indicates the receive DMA FSM state for channel 1. The MSB of this field always returns 0. This field does not generate an interrupt. 0000b - Stopped (Reset or Stop receive command issued) 0001b - Running (Fetching receive transfer descriptor) 0010b - Reserved for future use

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Field	Function
	0011b - Running (Waiting for receive packet) 0100b - Suspended (Receive descriptor unavailable) 0101b - Running (Closing the receive descriptor) 0110b - Timestamp write state 0111b - Running (Transferring the received packet data from the receive buffer to the system memory)
15-12 TPS0	DMA Channel 0 Transmit Process State Indicates the transmit DMA FSM state for channel 0. The MSB of this field always returns 0. This field does not generate an interrupt. 0000b - Stopped (Reset or stop transmit command issued) 0001b - Running (Fetching transmit transfer descriptor) 0010b - Running (Waiting for status) 0011b - Running (Reading data from system memory buffer and queuing it to the transmit buffer (Tx FIFO)) 0100b - Timestamp write state 0101b - Reserved for future use 0110b - Suspended (Transmit descriptor unavailable or transmit buffer underflow) 0111b - Running (Closing transmit descriptor)
11-8 RPS0	DMA Channel 0 Receive Process State Indicates the receive DMA FSM state for channel 0. The MSB of this field always returns 0. This field does not generate an interrupt. 0000b - Stopped (Reset or stop receive command issued) 0001b - Running (Fetching receive transfer descriptor) 0010b - Reserved for future use 0011b - Running (Waiting for receive packet) 0100b - Suspended (Receive descriptor unavailable) 0101b - Running (Closing the receive descriptor) 0110b - Timestamp write state 0111b - Running (Transferring the received packet data from the receive buffer to the system memory)
7-2 —	Reserved.
1	Reserved.

Table continues on the next page...

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Field	Function
—	
0 AXWHSTS	AHB Master Status Indicates whether the AXI master write channel or AHB master status is detected. When this field is 1, it indicates that the AHB master FSMs are in the non-idle state. 0b - Not detected 1b - detected

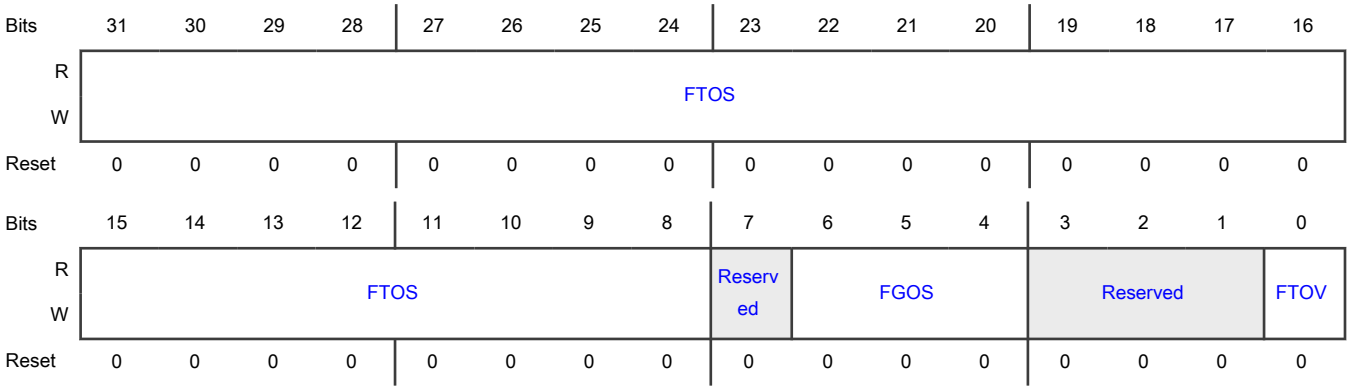
78.17.243 DMA TBS Control (DMA_TBS_CTRL)

Offset

Register	Offset
DMA_TBS_CTRL	1050h

Function
Controls the TBS attributes.

Diagram



Fields

Field	Function
31-8 FTOS	Fetch Time Offset Deduct the value in units of 256 nanoseconds, from the launch time to compute the fetch Time. Max value: 999,999,999 nanosecond, must be smaller than CTR-1 value when ESTM mode = 1, because this value is a modulo CTR value.
7	Reserved.

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Field	Function
—	
6-4 FGOS	Fetch GSN Offset Deduct the number GSN slots from the launch GSN to compute the fetch GSN. The value is valid only when DMA_TBS_CTRL[FTOV] = 1.
3-1 —	Reserved.
0 FTOV	Fetch Time Offset Valid Indicates whether the fetch time offset is valid. When this field is 1, it indicates that DMA_TBS_CTRL[FTOS] is valid. When this field is not 1, it indicates that the fetch offset is not valid and the DMA engine can fetch the frames from host memory without any time restrictions. 0b - Invalid 1b - Valid

78.17.244 DMA Safety Interrupt Status (DMA_Safety_Interrupt_Status)

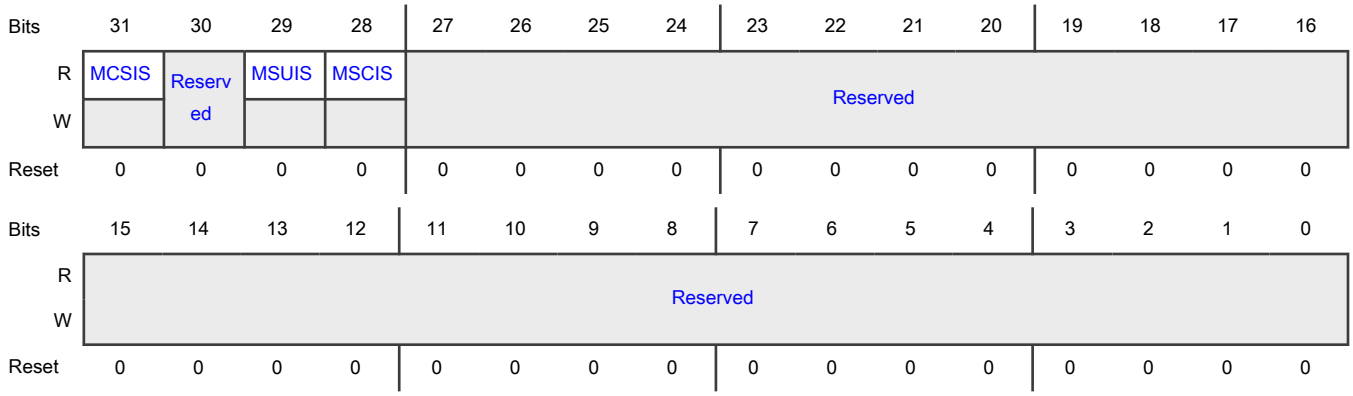
Offset

Register	Offset
DMA_Safety_Interrupt_Status	1080h

Function

Indicates summary (whether error occurred in DMA/MTL/MAC and correctable/uncorrectable) of the automotive safety related error interrupts.

Diagram



Fields

Field	Function
31 MCSIS	MAC Safety Uncorrectable Interrupt Status Indicates whether the MAC safety uncorrectable interrupt status is detected. Indicates that an uncorrectable safety related interrupt is 1 in the MAC module. When this field is 1, it indicates that you must read the MAC_DPP_FSM_Interrupt_Status, to get the cause of the safety interrupt in MAC. 0b - Not detected 1b - Detected
30 —	Reserved.
29 MSUIS	MTL Safety Uncorrectable Error Interrupt Status Indicates whether the MTL safety uncorrectable error interrupt status is detected. Indicates an uncorrectable error interrupt event in MTL. To get exact cause of the interrupt you must read the MTL_Safety_Interrupt_Status. 0b - Not detected 1b - Detected
28 MSCIS	MTL Safety Correctable Error Interrupt Status Indicates whether the MTL safety correctable error interrupt status is detected. Indicates a correctable error interrupt event in MTL. To get the exact cause of the interrupt you must read the MTL_Safety_Interrupt_Status. 0b - Not detected 1b - Detected
27-0 —	Reserved.

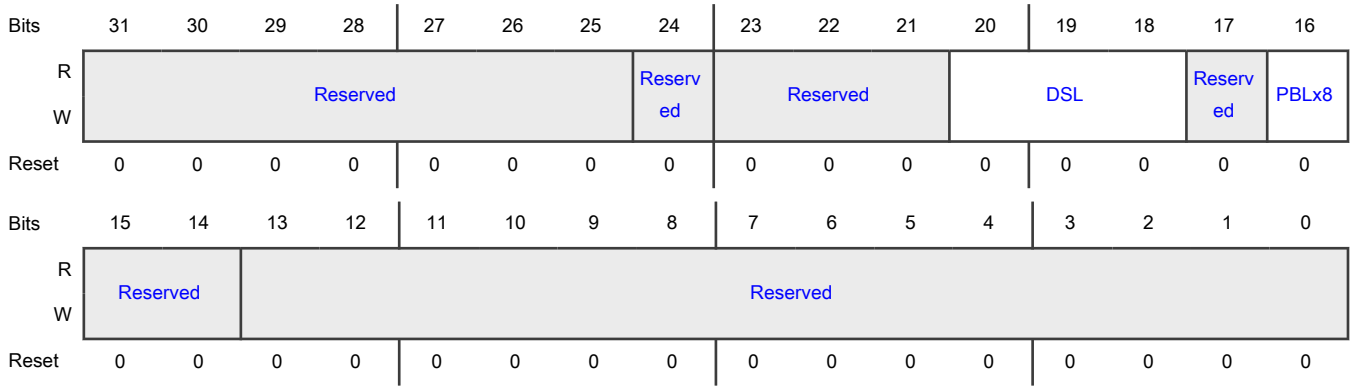
78.17.245 DMA Channel 0 Control (DMA_CH0_Control)

Offset

Register	Offset
DMA_CH0_Control	1100h

Function
Specifies the MSS value for segmentation, length to skip between two descriptors, and also the features such as header splitting and 8xPBL mode.

Diagram



Fields

Field	Function
31-25 —	Reserved.
24 —	Reserved.
23-21 —	Reserved.
20-18 DSL	Descriptor Skip Length Specifies the Word, Dword, or Lword number (depending on the 32-bit, 64-bit, or 128-bit bus) to skip between two unchained descriptors. The address skipping starts from the end of the current descriptor to the start of the next descriptor. The DMA assumes the descriptor table as contiguous, when the DSL value is equal to zero.
17 —	Reserved.
16 PBLx8	8xPBL mode Indicates whether 8xPBL mode is enabled. When this field is 1, it indicates that the PBL value programmed in Bits[21:16] in DMA_CH(#i)_Tx_Control and Bits[21:16] in DMA_CH(#i)_Rx_Control is multiplied by eight times. Therefore, the DMA transfers the data in 8, 16, 32, 64, 128, and 256 beats depending on the PBL value. 0b - Disabled 1b - Enabled
15-14 —	Reserved.

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Field	Function
13-0 —	Reserved.

78.17.246 DMA Channel Tx Control (DMA_CH0_Tx_Control)

Offset

Register	Offset
DMA_CH0_Tx_Control	1104h

Function

Controls the transmit features such as PBL, TCP segmentation, and transmit channel weights.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved			EDSE	Reserved				Reserved	ETIC	TxPBL					
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved	Reserved		Reserved	Reserved							OSF	TCW			ST
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved.
28 EDSE	Enhanced Descriptor Enable Indicates whether an enhanced descriptor is enabled. When this field is 1, it indicates that the corresponding channel uses 32 bytes enhanced descriptors for both normal and context descriptors. When this field becomes 0, it indicates that the corresponding channel uses the 16 bytes descriptors. 0b - Disabled 1b - Enabled

Table continues on the next page...

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Field	Function
27-24 —	Reserved.
23 —	Reserved.
22 ETIC	Early Transmit Interrupt Control Indicates whether an early transmit interrupt is enabled. When this field is 1, it indicates that an early transmit interrupt (ETI) status = 1 after the data transfer from buffers of a transmit descriptor completes in which IOC bit (TDES2[31]) = 1. When this field becomes 1, it indicates that ETI = 1 only after a complete packet transfers to the MTL TX FIFO memory. 0b - Disabled 1b - Enabled
21-16 TxPBL	Transmit Programmable Burst Length Indicates the maximum number of beats to transfer in one DMA block data transfer. DMA always attempts max burst as specified in PBL each time it starts a burst transfer on the application bus. You can program PBL with any of these values: 1, 2, 4, 8, 16, or 32. Any other value results in undefined behavior. Perform these steps to transfer more than 32 beats: 1. Set DMA_CH0_Control[PBLx8]. 2. Set the TxPBL. **NOTE** The maximum value of TxPBL must be less than or equal to half the transit queue size (TQS field of MTL_TxQ(#i)_Operation_Mode register) in terms of beats. This is required so that the transit queue has space to store at least another TxPBL worth of data while the MTL Tx queue controller transfers data to MAC. For example, in 64-bit data width configurations the total locations in transit queue of size 512 bytes is 64. You must program TxPBL and 8xPBL to less than or equal to 32.
15 —	Reserved.
14-13 —	Reserved.
12 —	Reserved.
11-5 —	Reserved.

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Table continued from the previous page...

Field	Function
4 OSF	Operate on Second Packet Indicates whether the operation on second packet is enabled. When this field is 1, it instructs DMA to process the second packet of the transmit data even before you receive the status for the first packet. 0b - Disabled 1b - Enabled
3-1 TCW	Transmit Channel Weight Indicates the weight assigned to the corresponding transmit channel. When reset completes, this field is 0 for all the channels by default, which results in equal weights to all channels.
0 ST	Start or Stop Transmission Command Indicates whether to start or stop the transmission command. When this field is 1, it indicates that the transmission is in the running state. DMA checks the transmit list at the current position for a packet to be transmitted. DMA tries to acquire descriptor from either of these positions: • The current position in the list. This is the base address of the transmit list to which DMA_CH0_TxDesc_List_Address sets. • The position at which the transmission was previously stopped. The transmission enters the suspended state and DMA_CH0_Status[TBU] = 1, if DMA does not own the current descriptor. The start transmission command is effective only when the transmission stops. If the command is issued before setting DMA_CH0_TxDesc_List_Address, you cannot predict the DMA behavior. When this field becomes 0, it indicates that the transmission process is placed in the stopped state when the transmission of the current packet completes . The next descriptor position in the transmit list is saved, and it becomes the current position when you restart the transmission. To change the list address, you must program DMA_CH0_TxDesc_List_Address with a new value when this field becomes 0.You can consider the new value when this field is 1 again. The stop transmission command is effective only when the transmission of the current packet completes or the transmission is in the suspended state. 0b - Stop 1b - Start

78.17.247 DMA Channel Rx Control (DMA_CH0_Rx_Control)

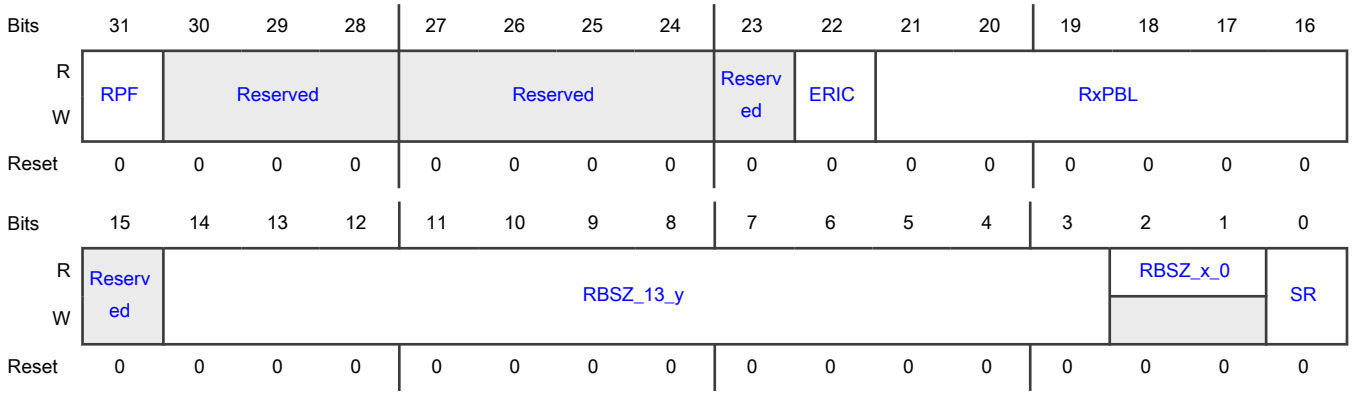
Offset

Register	Offset
DMA_CH0_Rx_Control	1108h

Function

Controls the receive features such as PBL, buffer size, and extended status.

Diagram



Fields

Field	Function
31 RPF	Rx Packet Flush Indicates whether the receive packet flush is enabled. When this field is 1, it indicates that the module automatically flushes the packet from the receive queues destined to this DMA receive channel, when it stops. When this field remains 1 and the software driver re-starts DMA, the packets residing in the receive queues that were received when this RxDMA stops and flushes out. The packets that MAC receives after the RxDMA re-starts, route to the RxDMA. The flushing takes place on the read side of the receive queue. When this field is 0, it indicates that the module do not flush the packet in the receive queue destined to this RxDMA channel when it is in STOP state. This may cause head-of-line blocking in the corresponding receive queue. **NOTE** The packet flow from a receive DMA channel to the application by writing 1 to this field stops, only when there is one-to-one mapping of receive queue to receive DMA channels. In Dynamic mapping mode, writing 1 to this field in any DMA_CH(#i)_Rx_Control register might flush packets from an unintended receive queues which are destined to the stopped receive DMA channel. 0b - Disabled 1b - Enabled
30-28 —	Reserved.
27-24 —	Reserved.
23 —	Reserved.
22	Early Receive Interrupt Control

Table continues on the next page...

Table continued from the previous page...

Field	Function
ERIC	Indicates whether an early receive interrupt is enabled. When this field is 1, it indicates that the early receive interrupt (ERI) status sets after every burst transfer of data from the Rx DMA to the buffer completes. When this field becomes 0, it indicates that ERI sets only after a complete buffer is filled by the RxDMA. 0b - Disabled 1b - Enabled
21-16 RxPBL	Receive Programmable Burst Length Indicates the maximum number of beats to be transferred in one DMA block data transfer. DMA always attempts max burst as specified in PBL every time it starts a burst transfer on the application bus. You can program PBL with any of these values: 1, 2, 4, 8, 16, or 32. Any other value results in undefined behavior. To transfer more than 32 beats, perform the following steps: 1. Set DMA_CH0_Control[PBLx8]. 2. Set the RxPBL. **NOTE** The maximum value of RxPBL must be less than or equal to half the receive queue size (RQS field of MTL_RxQ(#i)_Operation_Mode register) in terms of beats. This is required so that the receive queue has space to store at least another Rx PBL worth of data while the receive DMA transfers a block of data. For example, in 64-bit data width configurations the total locations in receive queue of size 512 bytes is 64. You must program RxPBL and 8xPBL to less than or equal to 32.
15 —	Reserved.
14-3 RBSZ_13_y	Receive Buffer size High RBSZ[13:0] splits into two fields, higher field is RBSZ_13_y and lower field is RBSZ_x_0. RBSZ[13:0] field indicates the receive buffers size specified in bytes. The maximum buffer size is limited to 16K bytes. The buffer size is applicable to payload buffers when split headers are enabled. **NOTE** The buffer size must be a multiple of 4, 8, or 16 depending on the data bus widths (32-bit, 64-bit, or 128-bit respectively). This is required even if the buffer address pointer value is not aligned with data bus width. Hence the lower RBSZ_x_0 fields are read-only and the value is considered as all-zero. Thus RBSZ_13_y field indicates the buffer size in terms of locations (with the width same as bus-width).
2-1 RBSZ_x_0	Receive Buffer size Low RBSZ[13:0] splits into two fields RBSZ_13_y and RBSZ_x_0. The RBSZ_x_0 is the lower field whose width is based on data bus width of the configuration. The field width is of 2, 3, or 4 bits for 32-bit, 64-bit, or 128-bit data bus width respectively. This field is read-only (RO).

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 SR	Start or Stop Receive Indicates whether to start or stop receive. When this field is 1, it indicates that the DMA tries to acquire the descriptor from the receive list and processes the incoming packets. DMA tries to acquire descriptor from either of these positions: • The current position in the list. This is the address which DMA_CH0_RxDesc_List_Address sets. • The position at which the receive process was previously stopped. If DMA does not own the current descriptor, the reception is suspended and DMA_CH0_Status[RBU] = 1. The start receive command is effective only when the reception stops. If the command is issued before setting DMA_CH0_RxDesc_List_Address, the DMA behavior is unpredictable. When this field becomes 0, it indicates that the receive DMA operation stops after the transfer of the current packet. The next descriptor position in the receive list is saved, and it becomes the current position after the receive process restarts. The stop receive command is effective only when the receive process is in the running (waiting for receive packet) or suspended state. 0b - Stop 1b - Start

78.17.248 DMA Channel 0 Tx Descriptor List Address (DMA_CH0_TxDesc_List_Address)

Offset

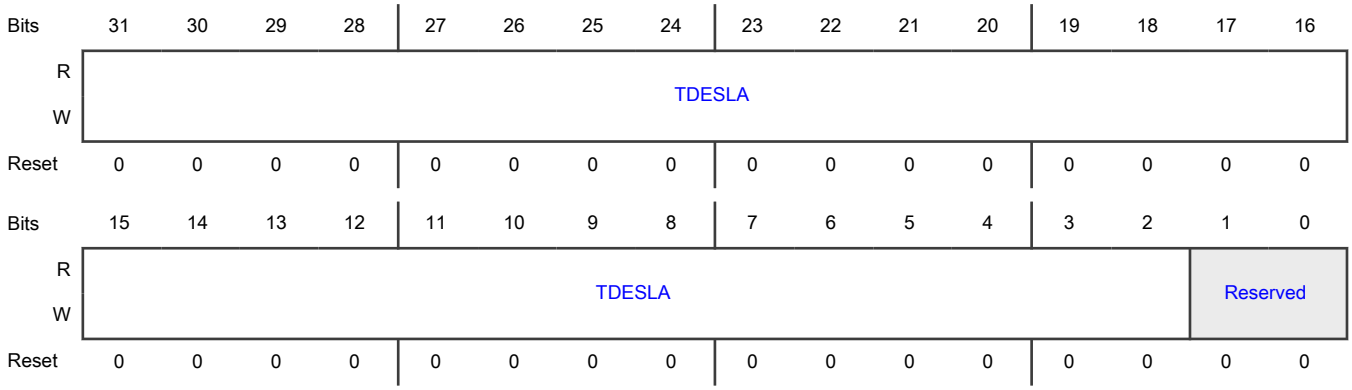
Register	Offset
DMA_CH0_TxDesc_List_Address	1114h

Function

Specifies DMA to the start of transmit descriptor list. The descriptor lists reside in the physical memory space of the application and must be Word, Dword, or Lword-aligned (for 32-bit, 64-bit, or 128-bit data bus). DMA internally converts it to bus width aligned address by making the corresponding LSB low.

You can write to this register only when the transit DMA stops, that is, DMA_CH0_Tx_Control[ST] = 0. When stopped, write this register with a new descriptor list address. When DMA_CH0_Tx_Control[ST] = 1, DMA uses the newly-programmed descriptor base address. If this register does not change when DMA_CH0_Tx_Control[ST] = 0, DMA uses the descriptor address where it was stopped earlier.

Diagram



Fields

Field	Function
31-2 TDESLA	Start of Transmit List Contains the base address of the first descriptor in the transmit descriptor list. DMA ignores the LSB bits (1:0, 2:0, or 3:0) for 32-bit, 64-bit, or 128-bit bus width and internally takes these bits as all-zero. Therefore, these LSB bits are read-only (RO). The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

78.17.249 DMA Channel 0 Rx Descriptor List Address (DMA_CH0_RxDesc_List_Address)

Offset

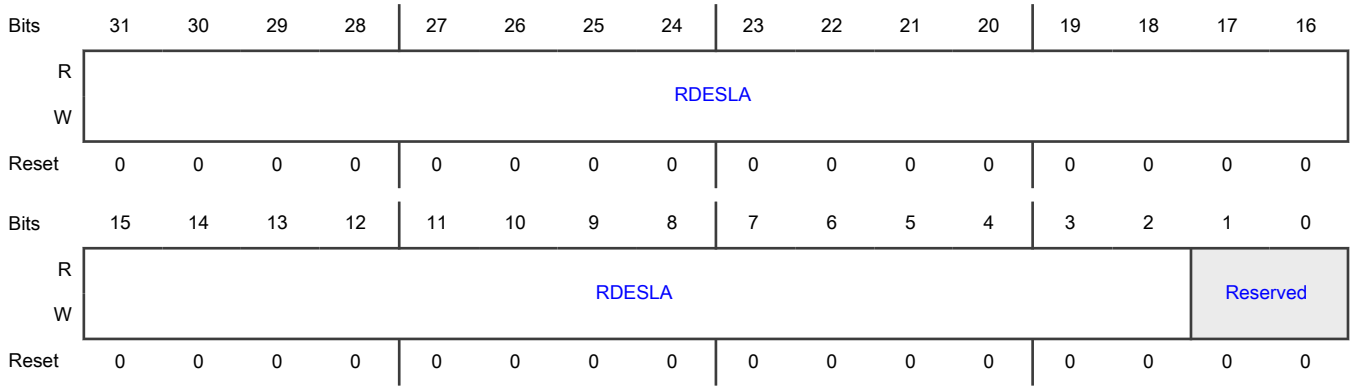
Register	Offset
DMA_CH0_RxDesc_List_Address	111Ch

Function

Specifies DMA to the start of receive descriptor list. The descriptor lists reside in the physical memory space of the application and must be Word, Dword, or Lword-aligned (for 32-bit, 64-bit, or 128-bit data bus). DMA internally converts it to bus width aligned address by making the corresponding LS bits low. You can write to this register only when reception stops. When stopped, write this register before the receive start command is given. You can write to this register only when Rx DMA stops, that is, DMA_CH0_Rx_Control[SR] = 0. When stopped, write this register with a new descriptor list address.

When DMA_CH0_Rx_Control[SR] = 1, it indicates that DMA takes the newly programmed descriptor base address.

Diagram



Fields

Field	Function
31-2 RDESLA	Start of Receive List Contains the base address of the first descriptor in the receive descriptor list. DMA ignores the LSB bits (1:0, 2:0, or 3:0) for 32-bit, 64-bit, or 128-bit bus width and internally takes these bits as all-zero. Therefore, these LSB bits are read-only (RO). The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

78.17.250 DMA Channel 0 Tx Descriptor Tail Pointer (DMA_CH0_TxDesc_Tail_Pointer)

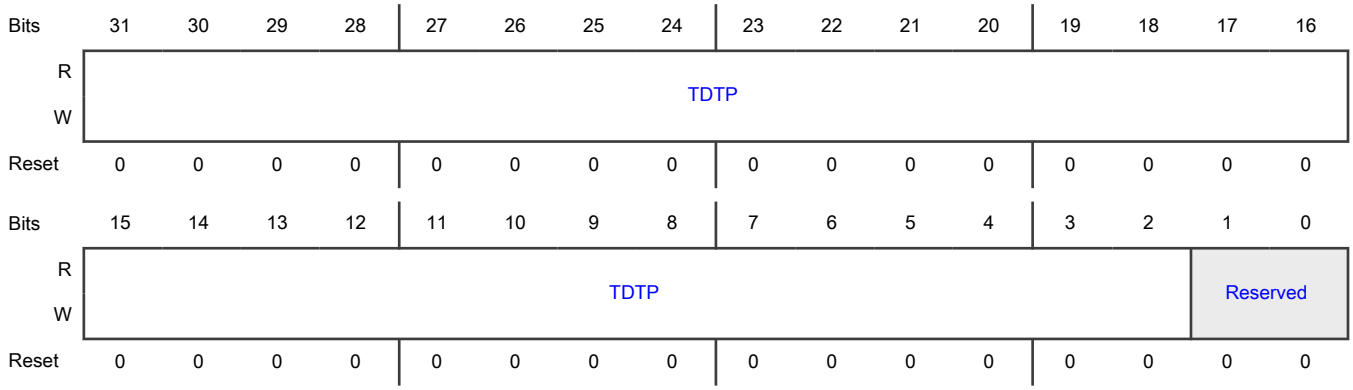
Offset

Register	Offset
DMA_CH0_TxDesc_Tail_Pointer	1120h

Function

Points to an offset from the base and indicates the location of the last valid descriptor.

Diagram



Fields

Field	Function
31-2 TDTP	Transmit Descriptor Tail Pointer Contains the tail pointer for the transit descriptor ring. You must write the tail pointer to add more descriptors to the transit channel. The hardware tries to transmit all packets to the descriptors referenced between the head and the tail pointer registers. The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

78.17.251 DMA Channel 0 Rx Descriptor List Pointer (DMA_CH0_RxDesc_Tail_Pointer)

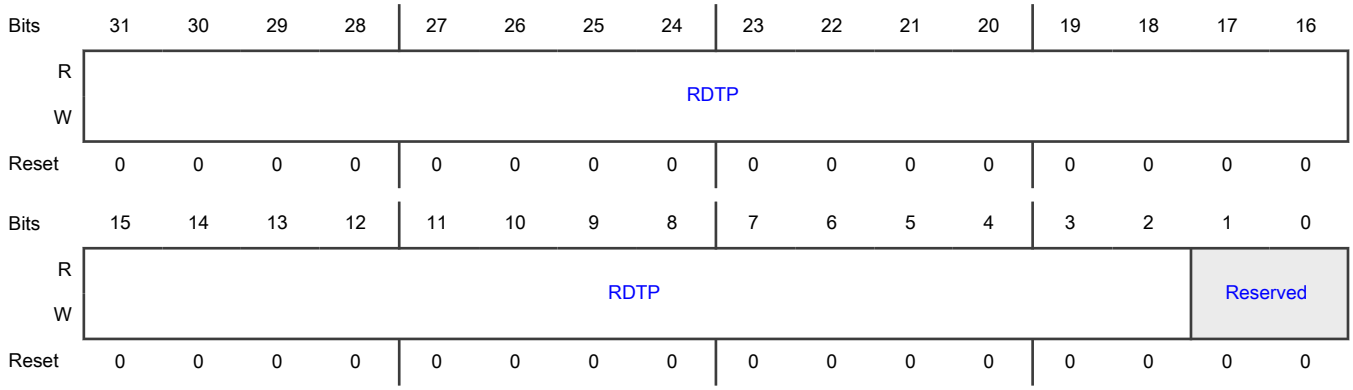
Offset

Register	Offset
DMA_CH0_RxDesc_Tail_Pointer	1128h

Function

Specifies an offset from the base and indicates the location of the last valid descriptor.

Diagram



Fields

Field	Function
31-2 RDTP	Receive Descriptor Tail Pointer Contains the tail pointer for the receive descriptor ring. You must write the tail pointer to add more descriptors to the receive channel. The hardware tries to write all received packets to the descriptors referenced between the head and the tail pointer registers. The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

78.17.252 DMA Channel 0 Tx Descriptor Ring Length (DMA_CH0_TxDesc_Ring_Length)

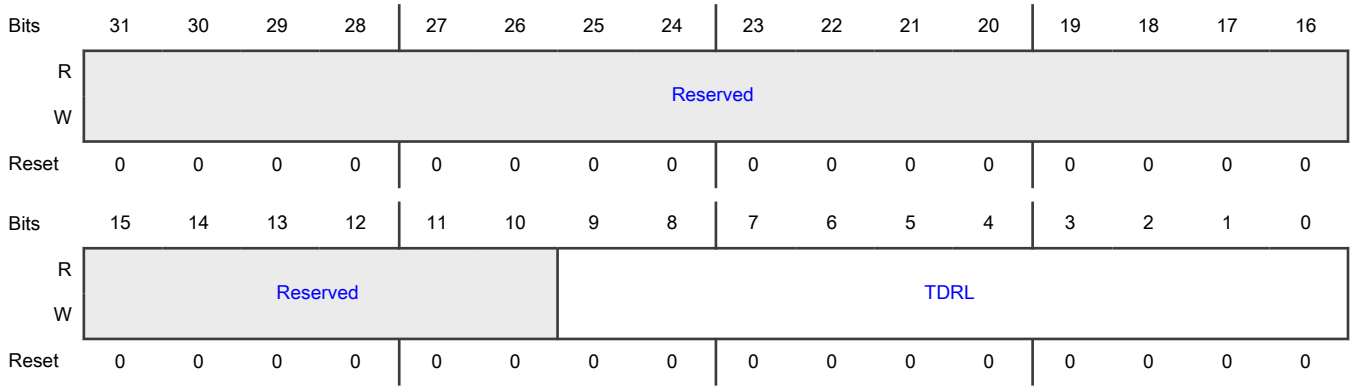
Offset

Register	Offset
DMA_CH0_TxDesc_Ring_Length	112Ch

Function

Contains the length of the transmit descriptor ring.

Diagram



Fields

Field	Function
31-10 —	Reserved.
9-0 TDRL	Transmit Descriptor Ring Length Sets the maximum number of transmit descriptors in the circular descriptor ring. The maximum number of descriptors are limited to 1K descriptors. NXP recommends a minimum ring descriptor length of 4. For example, you can program any value up to 0x3FF in this field. This field is 10 bits wide, if you program 0x3FF, you can have 1024 descriptors. Program this field to a value of 0x9, if you want to have 10 descriptors.

78.17.253 DMA Channel 0 Rx Descriptor Ring Length (DMA_CH0_RxDesc_Ring_Length)

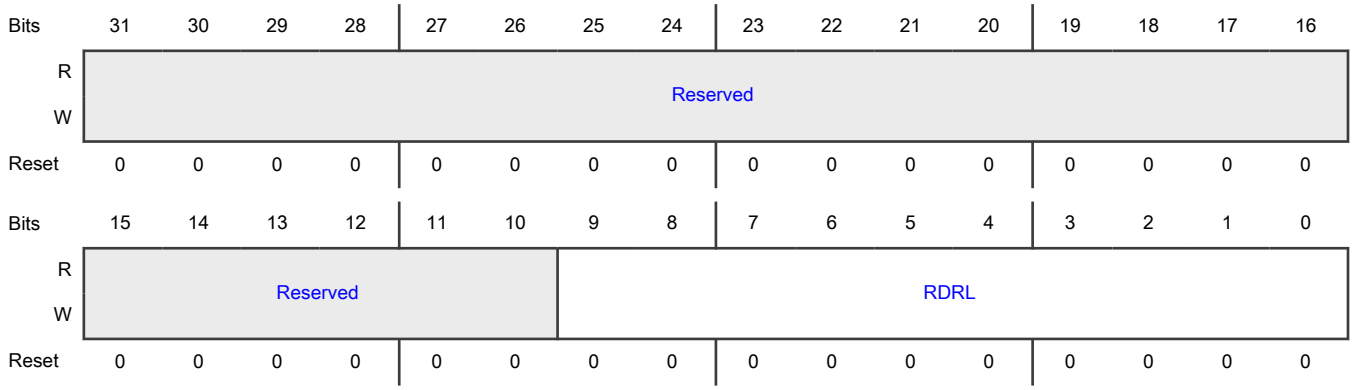
Offset

Register	Offset
DMA_CH0_RxDesc_Ring_Length	1130h

Function

Contains the length of the receive descriptor circular ring.

Diagram



Fields

Field	Function
31-10 —	Reserved.
9-0 RDRL	Receive Descriptor Ring Length Sets the maximum number of receive descriptors in the circular descriptor ring. The maximum number of descriptors is limited to 1K descriptors. For example, you can program any value up to 0x3FF in this field. This field is 10 bits wide, if you program 0x3FF, you can have 1024 descriptors. Program this field to a value of 0x9, if you want to have 10 descriptors.

78.17.254 DMA Channel 0 Interrupt Enable (DMA_CH0_Interrupt_Enable)

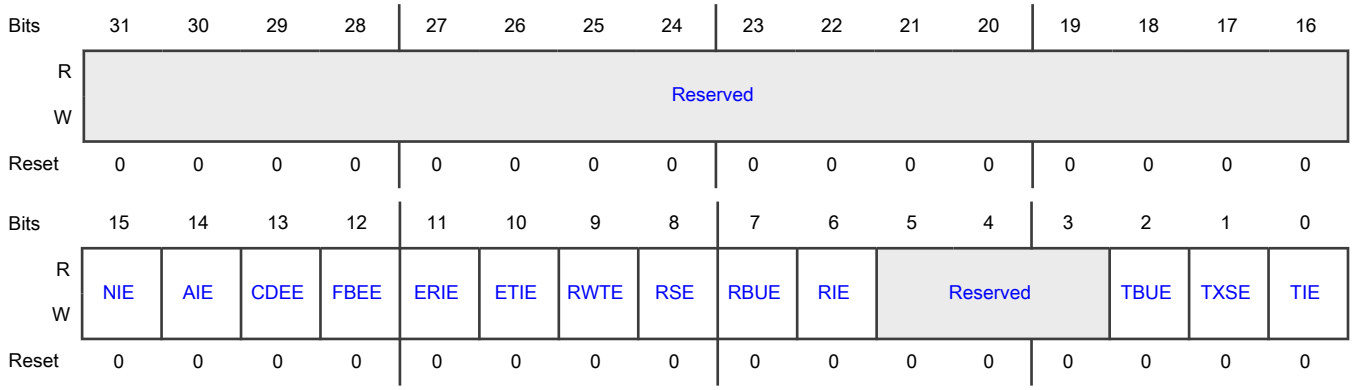
Offset

Register	Offset
DMA_CH0_Interrupt_Enable	1134h

Function

Enables the interrupts which the status register report.

Diagram



Fields

Field	Function
31-16 —	Reserved.
15 NIE	Normal Interrupt Summary Enable Enables or disables the normal interrupt summary. When this field is 1, it enables the normal interrupt summary. This field also enables the following interrupts in DMA_CH0_Status: -Bit 0 - Transmit interrupt Bit 2 - Transmit buffer unavailable Bit 6 - Receive interrupt Bit 11 - Early receive interrupt When this field becomes 0, it disables the normal interrupt summary. 0b - Disable 1b - Enable
14 AIE	Abnormal Interrupt Summary Enable Enables or disables the abnormal interrupt summary. When this field is 1, it enables the abnormal interrupt summary. This field also enables the following interrupts in DMA_CH0_Status: Bit 1 - Transmit process stopped Bit 7 - Rx buffer unavailable Bit 8 - Receive process stopped Bit 9 - Receive watchdog timeout Bit 10 - Early transmit interrupt Bit 12 - Fatal bus error Bit 13 - Context descriptor error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When this field becomes 0, it disables the abnormal interrupt summary. 0b - Disable 1b - Enable
13 CDEE	Context Descriptor Error Enable Enables or disables the context descriptor error. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the descriptor error interrupt. When this field becomes 0, it disables the descriptor error interrupt. 0b - Disable 1b - Enable
12 FBEE	Fatal Bus Error Enable Enables or disables the fatal bus error. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the fatal bus error interrupt. When this field becomes 0, it disables the fatal bus error interrupt. 0b - Disable 1b - Enable
11 ERIE	Early Receive Interrupt Enable Enables or disables the early receive interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the early receive interrupt. When this field becomes 0, it disables the early receive interrupt. 0b - Disable 1b - Enable
10 ETIE	Early Transmit Interrupt Enable Enables or disables the early transmit interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the early transmit interrupt. When this field becomes 0, it disables the early transmit interrupt. 0b - Disable 1b - Enable
9 RWTE	Receive Watchdog Timeout Enable Enables or disables the receive watchdog timeout. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the receive watchdog timeout interrupt. When this field becomes 0, it disables the receive watchdog timeout interrupt. 0b - Disable 1b - Enable

Table continues on the next page...

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Field	Function
8 RSE	Receive Stopped Enable Enables or disables the receive stopped interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the receive stopped interrupt. When this field becomes 0, it disables the receive stopped interrupt. 0b - Disable 1b - Enable
7 RBUE	Receive Buffer Unavailable Enable Enables or disables the receive buffer unavailable interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the receive buffer unavailable interrupt. When this field becomes 0, it disables the receive buffer unavailable interrupt. 0b - Disable 1b - Enable
6 RIE	Receive Interrupt Enable Enables or disables the receive interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the receive interrupt. When this field becomes 0, it disables the receive interrupt. 0b - Disable 1b - Enable
5-3 —	Reserved.
2 TBUE	Transmit Buffer Unavailable Enable Enables or disables the transmit buffer unavailable interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the transmit buffer unavailable interrupt. When this field becomes 0, it disables the transmit buffer unavailable interrupt. 0b - Disable 1b - Enable
1 TXSE	Transmit Stopped Enable Enables or disables the transmit stopped interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the transmission stopped interrupt. When this field becomes 0, it disables the transmission stopped interrupt. 0b - Disable 1b - Enable
0	Transmit Interrupt Enable

Table continues on the next page...

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Field	Function
TIE	Enables or disables the transmit interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the transmit interrupt. When this field becomes 0, it disables the transmit interrupt. 0b - Disable 1b - Enable

78.17.255 DMA Channel 0 Rx Interrupt Watchdog Timer (DMA_CH0_Rx_Interrupt_Watchdog_Timer)

Offset

Register	Offset
DMA_CH0_Rx_Interrupt_Watchdog_Timer	1138h

Function

Indicates the watchdog timeout for receive interrupt (RI) from DMA. When you write this register with a non-zero value, it enables the watchdog timer for the RI bit of the DMA_CHi_Status register.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved														RWTU	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved								RWT							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-18 —	Reserved.
17-16 RWTU	Receive Interrupt Watchdog Timer Count Units Indicates the system clock cycles number corresponding to one unit in DMA_CH0_Rx_Interrupt_Watchdog_Timer[RWT].

Table continues on the next page...

Table continued from the previous page...

Field	Function
	2'b00 - 256 2'b01 - 512 2'b10 - 1024 2'b11 - 2048 For example, when DMA_CH0_Rx_Interrupt_Watchdog_Timer[RWT] = 2 and DMA_CH0_Rx_Interrupt_Watchdog_Timer[RWTU] = 1, the watchdog timer sets for 2*512=1024 system clock cycles.
15-8 —	Reserved.
7-0 RWT	Receive Interrupt Watchdog Timer Count Indicates the number of system clock cycles, multiplied by factor which DMA_CH0_Rx_Interrupt_Watchdog_Timer[RWTU] indicates, for which you set the watchdog timer. The watchdog timer triggers with the programmed value after the receive DMA completes the packet transfer for which the RI bit is not set in the DMA_CH(#i)_Status register, because of the setting of interrupt enable bit in the corresponding descriptor RDES3[30]. When the watchdog timer runs out, it indicates that the RI bit is 1 and the timer stops. The watchdog timer resets when the RI bit is 1 because of automatic setting of RI per the interrupt enable bit RDES3[30] of any received packet.

78.17.256 DMA Channel 0 Slot Function Control Status (DMA_CH0_Slot_Function_Control_Status)

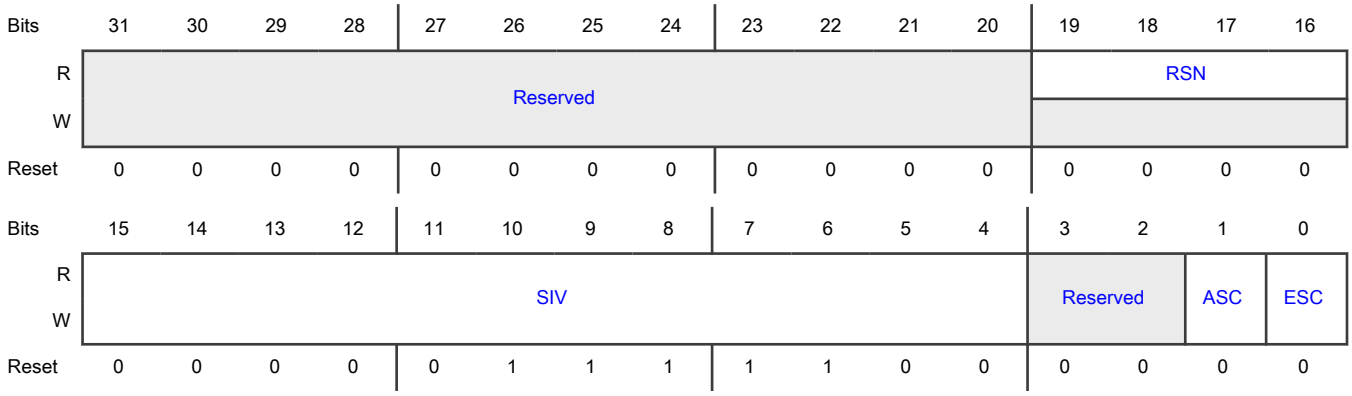
Offset

Register	Offset
DMA_CH0_Slot_Function_Control_Status	113Ch

Function

Contains the control bits for slot function and the status for transmit path.

Diagram



Fields

Field	Function
31-20 —	Reserved.
19-16 RSN	Reference Slot Number Provides the current value of the reference slot number in DMA. It is used for slot comparison.
15-4 SIV	Slot Interval Value Controls the period of the slot interval in which the TxDMA fetches the scheduled packets. A value of 0 specifies the slot interval of 1 us while the maximum value 4095 specifies the slot interval of 4096 us. The default or reset value is 0x07C which corresponds to slot interval of 125 us
3-2 —	Reserved.
1 ASC	Advance Slot Check Indicates whether the advance slot check is enabled. When this field is 1, it enables DMA to fetch the data from the buffer when the slot number (SLOTNUM) programmed in the transit descriptor is either: Equal to the reference slot number given in DMA_CH0_Slot_Function_Control_Status[RSN], or Ahead of the reference slot number by up to two slots. This field is applicable only when DMA_CH0_Slot_Function_Control_Status[ESC] = 1. 0b - Disabled 1b - Enabled
0 ESC	Enable Slot Comparison Indicates whether the slot comparison is enabled.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When this field is 1, it enables the checking of the slot numbers programmed in the transit descriptor with the current reference given in DMA_CH0_Slot_Function_Control_Status[RSN]. DMA fetches the data from the corresponding buffer only when the slot number is either: • Equal to the reference slot number, or • Ahead of the reference slot number by one slot. When this field becomes 0, it disables the checking of the slot numbers. DMA fetches the data immediately after you process the descriptor. **NOTE** You must not enable the UFO (UDP Fragmentation over IPv4)/TSO/USO along with TBS/AVB slot number check. The UFO/TSO/USO involves multiple packets/segments/ fragments transmission for single packet received from application and the slot number check are applicable for fetching only first segment/fragment. As a result it might be difficult for you to specify slot number for subsequent packets. 0b - Disabled 1b - Enabled

78.17.257 DMA Channel 0 Current Application Transmit Descriptor (DMA_CH0_Current_App_TxDesc)

Offset

Register	Offset
DMA_CH0_Current_App_TxDesc	1144h

Function
Specifies the current transmit descriptor which DMA reads.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CURTDESAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CURTDESAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CURTDESAPTR	Application Transmit Descriptor Address Pointer Indicates that DMA updates this pointer during the transit operation. This pointer clears when reset.

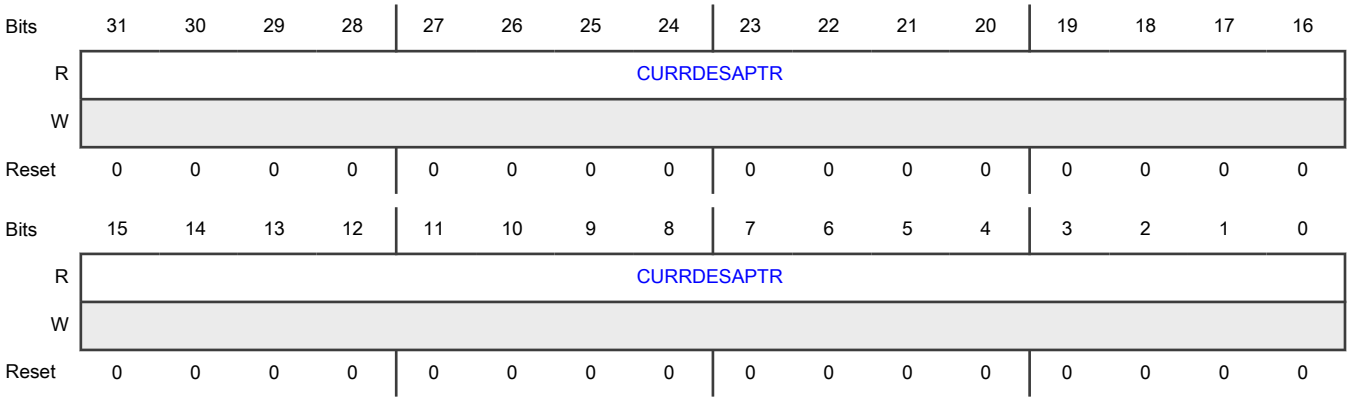
78.17.258 DMA Channel 0 Current Application Receive Descriptor (DMA_CH0_Current_App_RxDesc)

Offset

Register	Offset
DMA_CH0_Current_App_RxDesc	114Ch

Function
Specifies the current receive descriptor which DMA read.

Diagram



Fields

Field	Function
31-0 CURRDESAPTR	Application Receive Descriptor Address Pointer Indicates that the DMA updates this pointer during the receive operation. This pointer clears when reset.

78.17.259 DMA Channel 0 Current Application Transmit Descriptor (DMA_CH0_Current_App_TxBuffer)

Offset

Register	Offset
DMA_CH0_Current_App_TxBuffer	1154h

Function
Specifies the current transit buffer address which DMA reads.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CURTBUFAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CURTBUFAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CURTBUFAPTR	Application Transmit Buffer Address Pointer Indicates that DMA updates this pointer during the transit operation. This pointer clears when reset.

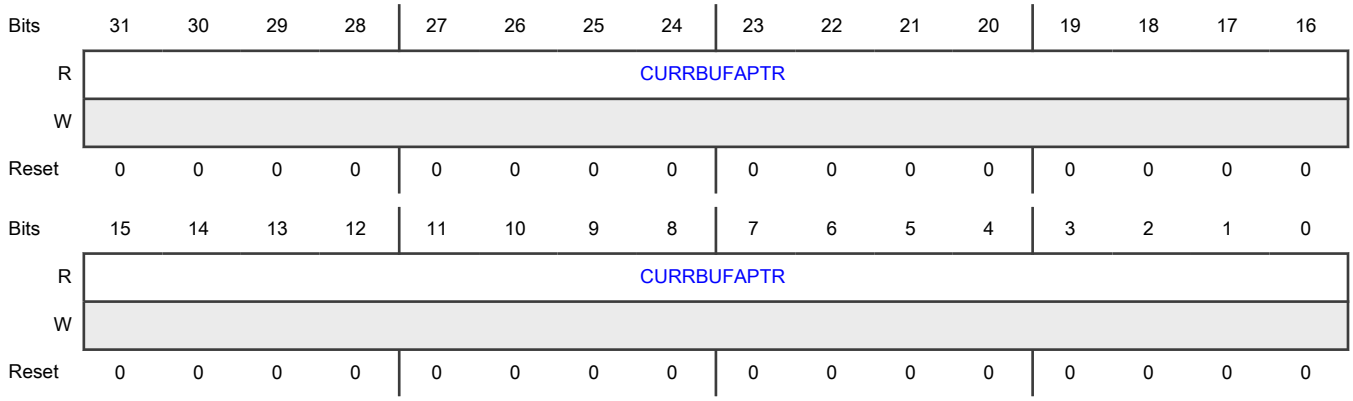
78.17.260 DMA Channel 0 Current Application Receive Buffer (DMA_CH0_Current_App_RxBuffer)

Offset

Register	Offset
DMA_CH0_Current_App_RxBuffer	115Ch

Function
Specifies the current receive buffer address which DMA read.

Diagram



Fields

Field	Function
31-0 CURRBUFAPTR	Application Receive Buffer Address Pointer Indicates that DMA updates this pointer during the receive operation. This pointer clears when reset.

78.17.261 DMA Channel 0 Status (DMA_CH0_Status)

Offset

Register	Offset
DMA_CH0_Status	1160h

Function

Indicates that the software driver (application) reads the status register during an interrupt service routine or polling to determine the DMA status.

NOTE

The number of DMA_CH(#i)_Status register in the configuration is the higher of number of receive DMA channels and transit DMA channels.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved										REB			TEB		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NIS	AIS	CDE	FBE	ERI	ETI	RWT	RPS	RBU	RI	Reserved			TBU	TPS	TI
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-22 —	Reserved.
21-19 REB	Rx DMA Error Bits Indicates the type of error that causes a bus error. For example, error response on the AHB or AXI interface. Bit 21 1'b1 - Error during data transfer by Rx DMA 1'b0 - No Error during data transfer by Rx DMA Bit 20 1'b1 - Error during descriptor access 1'b0 - Error during data buffer access Bit 19 1'b1 - Error during read transfer 1'b0 - Error during write transfer This field is valid only when DMA_CH0_Status[FBE] = 1. This field does not generate an interrupt.
18-16 TEB	Tx DMA Error Bits Indicates the type of error that causes a bus error. For example, error response on the AHB or AXI interface. Bit 18 1'b1 - Error during data transfer by Tx DMA 1'b0 - No Error during data transfer by Tx DMA Bit 17 1'b1 - Error during descriptor access 1'b0 - Error during data buffer access

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Bit 16 1'b1 - Error during read transfer 1'b0 - Error during write transfer This field is valid only when DMA_CH0_Status[FBE] = 1. This field does not generate an interrupt.
15 NIS	Normal Interrupt Summary Indicates whether the normal interrupt summary status is detected. This field is the logical OR of the following bits when you enables the corresponding interrupt bits in DMA_CH0_Interrupt_Enable: Bit 0 - Transmit interrupt Bit 2 - Transmit buffer unavailable Bit 6 - Receive interrupt Bit 11 - Early receive interrupt Only unmasked bits (interrupts for which interrupt enable sets in DMA_CH0_Interrupt_Enable) affect this field. This is a sticky bit. You must clear this field by writing 1 to it each time a corresponding field which sets this field clears. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
14 AIS	Abnormal Interrupt Summary Indicates whether an abnormal interrupt summary status is detected. This field is the logical OR of the following bits when you enables the corresponding interrupt bits in DMA_CH0_Interrupt_Enable: Bit 1 - Transmit process stopped Bit 7 - Receive buffer unavailable Bit 8 - Receive process stopped Bit 10 - Early transmit interrupt Bit 12 - Fatal bus error Bit 13 - Context descriptor error Only unmasked bits affect this field. This is a sticky bit. You must clear this field by writing 1 to it each time a corresponding field, which sets this field, clears. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not detected 1b - Detected
13 CDE	Context Descriptor Error Indicates whether the context descriptor error status is detected. This field indicates that the DMA Tx/Rx engine receives a descriptor error, which indicates an invalid context in the middle of packet flow (intermediate descriptor) or all one's descriptor in transit case and on receive side it indicates DMA has read a descriptor with either of the buffer address as ones which is considered to be invalid. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
12 FBE	Fatal Bus Error Indicates whether the fatal bus error status is detected. This field indicates that a bus error occurred (as described in the EB field). When this field is 1, it indicates that the corresponding DMA channel engine disables all bus accesses. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
11 ERI	Early Receive Interrupt Indicates whether an early receive interrupt status is detected. When this field is 1, it indicates that the RxDMA completes the packet data transfer to the memory. In configs supporting ERIC, this field is 1 only after the receive DMA fills a complete receive buffer with packet data, when DMA_CH0_Rx_Control[ERIC] = 0. This field is 1 after every burst transfer of data from the receive DMA to the buffer, when DMA_CH0_Rx_Control[ERIC] = 1. Writing 1 to RI field automatically clears this field. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
10 ETI	Early Transmit Interrupt Indicates whether an early transmit interrupt status is detected. When this field is 1, it indicates that the TxDMA completes the packet data transfer to the MTL TXFIFO memory.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	In configs supporting ERIC: this field is 1 only after the transit DMA transfers a complete packet to MTL, when DMA_CH0_Tx_Control[ETIC] = 0. This field is 1 after packet data transfers from buffer completes (partial) in the transmit descriptor in which IOC = 1, when DMA_CH0_Tx_Control[ETIC] = 1. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
9 RWT	Receive Watchdog Timeout Indicates whether the receive watchdog timeout status is detected. Asserts when you receives a packet with length greater than 2,048 bytes (10,240 bytes when Jumbo Packet mode is enabled). 0b - Not detected 1b - Detected
8 RPS	Receive Process Stopped Indicates whether the receive process stopped status is detected. Asserts when the receive process enters the stopped state. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
7 RBU	Receive Buffer Unavailable Indicates whether the receive buffer unavailable status is detected. This field indicates that the application owns the next descriptor in the receive list, and DMA cannot acquire it. The receive process is suspended. To resume processing receive descriptors, the application must change the ownership of the descriptor and issue a receive poll demand command. If this command is not issued, the receive process resumes when you receive the next recognized incoming packet. In ring mode, the application must advance the receive descriptor tail pointer register of a channel. This field is 1 only when DMA owns the previous receive descriptor. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
6 RI	Receive Interrupt Indicates that the receive interrupt status is detected.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field indicates that the packet reception is complete. When packet reception completes, bit 31 of RDES3 resets in the last descriptor, and you can update the specific packet status information in the descriptor. The reception remains in the running state. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
5-3 —	Reserved.
2 TBU	Transmit Buffer Unavailable Indicates whether the transmit buffer unavailable status is detected. This field indicates that the application owns the next descriptor in the transmit list, and the DMA cannot acquire it. Transmission is suspended. DMA_Debug_Status0[TPS0] explains the transmit process state transitions. To resume processing the transmit descriptors, the application must perform these steps: 1. Change the ownership of the descriptor by writing 1 to bit 31 of TDES3. 2. Issue a transmit poll demand command. For Ring mode, the application must advance the transmit descriptor tail pointer register of a channel. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
1 TPS	Transmit Process Stopped Indicates whether the transmit process stopped status is detected. This field is 1 when the transmission stops. Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
0 TI	Transmit Interrupt Indicates whether the transmit interrupt status is detected. This field indicates that the packet transmission is complete. When transmission completes, Bit 31 of TDES3 resets in the last descriptor, and you can update the specific packet status information in the descriptor.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Access restriction apply to this field. It automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected

78.17.262 DMA Channel 0 Miss Frame Counter (DMA_CH0_Miss_Frame_Cnt)

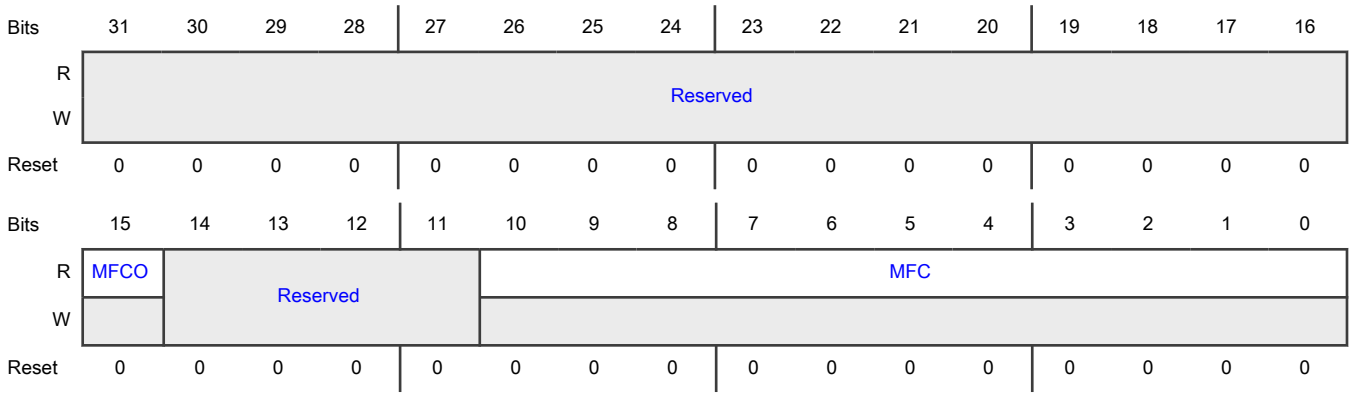
Offset

Register	Offset
DMA_CH0_Miss_Frame_Cnt	1164h

Function

Indicates the number of packet counter that DMA drops either due to bus error or due to programming RPF field in DMA_CH${i}_Rx_Control register.

Diagram



Fields

Field	Function
31-16 —	Reserved.
15 MFCO	Overflow status of the MFC Counter Indicates whether the miss frame counter overflow has occurred. When this field is 1, it indicates that the MFC counter does not increment further. This field is 0 when this register is read.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not occurred 1b - Occurred
14-11 —	Reserved.
10-0 MFC	Dropped Packet Counters Indicates the number of packet counters that DMA drops either because of bus error or because of programing RPF field in DMA_CH${i}_Rx_Control register. This field is 0 when this register is read. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.

78.17.263 DMA Channel 0 Rx Parser Accept Count (DMA_CH0_RXP_Accept_Cnt)

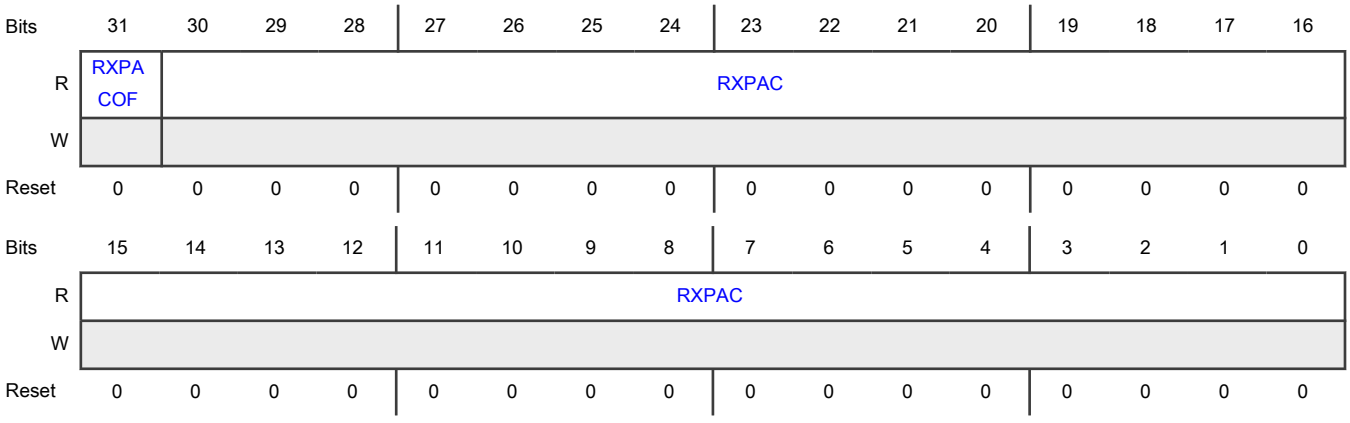
Offset

Register	Offset
DMA_CH0_RXP_Accept_Cnt	1168h

Function

Provides the count of the number of frames which the receive parser accept.

Diagram



Fields

Field	Function
31 RXPACOF	Rx Parser Accept Counter Overflow Bit Indicates whether the receive parser accept counter overflow has occurred. When this field is 1, it indicates that the RXPAC counter field has crossed the maximum limit. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not occurred 1b - Occurred
30-0 RXPAC	Rx Parser Accept Counter Implements whenever a receive parser accept a packet because AF = 1. The counter clears when the register is read.

78.17.264 DMA Channel 0 Rx ERI Count (DMA_CH0_RX_ERI_Cnt)

Offset

Register	Offset
DMA_CH0_RX_ERI_Cnt	116Ch

Function
Provides the count of the number of times ERI is asserted.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved				ECNT											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12	Reserved.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
11-0 ECNT	ERI Counter Indicates that when ERIC bit of DMA_CH(#i)_RX_Control register is 1, this counter increments for burst transfer which the receive DMA completes from the start of packet transfer. This field becomes 0 at the start of new packet.

78.17.265 DMA Channel 1 Control (DMA_CH1_Control)

Offset

Register	Offset
DMA_CH1_Control	1180h

Function

Specifies the MSS value for segmentation, length to skip between two descriptors, and also the features such as header splitting and 8xPBL mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved							Reserved	Reserved				DSL			Reserved	PBLx8
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved				Reserved											
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-25 —	Reserved.
24 —	Reserved.
23-21	Reserved.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
20-18 DSL	Descriptor Skip Length Specifies the Word, Dword, or Lword number (depending on the 32-bit, 64-bit, or 128-bit bus) to skip between two unchained descriptors. The address skipping starts from the end of the current descriptor to the start of the next descriptor. When this field is 0, it indicates that DMA takes the descriptor table as contiguous.
17 —	Reserved.
16 PBLx8	8xPBL mode Indicates whether the 8xPBL mode is enabled. When this field is 1, it indicates that you must program the PBL value in Bits[21:16] in DMA_CH(#i)_Tx_Control and Bits[21:16] in DMA_CH(#i)_Rx_Control and multiply it eight times. Therefore, DMA transfers the data in 8, 16, 32, 64, 128, and 256 beats depending on the PBL value. 0b - Disabled 1b - Enabled
15-14 —	Reserved.
13-0 —	Reserved.

78.17.266 DMA Channel 1 Tx Control (DMA_CH1_Tx_Control)

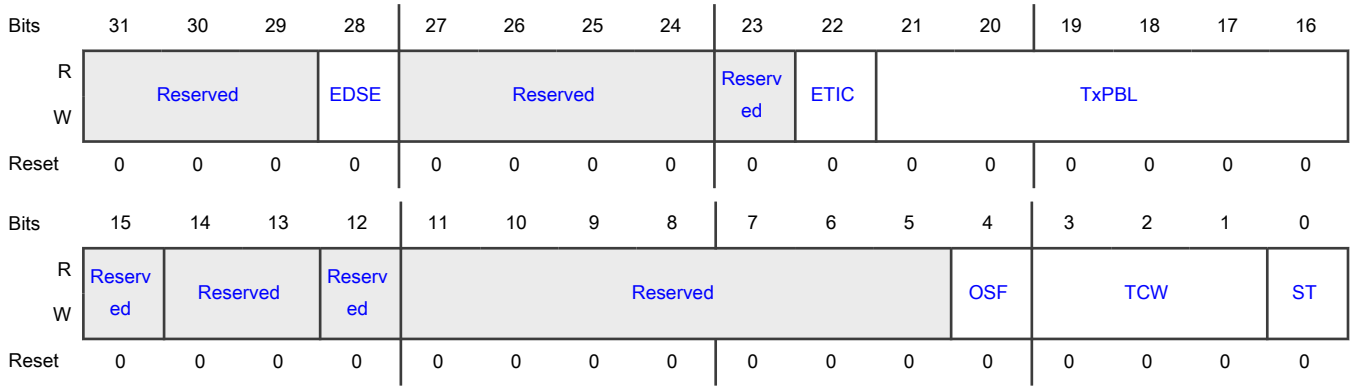
Offset

Register	Offset
DMA_CH1_Tx_Control	1184h

Function

Controls the transmit features such as PBL, TCP segmentation, and transmit channel weights.

Diagram



Fields

Field	Function
31-29 —	Reserved.
28 EDSE	Enhanced Descriptor Enable Indicates whether an enhanced descriptor is enabled. When this field is 1, it indicates that the corresponding channel uses enhanced descriptors that are 32 Bytes for both normal and context descriptors. When this field becomes 0, it indicates that the corresponding channel uses the descriptors that are 16 Bytes. 0b - Disabled 1b - Enabled
27-24 —	Reserved.
23 —	Reserved.
22 ETIC	Early Transmit Interrupt Control Indicates whether an early transmit interrupt is enabled. When this field is 1, it indicates that an early transmit interrupt (ETI) status sets after the data transfer completes from buffers of a transmit descriptor in which IOC bit (TDES2[31]) sets. When this field becomes 0, it indicates that the ETI sets only after a complete packet transfers to the MTL TX FIFO memory. 0b - Disabled 1b - Enabled
21-16	Transmit Programmable Burst Length

Table continues on the next page...

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Field	Function
TxPBL	Indicates the maximum number of beats to transfer in one DMA block data. DMA always attempts max burst as specified in PBL each time it starts a burst transfer on the application bus. You can program PBL with any of these values: 1, 2, 4, 8, 16, or 32. Any other value results in an undefined behavior. To transfer more than 32 beats, perform the following steps: 1. Write 1 to DMA_CH0_Control[PBLx8]. 2. Write 1 to this field. **NOTE** The maximum value of this field must be less than or equal to half the transit queue size (TQS field of MTL_TxQ(#i)_Operation_Mode register) in terms of beats. This is required so that the transit queue has space to store at least another Tx PBL worth of data while the MTL Tx Queue controller transfers data to MAC. For example, in 64-bit data width configurations the total locations in transit queue of size 512 bytes is 64. You must program TxPBL and 8xPBL to less than or equal to 32.
15 —	Reserved.
14-13 —	Reserved.
12 —	Reserved.
11-5 —	Reserved.
4 OSF	Operate on Second Packet Indicates whether an operation on second packet is enabled. When this field is 1, it instructs DMA to process the second packet of the transmit data even before the first packet status is obtained. 0b - Disabled 1b - Enabled
3-1 TCW	Transmit Channel Weight Indicates the weight assigned to the corresponding transmit channel. When reset completes, this field becomes 0 for all channels by default, resulting in equal weights to all channels.
0 ST	Start or Stop Transmission Command Indicates whether to start or stop transmission command. When this field is 1, it indicates that the transmission is placed in the running state. DMA checks the transmit list at the current position to transmit a packet.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	DMA tries to acquire descriptor from either of the following positions: • The current position in the list. This is the base address of the transmit list which DMA_CH0_TxDesc_List_Address sets. • The position at which the transmission was previously stopped If DMA does not own the current descriptor, the transmission enters the suspended state and DMA_CH0_Status[TBU] = 1. The start transmission command is effective only when the transmission stops. If you issue the command before writing 1 to DMA_CH0_TxDesc_List_Address, then DMA behavior is unpredictable. When this field becomes 0, it indicates that the transmission process is placed in the stopped state after the transmission of the current packet completes. The next descriptor position in the transmit list is saved, and it becomes the current position when the transmission restarts. To change the list address, you must program DMA_CH0_TxDesc_List_Address with a new value when this field becomes 0. The new value is considered when this field is 1 again. The stop transmission command is effective only when the transmission of the current packet completes or the transmission is in the suspended state. 0b - Stop 1b - Start

78.17.267 DMA Channel 1 Rx Control (DMA_CH1_Rx_Control)

Offset

Register	Offset
DMA_CH1_Rx_Control	1188h

Function

Controls the receive features such as PBL, buffer size, and extended status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	RPF	Reserved			Reserved				Reserved	ERIC	RxPBL					
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	RBSZ_13_y												RBSZ_x_0		SR
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 RPF	Rx Packet Flush Indicates whether the receive packet flush is enabled. When this field is 1, it indicates that the module automatically flushes the packet from the receive queues destined to this DMA receive channel, when it stops. When this field remains 1 and the software driver re-starts DMA, the packets residing in the receive queues that were received when this RxDMA was stopped, flushes out. Route the packets to the RxDMA that the MAC receives after the RxDMA re-starts. The flushing takes place on the read side of the receive queue. When this field is 0, it indicates that the module do not flush the packet in the receive queue destined to this RxDMA channel when it is in stop state. This might in turn cause head-of-line blocking in the corresponding RxQueue. **NOTE** The stopping of packet flow from a Rx DMA Channel to the application by writing 1 to this field works only when there is one-to-one mapping of receive queue to the receive DMA channels. In Dynamic mapping mode, writing 1 to this field in any DMA_CH(#i)_Rx_Control register might flush packets from unintended receive queues which are destined to the stopped Rx DMA Channel. 0b - Disabled 1b - Enabled
30-28 —	Reserved.
27-24 —	Reserved.
23 —	Reserved.
22 ERIC	Early Receive Interrupt Control Indicates whether an early receive interrupt control status is enabled. When this field is 1, it indicates that an early receive interrupt (ERI) status sets after every burst transfer of data from the receive DMA to the buffer completes. When this field becomes 0, it indicates that ERI sets only after the RxDMA fills the complete buffer is filled. 0b - Disabled 1b - Enabled
21-16 RxPBL	Receive Programmable Burst Length Indicates the maximum number of beats to transfer in one DMA block data. DMA always attempts max burst as specified in PBL, each time it starts a burst transfer on the application bus. You can program PBL with any of the following values: 1, 2, 4, 8, 16, or 32. Any other value results in an undefined behavior. To transfer more than 32 beats, perform the following steps:

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1. Write 1 to DMA_CH0_Control[PBLx8]. 2. Write 1 to RxPBL. **NOTE** The maximum value of RxPBL must be less than or equal to half the receive queue size (RQS field of MTL_RxQ(#i)_Operation_Mode register) in terms of beats. This is required so that the receive queue has space to store at least another Rx PBL worth of data when the receive DMA transfers a block of data. For example, in 64-bit data width configurations the total locations in receive queue of size 512 bytes is 64, so you must program RxPBL and 8xPBL to less than or equal to 32.
15 —	Reserved.
14-3 RBSZ_13_y	Receive Buffer size High Indicates that RBSZ[13:0] splits into two fields higher RBSZ_13_y and lower RBSZ_x_0. RBSZ[13:0] field indicates the size of the receive buffers specified in bytes. The maximum buffer size is limited to 16K bytes. The buffer size is applicable to payload buffers when you enable split headers. **NOTE** The buffer size must be a multiple of 4, 8, or 16 depending on the data bus widths (32-bit, 64-bit, or 128-bit respectively). This is required even if the value of buffer address pointer is not aligned to data bus width. Hence the lower RBSZ_x_0 bits are read-only and the value is considered as all-zero. Thus RBSZ_13_y indicates the buffer size in terms of locations (with the width same as bus-width).
2-1 RBSZ_x_0	Receive Buffer size Low Indicates that RBSZ[13:0] splits into two fields RBSZ_13_y and RBSZ_x_0. RBSZ_x_0 is the lower field whose width is based on data bus width of the configuration. This field width is of 2, 3, or 4 bits for 32-bit, 64-bit, or 128-bit data bus width respectively. This field is read-only (RO).
0 SR	Start or Stop Receive Indicates whether to start or stop receive. When this field is 1, it indicates that DMA tries to acquire the descriptor from the receive list and processes the incoming packets. DMA tries to acquire descriptor from either of the following positions: • The current position in the list. This is the address that DMA_CH0_RxDesc_List_Address sets. • The position at which the receive process was previously stopped If DMA does not own the current descriptor, the reception suspends and DMA_CH0_Status[RBU] = 1. The start receive command is effective only when the reception stops. If the command is issued before writing 1 to DMA_CH0_RxDesc_List_Address, DMA behavior is unpredictable.

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Field	Function
	When this field becomes 0, it indicates that the receive DMA operation stops after the transfer of the current packet. The next descriptor position in the receive list is saved, and it becomes the current position after the receive process restarts. The stop receive command is effective only when the receive process is in the running (waiting for Rx packet) or suspended state. 0b - Stop 1b - Start

78.17.268 DMA Channel 1 Tx Descriptor List Address (DMA_CH1_TxDesc_List_Address)

Offset

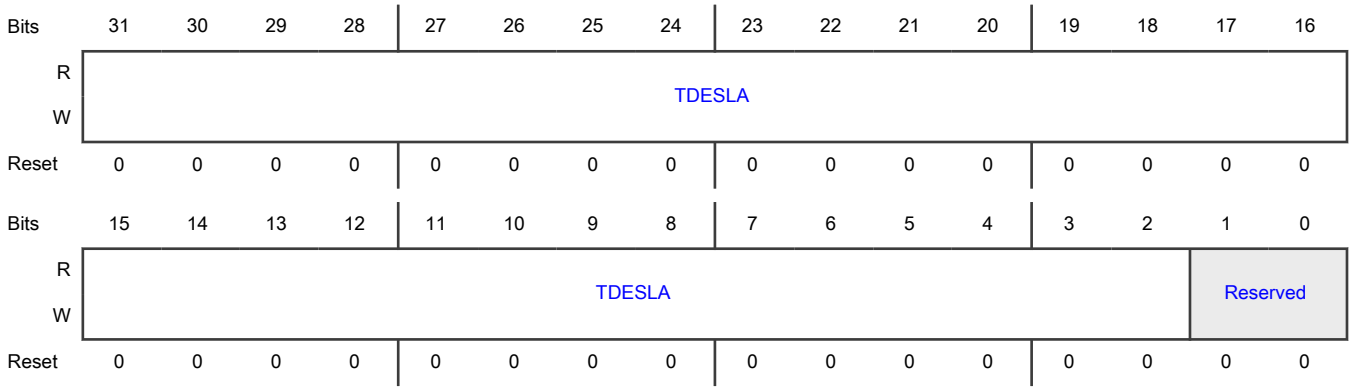
Register	Offset
DMA_CH1_TxDesc_List_Address	1194h

Function

Specifies DMA to the start of transmit descriptor list. The descriptor lists reside in the application's physical memory space and must be Word, Dword, or Lword-aligned (for 32-bit, 64-bit, or 128-bit data bus). The DMA converts the corresponding LSB bits to low to internally convert the descriptor lists to bus width aligned address.

You can write to this register only when the transmit DMA stops, that is, DMA_CH0_Tx_Control[ST] = 0. When stopped, you can write this register with a new descriptor list address. When DMA_CH0_Tx_Control[ST] = 1, the DMA takes the newly-programmed descriptor base address. If this register do not change when DMA_CH0_Tx_Control[ST] = 0, DMA takes the descriptor address where it was stopped earlier.

Diagram



Fields

Field	Function
31-2	Start of Transmit List

Table continues on the next page...

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Field	Function
TDESLA	Contains the first descriptor base address in the transmit descriptor list. DMA ignores the LSB bits (1:0, 2:0, or 3:0) for 32-bit, 64-bit, or 128-bit bus width and internally assumes these bits as all-zero. Therefore, these LSB bits are read-only (RO). The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

78.17.269 DMA Channel 1 Rx Descriptor List Address (DMA_CH1_RxDesc_List_Address)

Offset

Register	Offset
DMA_CH1_RxDesc_List_Address	119Ch

Function

Specifies DMA to the start of receive descriptor list. The descriptor lists resides in the application's physical memory space and must be Word, Dword, or Lword-aligned (for 32-bit, 64-bit, or 128-bit data bus). DMA converts the corresponding LS bits low to internally convert the descriptor lists to bus width aligned address. You can write to this register only when reception stops. When stopped, you must write this register before the receive start command is given.

You can write to this register when receive DMA has stopped, that is, DMA_CH0_Rx_Control[SR] = 0. When stopped, you can this register with a new descriptor list address.

When DMA_CH0_Rx_Control[SR] = 1, DMA takes the newly programmed descriptor base address.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	RDESLA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	RDESLA														Reserved	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-2 RDESLA	Start of Receive List Contains the first descriptor base address in the receive descriptor list. DMA ignores the LSB bits (1:0, 2:0, or 3:0) for 32-bit, 64-bit, or 128-bit bus width and internally assume these bits as all-zero. Therefore, these LSB bits are read-only (RO). The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

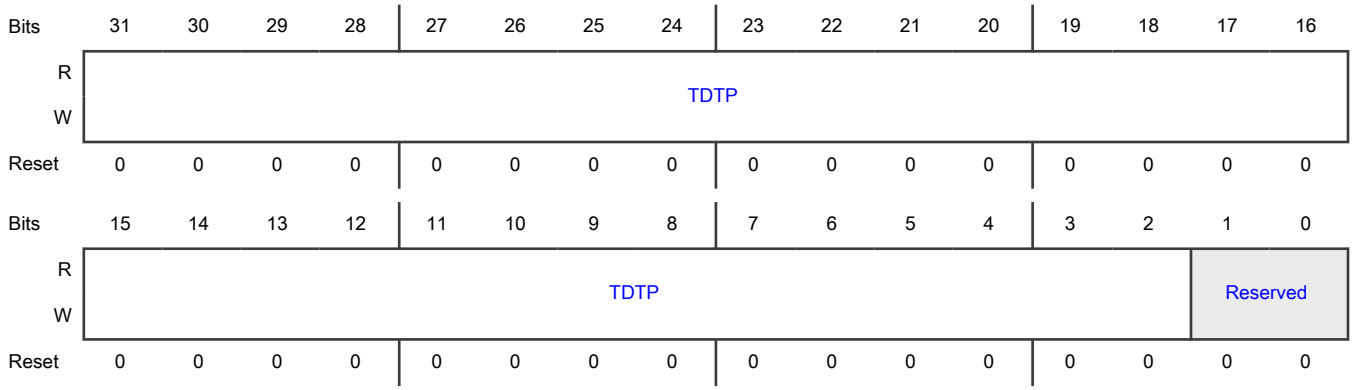
78.17.270 DMA Channel 1 Tx Descriptor Tail Pointer (DMA_CH1_TxDesc_Tail_Pointer)

Offset

Register	Offset
DMA_CH1_TxDesc_Tail_Pointer	11A0h

Function
Specifies to an offset from the base and indicates the location of the last valid descriptor.

Diagram



Fields

Field	Function
31-2	Transmit Descriptor Tail Pointer

Table continues on the next page...

Table continued from the previous page...

Field	Function
TDTP	Contains the tail pointer for the transit descriptor ring. The software writes the tail pointer to add more descriptors to the transit channel. The hardware tries to transmit all the packets which the descriptors referenced between the head and the tail pointer registers. The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

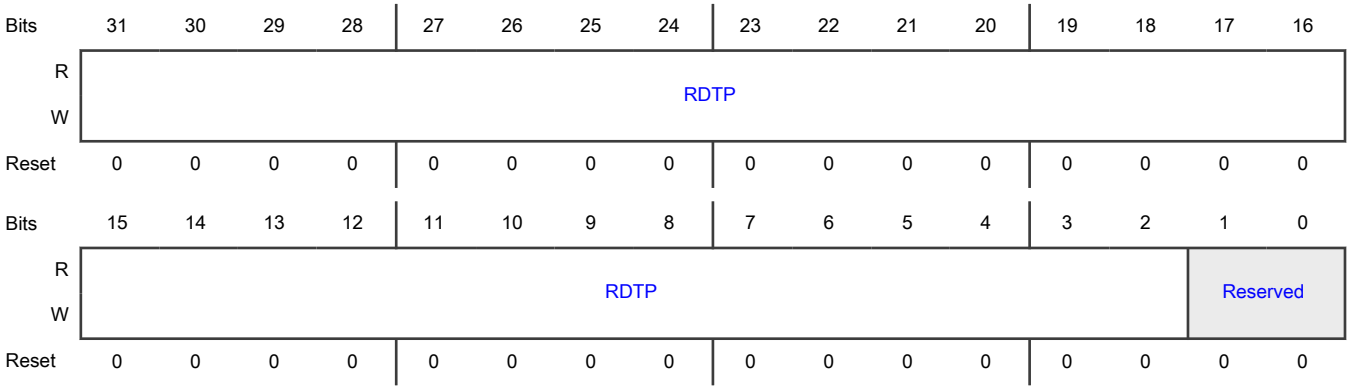
78.17.271 DMA Channel 1 Rx Descriptor Tail Pointer (DMA_CH1_RxDesc_Tail_Pointer)

Offset

Register	Offset
DMA_CH1_RxDesc_Tail_Pointer	11A8h

Function
Specifies to an offset from the base and indicates the location of the last valid descriptor.

Diagram



Fields

Field	Function
31-2 RDTP	Receive Descriptor Tail Pointer

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Contains the tail pointer for the receive descriptor ring. The software writes the tail pointer to add more descriptors to the receive channel. The hardware tries to write all received packets to the descriptors referenced between the head and the tail pointer registers. The field width depends on the configuration: 31:2 for 32-bit configuration 31:3 for 64-bit configuration 31:4 for 128-bit configuration
1-0 —	Reserved.

78.17.272 DMA Channel 1 Tx Descriptor Ring Length (DMA_CH1_TxDesc_Ring_Length)

Offset

Register	Offset
DMA_CH1_TxDesc_Ring_Length	11ACh

Function
Contains the length of the transmit descriptor ring.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved						TDRL									
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-10 —	Reserved.

Table continues on the next page...

Table continued from the previous page...

Field	Function
9-0 TDRL	Transmit Descriptor Ring Length Sets the maximum number of transmit descriptors in the circular descriptor ring. The maximum number of descriptors is limited to 1 K descriptors. NXP recommends a minimum ring descriptor length of 4. For example, you can program any value up to 0x3FF in this field. This field is 10 bits wide, if you program 0x3FF, you can have 1024 descriptors. Program it to a value of 0x9 if you want to have 10 descriptors.

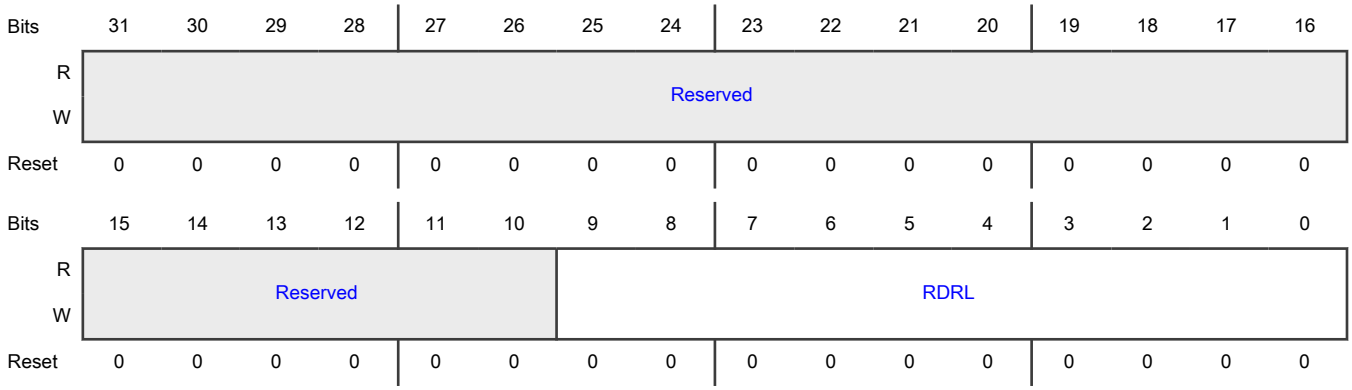
78.17.273 DMA Channel 1 Rx Descriptor Ring Length (DMA_CH1_RxDesc_Ring_Length)

Offset

Register	Offset
DMA_CH1_RxDesc_Ring_Length	11B0h

Function
Contains the length of the receive descriptor circular ring.

Diagram



Fields

Field	Function
31-10 —	Reserved.
9-0 RDRL	Receive Descriptor Ring Length Sets the maximum number of receive descriptors in the circular descriptor ring. The maximum number of descriptors are limited to 1 K descriptors. For example, you can program any value up to 0x3FF in this field. This field is 10 bits wide, if you program 0x3FF, you can have 1024 descriptors. Program it to a value of 0x9 if you want to have 10 descriptors.

78.17.274 DMA Channel 1 Interrupt Enable (DMA_CH1_Interrupt_Enable)

Offset

Register	Offset
DMA_CH1_Interrupt_Enable	11B4h

Function
Enables the interrupts which the status register reports.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	NIE	AIE	CDEE	FBEE	ERIE	ETIE	RWTE	RSE	RBUE	RIE	Reserved			TBUE	TXSE	TIE
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved.
15 NIE	Normal Interrupt Summary Enable Enables or disables the normal interrupt summary. When this field is 1, it enables the normal interrupt summary. This field also enables the following interrupts in DMA_CH0_Status: Bit 0 - Transmit interrupt Bit 2 - Transmit buffer unavailable Bit 6 - Receive interrupt Bit 11 - Early receive interrupt When this field becomes 0, it disables the normal interrupt summary. 0b - Disable 1b - Enable
14	Abnormal Interrupt Summary Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
AIE	Enables or disables the abnormal interrupt summary. When this field is 1, it enables the abnormal interrupt summary. This field also enables the following interrupts in DMA_CH0_Status: Bit 1 - Transmit process stopped Bit 7 - Rx buffer unavailable Bit 8 - Receive process stopped Bit 9 - Receive watchdog timeout Bit 10 - Early transmit interrupt Bit 12 - Fatal bus error Bit 13 - Context descriptor error When this field becomes 0, it disables the abnormal interrupt summary. 0b - Disable 1b - Enable
13 CDEE	Context Descriptor Error Enable Enables or disables the context descriptor error. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the descriptor error interrupt. When this field becomes 0, it disables the descriptor error interrupt. 0b - Disable 1b - Enable
12 FBEE	Fatal Bus Error Enable Enables or disables fatal bus error. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the fatal bus error interrupt. When this field becomes 0, it disables the fatal bus error interrupt. 0b - Disable 1b - Enable
11 ERIE	Early Receive Interrupt Enable Enables or disables the early receive interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the early receive interrupt. When this field becomes 0, it disables the early receive interrupt. 0b - Disable 1b - Enable
10 ETIE	Early Transmit Interrupt Enable Enables or disables the early transmit interrupt.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the early transmit interrupt. When this field becomes 0, it disables the early transmit interrupt. 0b - Disable 1b - Enable
9 RWTE	Receive Watchdog Timeout Enable Enables or disables the receive watchdog timeout interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the receive watchdog timeout interrupt. When this field becomes 0, it disables the receive watchdog timeout interrupt. 0b - Disable 1b - Enable
8 RSE	Receive Stopped Enable Enables or disables the receive stopped interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], It enables the receive stopped interrupt. When this field becomes 0, it disables the receive stopped interrupt. 0b - Disable 1b - Enable
7 RBUE	Receive Buffer Unavailable Enable Enables or disables the receive buffer unavailable interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the receive buffer unavailable interrupt. When this field becomes 0, it disables the receive buffer unavailable interrupt. 0b - Disable 1b - Enable
6 RIE	Receive Interrupt Enable Enables or disables the receive interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the receive interrupt. When this field becomes 0, it disables the receive interrupt. 0b - Disable 1b - Enable
5-3 —	Reserved.
2 TBUE	Transmit Buffer Unavailable Enable Enables or disables the transmit buffer unavailable interrupt.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the transmit buffer unavailable interrupt. When this field becomes 0, it disables the transmit buffer unavailable interrupt. 0b - Disable 1b - Enable
1 TXSE	Transmit Stopped Enable Enables or disables the transmit stopped interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[AIE], it enables the transmission stopped interrupt. When this field becomes 0, it disables the transmission Stopped interrupt. 0b - Disable 1b - Enable
0 TIE	Transmit Interrupt Enable Enables or disables the transmit interrupt. When this field is 1 along with DMA_CH0_Interrupt_Enable[NIE], it enables the transmit interrupt. When this field becomes 0, it disables the transmit interrupt. 0b - Disable 1b - Enable

78.17.275 DMA Channel 1 Rx Interrupt Watchdog Timer (DMA_CH1_Rx_Interrupt_Watchdog_Timer)

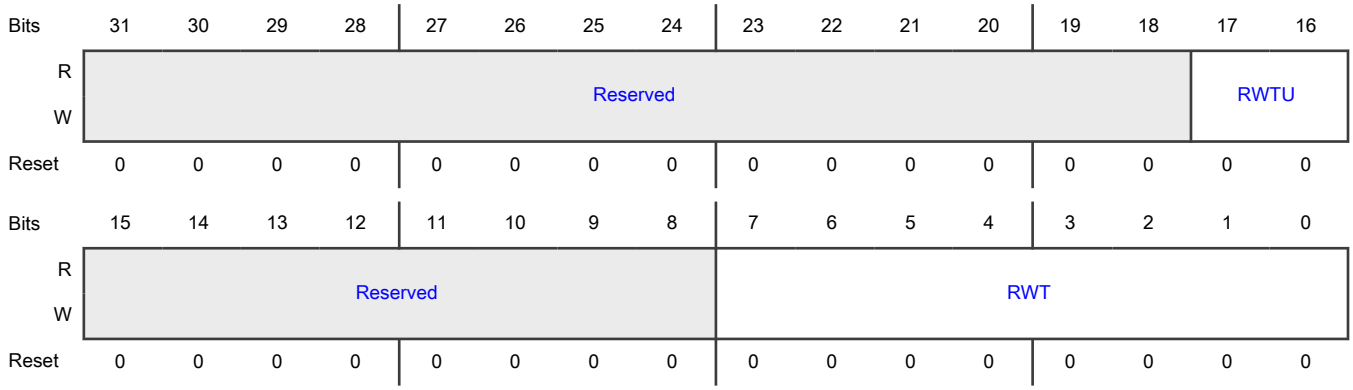
Offset

Register	Offset
DMA_CH1_Rx_Interrupt_Watchdog_Timer	11B8h

Function

Indicates the watchdog timeout for receive interrupt (RI) from DMA. When you write this register with a non-zero value, it enables the watchdog timer for the RI bit of the DMA_CHi_Status register.

Diagram



Fields

Field	Function
31-18 —	Reserved.
17-16 RWTU	Receive Interrupt Watchdog Timer Count Units Indicates the number of system clock cycles corresponding to one unit in DMA_CH1_Rx_Interrupt_Watchdog_Timer[RWT]. 2'b00 - 256 2'b01 - 512 2'b10 - 1024 2'b11 - 2048 For example, the watchdog timer sets for 2*512=1024 system clock cycles, when DMA_CH1_Rx_Interrupt_Watchdog_Timer[RWT] = 2 and DMA_CH1_Rx_Interrupt_Watchdog_Timer[RWTU] = 1.
15-8 —	Reserved.
7-0 RWT	Receive Interrupt Watchdog Timer Count Indicates the number of system clock cycles, multiplied by factor indicated in DMA_CH1_Rx_Interrupt_Watchdog_Timer[RWTU], for which the watchdog timer sets. The watchdog timer triggers with the programmed value after the receive DMA completes the packet transfer for which the RI bit is not 1 in DMA_CH(#i)_Status register, because of the setting of interrupt enable bit in the corresponding descriptor RDES3[30]. RI bit is 1 and the timer stops when the watchdog timer runs out. The watchdog timer becomes 0 when RI bit is 1 because RI sets automatically per the interrupt enable bit RDES3[30] of any received packet.

78.17.276 DMA Channel 1 Slot Function Control Status (DMA_CH1_Slot_Function_Control_Status)

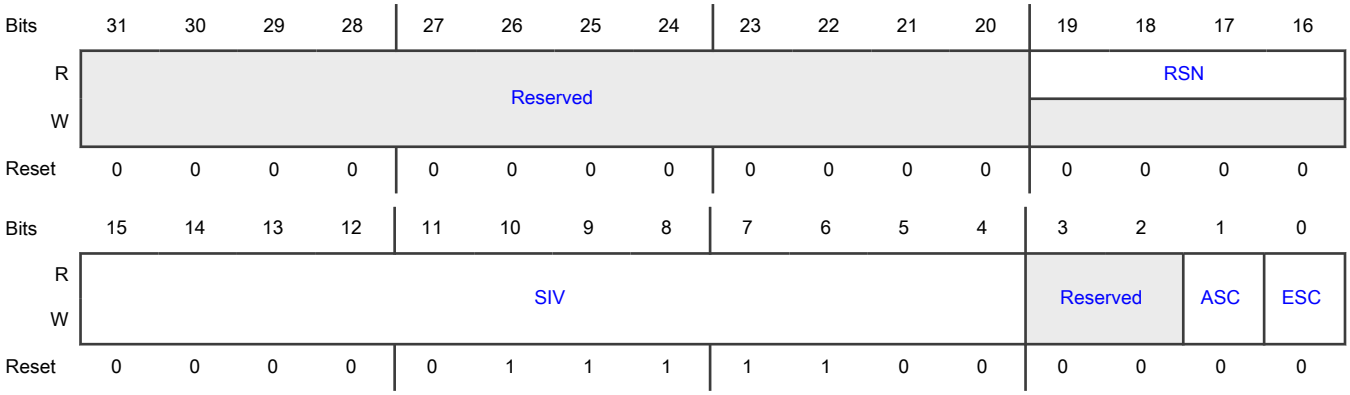
Offset

Register	Offset
DMA_CH1_Slot_Function_Control_Status	11BCh

Function

Contains the control field for slot function and the status for transmit path.

Diagram



Fields

Field	Function
31-20 —	Reserved.
19-16 RSN	Reference Slot Number Provides the current value of the reference slot number in DMA. It is used for slot comparison.
15-4 SIV	Slot Interval Value Controls the period of the slot interval in which the TxDMA fetches the scheduled packets. A value of 0 specifies the slot interval of 1 us while the maximum value 4095 specifies the slot interval of 4096 us. The default or reset value is 0x07C which corresponds to slot interval of 125 us.
3-2 —	Reserved.
1 ASC	Advance Slot Check Indicates whether an advance slot check is enabled. When this field is 1, it enables DMA to fetch the data from the buffer when the slot number (SLOTNUM) programmed in the transmit descriptor is:

Table continues on the next page...

Table continued from the previous page...

Field	Function
	• Equal to the reference slot number given in DMA_CH1_Slot_Function_Control_Status[RSN], or • Ahead of the reference slot number by up to two slots. This field is applicable only when DMA_CH1_Slot_Function_Control_Status[ESC] = 1. 0b - Disabled 1b - Enabled
0 ESC	Enable Slot Comparison Enables slot comparison. When this field is 1, it enables the checking of the slot numbers programmed in the transmit descriptor with the current reference given in DMA_CH1_Slot_Function_Control_Status[RSN]. DMA fetches the data from the corresponding buffer only when the slot number is: • Equal to the reference slot number, or • Ahead of the reference slot number by one slot. When this field becomes 0, it disables the checking of the slot numbers. DMA fetches the data immediately after you process the descriptor. **NOTE** You must not enable the UFO (UDP Fragmentation over IPv4)/TSO/USO along with TBS/AVB slot number check. The UFO/TSO/USO involves multiple packets or segments or fragments transmission for single packet received from application and the slot number check are applicable for fetching only first segment/fragment. As a result it might be difficult for you to specify slot number for subsequent packets. 0b - Disable 1b - Enable

78.17.277 DMA Channel 1 Current Application Transmit Descriptor (DMA_CH1_Current_App_TxDesc)

Offset

Register	Offset
DMA_CH1_Current_App_TxDesc	11C4h

Function
Specifies the current transmit descriptor which DMA reads.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CURTDESAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CURTDESAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CURTDESAPTR	Application Transmit Descriptor Address Pointer Indicates that DMA updates this pointer during the transmit operation. This pointer is 0 on reset.

78.17.278 DMA Channel 1 Current Application Receive Descriptor (DMA_CH1_Current_App_RxDesc)

Offset

Register	Offset
DMA_CH1_Current_App_RxDesc	11CCh

Function

Specifies the current receive descriptor which DMA reads.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CURRDESAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CURRDESAPTR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CURRDESAPTR	Application Receive Descriptor Address Pointer Indicates that DMA updates this pointer during the receive operation. This pointer is 0 on reset.

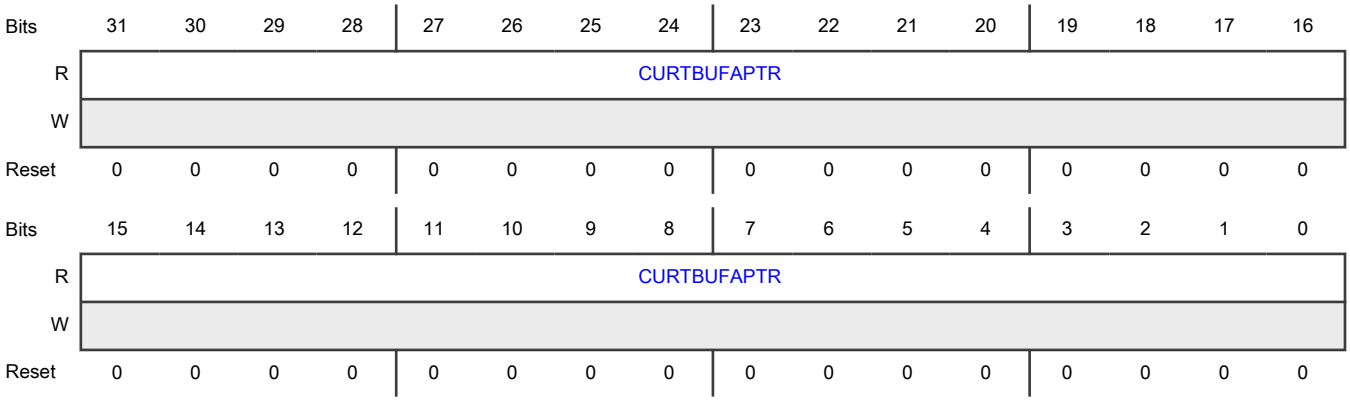
78.17.279 DMA Channel 1 Current Application Transmit Buffer (DMA_CH1_Current_App_TxBuffer)

Offset

Register	Offset
DMA_CH1_Current_App_TxBuffer	11D4h

Function
Specifies the current transmit buffer address which DMA reads.

Diagram



Fields

Field	Function
31-0 CURTBUFAPTR	Application Transmit Buffer Address Pointer Indicates that DMA updates this pointer during the transmit operation. This pointer is 0 on reset.

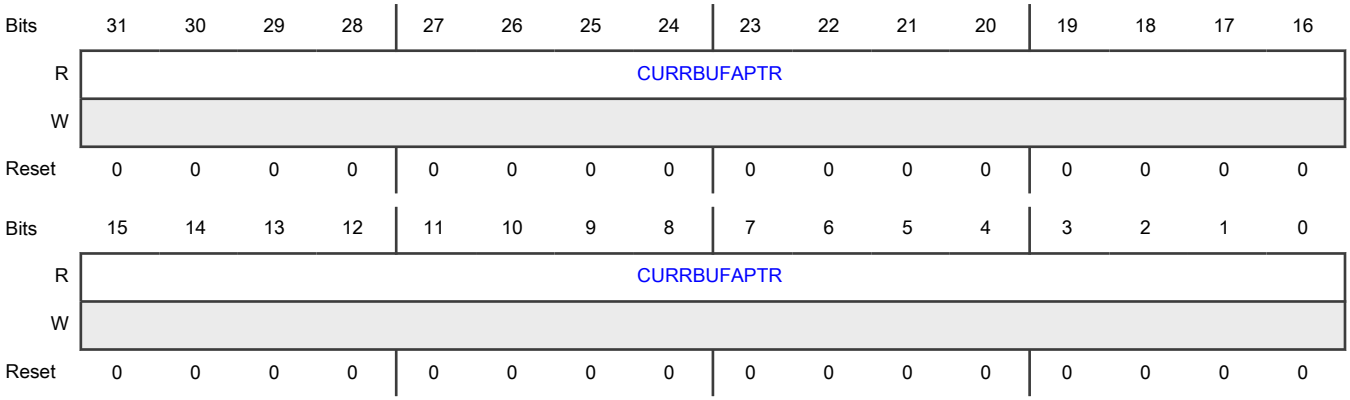
78.17.280 DMA Channel 1 Current Application Receive Buffer (DMA_CH1_Current_App_RxBuffer)

Offset

Register	Offset
DMA_CH1_Current_App_RxBuffer	11DCh

Function
Indicates that DMA_CH0_Current_App_RxBuffer points to the current receive buffer address which the DMA reads.

Diagram



Fields

Field	Function
31-0 CURRBUFAPTR	Application Receive Buffer Address Pointer Indicates that DMA update this pointer during the receive operation. This pointer is 0 on reset.

78.17.281 DMA Channel 1 Status (DMA_CH1_Status)

Offset

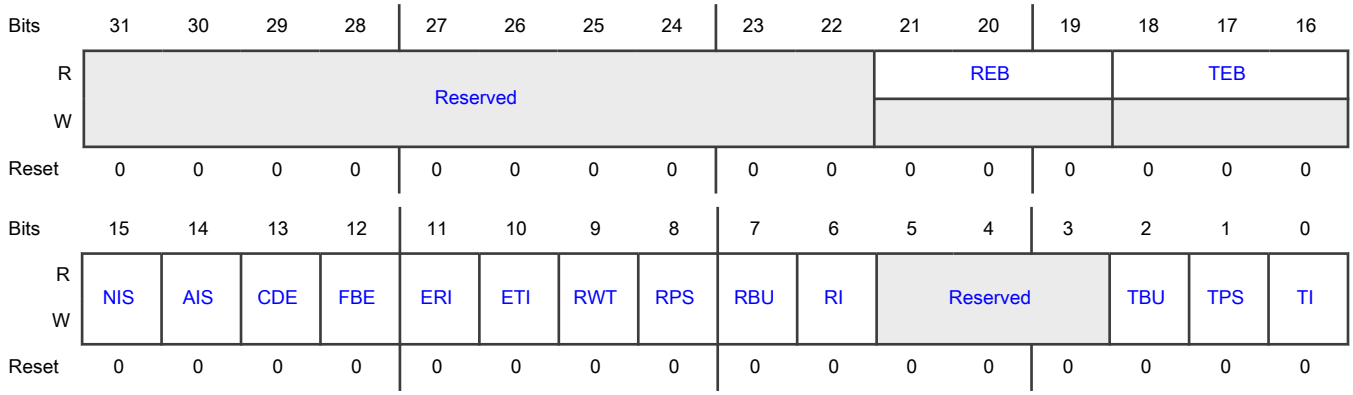
Register	Offset
DMA_CH1_Status	11E0h

Function
Indicates that to determine the status of DMA, the application reads the status register during an interrupt service routine or polling.

NOTE

The number of DMA_CH(#i)_Status register in the configuration is the higher of number of receive DMA Channels and transmit DMA Channels.

Diagram



Fields

Field	Function
31-22 —	Reserved.
21-19 REB	Rx DMA Error Bits Indicates the type of error that causes a bus error. For example, an error response on the AHB or AXI interface. Bit 21 1'b1 - Error during data transfer by Rx DMA 1'b0 - No Error during data transfer by Rx DMA Bit 20 1'b1 - Error during descriptor access 1'b0 - Error during data buffer access Bit 19 1'b1 - Error during read transfer 1'b0 - Error during write transfer This field is valid only when DMA_CH1_Status[FBE] = 1. It does not generate an interrupt.
18-16 TEB	Tx DMA Error Bits Indicates the type of error that causes a bus error. For example, error response on the AHB or AXI interface. Bit 18 1'b1 - Error during data transfer by Tx DMA 1'b0 - No Error during data transfer by Tx DMA Bit 17 1'b1 - Error during descriptor access

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1'b0 - Error during data buffer access Bit 16 1'b1 - Error during read transfer 1'b0 - Error during write transfer This field is valid only when DMA_CH1_Status[FBE] = 1. It does not generate an interrupt.
15 NIS	Normal Interrupt Summary Indicates whether the normal interrupt summary status is detected. The field value is the logical OR of the following bits when the corresponding interrupt bits enable in DMA_CH0_Interrupt_Enable: Bit 0 - Transmit interrupt Bit 2 - Transmit buffer unavailable Bit 6 - Receive interrupt Bit 11 - Early receive interrupt Only unmasked bits (interrupts for which interrupt enable sets in DMA_CH0_Interrupt_Enable) affect this field. This is a sticky field. You must clear this field (by writing 1 to this field) each time a corresponding bit which sets it, clears. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
14 AIS	Abnormal Interrupt Summary Indicates whether an abnormal interrupt summary status is detected. The field value is the logical OR of the following bits when the corresponding interrupt bits enable in DMA_CH0_Interrupt_Enable: Bit 1 - Transmit process stopped Bit 7 - Receive buffer unavailable Bit 8 - Receive process stopped Bit 10 - Early transmit interrupt Bit 12 - Fatal bus error Bit 13 - Context descriptor error Only unmasked bits affect this field. This is a sticky bit. You must clear this field (by writing 1 to this bit) each time a corresponding bit, which sets it, clears.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
13 CDE	Context Descriptor Error Indicates whether the context descriptor error status is detected. This field indicates that the DMA Tx/Rx engine receive a descriptor error, which indicates an invalid context in the middle of packet flow (intermediate descriptor) or all one's descriptor in transmit case and on receive side. It indicates that DMA has read a descriptor with either of the buffer address as ones which you can consider invalid. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
12 FBE	Fatal Bus Error Indicates whether the fatal bus error status is detected. This field indicates that a bus error has occurred (as described in the EB field). When this field is 1, it indicates that the corresponding DMA channel engine disables all bus accesses. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
11 ERI	Early Receive Interrupt Indicates whether an early receive interrupt status is detected. When this field is 1, it indicates that the RxDMA has completed the packet data transfer to the memory. In configs supporting ERIC, When DMA_CH1_Rx_Control[ERIC] = 0, this field is 1 only after the Rx DMA fills a complete receive buffer with packet data. When DMA_CH1_Rx_Control[ERIC] = 1, this field is 1 after every burst data transfer from the receive DMA to the buffer. If DMA_CH1_Status[RI] = 1, this field clears automatically. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
10 ETI	Early Transmit Interrupt Indicates whether an early transmit interrupt status is detected.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	When this field is 1, it indicates that the TxDMA has completed the packet data transfer to the MTL TXFIFO memory. In configs supporting ERIC: When DMA_CH1_Tx_Control[ETIC] = 0, this field is 1 only after the Tx DMA transfers a complete packet to MTL. When DMA_CH1_Tx_Control[ETIC] = 1, this field is 1 after the packet data transfer completes (partial) from buffers in the Transmit descriptor in which IOC=1. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
9 RWT	Receive Watchdog Timeout Indicates whether a receive watchdog timeout status is detected. This field asserts when it receives a packet with length greater than 2,048 bytes (10,240 bytes when Jumbo Packet mode is enabled). 0b - Not detected 1b - Detected
8 RPS	Receive Process Stopped Indicates whether a receive process stopped status is detected. This field asserts when the receive process enters the stopped state. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
7 RBU	Receive Buffer Unavailable Indicates whether a receive buffer unavailable status is detected. This field indicates that the application owns the next descriptor in the receive list, and the DMA cannot acquire it. The receive process is suspended. To resume processing receive descriptors, the application must change the ownership of the descriptor and issue a receive poll demand command. If this command is not issued, the receive process resumes when you receives the next recognized incoming packet. In Ring mode, the application must advance the receive descriptor tail pointer register of a channel. This field is 1 only when the DMA owns the previous receive descriptor. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
6 RI	Receive Interrupt Indicates whether the receive interrupt status is detected.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field indicates that the packet reception is complete. Bit 31 of RDES3 resets in the last descriptor, and updates the specific packet status information in the descriptor, when the packet reception is complete. The reception remains in the running state. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
5-3 —	Reserved.
2 TBU	Transmit Buffer Unavailable Indicates whether the transmit buffer unavailable status is detected. This field indicates that the application owns the next descriptor in the transmit list, and the DMA cannot acquire it. Transmission is suspended. DMA_Debug_Status0[TPS0] explains the transmit process state transitions. The application must perform these actions, to resume the processing of transmit descriptors: 1. Write 1 to bit 31 of TDES3 to change the ownership of the descriptor. 2. Issue a transmit poll demand command. For Ring mode, the application must advance the transmit descriptor tail pointer register of a channel. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
1 TPS	Transmit Process Stopped Indicates that the transmit process stopped status is detected. This field is 1 when the transmission stops. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect. 0b - Not detected 1b - Detected
0 TI	Transmit Interrupt Indicates whether the transmit interrupt status is detected. This field indicates that the packet transmission is complete. When transmission completes, bit 31 of TDES3 resets in the last descriptor, and the specific packet status information is updated in the descriptor. Access restriction apply to this field. Automatically becomes 1 on an internal event occurrence. Writing 1 clears this field and writing 0 has no effect.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not detected 1b - Detected

78.17.282 DMA Channel 1 Miss Frame Counter (DMA_CH1_Miss_Frame_Cnt)

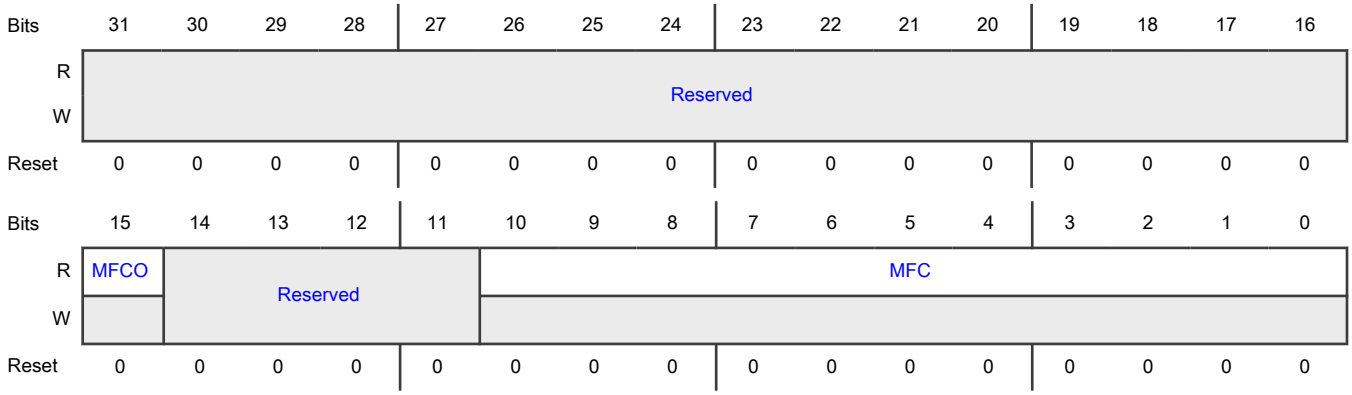
Offset

Register	Offset
DMA_CH1_Miss_Frame_Cnt	11E4h

Function

Provides the number of packet counter that the DMA drops either because of bus error or programming RPF field in DMA_CH${i}_Rx_Control register.

Diagram



Fields

Field	Function
31-16 —	Reserved.
15 MFCO	Overflow status of the MFC Counter Indicates whether the miss frame counter overflow has occurred. When this field is 1, it indicates that the MFC counter does not increments further. This field becomes 0 when this register is read. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not occurred 1b - Occurred
14-11 —	Reserved.
10-0 MFC	Dropped Packet Counters Indicates the number of packet counters that DMA drops either because of bus error or programing RPF field in DMA_CH${i}_Rx_Control register. This counter is 0 when this register is read. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence.

78.17.283 DMA Channel 1 Rx Parser Accept Count (DMA_CH1_RXP_Accept_Cnt)

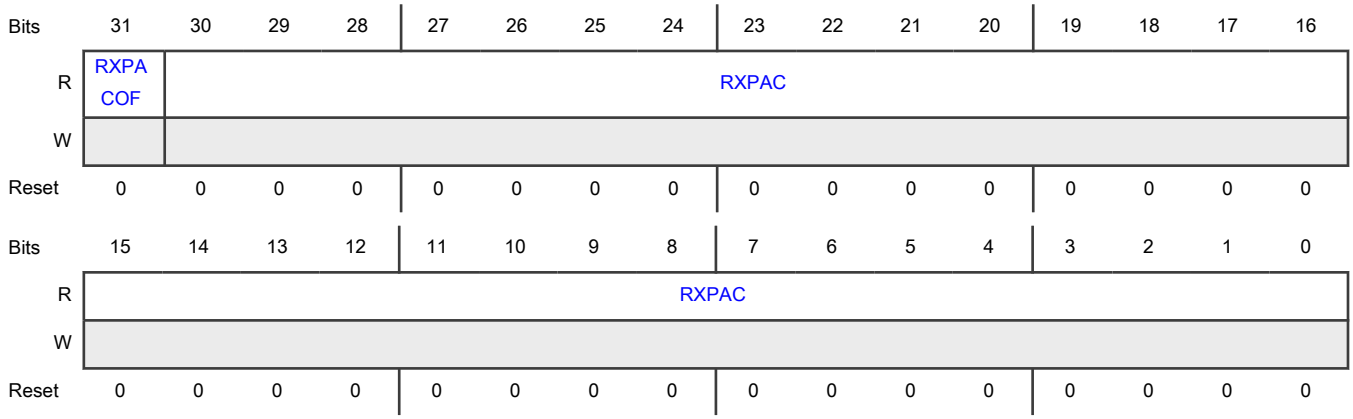
Offset

Register	Offset
DMA_CH1_RXP_Accept_Cnt	11E8h

Function

Provides the count of the number of frames which the receive parser accepts.

Diagram



Fields

Field	Function
31	Rx Parser Accept Counter Overflow Bit

Table continues on the next page...

Table continued from the previous page...

Field	Function
RXPACOF	Indicates whether the receive parser accept counter overflow have occurred. When this field is 1, it indicates that the DMA_CH1_RXP_Accept_Cnt[RXPAC] has crossed the maximum limit. Access restriction apply to this field. It clears on read and automatically becomes 1 on an internal event occurrence. 0b - Not occurred 1b - Occurred
30-0 RXPAC	Rx Parser Accept Counter Implements whenever a receive parser accept a packet because AF = 1. The counter clears when the register is read.

78.17.284 DMA Channel 1 Rx ERI Count (DMA_CH1_RX_ERI_Cnt)

Offset

Register	Offset
DMA_CH1_RX_ERI_Cnt	11ECh

Function

Provides the count of the number of times ERI asserts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved				ECNT											
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-12	Reserved.

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
11-0 ECNT	ERI Counter ERI Counter When ERIC bit of DMA_CH(#i)_RX_Control register is 1, it indicates that this counter increments for burst transfer which the Rx DMA completes from the start of packet transfer. This counter resets at the start of new packet.

78.18 Glossary

AFM Address filtering module

ARI Application receive interface

ATI Application transmit interface

AVB Audio video bridging

AXI Advanced extensible interface

BTR Base time register

CPT Current presentation time

CRC Cyclic redundancy check

DA Destination address

DCB Data center bridging

DUT Device under test

EOP End of packet

FCS A 32-bit cyclic redundancy check used to detect an in-transit corruption of data. Also marks the end of an Ethernet frame.

FIFO First in first out

GCL Gate control list

GMII Gigabit media independent interface

MAC Media access controller

MCI MAC control interface

MDC Management data clock

MDIO Management data input/output

MII Media independent interface

MRI MAC receive interface

MTI MAC transmit interface

MTL MAC transmit layer

PBL Programmable burst length

PHY	The physical interface transceiver that implements the OSI physical layer for an ethernet network. The IEEE 802.3 standard defines it.
RGMII	Reduced gigabit media independent interface
RMII	Reduced media independent interface
RMON	Remote network monitoring
SA	Source address
SFD	Start frame delimiter
SGMII	Serial gigabit media independent interface
SMA	Station management agent
TCP	Transmission control protocol
UDP	User datagram protocol
VLAN	Virtual local area network

Chapter 79
Low Power Universal Asynchronous Receiver/ Transmitter (LPUART)

79.1 Chip-specific LPUART information

79.1.1 LPUART instances and configuration

The following are the LPUART instances

- LPUART_0
- LPUART_1
- LPUART_2
- LPUART_3
- LPUART_MSC

NOTE

MODBUS is supported for only LPUART0/1.

NOTE

CTS/RTS hardware triggering is supported for only LPUART0/1/2.

NOTE

LPUART MSC instance supports only receiving of data and not transmission of data.

Table 678. LPUART Configuration

Feature	Configuration
S32K396	
TX FIFO size	16 Words (for instance 0,1) 4 Words (for instance 2,3, LPUART_MSC)
RX FIFO size	16 Words (for instance 0,1) 4 Words (for instance 2,3, LPUART_MSC)
Functionality supported	Standard LPUART functionality with MODEM/IrDA and MODBUS support.
	LIN master and slave operation

NOTE

LPUART instances are not available during Standby.

79.2 Overview

LPUART provides asynchronous, serial communication capabilities with external devices. It supports the non-return-to-zero (NRZ) encoding format and infrared data association (IrDA)-compatible, low-speed serial infrared (SIR) protocol. LPUART can continue operating when the processor is in Low-Power mode, if an appropriate peripheral clock is available.

79.2.1 Block diagram

Figure 592 shows the transmitter portion of LPUART.

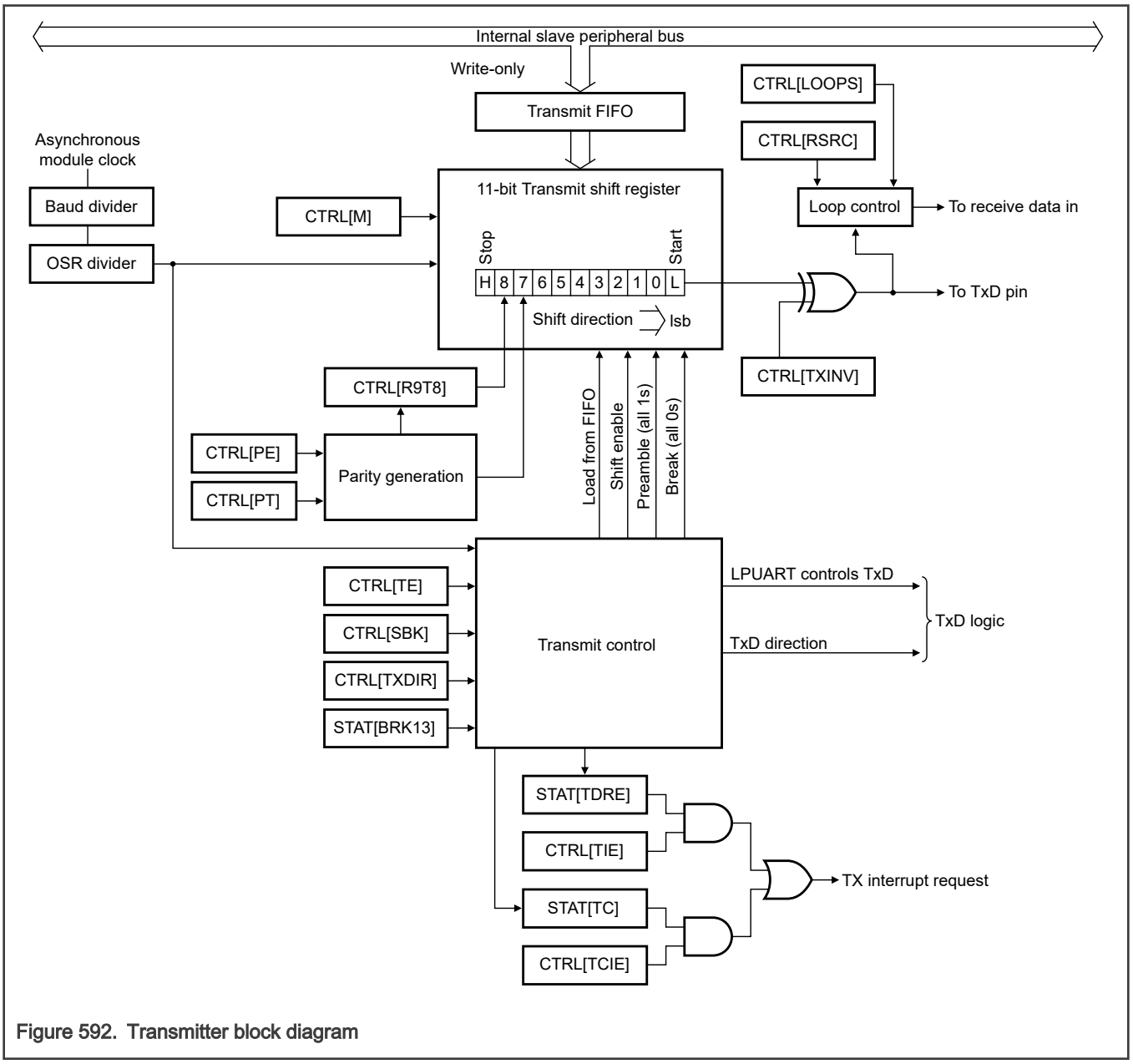


Figure 592. Transmitter block diagram

Figure 593 shows the receiver portion of LPUART.

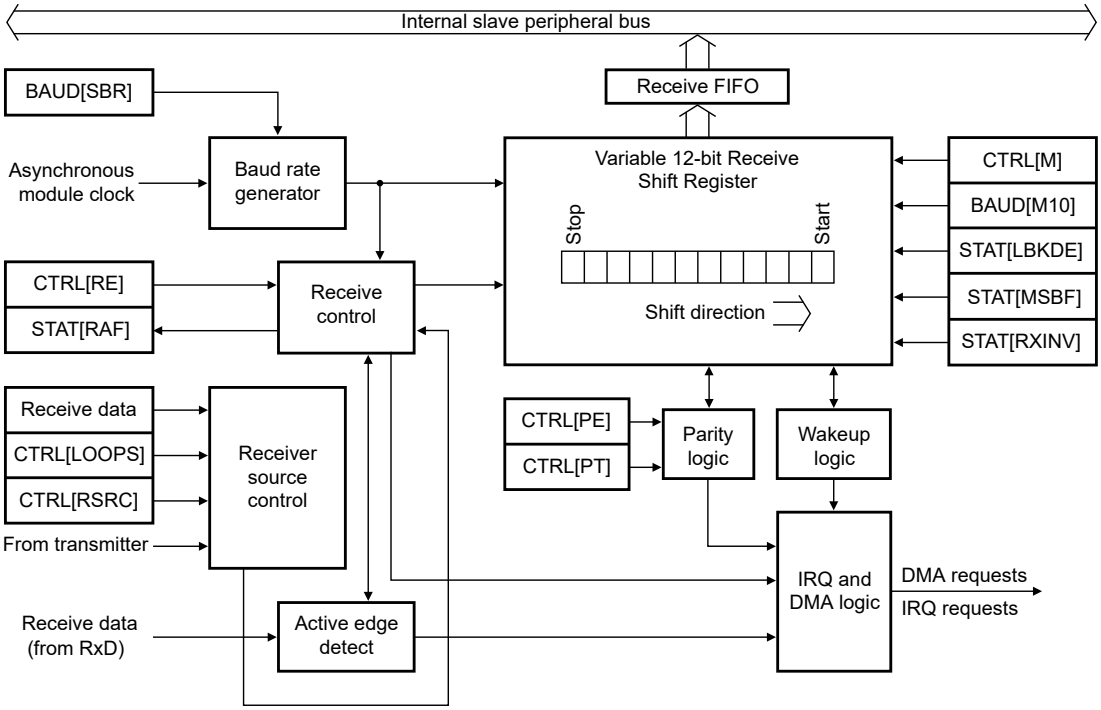


Figure 593. Receiver block diagram

79.2.2 Features

- Full-duplex, standard NRZ format
- Programmable baud rates (13-bit modulo divider) with a configurable oversampling ratio (OSR) from 4× to 32×
- Asynchronous operation of transmit and receive baud rates with respect to the bus clock:
  - Baud rate can be configured independently of the bus clock frequency.
  - Operation in Low-Power modes is supported.
- Interrupt, DMA, or polled operations:
  - Transmit data empty and transmission complete
  - Receive data full
  - Receive overrun, parity error, framing error, and noise error
  - Idle receiver detect
  - Active edge on receive pin
  - Break detect supporting LIN
  - Receive data match
- Hardware parity generation and checking
- Programmable 7-bit, 8-bit, 9-bit, or 10-bit character length
- Programmable 1-bit or 2-bit stop bits
- Support for three receiver wake-up methods:
  - Idle line wake-up

  - Address mark wake-up
  - Receive data match
- Automatic address matching to reduce ISR overhead:
  - Address mark matching
  - Idle line address matching
  - Address match start, address match end
- Optional 13-bit and 11-bit break character generation
- Configurable idle length detection supporting 1, 2, 4, 8, 16, 32, 64, or 128 idle characters
- Selectable transmitter output and receiver input polarity
- Hardware flow control support for request to send (RTS) and clear to send (CTS) signals
- Selectable IrDA 1.4 return-to-zero-inverted (RZI) format with a programmable pulse width
- Independent FIFO structure for transmit and receive functions:
  - Separate configurable watermarks for receive and transmit requests
  - Option for receiver to assert request after a configurable number of idle characters, if receive FIFO is not empty

79.3 Functional description

LPUART supports full-duplex, asynchronous, NRZ serial communication and comprises a baud rate generator, transmitter, and receiver block. The transmitter and receiver operate independently, although they use the same baud rate generator. The following sections describe all LPUART blocks.

79.3.1 Baud rate generation

A 13-bit modulus counter in the baud rate generator derives the baud rate for both the receiver and transmitter. The value, ranging from 1 to 8191, written to BAUD[SBR] determines the baud clock divisor for the asynchronous LPUART baud clock. The baud rate clock drives the receiver, while a bit clock, generated from the baud rate clock divided by the OSR, drives the transmitter. Depending on the OSR, the receiver has an acquisition rate of 4 to 32 samples per bit time.

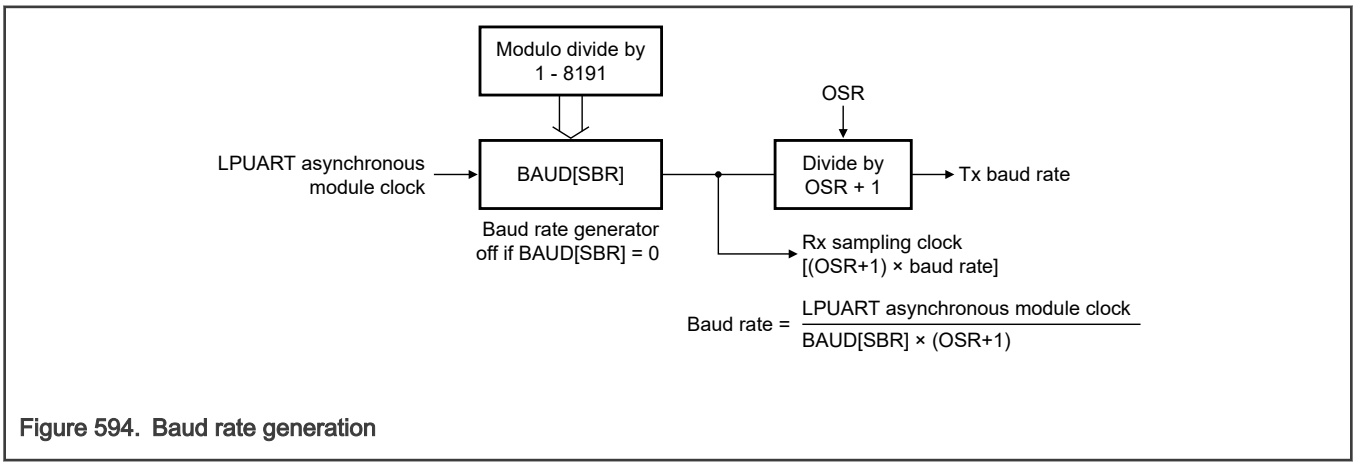


Figure 594. Baud rate generation

Baud rate generation is subject to these sources of error:

- Integer division of the asynchronous LPUART baud clock may not give the exact target frequency.
- Synchronization with the asynchronous LPUART baud clock can lead to a phase shift.

Baud rate generation is a free-running counter that continues whenever the transmitter or receiver is enabled. The transmitter bit clock continues whenever the transmitter is enabled; each transmitted character aligns to the next edge of the transmit bit clock.

In general, configuring OSR for a higher ratio and/or sampling on both edges of the clock slightly improves LPUART's tolerance to baud rate mismatch between the received data and LPUART configured baud rate. However, the three data samples in each bit (see Data sampling technique) are also closer together, which may impact noise sensitivity.

79.3.2 Baud rate tolerance

A transmitting device may operate at a baud rate below or above that of the receiver.

Accumulated bit time misalignment can cause one of the three stop bit data samples to fall outside the actual stop bit. A noise error will occur if the three samples are not all the same logical values. A framing error will occur if the receiver clock is misaligned in such a way that the majority of the three stop bit samples are a logic zero.

As the receiver samples an incoming frame, it may re-synchronize the oversampling clock on any valid falling edge within the frame. Resynchronization within frames will correct a misalignment between transmitter bit times and receiver bit times.

In general, increasing the number of samples per bit will increase the baud rate tolerance and decreasing the number of samples per bit will reduce the baud rate tolerance. Note that since LPUART implements triple voting on consecutive receive data samples, increasing the number of samples per bit will move those samples closer together which would reduce the width of noise that can be filtered by the triple voting logic.

79.3.3 Calculating baud rate tolerance

Using the following definitions:

- SAM is the number of sample points per bit (valid range from 8 to 32; equal to (OSR + 1) × (BOTHEDGE + 1)).
- BIT is the number of bits in a character including start, data and stop bits (valid range from 9 to 13).

The ideal baud rate tolerance can be calculated as follows:

- Slow data rate tolerance = ((SAM ÷ 2) - 1) ÷ ((SAM × BIT) - (SAM ÷ 2) + 2)
- Fast data rate tolerance = ((SAM ÷ 2) - 2) ÷ (SAM × BIT)

As an example, if configured for 8-bit data, 1 stop bit (BIT = 10) and with OSR=0x7 and BOTHEDGE = 1 (SAM = 16):

- Slow data rate tolerance = (8 - 1) ÷ (160 - 8 + 2) = 7 ÷ 154 = 4.54%
- Fast data rate tolerance = (8 - 2) ÷ 160 = 6 ÷ 160 = 3.75%

If configured for 9-bit data with 1 stop bit (BIT = 11) with same oversampling configuration, then:

- Slow data rate tolerance = (8 - 1) ÷ (176 - 8 + 2) = 7 ÷ 170 = 4.12%
- Fast data rate tolerance = (8 - 2) ÷ 176 = 6 ÷ 176 = 3.41%

NOTE

Additional factors can contribute to a lower baud rate tolerance than the ideal. These include clock uncertainty or jitter on the LPUART functional clock source, differences in rise and fall times on the transmitter output and synchronization of the external receive pin to the local LPUART functional clock.

79.3.4 Transmitter functional description

This section describes the functioning of the LPUART transmitter, as shown in the transmitter portion of Block diagram, as well as specialized functions for sending break and idle characters.

The transmitter output (TXD) idle state defaults to logic high; the transmitter output is inverted when you write 1 to CTRL[TXINV], which becomes 0 following reset. You can enable the transmitter by writing 1 to CTRL[TE]. This queues a preamble character that is one full character frame of the Idle state. The transmitter then remains idle until data is available in the transmit FIFO and programs store data in the transmit FIFO by writing to Data (DATA).

The central element of the LPUART transmitter is the transmit shift register that is 9-bit to 13-bit long depending on the settings of CTRL[M], CTRL[M7], BAUD[M10], and BAUD[SBNS]. Going forward in this discussion, assume that CTRL[M], CTRL[M7], BAUD[M10], and BAUD[SBNS] are 0, selecting the normal 8-bit Data mode, in which the shift register holds a start bit, eight data

bits, and a stop bit. When the transmit shift register is available for a new character, the value waiting in transmit FIFO is transferred to the transmit shift register, synchronized with the baud rate clock, and STAT[TDRE] becomes 1 to indicate that another character may be written to the transmit FIFO at Data (DATA).

If no new character is waiting in the transmit FIFO after a stop bit is shifted out of the TXD pin, the transmitter sets the transmit complete flag and enters an idle mode, with TXD high, waiting for more characters to transmit.

Writing 0 to CTRL[TE] does not immediately disable the transmitter. The current transmit activity in progress must first be completed (that could include a data character, idle character, or break character), although the transmitter does not start transmitting another character.

79.3.4.1 Break character length

CTRL[SBK] sends break characters, originally used to gain the attention of old teletype receivers. Break characters are a full character time of logic 0, 9-bit to 12-bit times, including the start and stop bits. You can enable a longer break of 13-bit times by writing 1 to STAT[BRK13]. Normally, a program waits for STAT[TDRE] to become 1 to indicate that the last character of a message has moved to the transmit shifter. Next, the program writes 1 and then writes 0 to CTRL[SBK]. This action queues a break character to be sent as soon as the shifter is available. If CTRL[SBK] remains 1 when the queued break moves into the shifter, synchronized with the baud rate clock, an additional break character is queued. When LPUART is the receiving module, it receives a break character as 0s in all data bits and a framing error (STAT[FE] = 1) is detected.

You can also transmit a break character by writing to Data (DATA) with DATA[FRETSC] = 1 and the data bits clear. This supports transmitting the break character as part of the normal data stream and also allows DMA to transmit a break character.

When idle line wake-up is used, a full character time of idle (logic 1) is needed between messages to wake up any sleeping receivers. Normally, a program waits for STAT[TDRE] to become 1 to indicate that the last character of a message has moved to the transmit shifter. Next, write 0 and then write 1 to CTRL[TE]. This action queues an idle character to be sent as soon as the shifter is available. As long as the character in the shifter does not finish while CTRL[TE] becomes 0, the LPUART transmitter does not release control of the TXD pin.

You can also write to Data (DATA) to transmit an idle character, with DATA[FRETSC] and DATA[R9T9] = 1 and the values of all the other fields = 0. This supports transmitting the idle character as part of the normal data stream and also allows DMA to transmit an idle character.

As shown in the following table, STAT[BRK13], CTRL[M], CTRL[M7], BAUD[M10], and BAUD[SBNS] affect the length of the break character.

Table 679. Break character length

STAT[BRK13]	CTRL[M]	BAUD[M10]	CTRL[M7]	BAUD[SBNS]	Break character length (in bit times)
0	0	0	0	0	10
0	0	0	0	1	11
0	0	0	1	0	9
0	0	0	1	1	10
0	1	0	—	0	11
0	1	0	—	1	12
0	—	1	—	0	12
0	—	1	—	1	13
1	0	0	0	0	13
1	0	0	0	1	13
1	0	0	1	0	12

Table continues on the next page...

Table 679. Break character length (continued)

STAT[BRK13]	CTRL[M]	BAUD[M10]	CTRL[M7]	BAUD[SBNS]	Break character length (in bit times)
1	0	0	1	1	12
1	1	0	—	0	14
1	1	0	—	1	14
1	—	1	—	0	15
1	—	1	—	1	15

79.3.4.2 Hardware flow control

The transmitter supports hardware flow control by gating the transmission with the value of CTS_B. If the CTS operation is enabled, the character is transmitted when CTS_B is asserted. If CTS_B is deasserted in the middle of a transmission with characters remaining in the transmitter FIFO, the character in the transmit shift register is complete. Any characters in the FIFO wait for CTS_B to assert again, and TXD remains in the mark state (idle state) until CTS_B is reasserted. The CTS_B pin must assert for longer than one bit period to guarantee that a new transmission is started when the transmitter is idle with CTS.

If the CTS operation is disabled, the transmitter ignores the state of CTS_B.

The transmitter's CTS_B signal can be enabled even if the same LPUART receiver's RTS_B signal is disabled.

79.3.4.3 Transceiver driver enable

The transmitter can use RTS_B as an enable signal for the driver of an external transceiver. See Transceiver driver enable using RTS_B for details. If the RTS operation is enabled, when a character is placed into an empty transmit shift register, RTS_B asserts 1-bit time before the start bit is transmitted. RTS_B remains asserted for the whole time that the transmit shift register has any characters. RTS_B deasserts 1-bit time after all characters in the transmit FIFO and shift register are completely sent, including the last stop bit. In other words, when RTS_B is used as a transceiver enable, RTS_B asserts 1-bit time before the transmitter starts transmitting and negates 1-bit time after the transmitter goes idle.

Transmitting a break character also asserts RTS_B, with the same assertion and deassertion timing as having a character in the transmit shift register.

The transmitter's RTS_B signal asserts only when the transmitter is enabled. However, the transmitter's RTS_B signal is unaffected by its CTS_B signal. RTS_B remains asserted until the transfer is complete, even if the transmitter is disabled mid-way through a data transfer.

You can configure HDCR[RTSEXT] to the desired length by delaying the transmitter's RTS_B negation by up to 256-bit clock (baud rate) after the last stop bit.

79.3.4.4 Transceiver driver enable using RTS_B

RS-485 is a multiple drop communication protocol in which the LPUART transceiver's driver is three-stated unless LPUART is driving. The transmitter can use the RTS_B signal to enable the driver of a transceiver. The polarity of RTS_B can be matched to the polarity of the transceiver's driver enable signal.

The following figure shows the receiver enable signal asserted. This connection can also connect RTS_B to both DE and RE_B. The transceiver's receiver is disabled when driving. A pullup can pull RXD to a nonfloating value during this time. You can refine this option further by operating LPUART in Single-Wire mode, freeing the RXD pin for other uses.

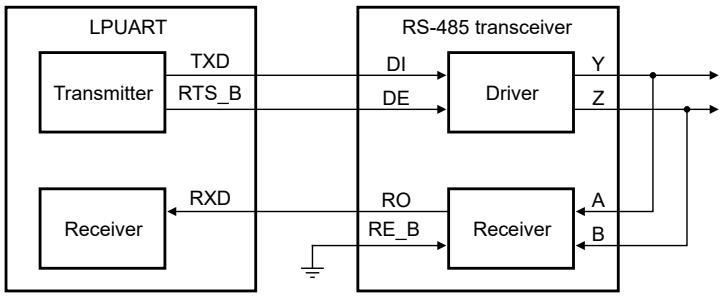


Figure 595. Transceiver driver enable using RTS_B

79.3.5 Receiver functional description

This section discusses the functioning of the LPUART receiver, as shown in the receiver portion of Block diagram. The section also discusses:

- The data sampling technique used to reconstruct receiver data.
- Different variations of the receiver wake-up function.

You can invert the receiver input by writing 1 to STAT[RXINV] and enable the receiver by writing 1 to CTRL[RE]. Character frames consist of a start bit of logic 0, along with N (7, 8, 9, 10) bits (MSB or LSB first), and one or two stop bits of logic 1. For information about 7-bit, 9-bit, or 10-bit Data mode, see Data modes. Going forward in this discussion, assume that LPUART is configured for a normal 8-bit Data mode.

After receiving the stop bit into the receive shifter, and provided the receive data register is not already full (STAT[RDRF] = 0), the data character is transferred to the receive FIFO, resulting in STAT[RDRF] becoming 1. However, if STAT[RDRF] is already 1, indicating that the receive data buffer is already full, STAT[OR] becomes 1 and the new data is lost.

Because the LPUART receiver is separate from the receive FIFO, the receive shift register can receive the next word when the receive FIFO is full, and it is only at the end of the character that the next data is written into the receive FIFO, potentially triggering the overrun flag if the FIFO is full.

When a program detects that the receive data register is full (STAT[RDRF] = 1), it gets the data from the FIFO by reading Data (DATA). See Interrupts for details about flag clearing.

79.3.5.1 Data sampling technique

The LPUART receiver supports a configurable oversampling rate of between 4× and 32× of the baud rate clock for sampling. The receiver starts by considering logic level samples at the oversampling rate times the baud rate to search for a falling edge on the RXD serial data input pin. A falling edge is defined as a logic 0 sample after three consecutive logic 1 samples. The oversampling baud rate clock divides the bit time into 4 to 32 segments from 1 to OSR (where OSR is the configured oversampling ratio). When a falling edge is located, three more samples are taken at (OSR ÷ 2), (OSR ÷ 2) + 1, and (OSR ÷ 2) + 2 to ensure that this is a real start bit and not merely noise. If at least two of these three samples are 0, the receiver assumes they are synchronized to a received character. If another falling edge is detected before the receiver is considered synchronized, the receiver restarts sampling from the first segment.

The receiver then samples each bit time, including the start and stop bits, at (OSR ÷ 2), (OSR ÷ 2) + 1, and (OSR ÷ 2) + 2, to determine the logic level for that bit. The logic level is interpreted to be that of the majority of the samples taken during the bit time. If any sample in any bit time, including the start and stop bits, in a character frame fails to agree with the logic level for that bit, noise flag (STAT[NF]) becomes 1 when the received character is transferred to the receive FIFO.

When the LPUART receiver is configured to sample on both edges of the baud rate clock (that is, when BAUD[BOTHEDGE] = 1), the number of segments in each received bit is effectively doubled (from 1 to OSR× 2). The start and data bits are then sampled at OSR, OSR + 1, and OSR + 2. You must enable sampling on both edges of the clock for oversampling rates of 4× to 7×. This sampling is optional for higher oversampling rates.

The synchronization feature of LPUART synchronizes the internal oversampling counter with a detected falling edge on the receive signal, and to adjust the data sampling window. The falling edge detection needs three consecutive 1s prior to the "1->0" (one to zero) transition. After the initial falling edge detection for the start bit, the circuit continuously monitors the next falling edge, and resets the counter after another falling edge is detected. This synchronization to the start bit is termed as resynchronizarion.

When BAUD[RESYNCDIS] is 0, you perform this falling edge detection and resynchronization not only for the start bit but also for the rest of the character reception after the start bit.

When BAUD[RESYNCDIS] is 1, you perform the falling edge detection and resynchronization only for the start bit. The use case for disabling the resynchronization is protocols that require this (for example, LIN 2.1 prohibits resynchronization within a byte).

The following table and figure explain LPUART resynchronization.

Table 680. LPUART resynchronization settings

Resynchronization	BAUD[RESYNCDIS] = 0	BAUD[RESYNCDIS] = 1
For the starting bit falling edge	Yes	Yes
For all falling edges after the start bit	Yes	No

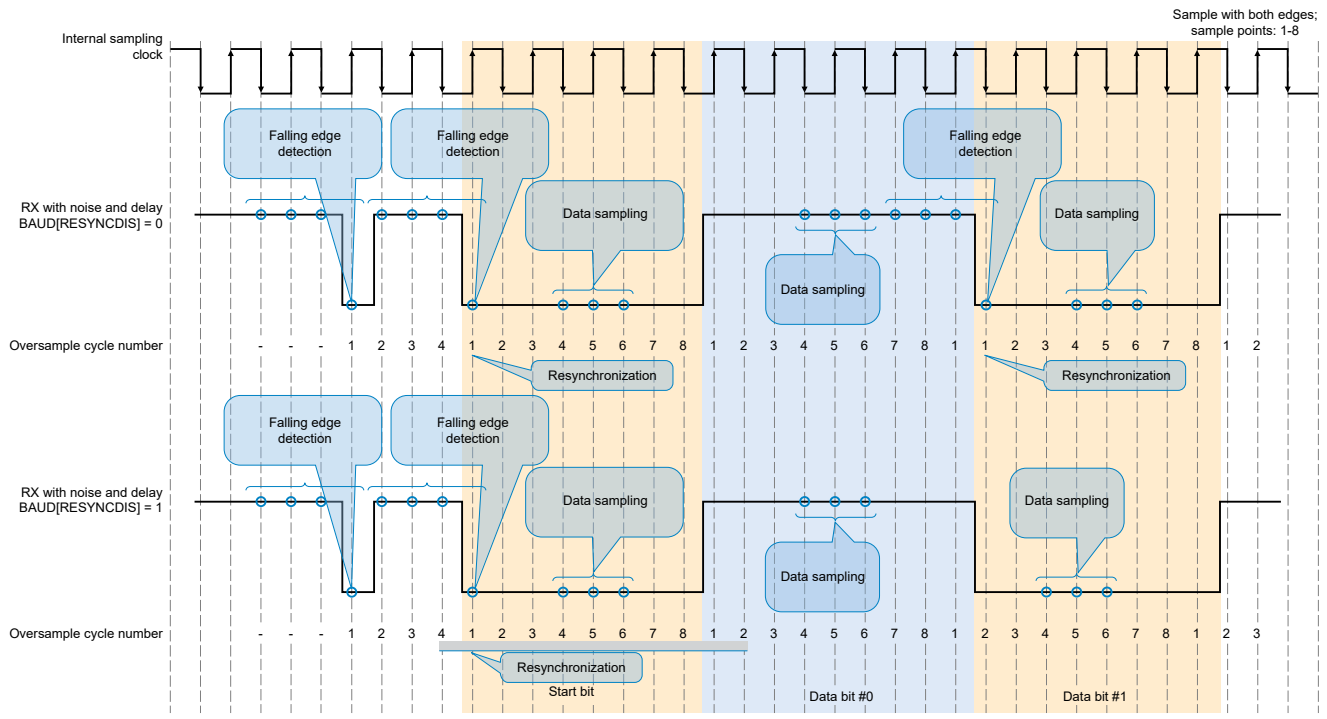


Figure 596. LPUART resynchronization diagram

79.3.5.2 Receiver wake-up operation

Receiver wake-up and receiver address matching are hardware mechanisms that allow an LPUART receiver to ignore the characters in a message intended for a different receiver.

During receiver wake-up, all receivers evaluate the first character(s) of each message, and as soon as they determine the message is intended for a different receiver, they write 1 to CTRL[RWU].

When CTRL[RWU] and STAT[RWUID] are 1, the status fields associated with the receiver, with the exception of STAT[IDLE], are inhibited from becoming 1, thus eliminating the software overhead for handling the unimportant message characters. At the end of a message, all receivers automatically force CTRL[RWU] to become 0. This results in all receivers waking up in time to look at the first character(s) of the next message.

During receiver address matching, the address matching is performed in hardware and the LPUART receiver ignores all characters that do not meet the address match requirements.

Table 681. Receiver wake-up options

CTRL[RWU]	BAUD[MAEN1] | BAUD[MAEN2]	BAUD[MATCFG]	CTRL[WAKE]: STAT[RWUID]	Receiver wake-up
0	0	X	X	Normal operation
1	0	00	00	Receiver wake-up on idle line; STAT[IDLE] = 0
1	0	00	01	Receiver wake-up on idle line; STAT[IDLE] = 1
1	0	00	10	Receiver wake-up on address mark
1	1	11	10	Receiver wake-up on data match
0	1	00	X0	Address mark address match; STAT[IDLE] = 0 for discarded characters
0	1	00	X1	Address mark address match; STAT[IDLE] = 1 for discarded characters
0	1	01	X0	Idle line address match
0	1	10	X0	Match on and match off; STAT[IDLE] = 0 for discarded characters
0	1	10	X1	Match on and match off; STAT[IDLE] = 1 for discarded characters

79.3.5.2.1 Idle line wake-up

When CTRL[WAKE] is 0, you can configure the receiver for an idle line wake-up. In this mode, CTRL[RWU] becomes 0 automatically when the receiver detects a full character time of the idle-line level.

CTRL[M], CTRL[M7], and BAUD[M10] select 7-bit to 10-bit Data mode and BAUD[SBNS] selects a 1-bit or 2-bit stop bit number that determines how many bit times of idle are needed to constitute a full character time, 9 to 13 bit times because of the start and stop bits.

When CTRL[RWU] is 1 and STAT[RWUID] is 0, the idle condition that wakes up the receiver does not lead to STAT[IDLE] becoming 1. The receiver wakes up and waits for the first data character of the next message that leads to STAT[RDRF] becoming 1 and generates an interrupt if enabled. When STAT[RWUID] is 1, any idle condition leads to STAT[IDLE] becoming 1 and generates an interrupt if enabled, regardless of whether CTRL[RWU] is 0 or 1.

These are the ways to detect an idle line:

- When CTRL[ILT] is 0, the idle bit counter starts after the start bit so that the stop bit and any logic 1s at the end of a character count to calculate the full character time of idle.
- When CTRL[ILT] is 1, the idle bit counter does not start until after the stop bit time so that the data in the last character of the previous message does not impact the idle detection.

79.3.5.2.2 Address mark wake-up

When CTRL[WAKE] is 1, you can configure the receiver for an address mark wake-up. In this mode, CTRL[RWU] becomes 0 automatically when the receiver detects a logic 1 in the most significant bit of the received character. When parity is enabled, the second most significant bit is used for address mark wake-up.

Address mark wake-up allows messages to contain idle characters, but requires one bit to be reserved for use in address frames. The logic 1 in the most significant bit (or second most significant bit when parity is enabled) of an address frame writes 0 to CTRL[RWU] and writes 1 to STAT[RDRF]. In this case, the character with the address mark bit is received even if the receiver is sleeping during most of this character time.

79.3.5.2.3 Data match wake-up

When CTRL[RWU] and CTRL[WAKE] are 1, and BAUD[MATCFG] equals 11, the receiver is configured for a data match wake-up. In this mode, CTRL[RWU] becomes 0 automatically when the receiver detects a character that matches MATCH[MA1] when BAUD[MAEN1] is 1, or that matches MATCH[MA2] when BAUD[MAEN2] is 1.

79.3.5.2.4 Address match operation

You can enable the address match operation when either BAUD[MAEN1] or BAUD[MAEN2] is 1 and BAUD[MATCFG] is 0. In this function, a character that the RXD pin receives with a logic 1 in the most significant bit (or the second most significant bit when parity is enabled) is considered an address and is compared to the associated MATCH[MA1] or MATCH[MA2]. The character is only transferred to the receive buffer, and STAT[RDRF] becomes 1 if the comparison matches. All subsequent characters received with a logic 0 in the most significant bit (or the second most significant bit when parity is enabled) are considered to be data associated with the address and are transferred to the receive FIFO. If no marked address match occurs, no transfer is made to the receive FIFO, and all the characters that follow, with logic 0 in the most significant bit (or second most significant bit when parity is enabled), are also discarded. If both BAUD[MAEN1] and BAUD[MAEN2] are 0, the receiver operates normally, and all the received data is transferred to the receive FIFO.

The address match operation functions in the same way for both MATCH[MA1] and MATCH[MA2]:

- If either BAUD[MAEN1] or BAUD[MAEN2] is 1, a marked address is compared only to the associated Match Address (MATCH) and data is transferred to the receive FIFO only on a match.
- If both BAUD[MAEN1] and BAUD[MAEN2] are 1, a marked address is compared to both MATCH[MA1] and MATCH[MA2] and data is transferred only on a match with either of these fields.

79.3.5.2.5 Idle match operation

You can enable the idle match operation when either BAUD[MAEN1] or BAUD[MAEN2] is 1 and BAUD[MATCFG] is 1. In this function, the first character that the RXD pin receives after an idle line condition is considered an address and is compared to the associated MATCH[MA1] or MATCH[MA2]. The character is transferred only to the receive buffer, and STAT[RDRF] becomes 1, if the comparison matches. All subsequent characters are considered to be data associated with the address and are transferred to the receive FIFO until the next idle line condition is detected. If no address match occurs, no transfer is made to the receive FIFO, and all the frames that follow, until the next idle condition, are also discarded. If both BAUD[MAEN1] and BAUD[MAEN2] are 0, the receiver operates normally, and all the received data is transferred to the receive FIFO.

An idle match operation functions in the same way for both MATCH[MA1] and MATCH[MA2]:

- If either BAUD[MAEN1] or BAUD[MAEN2] is 1, the first character after an idle line is compared only to the associated Data (DATA) and data is transferred to the receive FIFO only on a match.

- If both BAUD[MAEN1] and BAUD[MAEN2] are 1, the first character after an idle line is compared to both MATCH[MA1] and MATCH[MA2] and data is transferred only on a match with either of these fields.

79.3.5.2.6 Match on, match off operation

The match on, match off operation is enabled when both BAUD[MAEN1] and BAUD[MAEN2] are 1 and BAUD[MATCFG] = 10. In this function, a character that the RXD pin receives matches MATCH[MA1] and is transferred to the receive buffer, and STAT[RDRF] becomes 1. All subsequent characters are considered to be data and are also transferred to the receive FIFO, until a character that matches MATCH[MA2] is received. The character that matches MATCH[MA2], along with all subsequent characters, is discarded; and this continues until another character that matches MATCH[MA1] is received. If both BAUD[MAEN1] and BAUD[MAEN2] are 0, the receiver operates normally, and all the received data is transferred to the receive FIFO.

NOTE

The match on, match off operation requires both BAUD[MAEN1] and BAUD[MAEN2] to be 1.

79.3.5.3 Hardware flow control

To support hardware flow control, you can program the receiver to automatically assert and deassert RTS_B:

- RTS_B remains asserted until the transfer is complete, even if the transmitter is disabled midway through a data transfer. See Transceiver driver enable using RTS_B for more information.
- If the receiver RTS functionality is enabled, the receiver automatically deasserts RTS_B if STAT[RDRF] is 1 or a start bit is detected that causes STAT[RDRF] to become 1.
- The receiver asserts RTS_B when STAT[RDRF] is 0 and has not detected a start bit that causes STAT[RDRF] to become 1. There is no impact if STAT[RDRF] is 1 already.
- Even if RTS_B is deasserted, the receiver continues to receive characters until the receive FIFO is overrun.
- If the receiver RTS functionality is disabled, the receiver's RTS_B remains deasserted.

79.3.6 Additional LPUART functions

79.3.6.1 Data modes

You can configure the LPUART transmitter and receiver to operate in 7-bit Data mode by writing 1 to CTRL[M7], 9-bit Data mode by writing 1 to CTRL[M], or 10-bit Data mode by writing 1 to BAUD[M10]. In 9-bit Data mode, there exists a ninth data bit and in 10-bit mode, there exists a tenth data bit.

When performing 8-bit writes to the transmit FIFO, the ninth and tenth bits are pushed into the FIFO from CTRL[T8] and CTRL[T9]. For coherent 8-bit writes, you must write to CTRL[T8] and CTRL[T9] before writing to Data (DATA)[7:0]. However, if the values in CTRL[T8] or CTRL[T9] do not need to change, it is not necessary to update CTRL[T8] and CTRL[T9] before every 8-bit write to Data (DATA).

When performing 16-bit or 32-bit writes to the transmit FIFO, all 10 bits are pushed into the transmit FIFO from the write data.

When performing 8-bit reads of the receive FIFO, the ninth and tenth bits are held in CTRL[R8] and CTRL[R9] but you must read them before reading Data (DATA). A 16-bit or 32-bit read of the receive FIFO returns all 10 bits in Data (DATA).

The 9-bit Data mode is typically used with parity to allow eight bits of data plus the parity in the ninth bit, or it is used with the address mark wake-up so that the ninth data bit can serve as the wake-up bit. The 10-bit Data mode is typically used with parity and address mark wake-up so that the ninth data bit can serve as the wake-up bit and the tenth bit can serve as the parity bit. In custom protocols, the ninth and/or tenth bits can also serve as software-controlled markers.

79.3.6.2 Idle length

An idle character is one where the start bit, all data bits, and stop bits are in the mark position (idle state, generally logic 1). You can configure CTRL[ILT] to start detecting an idle character from the previous start bit (any data bits and stop bits count for idle character detection) or from the previous stop bit.

You can also use CTRL[IDLECFG] to configure the number of idle characters that must be received before an idle line condition is detected. This field configures the number of idle characters that must be received before STAT[IDLE] becomes 1, STAT[RAF] becomes 0, and DATA[IDLINE] becomes 1 with the next received character.

CTRL[IDLECFG] also affects the idle line wake-up and idle match operations. When either the address match or match on/off operation is enabled, writing 1 to STAT[RWUID] causes any discarded characters to be treated as idle characters.

After the extended idle time is enabled for the receiver, you can configure an idle line condition by using REIR[IDTIME], which specifies the number of bits (baud rate) since the last stop bit that is required for an idle condition to be detected. This replaces the configuration of CTRL[ILT] and CTRL[IDLECFG].

The transmitter can also enable the extended idle time. In this case, any idle character queued through the transmit FIFO forces the transmitter to be idled for the configured number of bit clocks before the idle character is read from the FIFO and the transmitter continues.

After you enable the transmitter extended idle time, the transmitter does not automatically queue an idle character whenever it is enabled.

79.3.6.3 Loop mode

Enable Loop mode by setting CTRL[LOOPS] = 1 and CTRL[RSRC] = 0. You, sometimes, use Loop mode to check software, independent of connections in the external system, to help isolate system problems. In this mode, the transmitter output is internally connected to the receiver input and LPUART does not use the RXD pin.

Loop mode also internally connects the RTS_B output to the CTS_B input and the DTR_B output to the DSR_B input.

79.3.6.4 Single-Wire mode

Enable Single-Wire mode by setting CTRL[LOOPS] = 1 and CTRL[RSRC] = 1. Single-Wire mode implements a half-duplex serial connection. The receiver is internally connected to the transmitter output and TXD pin (the RXD pin is not used).

In Single-Wire mode, CTRL[TXDIR] controls the direction of serial data on the TXD pin. When CTRL[TXDIR] becomes 0, the TXD pin is an input to the receiver and the transmitter is temporarily disconnected from the TXD pin so that an external device can send serial data to the receiver. When CTRL[TXDIR] = 1, the TXD pin is an output that the transmitter drives. The internal loop back connection is disabled, and as a result, the receiver is unable to receive characters that the transmitter sends out.

Half Duplex Control (HDCR) replaces the implementation of CTRL[LOOPS] and CTRL[RSRC], and you can use this register to configure various options for both Single-Wire and Half-Duplex operations, using independent RXD and TXD pins:

- HDCR[TXSTALL] replaces the CTRL[TXDIR] functionality and prevents the transmitter from becoming busy or asserting the RTS_B transmitter if STAT[RAF] is 1.
- You can select the TXD pin, as the source for the receiver, to configure HDCR[RXSEL] for a single-wire operation. If HDCR[RXSEL] is 1, you must configure the TXD pin for an open-drain operation.
- HDCR[RXMSK] masks the receiver input when the RTS_B transmitter is asserted (this applies even if you have not configured RTS_B as an output).
- HDCR[RXWRMSK] blocks storage of the receive data in the receive FIFO when the RTS_B transmitter is asserted. This setting does not affect the receiver idle functionality.
- HDCR[RTSEXT] delays the negation of the RTS_B transmitter by the configured number of bit clocks (baud rate).

79.3.6.5 Timeout counter

LPUART implements four general-purpose timeout counters; counters 0 and 1 are used to monitor the receiver and counters 2 and 3 are used to monitor the transmitter. When enabled, you can configure each counter to monitor one of the following conditions:

- Idle time in number of bits, starting to increment when first enabled and an idle condition is detected. The counter restarts whenever a character is received or transmitted.
- Idle time in number of bits, starting to increment after the next character is received or transmitted. The counter restarts whenever a character is received or transmitted.

- Idle time is more than the timeout interval, in number of bits, but less than the extended idle timeout. The counter restarts whenever a character is received or transmitted. You can use this to detect a gap between characters that is greater than a threshold (timeout) but less than the configured extended idle time. This configuration requires the extended idle feature for the transmitter or receiver to be enabled for a proper operation.
- Number of characters received or transmitted is equal to the configured timeout. The counter asserts at the start of the character that equals the timeout value.

The timeout counters restart counting whenever the counter is disabled and then enabled. These timeout counters are disabled when the corresponding STAT[TSF] field is 1. If the timeout enable is still set after STAT[TSF] becomes 0, the timeout counter restarts as if the counter had been disabled and then enabled. You can measure the idle time in bit times from the end of the last stop bit and until a start bit is validated.

79.3.7 Peripheral triggers

The connection of the LPUART peripheral triggers with other peripherals is chip-specific.

79.3.7.1 Output triggers

LPUART generates the following output triggers that can be connected to other peripherals on the chip:

- The transmit word trigger asserts at the end of each transmitted word and negates after 1-bit period.
- The transmit data trigger is identical to the TXD pin output, but without support for input trigger modulation.
- The receive word trigger asserts at the end of each received word that is written to the receive FIFO, for one oversampling clock period.
- The receive idle trigger asserts when STAT[IDLE] becomes 1, and negates when the next valid start bit is detected.

79.3.7.2 Input trigger

LPUART supports a peripheral input trigger that you can configure in one of the following ways:

- By enabling the CTS function: You can connect the input trigger instead of the CTS_B pin input. The input trigger must assert for longer than 1-bit clock period when the transmitter is idle, with data to send, to guarantee a new transmission.
- By making the input trigger modulate the transmit data output (trigger is logically ANDed with the TXD output): The input trigger is expected to be a free-running clock (carrier signal) that generates from a timer or PWM source with a frequency that is greater than the bit-clock frequency. The carrier signal must not toggle faster than the maximum supported bit time.
- By connecting the input trigger instead of the RXD pin input: The input trigger is expected to be generated from a receive data source, such as an analog comparator or external pin.

79.3.8 Infrared (IR) interface

LPUART provides the capability of transmitting narrow pulses to an IR LED and receiving narrow pulses, transforming them to serial bits, which are then sent to LPUART. The IrDA physical layer specification defines a half-duplex IR communication link for exchanging data. The full standard includes data rates up to 16 Mbit/s. The LPUART IrDA support is limited to SIR mode that supports data rates only between 2.4 kbit/s and 115.2 kbit/s.

LPUART has an infrared transmit encoder and a receive decoder. The infrared decoder converts the received character from the IrDA format to the NRZ format, which the receiver uses. It also has an OSR oversampling baud rate clock counter that filters noise and indicates when a 1 is received. LPUART transmits serial bits of data, which the infrared submodule encodes, to transmit a narrow pulse for every zero bit. No pulse is transmitted for every single bit. When receiving data, an IR photo diode (external to LPUART) detects the IR pulses. The IR receive decoder transforms them to CMOS levels. The infrared receive decoder then stretches the narrow pulses to get back to a serial bit stream that LPUART receives. You can invert the polarity of transmitted pulses and expected receive pulses so that a direct connection can be made to external IrDA transceiver modules that use active-high pulses.

The IR submodule receives its clock sources from LPUART. The submodule selects one of these clocks to generate either 1 ÷ OSR, 2 ÷ OSR, 3 ÷ OSR, or 4 ÷ OSR narrow pulses during transmission.

79.3.8.1 Infrared transmit encoder

The infrared transmit encoder converts serial bits of data from the transmit shift register to the TXD signal. A narrow pulse is transmitted for a 0 bit and no pulse is transmitted for a 1 bit. The narrow pulse is sent at the start of the bit with a duration of 1 ÷ OSR, 2 ÷ OSR, 3 ÷ OSR, or 4 ÷ OSR of a bit time. A narrow low pulse is transmitted for a 0 bit when CTRL[TXINV] is 0, while a narrow high pulse is transmitted for a 0 bit when CTRL[TXINV] is 1.

79.3.8.2 Infrared receive decoder

The infrared receive block converts data from the RXD signal to the receive shift register. A narrow pulse is expected for each 0 received and no pulse is expected for each 1 received. A narrow low pulse is expected for a 0 bit when STAT[RXINV] is 0, while a narrow high pulse is expected for a 0 bit when STAT[RXINV] is 1. This receive decoder meets the edge jitter requirement as defined by the IrDA serial infrared physical layer specification.

79.3.8.3 Start-bit detection

When STAT[RXINV] is 0, the first falling edge of the received character corresponds to the start bit. The infrared decoder resets its counter. At this time, the receiver also begins its start bit detection process. After the start bit is detected, the receiver synchronizes its bit times to this start bit time. For the rest of the character reception, the infrared decoder's counter and the receiver's bit time counter count independently of each other.

79.3.8.4 Noise filtering

The decoder ignores any rising edges detected during the first half of the infrared decoder counter, and can leave any pulses less than one oversampling baud clock as undetected. This is regardless of whether the pulse is seen in the first or second half of the count.

79.3.8.5 Low-bit detection

During the second half of the decoder count, a rising edge is decoded as 0, which is sent to the receiver. The decoder counter is also reset.

79.3.8.6 High-bit detection

At OSR oversampling baud rate clocks after the previous rising edge, if a rising edge is not seen, the decoder sends a 1 to the receiver.

If the next bit is 0, which arrives late, a low bit is detected according to Low-bit detection. The value sent to the receiver is changed from 1 to 0. Then, if a noise pulse occurs outside the receiver's bit time sampling period, the delay of a 0 is not recorded as noise.

79.3.9 MODBUS protocol

79.3.9.1 MODBUS frame structure

MODBUS is an application layer messaging protocol, positioned at level 7 of the OSI model. It provides client and server communication between devices connected on different types of buses or networks.

The MODBUS protocol defines a simple protocol data unit (PDU) independent of the underlying communication layers. The mapping of the MODBUS protocol on specific buses or network can introduce some additional fields on the application data unit (ADU).

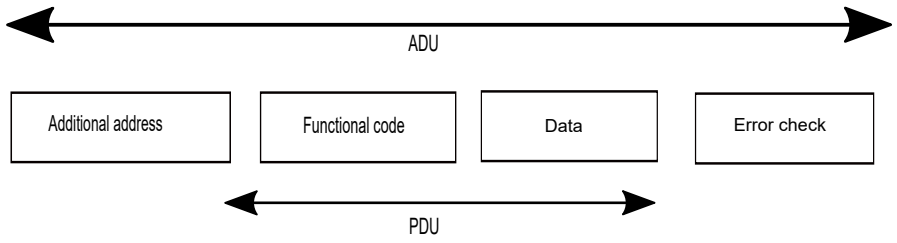


Figure 597. MODBUS frame structure

The function code field informs the server about which action to perform, as requested by the client (only the client can initiate the communication), where the data field contains additional information that the server uses to take the action defined by the function code. MODBUS PDU for serial line communication = 256 - server address (1 byte) - CRC (2 bytes) = 253 bytes.

You can set up a MODBUS controller to communicate on standard MODBUS networks using either of the two transmission modes: ASCII or RTU. RTU mode allows better character density and throughput for the same baud rate as the ASCII format allows 7 bits to represent a character where RTU keeps 8 bits for data representation in each packet.

79.3.9.2 MODBUS frame for LPUART

Though the protocol resides in the application layer, it can also be checked at the physical layer using LPUART by considering the frame structure shown in the following figure, following RTU mode of data transmission.

Start	Address	Function	Data	CRC	End
3.5 Char time	8 Bit	8 Bit	N * 8Bit	16 Bit	3.5 Char time

Figure 598. MODBUS frame for LPUART

An entire message frame of MODBUS must contain start character, address, function code, data, and end character. LPUART does not support CRC calculation for TX and RX, instead, each LPUART packet containing frame information is transmitted with its individual parity, and the same is checked in RX. Following the last transmitted character, a similar interval of at least 3.5 character times marks the end of the message and a new message can begin after this interval. The entire message frame must be transmitted as a continuous stream. If a silent interval of more than 1.5 character times occurs before the completion of the frame, the receiving device flushes the incomplete message, and assumes that the next byte is the address field of a new message. The correctness of timeout logic ensures the correctness of the MODBUS frame using LPUART.

Registers such as REIR, TEIR, TOCR, TOSR, TIMEOUT[0 - 3], TCBR, and TDBR are useful for realizing MODBUS using LPUART. The TX IDLE time is configured by using TEIR[IDTIME].

For higher baud rates, MODBUS recommends adopting fixed t1.5 and t3.5 times of 750us ms and 1.75 ms. The receiver idle line wake-up can be used by a MODBUS device to only wake-up on a matching address or broadcast address received after a valid idle time. The receiver end-of-packet DMA transfer can be used to offload the reception of a MODBUS packet onto the DMA controller.

79.3.9.3 MODBUS TX and RX programming sequence

The following programming sequences can be useful for sending and receiving MODBUS frames using LPUART.

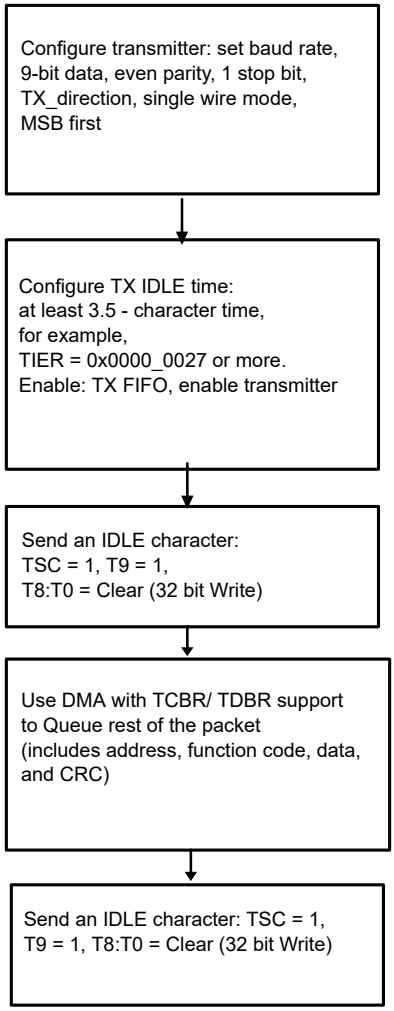


Figure 599. MODBUS TX programming

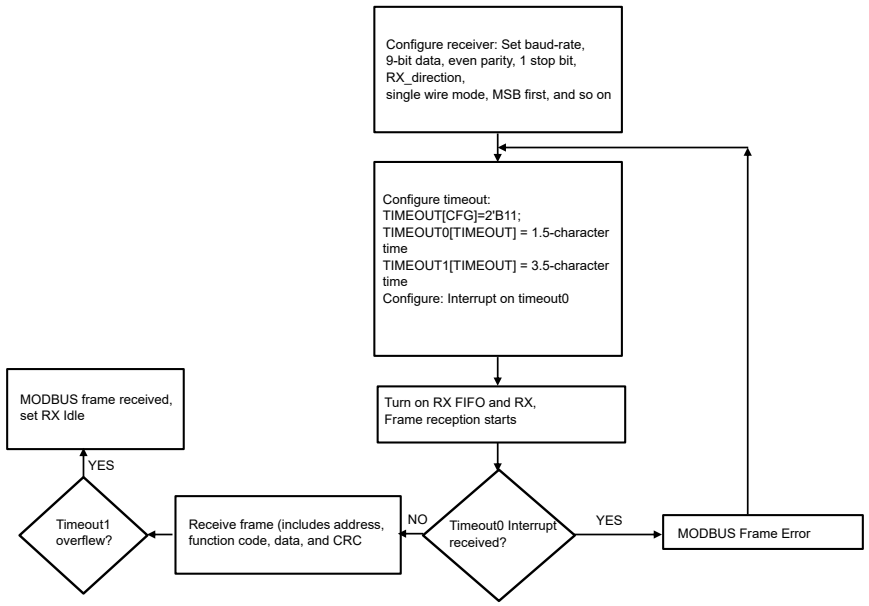


Figure 600. MODBUS RX programming

79.3.10 Modes of operation

79.3.10.1 Low-Power modes

LPUART remains functional during low-power modes, provided CTRL[DOZEEN] is 0 and the LPUART functional clock is enabled. LPUART can generate an interrupt or DMA request to cause a wake-up from low-power modes.

You can configure LPUART to be disabled in low-power modes, when CTRL[DOZEEN] is 1. In this case, the transmitter and receiver finish transmitting and receiving the current word.

If LPUART is disabled in low-power modes, it can generate a wake-up via STAT[RXEDGIF] if the receiver detects an active edge.

NOTE

See the chip-specific information for specific low-power modes available on your chip.

79.3.10.2 Debug mode

LPUART remains functional in Debug mode.

79.3.11 Clocking

Table 682. Types of clocks

Clock	Description
Functional	Is asynchronous to the bus clock and can remain enabled in Low-Power modes to support transmit and/or receive functions, including low-power wake-up.
Bus	Is only used for bus accesses to the control and configuration registers. The bus clock frequency must be sufficient to support the data bandwidth requirements of the LPUART transmit and receive registers, including the FIFOs.

79.3.12 Reset

Table 683. Types of resets

Reset	Description
Chip	Enables the logic and registers for the LPUART transmitter and receiver to reset to their default states.
Software	Resets the LPUART logic and registers to their default states, except for Global (GLOBAL). GLOBAL[RST] controls the LPUART software reset.
FIFO	Implements write-only control fields that reset the transmit FIFO (FIFO[TXFLUSH]) and receive FIFO (FIFO[RXFLUSH]). After a FIFO is reset, that FIFO becomes empty.

79.3.13 Interrupts

The LPUART transmitter has two status fields that can optionally generate hardware interrupt requests. If STAT[TDRE] is 1, it indicates that there is room in the transmit FIFO to write another transmit character to Data (DATA). If CTRL[TIE] is 1, a hardware interrupt is requested when STAT[TDRE] is 1.

STAT[TC] indicates that the transmitter is finished transmitting all data, preamble, and break characters and is idle with TXD at the inactive level. This field is often used in systems with modems to determine when it is safe to turn off the modem. If CTRL[TCIE] is 1, a hardware interrupt is requested when STAT[TC] is 1. Instead of hardware interrupts, software polling may be used to monitor STAT[TDRE] and STAT[TC] if the corresponding CTRL[TIE] or CTRL[TCIE] field is 0.

When a program detects that STAT[RDRF] is 1, it gets the data from this field by reading Data (DATA). The field becomes 0 by reading Data (DATA).

STAT[IDLE] includes logic that prevents it from becoming 1 repeatedly when the RXD line remains idle for an extended period of time. STAT[IDLE] becomes 0 when you write 1 to it, and cannot become 1 again until the receiver has received at least one new character and has 1 as the value of STAT[RDRF].

If the associated error is detected in the received character that caused STAT[RDRF] to become 1, STAT[NF], STAT[FE], and STAT[PF] become 1 at the same time STAT[RDRF] becomes 1. These flags do not become 1 in overrun cases.

If STAT[RDRF] is already 1 when a new character is ready to be transferred from the receive shifter to the receive FIFO, STAT[OR] becomes 1, instead of the data along with any associated STAT[NF], STAT[FE], or STAT[PF] condition getting lost.

If the received character matches the contents of MATCH[MA1] and/or MATCH[MA2], then STAT[MA1F] and/or STAT[MA2F] become 1 at the same time that STAT[RDRF] becomes 1.

At any time, an active edge on the RXD serial data input pin causes STAT[RXEDGIF] to become 1. STAT[RXEDGIF] becomes 0 when you write 1 to it. This function depends on the receiver being enabled (the value of CTRL[RE] being 1).

MODEM Status (MSR) can generate an interrupt from a configured status field, which STAT[MSF] indicates.

Timeout Status (TOSR) can generate an interrupt from a configured status field, which STAT[TSF] indicates.

79.3.14 DMA

79.3.14.1 DMA burst support

To support efficient DMA transfers to the transmit FIFO, two alias regions are implemented to support incrementing 8-bit, 16-bit, or 32-bit write accesses to the transmit FIFO:

- Transmit Command Burst (TCBR0 - TCBR127) is a 512-byte region that supports pushing 16-bit data into the transmit FIFO.
- Transmit Data Burst (TDBR0 - TDBR255) is a 1024-byte region that supports pushing zero extended 8-bit data into the transmit FIFO.

The aforementioned regions are contiguous, so a DMA transfer can start in Transmit Command Burst (TCBR0 - TCBR127) to initialize the transfer including address mark, idle word, or break character, and then complete the transfer in Transmit Data Burst (TDBR0 - TDBR255) with the data to transmit, without changing the transfer size.

The transmit FIFO block writes overflow the FIFO, but that does not signal an error. Do not perform 32-bit writes to Transmit Data Burst (TDBR0 - TDBR255) unless there are four empty slots in the transmit FIFO, and do not perform 16-bit writes to this register unless there are two empty slots in the transmit FIFO.

79.4 External signals

Table 684. External signals

Signal	Description	I/O
TXD	Transmit data: This pin is normally an output, but is an input (tristated) in Single-Wire mode whenever the transmitter is disabled or the transmit direction is configured for receive data.	I/O
RXD	Receive data	I
CTS_B	Clear-to-send	I
RTS_B	Request-to-send	O
DTR_B	Data terminal ready	O
DSR_B	Data set ready	I
DCD_B	Data carrier detect	I
RIN_B	Ring indicator	I

79.5 Initialization

This module does not require initialization.

79.6 LPUART register descriptions

LPUART includes registers to control baud rate, select options, report status, and store transmit and receive data. Access to an address outside the valid memory map generates a bus error.

NOTE

Writing to a read-only (RO) register or reading a write-only (WO) register can cause bus errors. LPUART does not verify whether programmed values in the registers are correct; you must write valid values to them.

79.6.1 LPUART memory map

LPUART_0 base address: 4032_8000h

LPUART_1 base address: 4032_C000h

LPUART_2 base address: 4033_0000h

LPUART_3 base address: 4033_4000h

LPUART_MSC base address: 4050_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Version ID (VERID)	32	R	See section
4h	Parameter (PARAM)	32	R	See section
8h	Global (GLOBAL)	32	RW	0000_0000h
Ch	Pin Configuration (PINCFG)	32	RW	0000_0000h
10h	Baud Rate (BAUD)	32	RW	0F00_0004h
14h	Status (STAT)	32	RW	00C0_0000h
18h	Control (CTRL)	32	RW	0000_0000h
1Ch	Data (DATA)	32	RW	0000_1000h
20h	Match Address (MATCH)	32	RW	0000_0000h
24h	MODEM IrDA (MODIR)	32	RW	0000_0000h
28h	FIFO (FIFO)	32	RW	See section
2Ch	Watermark (WATER)	32	RW	0000_0000h
30h	Data Read-Only (DATARO)	32	R	0000_1000h
40h	MODEM Control (MCR)	32	RW	0000_0000h
44h	MODEM Status (MSR)	32	RW	0000_0000h
48h	Receiver Extended Idle (REIR)	32	RW	0000_0000h
4Ch	Transmitter Extended Idle (TEIR)	32	RW	0000_0000h
50h	Half Duplex Control (HDCR)	32	RW	0000_0000h
58h	Timeout Control (TOCR)	32	RW	0000_0000h
5Ch	Timeout Status (TOSR)	32	RW	0000_000Fh
60h - 6Ch	Timeout N (TIMEOUT0 - TIMEOUT3)	32	RW	0000_0000h
200h - 3FCh	Transmit Command Burst (TCBR0 - TCBR127)	32	W	0000_0000h
400h - 7FCh	Transmit Data Burst (TDBR0 - TDBR255)	32	W	0000_0000h

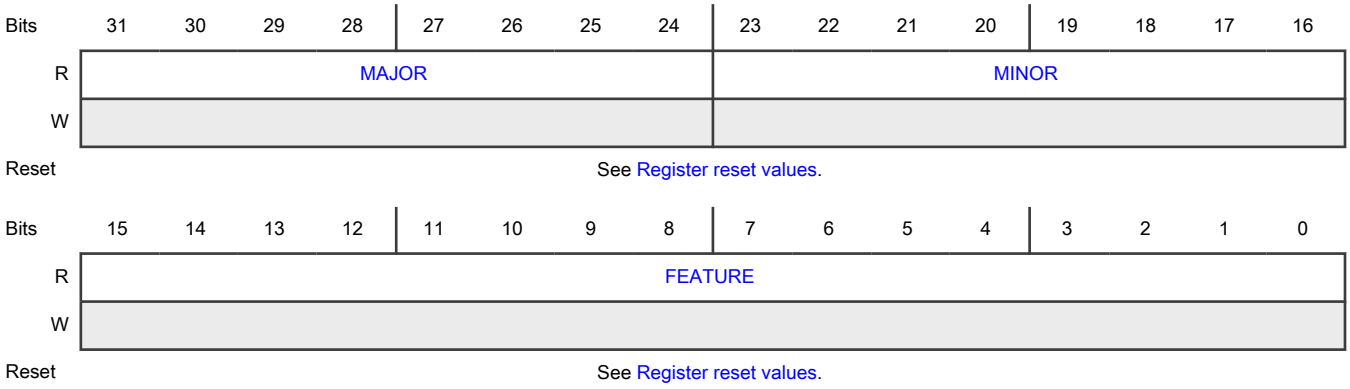
79.6.2 Version ID (VERID)

Offset

Register	Offset
VERID	0h

Function
Indicates the version integrated for this instance on the chip and also specifies the inclusion and exclusion of several optional features.

Diagram



Register reset values

Register	Reset value
VERID	LPUART_0,LPUART_1: 0404_0007h LPUART_2–LPUART_MSC: 0404_0003h

Fields

Field	Function
31-24 MAJOR	Major Version Number Indicates the major version number for the module specification.
23-16 MINOR	Minor Version Number Indicates the minor version number for the module specification.
15-0 FEATURE	Feature Identification Number Indicates the feature set number. 0000_0000_0000_0001b - Standard feature set 0000_0000_0000_0011b - Standard feature set with MODEM and IrDA support 0000_0000_0000_0111b - Enhanced feature set with full MODEM, IrDA, and enhanced idle detection

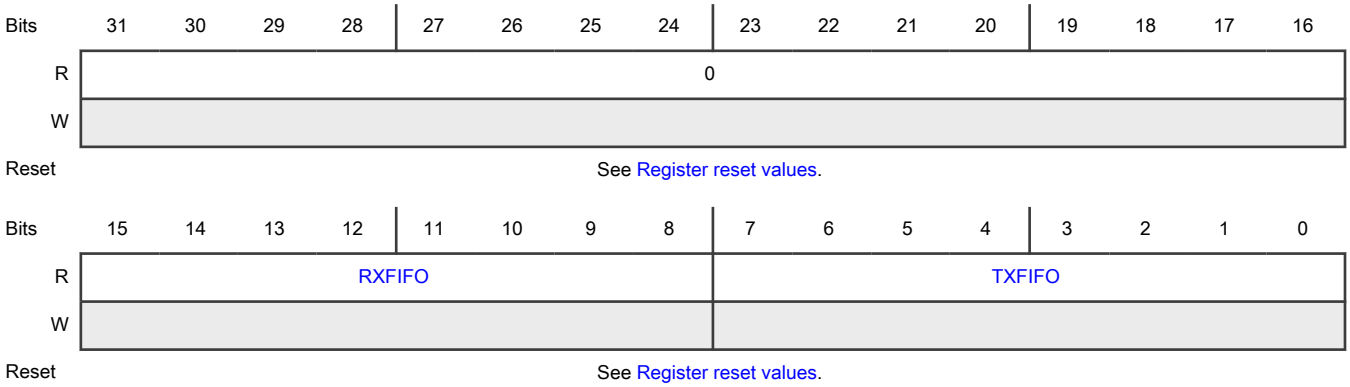
79.6.3 Parameter (PARAM)

Offset

Register	Offset
PARAM	4h

Function
Indicates the parameter configuration for this instance on the chip.

Diagram



Register reset values

Register	Reset value
PARAM	LPUART_0,LPUART_1: 0000_0404h LPUART_2–LPUART_MSC: 0000_0202h

Fields

Field	Function
31-16 —	Reserved
15-8 RXFIFO	Receive FIFO Size Indicates the number of characters in the receive FIFO, which is 2^RXFIFO.
7-0 TXFIFO	Transmit FIFO Size Indicates the number of characters in the transmit FIFO, which is 2^TXFIFO.

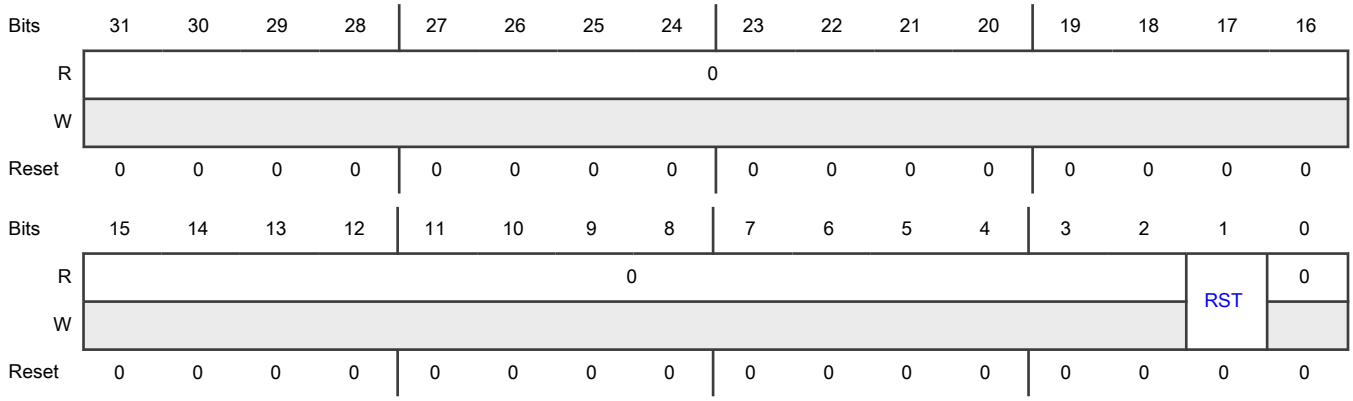
79.6.4 Global (GLOBAL)

Offset

Register	Offset
GLOBAL	8h

Function
Performs global functions.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 RST	Software Reset Specifies whether the module is reset. This field resets all internal logic and registers, except Global (GLOBAL). The reset takes effect immediately and remains asserted until you negate it. There is no minimum delay required before clearing the software reset. 0b - Not reset 1b - Reset
0 —	Reserved

79.6.5 Pin Configuration (PINCFG)

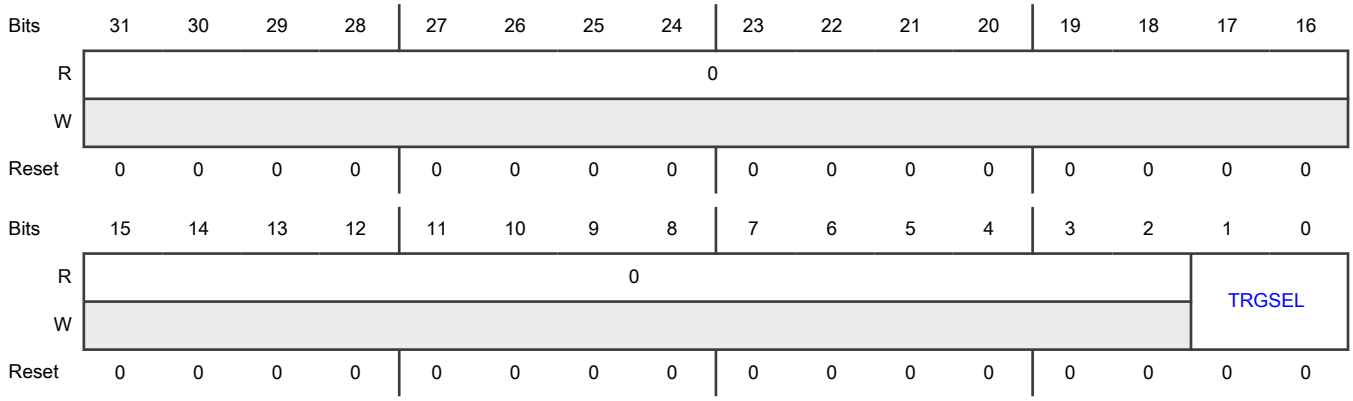
Offset

Register	Offset
PINCFG	Ch

Function

Enables the selection of input pins.

Diagram



Fields

Field	Function
31-2 —	Reserved
1-0 TRGSEL	Trigger Select Configures the input trigger usage. You must change the value of this field only when both the transmitter and receiver are disabled. 00b - Input trigger disabled 01b - Input trigger used instead of the RXD pin input 10b - Input trigger used instead of the CTS_B pin input 11b - Input trigger used to modulate the TXD pin output, which (after TXINV configuration) is internally ANDed with the input trigger

79.6.6 Baud Rate (BAUD)

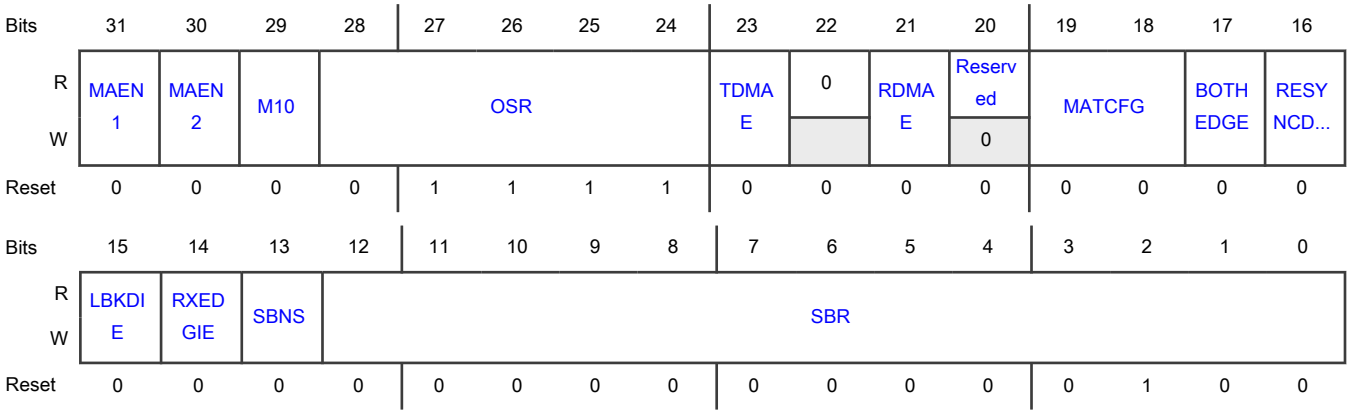
Offset

Register	Offset
BAUD	10h

Function

Configures the baud rate.

Diagram



Fields

Field	Function
31 MAEN1	Match Address Mode Enable 1 Enables automatic address matching or data matching mode for MATCH[MA1]. If this field is 0, normal operation takes place. 0b - Disable 1b - Enable
30 MAEN2	Match Address Mode Enable 2 Enables automatic address matching or data matching mode for MATCH[MA2]. If this field is 0, normal operation takes place. 0b - Disable 1b - Enable
29 M10	10-Bit Mode Select Causes the tenth bit to be a part of the serial transmission. You must change the value of this field only when both the transmitter and receiver are disabled. 0b - Receiver and transmitter use 7-bit to 9-bit data characters 1b - Receiver and transmitter use 10-bit data characters
28-24 OSR	Oversampling Ratio Configures the OSR of the receiver. You must change the value of this field only when both the transmitter and receiver are disabled. **NOTE** BAUD[OSR] results in an OSR of BAUD[OSR] + 1, for example, BAUD[OSR] = 0_0101b results in a final division by 6. 0_0000b - Results in an OSR of 16

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0_0001b - Reserved 0_0010b - Reserved 0_0011b - Results in an OSR of 4 (requires BAUD[BOTHEDGE] to be 1) 0_0100b - Results in an OSR of 5 (requires BAUD[BOTHEDGE] to be 1) 0_0101b - Results in an OSR of 6 (requires BAUD[BOTHEDGE] to be 1) 0_0110b - Results in an OSR of 7 (requires BAUD[BOTHEDGE] to be 1) 0_0111b - Results in an OSR of 8 0_1000b - Results in an OSR of 9 0_1001b - Results in an OSR of 10 0_1010b - Results in an OSR of 11 0_1011b - Results in an OSR of 12 0_1100b - Results in an OSR of 13 0_1101b - Results in an OSR of 14 0_1110b - Results in an OSR of 15 0_1111b - Results in an OSR of 16 1_0000b - Results in an OSR of 17 1_0001b - Results in an OSR of 18 1_0010b - Results in an OSR of 19 1_0011b - Results in an OSR of 20 1_0100b - Results in an OSR of 21 1_0101b - Results in an OSR of 22 1_0110b - Results in an OSR of 23 1_0111b - Results in an OSR of 24 1_1000b - Results in an OSR of 25 1_1001b - Results in an OSR of 26 1_1010b - Results in an OSR of 27 1_1011b - Results in an OSR of 28 1_1100b - Results in an OSR of 29 1_1101b - Results in an OSR of 30 1_1110b - Results in an OSR of 31 1_1111b - Results in an OSR of 32
23 TDMAE	Transmitter DMA Enable Enables STAT[TDRE] to generate a DMA request.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Disable 1b - Enable
22 —	Reserved
21 RDMAE	Receiver Full DMA Enable Enables STAT[RDRF] to generate a DMA request. 0b - Disable 1b - Enable
20 —	Reserved
19-18 MATCFG	Match Configuration Configures the match addressing mode used. You must change the value of this field only when both the transmitter and receiver are disabled. 00b - Address match wake-up 01b - Idle match wake-up 10b - Match on and match off 11b - Enables RWU on data match and match on or off for the transmitter CTS input
17 BOTHEDGE	Both Edge Sampling Enables sampling of the received data on both edges of the baud rate clock, effectively doubling the number of times the receiver samples the input data for a given OSR. This field must be 1 for OSRs between x4 and x7 and is optional for higher OSRs. You must change the value of this field only when the receiver is disabled. If this field is 0, the receiver samples input data using the rising edge of the baud rate clock. If this field is 1, the receiver samples input data using the rising and falling edges of the baud rate clock. 0b - Rising edge 1b - Both rising and falling edges
16 RESYNCDIS	Resynchronization Disable Disables resynchronization of the received data word when a data one followed by data zero transition is detected. You must change the value of this field only when the receiver is disabled. 0b - Enable 1b - Disable
15	LIN Break Detect Interrupt Enable

Table continues on the next page...

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Field	Function
LBKDIE	Enables STAT[LBKDIF] to generate hardware interrupt requests. If this field is 0, hardware interrupts from STAT[LBKDIF] (uses polling) are disabled. If this field is 1, hardware interrupts are requested when STAT[LBKDIF] is 1. 0b - Disable 1b - Enable
14 RXEDGIE	RX Input Active Edge Interrupt Enable Enables STAT[RXEDGIF] to generate interrupt requests. If this field is 0, hardware interrupts from STAT[RXEDGIF] are disabled. If this field is 1, hardware interrupts are requested when STAT[RXEDGIF] is 1. Changing the value of CTRL[LOOPS] or CTRL[RSRC] when this field (RXEDGIE) is 1 can cause STAT[RXEDGIF] to become 1. 0b - Disable 1b - Enable
13 SBNS	Stop Bit Number Select Determines whether data characters include one or two stop bits. You must change the value of this field only when both the transmitter and receiver are disabled. 0b - One stop bit 1b - Two stop bits
12-0 SBR	Baud Rate Modulo Divisor Sets the modulo divide rate for the baud rate generator. • If SBR is 0, baud rate generator is disabled. • If SBR is 1–8191, baud rate = baud clock ÷ ((OSR + 1) × SBR). You must update the 13-bit baud rate setting [SBR12:SBR0] only when both the transmitter and receiver are disabled (both CTRL[RE] and CTRL[TE] are 0).

79.6.7 Status (STAT)

Offset

Register	Offset
STAT	14h

Function
Provides the module status.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	LBKDIF	RXEDGIF	MSBF	RXINV	RWUID	BRK13	LBKDE	RAF	TDRE	TC	RDRF	IDLE	OR	NF	FE	PF
W	W1C	W1C										W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	MA1F	MA2F	0				TSF	MSF	0						AME	LBKFE
W	W1C	W1C														
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 LBKDIF	LIN Break Detect Interrupt Flag Indicates whether a LIN break character is detected. This field becomes 1 when the LIN break detect circuitry is enabled and a LIN break character is detected. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not detected 1b - Detected When writing 0b - No effect 1b - Clear the flag
30 RXEDGIF	RXD Pin Active Edge Interrupt Flag Indicates whether an active edge on the receive pin has occurred. This field becomes 1 whenever the receiver is enabled and an active edge (falling if STAT[RXINV] is 0; rising if STAT[RXINV] is 1) on the RXD pin occurs. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not occurred 1b - Occurred When writing 0b - No effect

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Field	Function
	1b - Clear the flag
29 MSBF	MSB First Specifies the first bit that is transmitted after the start bit. If this field is 0, LSB (bit 0) is the first bit transmitted after the start bit (which means, the first bit received after the start bit is identified as bit 0). If this field is 1, MSB (identified as bit 9, bit 8, bit 7, or bit 6) is the first bit that is transmitted, after the start bit, depending on the settings of CTRL[M], CTRL[PE], and BAUD[M10]. Writing 1 to this field reverses the order of the bits that are transmitted and received on the wire. This field does not affect the polarity of the bits, the location of the parity bit, or the location of the start or stop bits. You must change the value of this field only when both the transmitter and receiver are disabled. 0b - LSB 1b - MSB
28 RXINV	Receive Data Inversion Specifies whether receive data is inverted. Writing 1 to this field reverses the polarity of the received data input. You must change the value of this field only when the receiver is disabled. **NOTE** Writing 1 to this field inverts the RXD input for all cases: data bits, start and stop bits, break, and idle. 0b - Inverted 1b - Not inverted
27 RWUID	Receive Wake Up Idle Detect Controls, for CTRL[RWU] on idle character detection, whether the idle character that wakes up the receiver writes 1 to STAT[IDLE]. For address match wake-up, this field controls whether STAT[IDLE] = 1 when the address does not match. You must change the value of this field only when the receiver is disabled. If this field is 0, during the Receive Standby state (CTRL[RWU] = 1), STAT[IDLE] does not become 1 upon detection of an idle character. During address match wake-up, STAT[IDLE] does not become 1 when an address does not match. If this field is 1, during the Receive Standby state (CTRL[RWU] = 1), STAT[IDLE] becomes 1 upon detection of an idle character. During address match wake-up, STAT[IDLE] becomes 1 when an address does not match. 0b - STAT[IDLE] does not become 1 1b - STAT[IDLE] becomes 1
26 BRK13	Break Character Generation Length Selects the longer transmitted break character length.

Table continues on the next page...

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Field	Function
	The state of this field does not affect the detection of a framing error. You must change the value of this field only when the transmitter is disabled. You can send a break character by writing 1 to CTRL[SBK], or by writing the transmit FIFO when DATA[FRETSC] is 1 and DATA[R9T9] is 0. 0b - 9 to 13 bit times 1b - 12 to 15 bit times
25 LBKDE	LIN Break Detection Enable Enables LIN break detection. If this field is 0, LIN break detect is disabled, and only a normal break character can be detected. If this field is 1, LIN break detect is enabled and the LIN break character is detected at a length of 11 bit times (if CTRL[M] is 0), 12 bit times (if CTRL[M] is 1), or 13 bit times (if BAUD[M10] is 1). This field selects a longer break character detection length. When the field is 1, receive data is not stored in the receive FIFO. **NOTE** This field enables the LIN break detect circuit and disables writing receive data to FIFO. Therefore, it ignores all characters except a LIN break. 0b - Disable 1b - Enable
24 RAF	Receiver Active Flag Indicates whether the LPUART receiver is idle or active. This field becomes 1 when the receiver detects the beginning of a valid start bit, and the field becomes 0 automatically when the receiver detects an idle line. 0b - Idle, waiting for a start bit 1b - Receiver active (RXD pin input not idle)
23 TDRE	Transmit Data Register Empty Flag Indicates whether the transmit FIFO level is greater than, equal to, or less than the watermark. After the transmit FIFO is enabled, this field becomes 1 when the number of datawords in the transmit FIFO is equal to, or less than the number that WATER[TXWATER] indicates. To make the value of this field 0, write to it until the number of words in the transmit FIFO is greater than the number that WATER[TXWATER] indicates. After the transmit FIFO is disabled, this field becomes 1 to indicate that the FIFO level is less than the watermark. To make the value of this field 0 again, write to Data (DATA). This register is not affected by a character that is in the process of being transmitted; it is updated at the start of each transmitted character. 0b - Greater than watermark 1b - Equal to or less than watermark
22	Transmission Complete Flag Indicates whether the transmitter is active.

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Field	Function
TC	This field becomes 0 when a transmission is in progress or a preamble or break character is loaded; in other words, when the transmitter is active (sending data, a preamble, or a break). The field becomes 1 when the transmit buffer is empty and no data, preamble, or break character is being transmitted; in other words, when the transmission activity is complete. When this happens, the transmit data output signal becomes idle (logic 1). This field becomes 0 after you write to Data (DATA) to transmit new data, queuing a preamble by first writing 0 and then writing 1 to CTRL[TE], queuing a break character by writing 1 to CTRL[SBK]. 0b - Transmitter active 1b - Transmitter idle
21 RDRF	Receive Data Register Full Flag Indicates whether the receive FIFO level is less than, equal to, or greater than the watermark. This field becomes 1 when the number of datawords in the receive buffer is greater than the number that WATER[RXWATER] indicates and the receive FIFO is enabled. To write 0 to this field, read Data (DATA) until the number of datawords in the receive FIFO is equal to, or less than the number that WATER[RXWATER] indicates. When the receive FIFO is disabled, this field (RDRF) becomes 1 if the receive buffer (Data (DATA)) is full. To make this field 0, read Data (DATA). A character that is in the process of being received does not cause a change in this field until the entire character is received. Even if this field is 1, the character continues to be received until an overrun condition occurs after the entire character is received. 0b - Equal to or less than watermark 1b - Greater than watermark
20 IDLE	Idle Line Flag Indicates whether an idle line is detected. This field becomes 1 when the LPUART receive line becomes idle for a full character time after a period of activity. When CTRL[ILT] is 0, the receiver starts counting idle bit times after the start bit. If the receive character is all 1s, these bit times and the stop bit time count towards the full character time of logic high, 10 to 13 bit times, needed for the receiver to detect an idle line. After CTRL[ILT] becomes 1, the receiver does not start counting idle bit times until after the stop bits. The stop bits and any logic high bit times at the end of the previous character do not count towards the full character time of logic high needed for the receiver to detect an idle line. For this field to become 0, write 1 to it. After the field becomes 0, you cannot write 1 to it again until after a new character is stored in the receive buffer or a LIN break character writes 1 to STAT[LBKDIF]. This field becomes 1 only once, even if the receive line remains idle for an extended period. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Idle line detected 1b - Idle line not detected When writing

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Field	Function
	0b - No effect 1b - Clear the flag
19 OR	Receiver Overrun Flag Indicates whether there is receive overrun. This field becomes 1 when you cannot prevent STAT[RDRF] from overflowing with data. The field becomes 1 immediately after the stop bit is completely received for the dataword that overflows the buffer and all the other error fields (STAT[FE], STAT[NF], and STAT[PF]) are prevented from becoming 1. The data in the shift register is lost, but the data already in the LPUART data registers is not affected. If STAT[LBKDE] is enabled and a LIN break is detected, this field becomes 1 if STAT[LBKDIF] is not 0 before the next data character is received. When this field is 1, no additional data is stored in the receive FIFO even if sufficient room exists. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No overrun 1b - Receive overrun (new LPUART data is lost) When writing 0b - No effect 1b - Clear the flag
18 NF	Noise Flag Indicates whether noise is detected in the received character of Data (DATA). The advanced sampling technique used in the receiver takes three samples in each of the received bits. If some of these samples disagree with the rest of the samples within any bit time in the frame, then noise is detected for that character. This field becomes 1 whenever the next character to be read from Data (DATA) is received with noise detected within the character. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No noise detected 1b - Noise detected When writing 0b - No effect 1b - Clear the flag
17 FE	Framing Error Flag Indicates whether a framing error is detected.

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Field	Function
	This field becomes 1 whenever the next character to be read from Data (DATA) is received with logic 0 detected where a stop bit was expected. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No framing error detected (this does not guarantee that the framing is correct) 1b - Framing error detected When writing 0b - No effect 1b - Clear the flag
16 PF	Parity Error Flag Indicates whether a parity error is detected. This field becomes 1 whenever the next character to be read from Data (DATA) is received when parity is enabled (CTRL[PE] is 1) and the parity bit in the received character does not agree with the expected parity value. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No parity error detected 1b - Parity error detected When writing 0b - No effect 1b - Clear the flag
15 MA1F	Match 1 Flag Indicates whether the received data is equal to MATCH[MA1]. This field becomes 1 whenever the next character to be read from Data (DATA) matches the value of MATCH[MA1]. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Not equal to MA1 1b - Equal to MA1 When writing

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>0b - No effect
1b - Clear the flag</td></tr>
<tr><td>14
MA2F</td><td>Match 2 Flag
Indicates whether the received data is equal to MATCH[MA2].
This field becomes 1 whenever the next character to be read from Data (DATA) matches the value of MATCH[MA2].
NOTE
This field behaves differently for register reads and writes.
When reading
0b - Not equal to MA2
1b - Equal to MA2
When writing
0b - No effect
1b - Clear the flag</td></tr>
<tr><td>13-10
—</td><td>Reserved</td></tr>
<tr><td>9
TSF</td><td>Timeout Status Flag
Indicates whether a field in Timeout Status (TOSR) is 1 and configured to generate an interrupt.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPUART_0</td><td>STAT</td><td>—</td></tr>
<tr><td>LPUART_1</td><td>STAT</td><td>—</td></tr>
<tr><td>LPUART_2</td><td>—</td><td>STAT</td></tr>
<tr><td>LPUART_3</td><td>—</td><td>STAT</td></tr>
<tr><td>LPUART_MSC</td><td>—</td><td>STAT</td></tr>
</table>
0b - Field is 0
1b - Field is 1</td></tr>
</table>

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>8
MSF</td><td>MODEM Status Flag
Indicates whether a field in MODEM Status (MSR) is 1 and configured to generate an interrupt.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPUART_0</td><td>STAT</td><td>—</td></tr>
<tr><td>LPUART_1</td><td>STAT</td><td>—</td></tr>
<tr><td>LPUART_2</td><td>—</td><td>STAT</td></tr>
<tr><td>LPUART_3</td><td>—</td><td>STAT</td></tr>
<tr><td>LPUART_MSC</td><td>—</td><td>STAT</td></tr>
</table>
0b - Field is 0
1b - Field is 1</td></tr>
<tr><td>7-2
—</td><td>Reserved</td></tr>
<tr><td>1
AME</td><td>Address Mark Enable
Configures the location of the address mark when configured for MSB first transfers.
This field has no effect when configured for LSB first and you must change the value of this field only when both the transmitter and receiver are disabled. If this field is 0, address mark in character is MSB. If this field is 1, the address mark is stored in Data (DATA) at MSB (or MSB-1 when the parity bit is enabled). In other words, the address mark in character is the last bit before the stop bit (or parity bit when enabled).
0b - Disable
1b - Enable</td></tr>
<tr><td>0
LBKFE</td><td>LIN Break Flag Enable
Enables the LIN break flag to assert whenever a LIN break character is detected.
Unlike STAT[LBKDE], this does not impact data being stored in the receive data buffer, but does cause STAT[LBKDIF] to become 1 whenever a LIN break is detected.
Because a LIN break is longer than a normal character, the LIN break triggers a write to STAT[RDRF] with the data fields as 0 and STAT[FE] as 1. The character following the LIN break has DATA[LINBRK] as 1 to indicate that the previous character was a LIN break.
You must change the value of this field only when both the transmitter and receiver are disabled.</td></tr>
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Field	Function
	If this field is 1, the LIN break character is detected at a length of 11-bit times (if CTRL[M] is 0), 12 (if CTRL[M] is 1), or 13 (if BAUD[M10] is 1). 0b - Disable 1b - Enable

79.6.8 Control (CTRL)

Offset

Register	Offset
CTRL	18h

Function

Controls various optional features of the LPUART system.

You must write to the fields of this register only when both the transmitter and receiver are disabled.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	R8T9	R9T8	TXDIR	TXINV	ORIE	NEIE	FEIE	PEIE	TIE	TCIE	RIE	ILIE	TE	RE	RWU	SBK
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	MA1IE	MA2IE	0	0	M7	IDLECFG			LOOPS	DOZEEN	RSRC	M	WAKE	ILT	PE	PT
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 R8T9	Receive Bit 8 Transmit Bit 9 Contains R8 and T9 that correspond to different functions. R8 is the ninth data bit received after you configure LPUART for 9-bit or 10-bit data formats. When reading 9-bit or 10-bit data, read R8 before reading Data (DATA). T9 is the tenth data bit transmitted after you configure LPUART for 10-bit data formats. When writing 10-bit data, write T9 before writing to Data (DATA). If T9 does not need to change from its previous value, such

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Field	Function
	as when it is used to generate address mark or parity, then you need not write to it each time you write to Data (DATA). **NOTE** R8 is a read-only bit and T9 is a write-only bit; the value read is different from the value written.
30 R9T8	Receive Bit 9 Transmit Bit 8 Contains R9 and T8 that correspond to different functions. R9 is the tenth data bit received after you configure LPUART for 10-bit data formats. When reading 10-bit data, read R9 before reading Data (DATA). T8 is the ninth data bit transmitted after you configure LPUART for 9-bit or 10-bit data formats. When writing 9-bit or 10-bit data, write T8 before writing to Data (DATA). If T8 does not need to change from its previous value, such as when it is used to generate address mark or parity, then you need not write to it each time you write to Data (DATA). **NOTE** R9 is a read-only field and T8 is a write-only field; the value read is different from the value written.
29 TXDIR	TXD Pin Direction in Single-Wire Mode Determines the direction of data at the TXD pin, in Single-Wire mode, when LPUART is configured for a single-wire half-duplex operation (CTRL[LOOPS] and CTRL[RSRC] are 1). When writing 0 to this field, the transmitter finishes transmitting the current character (if any) before the receiver starts receiving data from the TXD pin. 0b - Input 1b - Output
28 TXINV	Transmit Data Inversion Specifies whether transmit data is inverted. Writing 1 to this field reverses the polarity of the transmitted data output. This action inverts the TXD output for all cases: data bits, start and stop bits, break, and idle. 0b - Not inverted 1b - Inverted
27 ORIE	Overrun Interrupt Enable Enables STAT[OR] to generate hardware interrupt requests. When this field is 1, a hardware interrupt is requested. Use polling when OR interrupts are disabled. 0b - Disable 1b - Enable
26	Noise Error Interrupt Enable

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Field	Function
NEIE	Enables STAT[NF] to generate hardware interrupt requests. When this field is 1, a hardware interrupt is requested. Use polling when NF interrupts are disabled. 0b - Disable 1b - Enable
25 FEIE	Framing Error Interrupt Enable Enables STAT[FE] to generate hardware interrupt requests. When this field is 1, a hardware interrupt is requested. Use polling when FE interrupts are disabled. 0b - Disable 1b - Enable
24 PEIE	Parity Error Interrupt Enable Enables STAT[PF] to generate hardware interrupt requests. When this field is 1, a hardware interrupt is requested. Use polling when PF interrupts are disabled. 0b - Disable 1b - Enable
23 TIE	Transmit Interrupt Enable Enables STAT[TDRE] to generate interrupt requests if STAT[TDRE] is 1. 0b - Disable 1b - Enable
22 TCIE	Transmission Complete Interrupt Enable Enables STAT[TC] to generate interrupt requests if STAT[TC] is 1. 0b - Disable 1b - Enable
21 RIE	Receiver Interrupt Enable Enables STAT[RDRF] to generate hardware interrupt requests if STAT[RDRF] is 1. 0b - Disable 1b - Enable
20 ILIE	Idle Line Interrupt Enable Enables hardware interrupts. This field enables STAT[IDLE] to generate interrupt requests. If this field is 0, hardware interrupts from STAT[IDLE] are disabled and polling is used, and if this field is 1, hardware interrupts are enabled when STAT[IDLE] is 1. 0b - Disable 1b - Enable

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Field	Function
19 TE	Transmitter Enable Enables the LPUART transmitter. Using this field, you can also queue an idle preamble by first writing 0 and then writing 1 to this field. After this field becomes 0, the field reads 1 until the transmitter has completed the current character and the TXD pin is tristated. You can also queue a single idle character by writing to the transmit FIFO with DATA[FRETSC] and DATA[R9T9] = 1. 0b - Disable 1b - Enable
18 RE	Receiver Enable Enables the LPUART receiver. After you write 0 to this field, this field remains 1 until the receiver finishes receiving the current character (if any). 0b - Disable 1b - Enable
17 RWU	Receiver Wake-Up Control Specifies whether the LPUART receiver in standby is waiting for a wake-up condition. You can write 1 to this field to place the LPUART receiver in a Standby state. The field becomes 0 automatically when an RWU event occurs, that is, in case of an idle event when CTRL[WAKE] is 0 or an address match when CTRL[WAKE] is 1 and STAT[RWUID] is 0. **NOTE** You must write 1 to this field only when CTRL[WAKE] is 0 (wake-up on idle), if the channel is currently not idle. You can determine this by the value of STAT[RAF]. If the field is 1 to wake up an idle event and the channel is already idle, LPUART, possibly, discards the data. This is because the data must be received or a LIN break is detected after an Idle condition is detected before the IDLE flag is allowed to be reasserted. 0b - Normal receiver operation 1b - LPUART receiver in standby, waiting for a wake-up condition
16 SBK	Send Break Specifies whether queue break character(s) are to be sent. Writing 1 and then 0 to this field queues a break character in the transmit data stream. Additional break characters of 9 to 13 bits, or 12 to 15 bits if STAT[BRK13] is 1, and bit times of logic 0 are queued as long as this field is 1. Depending on the timing when this field is 1 and 0, relative to the character currently being transmitted, a second break character may be queued before you write 0 to this field. If the time taken to write 0 to this field is too long, for example, if the field does not become 0 by the end of the first break character, a second break character is sent. This is compared to queuing a break character through the transmit FIFO that guarantees only one break character is sent.

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Field	Function
	You can also queue a single break character by writing to the transmit FIFO when DATA[FRETSC] is 1 and DATA[R9T9] is 0. 0b - Normal transmitter operation 1b - Queue break character(s) to be sent
15 MA1IE	Match 1 (MA1F) Interrupt Enable Enables the MA1F interrupt. 0b - Disable 1b - Enable
14 MA2IE	Match 2 (MA2F) Interrupt Enable Enables the MA2F interrupt. 0b - Disable 1b - Enable
13 —	Reserved
12 —	Reserved
11 M7	7-Bit Mode Select Specifies the data characters that the receiver and transmitter use. You must change the value of this field only after both the transmitter and receiver are disabled. 0b - 8-bit to 10-bit 1b - 7-bit
10-8 IDLECFG	Idle Configuration Configures the number of idle characters that must be received before you write 1 to STAT[IDLE]. 000b - 1 001b - 2 010b - 4 011b - 8 100b - 16 101b - 32 110b - 64 111b - 128
7	Loop Mode Select

Table continues on the next page...

Table continued from the previous page...

Field	Function
LOOPS	Selects Loop mode. After this field becomes 1, the RXD pin is disconnected from LPUART and the transmitter output is internally connected to the receiver input. The transmitter and receiver must be enabled to use the loop function. In Loop mode or Single-Wire mode, the transmitter outputs are internally connected to the receiver input (see CTRL[RSRC]). 0b - Normal operation: RXD and TXD use separate pins 1b - Loop mode or Single-Wire mode
6 DOZEEN	Doze Mode Enables LPUART in Doze mode. If this field is 1, LPUART remains active when not in Doze mode. 0b - Enable 1b - Disable
5 RSRC	Receiver Source Select Determines the source of the receiver shift register input if CTRL[LOOPS] is 1. This field has no effect unless CTRL[LOOPS] is 1. If this field is 0, internal Loopback mode is selected. LPUART does not use the RXD pin. Additionally, the CTS_B pin is not used and internally driven by the RTS_B output. If this field is 1, single-wire LPUART mode is selected where the TXD pin is connected to the transmitter output and receiver input. 0b - Internal Loopback mode 1b - Single-wire mode
4 M	9-Bit Or 8-Bit Mode Select Specifies the data characters that the receiver and transmitter use. 0b - 8-bit 1b - 9-bit
3 WAKE	Receiver Wake-Up Method Select Determines which condition wakes up LPUART when CTRL[RWU] = 1 and BAUD[MATCFG] = 0 (this field must be 1 when BAUD[MATCFG] = 11): • Address mark in the bit preceding the stop bit (or bit preceding the parity bit when parity is enabled) of the received data character • An idle condition on the receive pin input signal If this field is 0, CTRL[RWU] is configured for idle line wake-up, and if this field is 1, CTRL[RWU] is configured with address mark wake-up. 0b - Idle 1b - Mark

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 ILT	Idle Line Type Select Determines when the receiver starts counting logic 1s as idle character bits. The count begins either after a valid start bit or the stop bit. If the count begins after the start bit, a string of logic 1s preceding the stop bit can cause false recognition of an idle character. Beginning the count after the stop bit avoids false idle character recognition, but requires properly synchronized transmissions. **NOTE** In case you write 1 to this field, a logic 0 is automatically shifted after a received stop bit, therefore resetting the idle count. 0b - After the start bit 1b - After the stop bit
1 PE	Parity Enable Enables hardware parity generation and checking. If parity is enabled, the bit immediately before the stop bit is treated as the parity bit. 0b - Disable 1b - Enable
0 PT	Parity Type Selects the type of parity, even or odd, if parity is enabled (CTRL[PE] = 1): • Odd parity means that the total number of logic 1 bits in the data character, including the parity bit, is odd. • Even parity means that the total number of 1s in the data character, including the parity bit, is even. 0b - Even parity 1b - Odd parity

79.6.9 Data (DATA)

Offset

Register	Offset
DATA	1Ch

Function

Supports 8-bit, 16-bit, or 32-bit writes, each type of write performing a separate function. An 8-bit write to DATA[7:0] pushes {CTRL[R8T9], CTRL[R9T8], DATA[7:0]} the transmit FIFO with TSC clear. A 16-bit or 32-bit write pushes the data written into the FIFO and does not update the value of CTRL[R8T9] or CTRL[R9T8].

Reads and writes of this register are also involved in the automatic flag clearing mechanisms for some of the LPUART status fields.

NOTE

Reads return the contents of the read-only receive FIFO and writes go to the write-only transmit FIFO, making this register work as a set of two separate registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	NOISY	PARITYE	FRETSC	RXEMPT	IDLINE	LINBRK	R9T9	R8T8	R7T7	R6T6	R5T5	R4T4	R3T3	R2T2	R1T1	R0T0
W																
Reset	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15 NOISY	Noisy Data Received Indicates whether the current received dataword contained in DATA[R9:R0] is received with noise. 0b - Received without noise 1b - Received with noise
14 PARITYE	Parity Error Indicates whether the current received dataword contained in DATA[R9:R0] is received with a parity error. 0b - Received without a parity error 1b - Received with a parity error
13 FRETSC	Frame Error Transmit Special Character Specifies the way the dataword is received. For reads, this field indicates that the current received dataword contained in DATA[R9:R0] is received with a frame error. For writes, the field indicates that a break or idle character is to be transmitted instead of the contents in DATA[T9:T0]. T9 indicates a break character when it is 0 and indicates an idle character when it is 1. The contents of DATA[T8:T0] must be 0. 0b - Received without a frame error on reads or transmits a normal character on writes 1b - Received with a frame error on reads or transmits an idle or break character on writes
12	Receive Buffer Empty

Table continues on the next page...

Table continued from the previous page...

Field	Function
RXEMPT	Indicates whether the receive buffer contains valid data. This field becomes 1 when there is no data in the receive buffer. The field does not consider data in the receive shift register. 0b - Valid data 1b - Invalid data and empty
11 IDLINE	Idle Line Indicates whether the receiver line was idle before receiving the character in DATA[9:0]. It can be read as “1” on the first character when the receiver is first enabled. The difference between this field and STAT[IDLE] is that, STAT[IDLE] flag does not set on an idle line after the receiver is first enabled, it needs to receive a character before it can become set, whereas this field does not have this limitation and can be set on the first character received if an idle line is detected beforehand. 0b - Not idle 1b - Idle
10 LINBRK	LIN Break Indicates whether the receiver line detected a LIN break before receiving the character in DATA[9:0]. This field requires the value of STAT[LBKDIF] to be 1. If this field is 0, the LIN break detect circuitry is disabled. 0b - Not detected 1b - Detected
9 R9T9	Read receive FIFO bit 9 or write transmit FIFO bit 9
8 R8T8	Read receive FIFO bit 8 or write transmit FIFO bit 8
7 R7T7	Read receive FIFO bit 7 or write transmit FIFO bit 7
6 R6T6	Read receive FIFO bit 6 or write transmit FIFO bit 6
5 R5T5	Read receive FIFO bit 5 or write transmit FIFO bit 5
4 R4T4	Read receive FIFO bit 4 or write transmit FIFO bit 4
3 R3T3	Read receive FIFO bit 3 or write transmit FIFO bit 3

Table continues on the next page...

Table continued from the previous page...

Field	Function
2 R2T2	Read receive FIFO bit 2 or write transmit FIFO bit 2
1 R1T1	Read receive FIFO bit 1 or write transmit FIFO bit 1
0 R0T0	Read receive FIFO bit 0 or write transmit FIFO bit 0

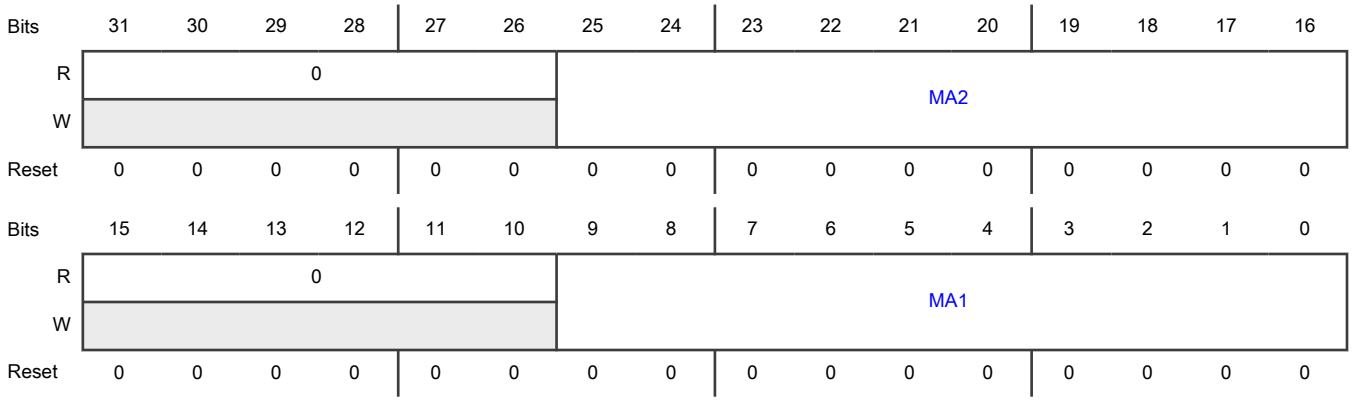
79.6.10 Match Address (MATCH)

Offset

Register	Offset
MATCH	20h

Function
Provides addresses for address matching during the receiver operation.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-16 MA2	Match Address 2

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Is compared to input data addresses when the most significant bit is 1 and the associated Baud Rate (BAUD) field is 1. If a match occurs, the data that follows is transferred to Data (DATA). If a match fails, the data that follows is discarded. You must write to MATCH[MA1] and MATCH[MA2] only when the associated Baud Rate (BAUD) field is 0.
15-10 —	Reserved
9-0 MA1	Match Address 1 Is compared to input data addresses when the most significant bit is 1 and the associated Baud Rate (BAUD) field is 1. If a match occurs, the data that follows is transferred to Data (DATA). If a match fails, the data that follows is discarded. You must write to MATCH[MA1] and MATCH[MA2] fields only when the associated field in Baud Rate (BAUD) is 0.

79.6.11 MODEM IrDA (MODIR)

Offset

Register	Offset
MODIR	24h

Function
Controls options for setting the MODEM configuration.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0													IREN	TNP	
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				RTSWATER				0		TXCTSSRC	TXCTSC	RXRTSE	TXRTSPOL	TXRTSE	TXCTSE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18 IREN	IR Enable Enables IR modulation and demodulation. You must change the value of this field only when both the transmitter and receiver are disabled. 0b - Disable 1b - Enable
17-16 TNP	Transmitter Narrow Pulse Specifies whether LPUART transmits a 1 ÷ OSR, 2 ÷ OSR, 3 ÷ OSR, or 4 ÷ OSR narrow pulse when the IR pulse is enabled. You must change the value of this field only when both the transmitter and receiver are disabled. The IR pulse width must be configured to less than half of the OSR. Common pulse widths are 3 ÷ 16, 1 ÷ 16, 1 ÷ 32, or 1 ÷ 4 of the bit length. You can configure these by selecting the appropriate OSR and pulse width. 00b - 1 ÷ OSR 01b - 2 ÷ OSR 10b - 3 ÷ OSR 11b - 4 ÷ OSR
15-12 —	Reserved

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>11-8
RTSWATER</td><td>Receive RTS Configuration
Configures the assertion and negation of the receiver's RTS_B output.
The receiver's RTS_B output negates when the number of empty words in the receive FIFO is greater or equal to the value of this field. If this field is 0, the RTS_B pin negates when the receive FIFO is full. For the purpose of receive RTS_B generation, the number of words in the receive FIFO updates when a start bit is detected. This supports additional latency between RTS_B negation and the external transmitter ceasing transmission. If both receive RTS_B and address or data matching is enabled, RTS_B could assert at the end of a character if there exists no match.
You must change the value of this field only when the receiver is disabled.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPUART_0</td><td>MODIR</td><td>—</td></tr>
<tr><td>LPUART_1</td><td>MODIR</td><td>—</td></tr>
<tr><td>LPUART_2</td><td>MODIR[9–8]</td><td>MODIR[11–10]</td></tr>
<tr><td>LPUART_3</td><td>MODIR[9–8]</td><td>MODIR[11–10]</td></tr>
<tr><td>LPUART_MSC</td><td>MODIR[9–8]</td><td>MODIR[11–10]</td></tr>
</table></td></tr>
<tr><td>7-6
—</td><td>Reserved</td></tr>
<tr><td>5
TXCTSSRC</td><td>Transmit CTS Source
Configures the source of the CTS input.
0b - The CTS_B pin
1b - An internal connection to the receiver address match result</td></tr>
<tr><td>4
TXCTSC</td><td>Transmit CTS Configuration
Configures whether the CTS state or input is checked or sampled at the start of each character or only when the transmitter is idle.
0b - Sampled at the start of each character
1b - Sampled when the transmitter is idle</td></tr>
<tr><td>3
RXRTSE</td><td>Receiver RTS Enable
Allows the RTS output to control the CTS input of the transmitting device to prevent receiver overrun.</td></tr>
</table>

Table continues on the next page...

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Field	Function
	You must change the value of this field only when the receiver is disabled. If this field is 0, the receiver has no effect on RTS. If this field is 1, RTS is deasserted if STAT[RDRF] is 1 or a start bit is detected that causes STAT[RDRF] to become 1. RTS is asserted if STAT[RDRF] is 0 and has not detected a start bit that causes STAT[RDRF] to become 1. **NOTE** Do not write 1 to both MODIR[RXRTSE] and MODIR[TXRTSE]. 0b - Disable 1b - Enable
2 TXRTSPOL	Transmitter RTS Polarity Controls the polarity of the transmitter RTS. This field does not affect the polarity of the receiver RTS that remains negated in the active-low state unless MODIR[TXRTSE] is 1. You must change the value of this field only when the transmitter is disabled. 0b - Active low 1b - Active high
1 TXRTSE	Transmitter RTS Enable Controls the operation of RTS before and after a transmission. You must change the value of this field only when the transmitter is disabled. If this field is 0, the transmitter has no effect on RTS, and if this field is 1, a character is placed into an empty transmit shift register. RTS asserts 1-bit time before the start bit is transmitted and deasserts 1-bit time after all characters in the transmitter FIFO and shift register are completely sent, including the last stop bit. 0b - Disable 1b - Enable
0 TXCTSE	Transmitter CTS Enable Enables the operation of the transmitter. You can write 1 to this field irrespective of the states of MODIR[TXRTSE] and MODIR[RXRTSE]. If this field is 1, the transmitter checks the state of the CTS signal each time it is ready to send a character. If CTS is asserted, the character is sent. If CTS is deasserted, the TXD signal remains in the mark state and transmission is delayed until CTS is asserted. Changes in CTS, when a character is being sent, do not affect its transmission. 0b - Disable 1b - Enable

79.6.12 FIFO (FIFO)

Offset

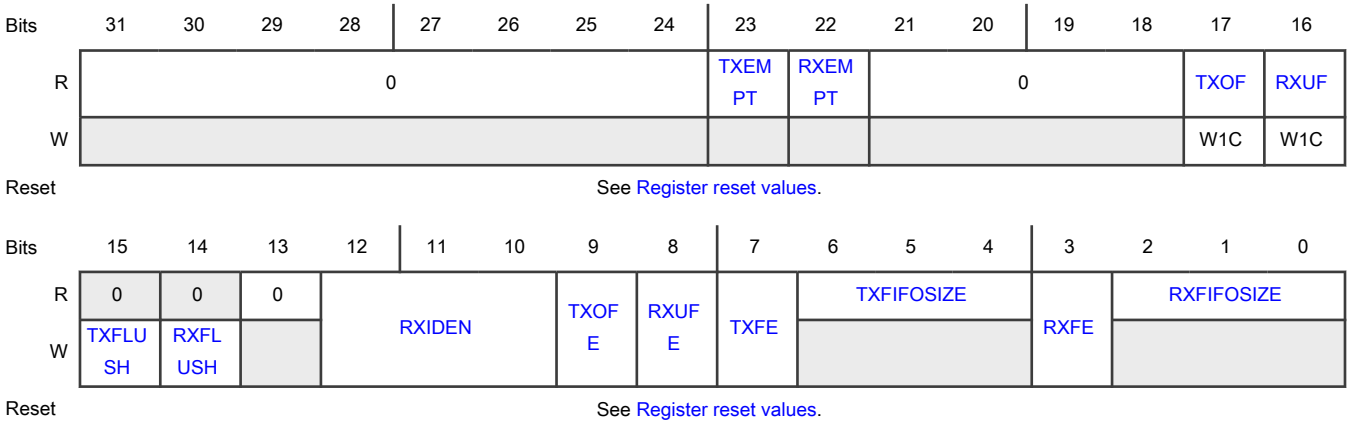
Register	Offset
FIFO	28h

Function

Provides you the ability to turn on and turn off the FIFO functionality.

This register also provides you the size of the FIFO that has been implemented. You can read this register at any time and must write to it only when CTRL[RE] and CTRL[TE] are 0 and the FIFO is empty.

Diagram



Register reset values

Register	Reset value
FIFO	LPUART_0,LPUART_1: 00C0_0033h LPUART_2–LPUART_MSC: 00C0_0011h

Fields

Field	Function
31-24 —	Reserved
23 TXEMPT	Transmit FIFO Or Buffer Empty Indicates whether the transmit buffer is empty. This field becomes 1 when there is no data in the transmit FIFO or buffer. The field does not consider data in the transmit shift register.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not empty 1b - Empty
22 RXEMPT	Receive FIFO Or Buffer Empty Indicates whether the receive buffer is empty. This field becomes 1 when there is no data in the receive FIFO or buffer. The field does not consider data in the receive shift register. 0b - Not empty 1b - Empty
21-18 —	Reserved
17 TXOF	Transmitter FIFO Overflow Flag Indicates whether more data has been written to the transmit FIFO than it can hold. If this field is 0, no transmit FIFO overflow has occurred since the last time the field was cleared, and if this field is 1, at least one transmit FIFO overflow has occurred since the last time the field was cleared. This field becomes 1 regardless of the value of FIFO[TXOFE]. However, an interrupt is issued to the host only if FIFO[TXOFE] is 1. **NOTE** This field behaves differently for register reads and writes. When reading 0b - No overflow 1b - Overflow When writing 0b - No effect 1b - Clear the flag
16 RXUF	Receiver FIFO Underflow Flag Indicates whether more data has been read from the receive FIFO than was present. If this field is 0, no receive FIFO underflow has occurred since the last time the field was cleared, and if this field is 1, at least one receive FIFO underflow has occurred since the last time the field was cleared. This field becomes 1 regardless of the value of FIFO[RXUFE]. However, an interrupt is issued to the host only if FIFO[RXUFE] is 1. **NOTE** This field behaves differently for register reads and writes. When reading

Table continues on the next page...

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Field	Function
	0b - No underflow 1b - Underflow When writing 0b - No effect 1b - Clear the flag
15 TXFLUSH	Transmit FIFO Flush Causes all data that is stored in the transmit FIFO to be flushed. If you write 0 to this field, no flush operation occurs, and if you write 1 to this field, all data in the transmit FIFO or buffer clears out. This does not affect data in the transmit shift register. 0b - No effect 1b - All data flushed out
14 RXFLUSH	Receive FIFO Flush Causes all data that is stored in the receive FIFO to be flushed. If you write 0 to this field, no flush operation occurs, and if you write 1 to this field, all data in the receive FIFO or buffer clears out. This does not affect data in the receive shift register. 0b - No effect 1b - All data flushed out
13 —	Reserved
12-10 RXIDEN	Receiver Idle Empty Enable Enables STAT[RDRF] to become 1 when the receiver is idle for a number of idle characters and the FIFO is not empty. This feature is not supported when the receiver extended idle time is enabled. 000b - Disable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle 001b - Enable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle for one character 010b - Enable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle for two characters 011b - Enable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle for four characters 100b - Enable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle for eight characters

Table continues on the next page...

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Field	Function
	101b - Enable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle for 16 characters 110b - Enable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle for 32 characters 111b - Enable STAT[RDRF] to become 1 because of partially filled FIFO when the receiver is idle for 64 characters
9 TXOFE	Transmit FIFO Overflow Interrupt Enable Enables FIFO[TXOF] to generate an interrupt to the host. 0b - Disable 1b - Enable
8 RXUFE	Receive FIFO Underflow Interrupt Enable Enables FIFO[RXUF] to generate an interrupt to the host. 0b - Disable 1b - Enable
7 TXFE	Transmit FIFO Enable Enables the transmit FIFO. If this field is 0, the transmit buffer operates as a FIFO of depth equal to 1 dataword, regardless of the value in FIFO[TXFIFOSIZE]. Both CTRL[TE] and CTRL[RE] must be 0 before you change the value of this field. If this field is 1, the built-in FIFO structure for the transmit buffer is enabled. FIFO[TXFIFOSIZE] indicates the size of the FIFO structure. 0b - Disable 1b - Enable
6-4 TXFIFOSIZE	Transmit FIFO Buffer Depth Indicates the maximum number of transmit datawords (transmit FIFO buffer depth) that can be stored in the transmit buffer. 000b - 1 001b - 4 010b - 8 011b - 16 100b - 32 101b - 64 110b - 128 111b - 256
3	Receive FIFO Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
RXFE	Enables the receive FIFO. If this field is 0, the receive buffer operates as a FIFO of depth equal to 1 dataword, regardless of the value in FIFO[RXFIFOSIZE]. Both CTRL[RE] and CTRL[TE] must be 0 before you change the value of this field. If this field is 1, the built-in FIFO structure for the receive buffer is enabled. FIFO[RXFIFOSIZE] indicates the size of the FIFO structure. 0b - Disable 1b - Enable
2-0 RXFIFOSIZE	Receive FIFO Buffer Depth Indicates the maximum number of receive datawords (receive FIFO buffer depth) that can be stored in the receive buffer before an overrun occurs. 000b - 1 001b - 4 010b - 8 011b - 16 100b - 32 101b - 64 110b - 128 111b - 256

79.6.13 Watermark (WATER)

Offset

Register	Offset
WATER	2Ch

Function

Provides the ability to set a programmable threshold for notification, or sets the programmable thresholds to indicate that transmit data can be written or receive data can be read.

You may read this register at any time but must write to it only when CTRL[TE] is 0.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0				RXCOUNT				0				RXWATER			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				TXCOUNT				0				TXWATER			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved
28-24 RXCOUNT	Receive Counter Indicates the number of datawords in the receive FIFO or buffer. If a dataword is being received in the receive shift register, it is not included in the count. This value may be used in conjunction with FIFO[RXFIFOSIZE] to calculate the room left in the receive FIFO or buffer. **NOTE** This field is not supported in every instance. The following table includes only supported registers.
23-20 —	Reserved
19-16 RXWATER	Receive Watermark Generates an interrupt or a DMA request if the number of datawords in the receive FIFO or buffer is greater than the value of this field.

Instance	Field supported in	Field not supported in
LPUART_0	WATER	—
LPUART_1	WATER	—
LPUART_2	WATER[26–24]	WATER[28–27]
LPUART_3	WATER[26–24]	WATER[28–27]
LPUART_MSC	WATER[26–24]	WATER[28–27]

Table continued from the previous page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td></td><td>For proper operation, the value of this field must be less than the size of the receive FIFO or buffer, as indicated by FIFO[RXFIFOSIZE] and FIFO[RXFE].
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPUART_0</td><td>WATER</td><td>—</td></tr>
<tr><td>LPUART_1</td><td>WATER</td><td>—</td></tr>
<tr><td>LPUART_2</td><td>WATER[17–16]</td><td>WATER[19–18]</td></tr>
<tr><td>LPUART_3</td><td>WATER[17–16]</td><td>WATER[19–18]</td></tr>
<tr><td>LPUART_MSC</td><td>WATER[17–16]</td><td>WATER[19–18]</td></tr>
</table></td></tr>
<tr><td>15-13
—</td><td>Reserved</td></tr>
<tr><td>12-8
TXCOUNT</td><td>Transmit Counter
Indicates the number of datawords in the transmit FIFO or buffer.
If a dataword is being transmitted to the transmit shift register, it is not included in the count. This value may be used in conjunction with the value of FIFO[TXFIFOSIZE] to calculate the room left in the transmit FIFO or buffer.
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPUART_0</td><td>WATER</td><td>—</td></tr>
<tr><td>LPUART_1</td><td>WATER</td><td>—</td></tr>
<tr><td>LPUART_2</td><td>WATER[10–8]</td><td>WATER[12–11]</td></tr>
<tr><td>LPUART_3</td><td>WATER[10–8]</td><td>WATER[12–11]</td></tr>
<tr><td>LPUART_MSC</td><td>WATER[10–8]</td><td>WATER[12–11]</td></tr>
</table></td></tr>
</table>

Table continues on the next page...

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<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>7-4
—</td><td>Reserved</td></tr>
<tr><td>3-0
TXWATER</td><td>Transmit Watermark
Generates an interrupt or a DMA request when the number of datawords in the transmit FIFO or buffer is equal to or less than the value of this field.
For proper operation, the value of this field must be less than the size of the transmit buffer or FIFO, as indicated by FIFO[TXFIFOSIZE] and FIFO[TXFE].
NOTE
This field is not supported in every instance. The following table includes only supported registers.
<table>
<tr><th>Instance</th><th>Field supported in</th><th>Field not supported in</th></tr>
<tr><td>LPUART_0</td><td>WATER</td><td>—</td></tr>
<tr><td>LPUART_1</td><td>WATER</td><td>—</td></tr>
<tr><td>LPUART_2</td><td>WATER[1–0]</td><td>WATER[3–2]</td></tr>
<tr><td>LPUART_3</td><td>WATER[1–0]</td><td>WATER[3–2]</td></tr>
<tr><td>LPUART_MSC</td><td>WATER[1–0]</td><td>WATER[3–2]</td></tr>
</table>
</td></tr>
</table>

79.6.14 Data Read-Only (DATARO)

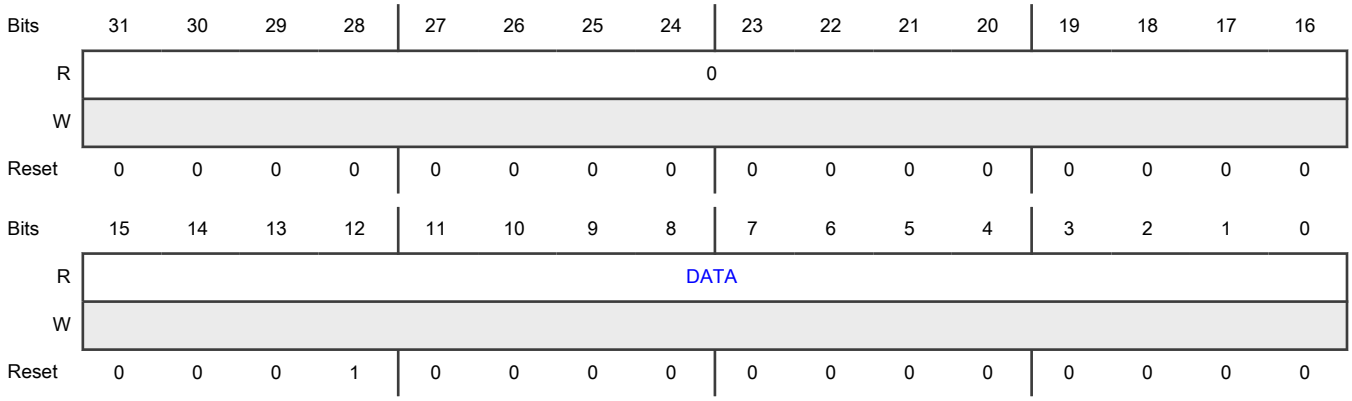
Offset

Register	Offset
DATARO	30h

Function

Indicates the first entry in the receive FIFO, but does not pull data from the FIFO.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 DATA	Receive Data Indicates the first entry from the receive FIFO. This register has the same functionality as that of Data (DATA).

79.6.15 MODEM Control (MCR)

Offset

Register	Offset
MCR	40h

Function

Controls the operation of the MODEM pins.

NOTE

Each module instance supports a different number of registers.

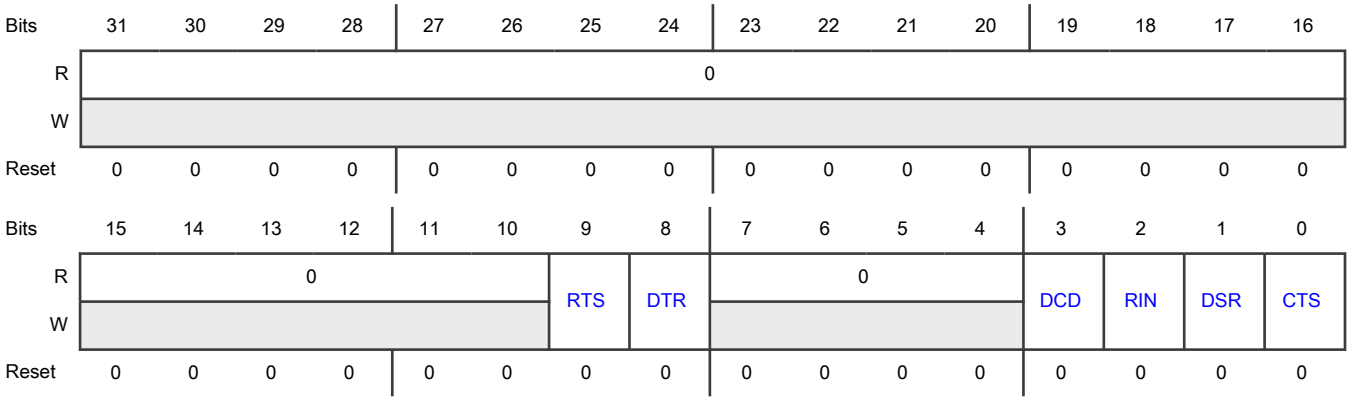
Instance	Register supported	Register not supported
LPUART_0	MCR	—
LPUART_1	MCR	—
LPUART_2	—	MCR

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
LPUART_3	—	MCR
LPUART_MSC	—	MCR

Diagram



Fields

Field	Function
31-10 —	Reserved
9 RTS	Request To Send Configures the default state of the RTS_B pin when the function is disabled. 0b - Logic one 1b - Logic zero
8 DTR	Data Terminal Ready Configures the default state of the DTR_B pin. 0b - Logic one 1b - Logic zero
7-4 —	Reserved
3 DCD	Data Carrier Detect Configures the interrupt, DCD_B, for change of state of the DCD_B pin. 0b - Disable interrupt

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Enable interrupt
2 RIN	Ring Indicator Configures the interrupt, RIN_B, for change of state on the RIN_B pin. 0b - Disable interrupt 1b - Enable interrupt
1 DSR	Data Set Ready Configures the interrupt, DSR_B, for change of state on the DSR_B pin. 0b - Disable interrupt 1b - Enable interrupt
0 CTS	Clear To Send Configures the interrupt, CTS_B, for change of state on the CTS_B pin. 0b - Disable interrupt 1b - Enable interrupt

79.6.16 MODEM Status (MSR)

Offset

Register	Offset
MSR	44h

Function
Indicates the status of the MODEM pins.

NOTE
You must appropriately configure the PAD connecting to DCD_B, RIN_B, DSR_B, and CTS_B inputs to get appropriate reset values for the MSR register fields.

NOTE
Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
LPUART_0	MSR	—
LPUART_1	MSR	—
LPUART_2	—	MSR

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
LPUART_3	—	MSR
LPUART_MSC	—	MSR

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								DCD	RIN	DSR	CTS	DDCD	DRI	DDSR	DCTS
W													W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7 DCD	Data Carrier Detect Indicates the state of the DCD_B pin. 0b - Logic one 1b - Logic zero
6 RIN	Ring Indicator Indicates the state of the RIN_B pin. 0b - Logic one 1b - Logic zero
5 DSR	Data Set Ready Indicates the state of the DSR_B pin. 0b - Logic one 1b - Logic zero
4	Clear To Send Indicates the state of the CTS_B pin.

Table continues on the next page...

Table continued from the previous page...

Field	Function
CTS	0b - Logic one 1b - Logic zero
3 DDCD	Delta Data Carrier Detect Indicates whether the DCD_B pin changed state since the last time this field was 0. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Did not change state 1b - Changed state When writing 0b - No effect 1b - Clear the flag
2 DRI	Delta Ring Indicator Indicates whether the RIN_B pin changed state since the last time this field was 0. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Did not change state 1b - Changed state When writing 0b - No effect 1b - Clear the flag
1 DDSR	Delta Data Set Ready Indicates whether the DSR_B pin changed state since the last time this field was 0. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Did not change state 1b - Changed state When writing 0b - No effect 1b - Clear the flag

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 DCTS	Delta Clear To Send Indicates whether the CTS_B pin changed state since the last time this field was 0. **NOTE** This field behaves differently for register reads and writes. When reading 0b - Did not change state 1b - Changed state When writing 0b - No effect 1b - Clear the flag

79.6.17 Receiver Extended Idle (REIR)

Offset

Register	Offset
REIR	48h

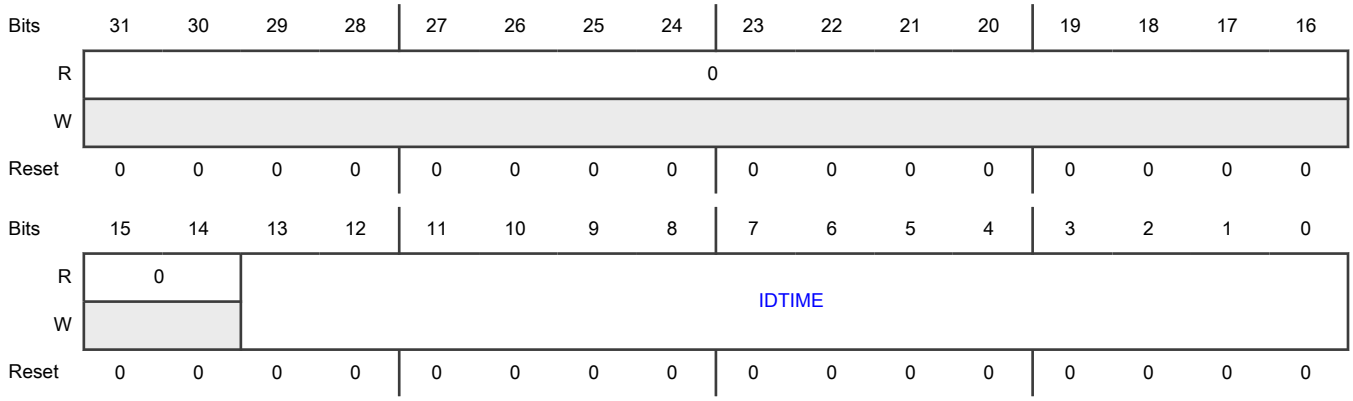
Function

Configures the receiver extended idle functionality. You must not change this value when the receiver is enabled.

NOTE
Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
LPUART_0	REIR	—
LPUART_1	REIR	—
LPUART_2	—	REIR
LPUART_3	—	REIR
LPUART_MSC	—	REIR

Diagram



Fields

Field	Function
31-14 —	Reserved
13-0 IDTIME	Idle Time Configures the idle length in number of bits (baud rate) since the end of the last stop bit. This affects the behavior of the idle wake-up, STAT[IDLE], DATA[IDLINE], and STAT[RAF]. The minimum supported extended idle time is equal to one idle character. The extended idle feature is disabled when this field is 0.

79.6.18 Transmitter Extended Idle (TEIR)

Offset

Register	Offset
TEIR	4Ch

Function

Configures the transmitter extended idle functionality. You must not change this value when the transmitter is enabled.

NOTE

Each module instance supports a different number of registers.

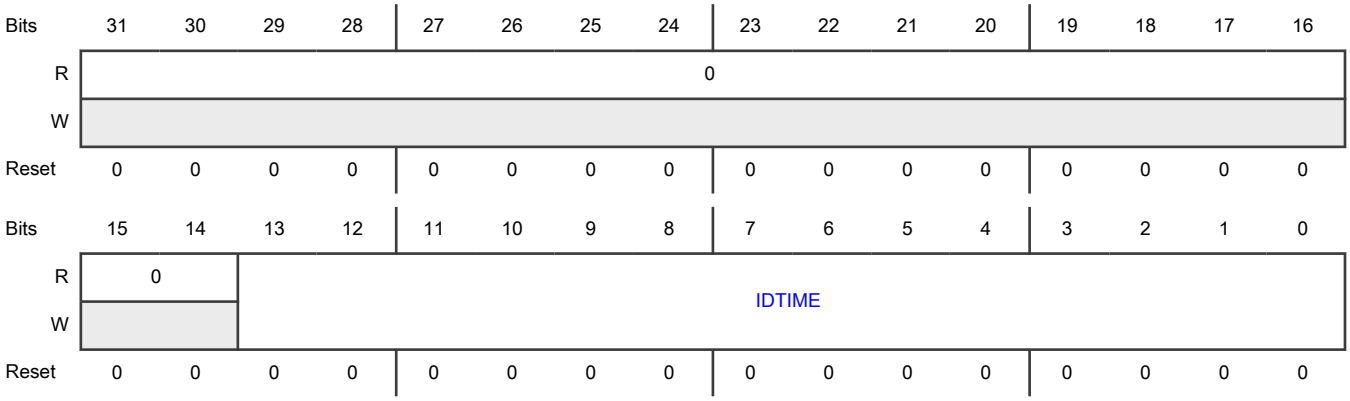
Instance	Register supported	Register not supported
LPUART_0	TEIR	—
LPUART_1	TEIR	—
LPUART_2	—	TEIR

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
LPUART_3	—	TEIR
LPUART_MSC	—	TEIR

Diagram



Fields

Field	Function
31-14 —	Reserved
13-0 IDTIME	Idle Time Configures the transmitter idle time in number of bits (baud rate) whenever an idle character is queued through the transmit FIFO. An idle character is not automatically queued whenever the transmitter is enabled. The minimum supported extended idle time equals one idle character. The extended idle feature is disabled when this field is 0.

79.6.19 Half Duplex Control (HDCR)

Offset

Register	Offset
HDCR	50h

Function

Provides control for half-duplex-related operations.

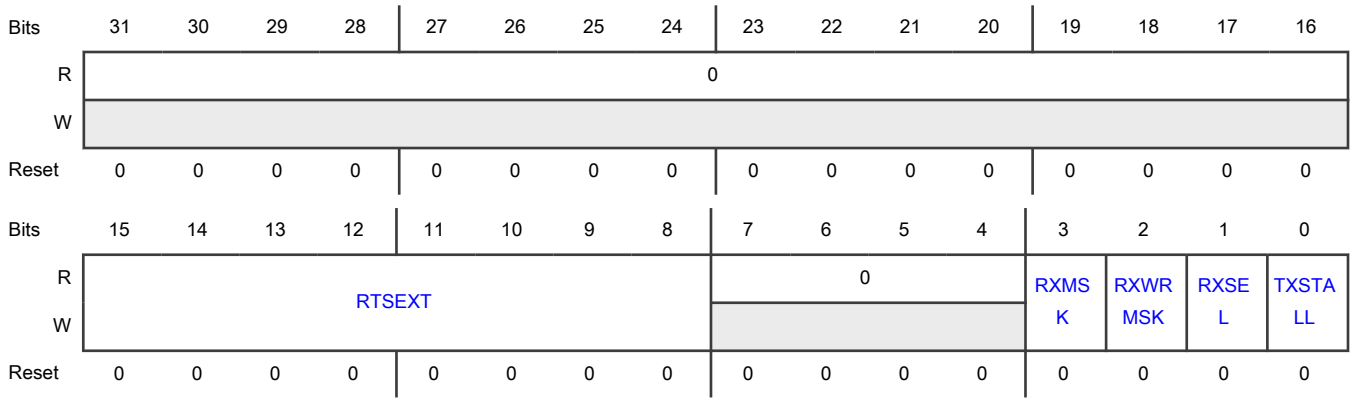
You can use this register instead of CTRL[LOOPS], CTRL[RSRC], and CTRL[TXDIR] functions, although you can use CTRL[LOOPS] to loop-back the transmitter outputs to the receiver.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
LPUART_0	HDCR	—
LPUART_1	HDCR	—
LPUART_2	—	HDCR
LPUART_3	—	HDCR
LPUART_MSC	—	HDCR

Diagram



Fields

Field	Function
31-16 —	Reserved
15-8 RTSEXT	RTS Extended Specifies RTS extension. The transmit RTS_B remains asserted for (RTSEXT + 1) bit times after the end of the last stop bit. This applies even when the transmitter's RTS_B output is disabled and is only used internally to mask the receiver.
7-4 —	Reserved
3 RXMSK	Receive Mask Specifies whether the transmitter RTS_B masks the receive data pin. When enabled, the transmitter RTS_B masks the receive data pin.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Do not mask 1b - Mask
2 RXWRMSK	Receive FIFO Write Mask Specifies whether the transmitter RTS_B masks writes to the receive FIFO. When enabled, the transmitter RTS_B masks receive FIFO writes, but the idle flag is not affected. 0b - Do not mask 1b - Mask
1 RXSEL	Receive Select Specifies the receive data pin. When enabled, the receive data is sourced from the TXD pin. 0b - RXD 1b - TXD
0 TXSTALL	Transmit Stall Specifies whether the transmitter becomes busy when the receiver is active. When enabled, the transmitter does not become busy or asserts transmitter RTS_B when the receiver is active (STAT[RAF] is 1). 0b - No effect 1b - Does not become busy

79.6.20 Timeout Control (TOCR)

Offset

Register	Offset
TOCR	58h

Function

Configures the behavior of the timeout logic. Timeouts 0 and 1 are used to monitor the receiver and timeouts 2 and 3 are used to monitor the transmitter.

NOTE

Each module instance supports a different number of registers.

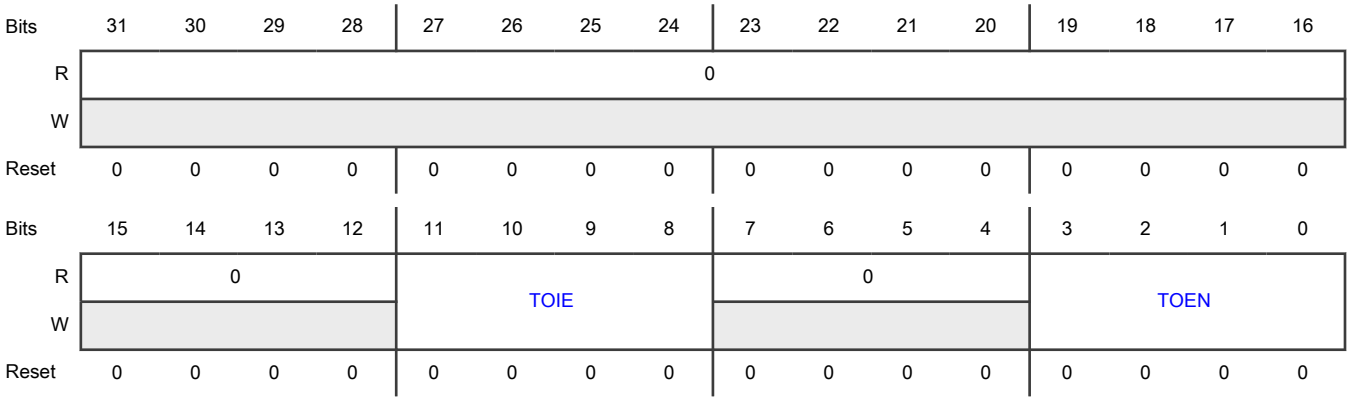
Instance	Register supported	Register not supported
LPUART_0	TOCR	—

Table continues on the next page...

Table continued from the previous page...

Instance	Register supported	Register not supported
LPUART_1	TOCR	—
LPUART_2	—	TOCR
LPUART_3	—	TOCR
LPUART_MSC	—	TOCR

Diagram



Fields

Field	Function
31-12 —	Reserved
11-8 TOIE	Timeout Interrupt Enable Enables the corresponding timeout flag to generate an interrupt.
7-4 —	Reserved
3-0 TOEN	Timeout Enable Enables the corresponding timeout counter.

79.6.21 Timeout Status (TOSR)

Offset

Register	Offset
TOSR	5Ch

Function

Indicates the status of the timeout logic. Timeouts 0 and 1 are used to monitor the receiver and timeouts 2 and 3 are used to monitor the transmitter.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
LPUART_0	TOSR	—
LPUART_1	TOSR	—
LPUART_2	—	TOSR
LPUART_3	—	TOSR
LPUART_MSC	—	TOSR

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				TOF				0				TOZ			
W					W1C											
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

Fields

Field	Function
31-12 —	Reserved
11-8 TOF	Timeout Flag Indicates whether the corresponding timeout occurred. The timeout counter is disabled when this field is 1. **NOTE** This field behaves differently for register reads and writes. When reading

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0000b - Not occurred 0001b - Occurred When writing 0000b - No effect 0001b - Clear the flag
7-4 —	Reserved
3-0 TOZ	Timeout Zero Indicates whether the corresponding timeout counter equals 0.

79.6.22 Timeout N (TIMEOUT0 - TIMEOUT3)

Offset

Register	Offset
TIMEOUT0	60h
TIMEOUT1	64h
TIMEOUT2	68h
TIMEOUT3	6Ch

Function

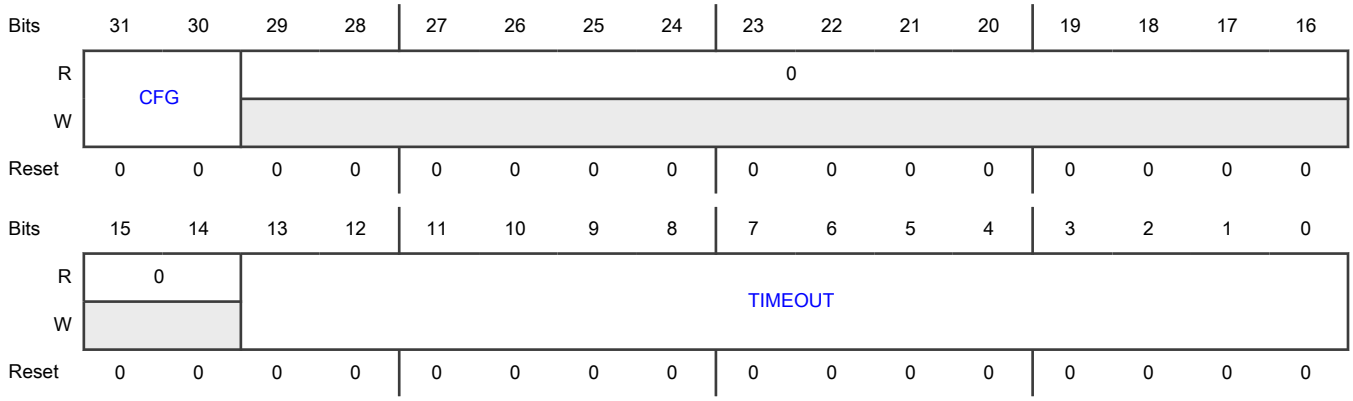
Configures the corresponding timeout counter and status field. Timeouts 0 and 1 are used to monitor the receiver and timeouts 2 and 3 are used to monitor the transmitter. You must write to this register only when the corresponding timeout is disabled or when the value of the corresponding timeout field is 1.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
LPUART_0	TIMEOUT0–TIMEOUT3	—
LPUART_1	TIMEOUT0–TIMEOUT3	—
LPUART_2	—	TIMEOUT0–TIMEOUT3
LPUART_3	—	TIMEOUT0–TIMEOUT3
LPUART_MSC	—	TIMEOUT0–TIMEOUT3

Diagram



Fields

Field	Function
31-30 CFG	Idle Configuration Configures the behavior of TIMEOUT[TIMEOUT]. 00b - Becomes 1 after timeout characters are received 01b - Becomes 1 when idle for timeout bit clocks 10b - Becomes 1 when idle for timeout bit clocks following the next character 11b - Becomes 1 when idle for at least timeout bit clocks, but a new character is detected before the extended idle timeout is reached
29-14 —	Reserved
13-0 TIMEOUT	Timeout Value Configures the timeout value.

79.6.23 Transmit Command Burst (TCBR0 - TCBR127)

Offset

For a = 0 to 127:

Register	Offset
TCBRa	200h + (a × 4h)

Function

Acts as an alias of Data (DATA), designed to support incrementing burst transfers to the transmit FIFO by a DMA controller, using aligned 8-bit, 16-bit, or 32-bit writes. The size of this register is 512 bytes:

- An aligned 32-bit write in this region pushes one entry into the transmit FIFO.
- An aligned 16-bit write in this region to TCBR*x*[15:0] pushes one entry into the transmit FIFO.

- An 8-bit write in this region to TCBR*x*[7:0] updates DATA[7:0], but does not push the data into the transmit FIFO.
- An 8-bit write in this region to TCBR*x*[15:8] pushes the data written to DATA[15:8] plus the previously written DATA[7:0] into the transmit FIFO.
- An 8-bit or 16-bit write in this region to TXBR*x*[31:16] is ignored.

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
LPUART_0	TCBR0–TCBR127	—
LPUART_1	TCBR0–TCBR127	—
LPUART_2	—	TCBR0–TCBR127
LPUART_3	—	TCBR0–TCBR127
LPUART_MSC	—	TCBR0–TCBR127

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	DATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 —	Reserved
15-0 DATA	Data Enables writing data to Data (DATA).

79.6.24 Transmit Data Burst (TDBR0 - TDBR255)

Offset

For a = 0 to 255:

Register	Offset
TDBRa	400h + (a × 4h)

Function

Acts as an alias of Data (DATA), designed to support incrementing burst transfers to the transmit FIFO by a DMA controller using 8-bit, 16-bit, or 32-bit writes. The size of this register is 1024 bytes:

- An aligned 32-bit write in this region pushes four DATA byte entries into the transmit FIFO (DATA0 byte first). The register access is extended by three wait states.
- An aligned 16-bit write in this region to either half of a 32-bit word pushes two DATA byte entries into the transmit FIFO (DATA0 or DATA2 first). The register access is extended by one wait state.
- An 8-bit write in this region pushes one DATA byte entry into the transmit FIFO.

Byte writes to Data (DATA) use the contents of CTRL[R9T8] for the ninth data bit, CTRL[R8T9] for the tenth data bit, and zero extend DATA[FRETSC].

NOTE

Each module instance supports a different number of registers.

Instance	Register supported	Register not supported
LPUART_0	TDBR0–TDBR255	—
LPUART_1	TDBR0–TDBR255	—
LPUART_2	—	TDBR0–TDBR255
LPUART_3	—	TDBR0–TDBR255
LPUART_MSC	—	TDBR0–TDBR255

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R																
W	DATA3								DATA2							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R																
W	DATA1								DATA0							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 DATA3	Data3 Enables writing of data to Data (DATA).
23-16 DATA2	Data2 Enables writing of data to Data (DATA).
15-8 DATA1	Data1 Enables writing of data to Data (DATA).
7-0 DATA0	Data0 Enables writing of data to Data (DATA).

79.7 Glossary

Baud rate Number of bits per second that LPUART transmits or receives

Break character Break character is generated when the transmitter is holding the data line at the space level for at least one character time

Oversampling Number of times the receive circuitry samples the receive input per baud period (that is, per data bit)

Chapter 80
Quad Serial Peripheral Interface (QuadSPI)

80.1 Chip-specific QuadSPI information

80.1.1 QuadSPI configuration

Table 685. QuadSPI configuration details

QuadSPI Tx FIFO size	256 words
QuadSPI Rx FIFO size	32 words
Look Up Table Size	16 words
AHB Buffer Size	1024 Bytes

NOTE

Boot from QuadSPI is not supported but execution from external memory is supported.

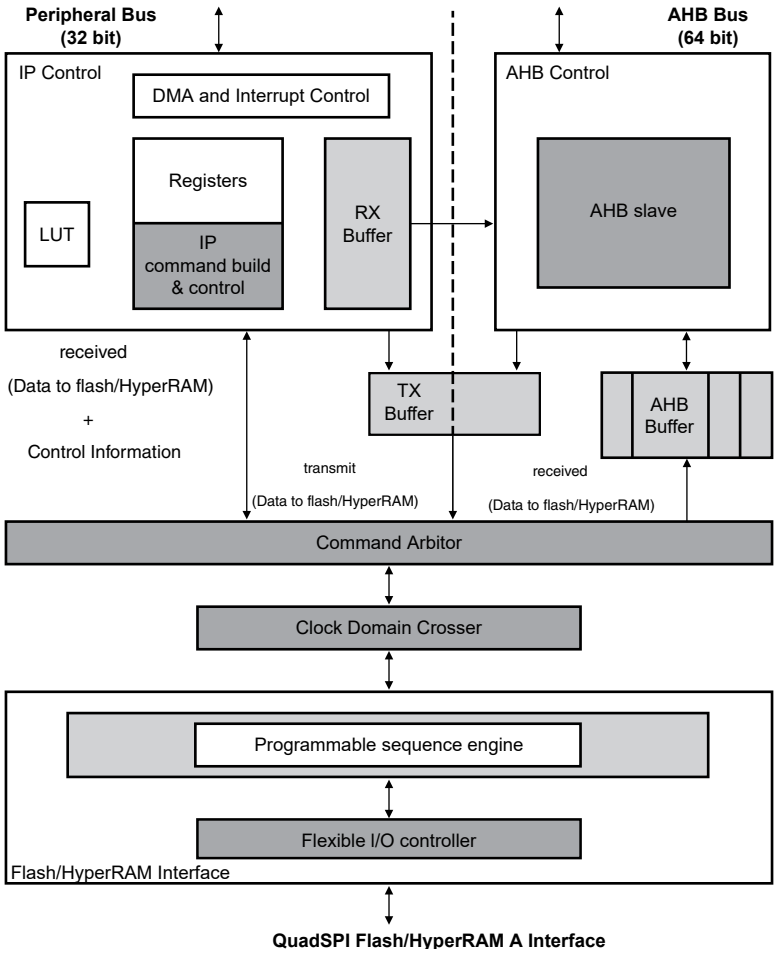


Figure 601. Block diagram

80.1.2 Supported read modes

The table below provides an overview of the QuadSPI read modes.

Table 686. QuadSPI read modes

QSPI Instance	Frequency (MHz)	Slave delay chain Setting (DLL)	Slave delay chain Setting (Tap selection)	DQS setting
QSPI	120	DDR	ON	External
QSPI	120	SDR	ON	Dummy pad loopback
QSPI	120	SDR	OFF	Dummy pad loopback

80.1.3 QuadSPI initialization sequence

Following initialization sequence should be followed for proper QuadSPI operation:

- Enable QuadSPI module by MC_ME peripheral clock enable (register PRTNx_COFBy_CLKEN present within MC_ME). Refer MC_ME chapter for peripheral mapping.
- Configure the SIUL2 registers MSCR[OBE] as 1 and MSCR[SSS] as 0 for QuadSPI_SCKFA pin.
- Initialize QuadSPI SCKFA by writing a sequence of 1010 to the SIUL2 register GPDO[PDO_a] for QuadSPI_SCKFA pin.
- Configure the SIUL2 register MSCR[OBE] back as 0 for the pins.
- Initiate a dummy flash/HyperRAM read to reset all DQS flops by itself and any crossing from DQS domain to IPS/AHB is taken care by CDC logic.
- Initiate a peripheral software reset to QuadSPI controller by writing to QuadSPI controller's MCR.
- Post this initialization sequence, the QuadSPI will work in intended deterministic manner.

NOTE

QuadSPI initialization is to be done before using QuadSPI after each functional reset.

80.1.4 Pad clock loopback

This chip supports pad clock loopback. The QuadSPI can be configured to use clock loopback to sample input data. SCK is delayed by the SCK pin output delay, plus the SCK pin input delay using pad loopback, and is configured by setting QuadSPI config registers SOCCR[SOCCFG] and MCR[DQS_FA_SEL]. Enabling the loopback version of SCK can improve the setup time of the input data from the Flash/HyperRAM.

For details of these register, see QuadSPI register descriptions.

80.1.5 QuadSPI SOC Configuration register SOCCR[SOCCFG] implementation

The QuadSPI SOC Configuration register QuadSPI_SOCCR[SOCCFG] register is used to control dummy loopback pads and obe_pull_timing_relax_b. Below is the description of it's bits:

Table 687. SOCCR[SOCCFG] implementation

Bit	Description
Bit[0]	obe_pull_timing_relax_b : enables the timing relaxation by pulling obe for pad 1 for half cycle, if 0 then enabled else disabled.

Table continues on the next page...

Table 687. SOCCR[SOCCFG] implementation (continued)

Bit[1]	ibe of QSPIA_SCK_DUMMY pad. 0: Disable input receiver 1: Enable input receiver.
Bit[2]	obe of QSPIA_SCK_DUMMY pad. 0: Disable output driver 1: Enable output driver.
Bit[3]	dse of QSPIA_SCK_DUMMY pad. 0: Disable drive strength 1: Enable drive strength.
Bit[4]	pue of QSPIA_SCK_DUMMY pad. 0: Disable internal pullup or pulldown resistor 1: Enable internal pullup or pulldown resistor.
Bit[5]	pus of QSPIA_SCK_DUMMYpad. 0: Enable internal pulldown resistor if pue is set 1: Enable internal pullup resistor if pue is set.
Bit[6]	sre of QSPIA_SCK_DUMMY pad. 0: Disable slew rate control 1: Enable slew rate control.
Bit[31:7]	Reserved

To Enable the Quadspi dummy PAD loopback use following settings

For Flash/HyperRAM-A: MCR[DQS_FA_SEL] = 0x2

SOCCR[SOCCFG] = 0x0000000E (ibe=1, obe=1, dse=1 and sre=0)

NOTE

This SoC does not support dual die flashes. Hence, the signal PCSFA2 from QuadSPI is not used.

80.1.6 Master ID mapping

See the chip-specific XRDC information for details on the master IDs.

80.2 Introduction

The QuadSPI module acts as an interface to a single serial flash memory device, with up to eight bidirectional data lines.

80.2.1 Features

QuadSPI supports the following features:

- Flexible sequence engine to support various flash memory vendor devices. As there is no specific standard, the module supports various kinds of flash memories from different vendors. See Serial flash memory devices for example sequences.
- Single, dual, and quad modes of operation supported for Quad flash memories
- Octal and single IO modes of operation supported for Octal flash memories
- Double Data Rate (DDR)/Double Transfer Rate (DTR) mode in which the data is generated on every edge of the serial flash memory clock
- Flash memory data strobe signal to support data sampling in DDR and Single Data Rate (SDR) mode
- Support for HyperFlash memory
- Support for HyperRAM
- Support for Macronix Octal Data integrity features such as ECC and R/W parity (CRC1)
- AHB master to read RX buffer data through AMBA AHB (64-bit width interface) or IPS registers space (32-bit access) and fill TX buffer via IPS registers space (32-bit access) or using AHB (64-bit width interface)
  - AHB master can be a DMA with a configurable inner loop size
- Multi-master accesses are allowed
  - Flexible and configurable buffer for each master—total available buffer size is 1024 bytes.

- All AHB accesses to flash/RAM memory devices are directly memory mapped to the chip system memory
- Programmable sequence engine to cater to future command/protocol changes and ability to support all existing vendor commands and operations. The software needs to select the corresponding sequence according to the connected flash memory device.
  - Support for all types of addressing

80.2.2 RX buffer push event

To add the valid entries into the RX buffer

By default, each buffer push event adds two entries to the RX buffer because the interface to the serial clock domain is 64 bits in width. Depending on the number of bytes read from the serial flash memory device, it is possible for the very last buffer push event that only one entry is added.

RBSR[RDBFL] is incremented by the number of entries added to the RX buffer.

80.2.3 RX buffer POP event

To remove valid entries from the RX buffer

Each buffer POP event removes (RBCT[WMRK] + 1) valid entries from the buffer. BSR[RDBFL] is decremented by the same number and RBSR[RDCTR] is incremented accordingly.

80.2.4 Block diagram

The following figure shows a block diagram of the QuadSPI module.

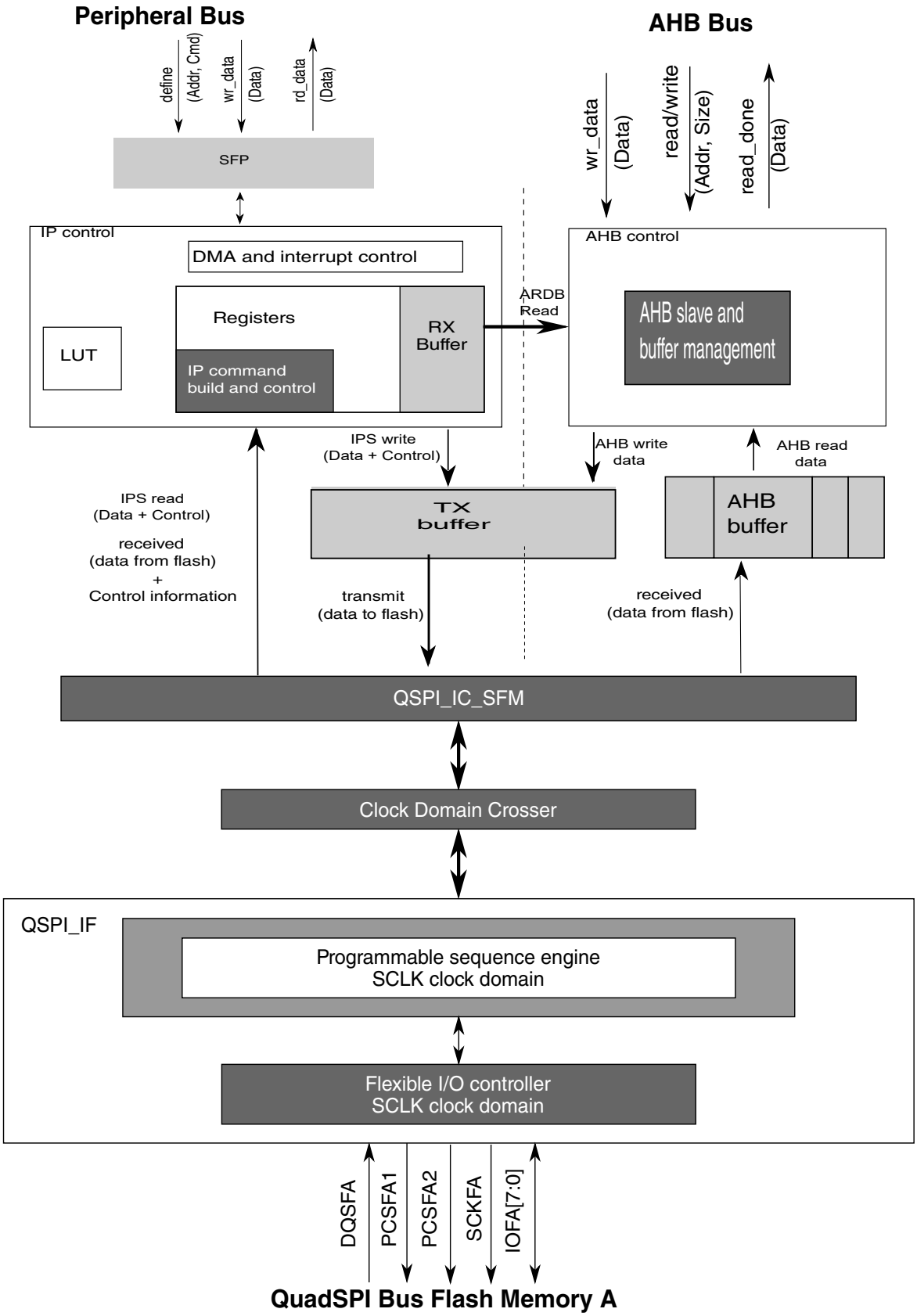


Figure 602. QuadSPI block diagram

80.2.5 QuadSPI modes of operation

QuadSPI supports the following modes of operation:

- Normal mode: You can use this mode for write or read accesses to an external serial flash memory device. See Normal mode for details.
  - Serial flash memory write: You can program data into the flash memory through the IP interface only. See Flash memory programming for details.
  - Serial flash memory read: Read the contents of the serial flash memory device. Two separate read channels are available through the RX buffer and AHB buffer. See Flash memory read for details.
- Module Disable mode: You can use this mode for disabling serial flash memory clock and AHB command. The clock to the non-memory mapped logic in QuadSPI can be stopped in the Module Disable mode. The module enters the mode by setting MCR[MDIS].

80.3 External signal description

This section provides the external signal information for the QuadSPI module.

The following table lists the external signals belonging to the module in conjunction with the different modes of operation.

Table 688. Signal properties

Signal name	Function	Direction	Description
PCSFA1	Peripheral Chip Select Flash Memory A1	O	This signal is the chip select for the serial flash memory device A1 that represents the first of the two flash memory devices that share IOFA.
PCSFA2	Peripheral Chip Select Flash Memory A2	O	This signal is the chip select for the serial flash memory device A2 that represents the second of the two flash memory devices that share IOFA.
SCKFA	Serial Clock Flash Memory A	O	This signal is the serial clock output to the serial flash memory device A.
IOFA[7:0]	Serial I/O Flash memory A	I/O	These signals are the data I/O lines to/from the serial flash memory device A. See Driving external signals for details about the signal drive and timing behavior. Note that the signal pins of the serial flash memory device may change their function according to the SFM Command executed, leaving them as control inputs when single and dual instructions are executed. The module supports driving these inputs to dedicated values. In single I/O mode, QuadSPI drives data on IOFA[0] and expects data on IOFA[1].
DQSFA	Data Strobe signal Flash Memory A	I/O	This is the data strobe signal for port A. Some flash memory vendors provide the Data Read Strobe (DQS) signal to which the read data is aligned in DDR mode. It is also provided as an output signal during write data phase.
INTA	ECC error signal for Flash Memory A	I	Flash Memory A drives this signal to active low value in case of an ECC error.

NOTE

Please refer to chip specific information to check the configuration of QuadSPI block.

80.3.1 Driving external signals

Single/dual/quad/octal instructions

Depending on the serial flash memory device connected to the QuadSPI module, there are instructions using a different number of data lines:

- Single pad: Single line I/O with one data out and one data in line to/from the serial flash memory device
- Dual pad: Dual line I/O with two bidirectional I/O lines, driven alternatively by the serial flash memory device or the QuadSPI module
- Quad pad: Quad line I/O with four bidirectional I/O lines, driven alternatively by the serial flash memory device or the QuadSPImodule
- Octal pad: Octal line I/O with eight bidirectional I/O lines, driven alternatively by the serial flash memory device or the QuadSPI module

The different phases of the serial flash memory access scheme are shown in the following figure.

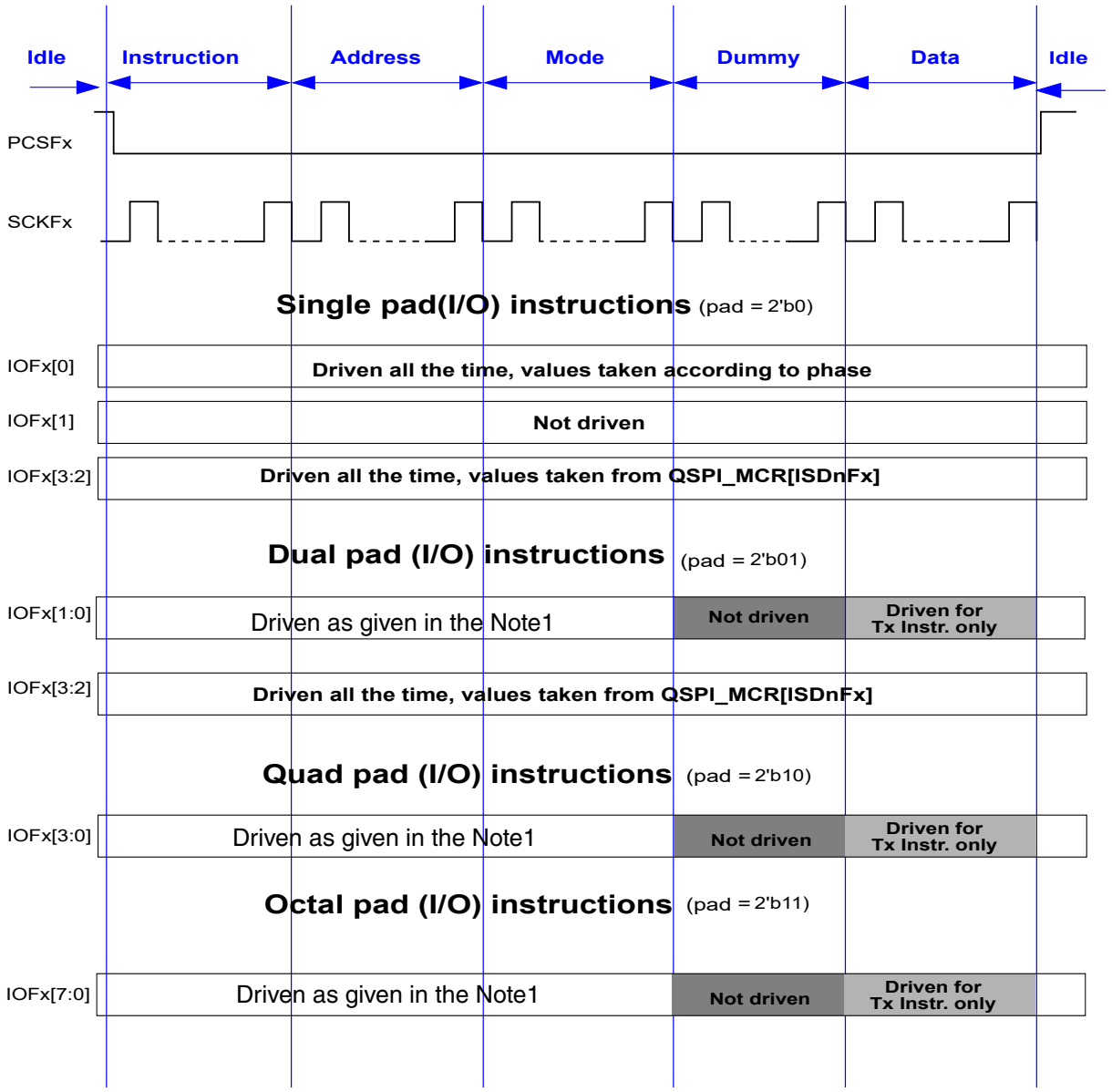


Figure 603. Serial flash memory access scheme

Note1:The IOs are driven from QuadSPI as per the number of pads configured for ongoing phase.

Note:The lines status will change based on command mode in case of instruction, address and mode phases. It can be either 1,2 or 4 lines

Following are the different phases and the I/O driving characteristics of the QuadSPI module:

- Idle: Serial flash memory device not selected – no interaction with the serial flash memory device and the IOFx signals are driven.
- Instruction: Serial flash memory device selected – the instruction is sent to the serial device and all the IOFx signals are driven.
- Address: Serial flash memory address is sent to the device – all the IOFx signals are driven and this phase is not applicable for all SFM commands.
- Mode: Mode bytes are sent to the serial flash memory device – all the IOFx signals are driven and this phase is not applicable for all SFM commands.
- Dummy: Dummy clocks are provided to the serial flash memory device. See Figure 603 for the IOFx signals driven. The actual data lines required for the SFM command executed are not driven for data read commands.

NOTE

— This phase is not applicable for all the SFM commands.

— All read commands in Dual pad, Quad pad /or Octal pad modes must use a Dummy phase immediately before the Data phase. The Dummy phase pad configuration in the LUT must use the same number of pads as the subsequent Data phase. Note that this restriction is not applicable to Single-pad mode.

- Data: Serial flash memory data are sent to or received from the serial flash memory device. See the preceding figure for the IOFx signals driven. The actual data lines required for the SFM command executed are not driven for data read commands.

NOTE

This phase is not applicable for all the SFM commands.

The PCSFx and SCKFx signals are driven permanently throughout all the phases. In the individual flash memory mode, this applies to the selected flash memory device.

Access to a single, individual serial flash memory device

See Serial flash memory access schemes for details.

Read access to two serial flash memory devices attached to the QuadSPI module in parallel. See Serial flash memory access schemes for details.

80.4 Functional description

This section provides a functional description of the QuadSPI module.

80.4.1 Serial flash memory access schemes

In the individual flash memory mode, all supported commands are available.

80.4.2 Normal mode

This mode allows communication with an external serial flash memory device. Compared to the standard SPI protocol, this communication method uses up to eight bidirectional data lines operating at high-data rates. The communication to the external serial flash memory device consists of an instruction code and optional address, mode, dummy, and data transfers. The flexible programmable core engine described below is immune to a wide variety of command or protocol differences in the serial flash memory devices provided by various flash memory vendors.

80.4.2.1 Programmable sequence engine

The core of the QuadSPI module is a programmable sequence engine that works on "instruction-operand" pairs. The core controller executes each programmed instruction sequentially. The complete list of instructions and the corresponding operands are provided in the following table.

Table 689. Instruction set

Instruction	Instruction encoding	Pins	Operand	Action on serial flash memories
CMD	1d	N={0,1,2,3}d 0d - One pad 1d - Two pads 2d - Four pads 3d- Eight pads	8-bit command value	Provides the serial flash memory with the SFM command operand (Encoded) on the number of pads specified in STR mode.
ADDR	2d		Number of address bits to be sent (for example, 24d => 24 address bits required)	Provide the serial flash memory with address cycles according to the operand on the number of pads specified The actual address to be provided is derived from the incoming address in case of AHB-initiated transactions and the value of SFAR in case of IPS-initiated transactions, if the value of SFACR[CAS] is set to 0. Otherwise, the actual address takes CAS into consideration.
DUMMY	3d		Number of dummy clock cycles (should be <= 64 and > 2 cycles)	Provide the serial flash memory with dummy cycles according the operand The PAD information defines the number of pads in input mode. For example, one pad implies that pad 1 is not driven, rest all are driven. **NOTE** If DLL is enabled and N dummy cycles are needed, you must program two back-to-back DUMMY instructions: DUMMY: N-2 followed by DUMMY:2.
MODE	4d		8-bit mode value	Provide the serial flash memory with 8-bit operand on the number of pads specified
MODE2	5d	N={0,1}d	2-bit mode value	Provide the serial flash memory with 2-bit operand on the number of pads[1] specified
MODE4	6d	N={0,1,2}d	4-bit mode value	Provide the serial flash memory with 4-bit operand on the number of pads[2] specified
READ	7d	N={0,1,2,3}d 0d - One pad 1d - Two pads 2d - Four pads 3d- Eight pads	Read data size in bytes (for AHB transactions, your application should ensure that data size is a multiple of 8 bytes)	Read data from flash memory on the number of pads specified The data size can be overwritten by writing to the ADATSZ field of the BUFxCR registers for AHB-initiated transactions and to the IDATSZ field of the IP Configuration Register (IPCR) for IPS-initiated transactions.
WRITE	8		Write data size in bytes	Write data on the number of pads specified The data size can be overwritten by writing to the IDATSZ field of IP Configuration Register (IPCR).

Table continues on the next page...

Table 689. Instruction set (continued)

Instruction	Instruction encoding	Pins	Operand	Action on serial flash memories
JMP_ON_CS [3]	9d	NA	Instruction number	Every time the CS is deasserted, jump to the instruction pointed to by the operand. This instruction allows the programmer to specify the behavior of the controller when a new read transaction is initiated following a CS deassertion. **NOTE** This instruction is not supported if DLL is enabled.
ADDR_DDR	10d	N={0,1,2,3}d 0d - One pad 1d - Two pads 2d - Four pads 3d- Eight pads	Number of address bits to be sent (for example, 24d => 24 address bits required)	Provide the serial flash memory with address cycles according to the operand on the number of pads specified at each clock edge of serial flash memory clock. The actual address to be provided is derived from the incoming address in case of AHB-initiated transactions and the value of SFAR in case of IPS-initiated transactions if SFACR[CAS] is set to 0. Otherwise, the actual address takes CAS into consideration.
MODE_DDR	11d		8-bit mode value	Provide the serial flash memory with 8-bit operand on the number of pads specified at each clock edge of serial flash memory
MODE2_DDR	12d	N={0}d	2-bit mode value	Provide the serial flash memory with 2-bit operand on the number of pads specified at each clock edge of serial flash memory [4]
MODE4_DDR	13d	N={0,1}d	4-bit mode value	Provide the serial flash memory with 4-bit operand on the number of pads specified at each clock edge of serial flash memory [5].
READ_DDR	14d	N={0,1,2,3}d 0d - One pad 1d - Two pads 2d - Four pads 3d - Eight pads	Read data size in bytes (for AHB transactions, the application should ensure that data size is in multiple of 8 bytes)	Read data from flash memory on the number of pads specified at each clock edge of serial flash memory. The data size might be overwritten by writing to the ADATSZ field of the BUFxCR registers for AHB-initiated transactions and IDATSZ field of IP Configuration Register (IPCR) for IP initiated transactions.
WRITE_DDR	15d		Write data size in bytes	Write data on the number of pads specified at each clock edge of serial flash memory The data size can be overwritten by writing to the IDATSZ field of IP Configuration Register (IPCR).
DATA_LEARN	16d	N={0,1,2,3}d 0d - One pad	Operand[7]-	Find the correct sampling point with the data learning pattern.

Table continues on the next page...

Table 689. Instruction set (continued)

Instruction	Instruction encoding	Pins	Operand	Action on serial flash memories
		1d - Two pads 2d - Four pads 3d- Eight pads	• 1 - DDR mode • 0 - SDR mode Operand[6:0]- • Number of bits to be used for data learning. For example, if operand is 16 then a 16-bit data learning pattern is read and compared.	When this instruction is encountered, the value of Sampling Register (SMPR) is ignored and the controller finds the correct sampling point on its own by sampling the data learning pattern.[6]
CMD_DDR	17d	N={0,1,2,3}d 0d - One pad 1d - Two pads 2d - Four pads 3d- Eight pads	8-bit command value	Provides the serial flash memory with the SFM command operand (Encoded) on the number of pads specified in DTR mode.
CADDR	18d		Number of column address bits to be sent (8d means 8 bits of column address is to be sent)	Provide the serial flash memory with column address cycles according to the operand on the number of pads specified. The actual address to be provided to flash memory depends on the value of SFACR[CAS]. For example, if the value of SFACR[CAS] is 3, then the address to flash memory will be [2:0] of incoming address in case of AHB and the value of SFAR in case of IP. This is appended with 0 if SFACR[CAS] is less than number of pads for a flash memory.
CADDR_DDR	19d		Number of column address bits to be sent(8d means 8 bits of column address is to be sent)	Provide the serial flash memory with column address cycles according to the operand on the number of pads specified at each clock edge of the serial flash memory. The actual address to be provided to flash memory depends on the value of SFACR[CAS]. For example, if CAS is 3, then the address to flash memory will be [2:0] of incoming address in case of AHB and the value of SFAR in case of IP. This is appended with 0 if CAS is less than the number of pads for a flash memory.
JMP_TO_SEQ[3]	20d	NA	Sequence number	Every time CS is deasserted, jump to the LUT sequence is pointed to by the operand. This instruction allows the programmer to join two sequences and initiates the second

Table continues on the next page...

Table 689. Instruction set (continued)

Instruction	Instruction encoding	Pins	Operand	Action on serial flash memories
				flash memory transaction automatically. It can be used to join write-enables with flash memory write or data learn with read. **NOTE** This instruction is not supported if DLL is enabled.
STOP[3]	0d	NA	NA	Stop execution; deassert CS

1. For a one-pad instruction, MODE2 takes two serial flash memory clock cycles on the flash memory interface.
2. For a one-pad instruction, MODE4 takes four serial flash memory clock cycles on the flash memory interface. For a four-pad instruction, MODE4 takes one serial flash memory clock cycle on the flash memory interface.
3. Sequence ending with this instruction must have all remaining bits as 0s after it.
4. For a one-pad instruction, MODE2_DDR takes one serial flash memory clock cycle on the flash memory interface.
5. For a one-pad instruction, MODE4_DDR takes two serial flash memory clock cycles on the flash memory interface. For a four-pad instruction MODE4_DDR takes half a cycle on the serial flash memory interface.
6. It is not recommended to have 0h or FFh as the data learning pattern.

The programmable sequence engine allows you to configure the QuadSPI module according to the serial flash memory connected on board. This flexible structure is compatible with new command or protocol changes from different vendors.

80.4.2.2 Flexible read xAHB buffers

To reduce the latency of the reads for AHB masters, the data read from serial flash memory is buffered in flexible AHB buffers. There are four such flexible buffers. The size of each of these buffers is configurable with the minimum size being 0 bytes and maximum size being the size of the complete buffer instantiated (1024 bytes). The size of buffer 0 ranges from 0 to BUF0IND. The size of buffer 1 ranges from BUF0IND to BUF1IND, buffer2 from BUF1IND to BUF2IND and, buffer 3 ranges from BUF2IND to the size of the complete buffer (1024 bytes).

Each flexible AHB buffer is associated with the following:

- An AHB master: Optionally, buffer3 may be configured as an "all master" buffer by writing 1 to BUF3CR[ALLMST]. When buffer3 is configured in such a way, any access from a master not associated with any other buffer is routed to buffer3.
- A datasize field representing the amount of data to be fetched from the flash memory on every missed access.

The master ID of every incoming request is checked and the data is returned or fetched into the corresponding associated buffer. See the chip-specific QuadSPI information for details about master IDs and their corresponding components. Every missed access to the buffer causes the controller to clear the buffer and fetch the BUFxCR[ADATSZ] amount of data from the serial flash memory. As such, you need not configure the buffer size to be greater than ADATSZ because the locations greater than ADATSZ are never used. For any AHB access, the sequence pointed to by BFGENCR[SEQID] is used for the initiated flash memory transaction. The data is returned to the master as soon as the requested amount is read from the serial flash memory. The controller; however, continues to prefetch the rest of the data in anticipation of a next consecutive request. See Figure 604 that shows flexible AHB buffers.

BFGENCR[SEQID] points to an index of the LUT. See LUT for details.

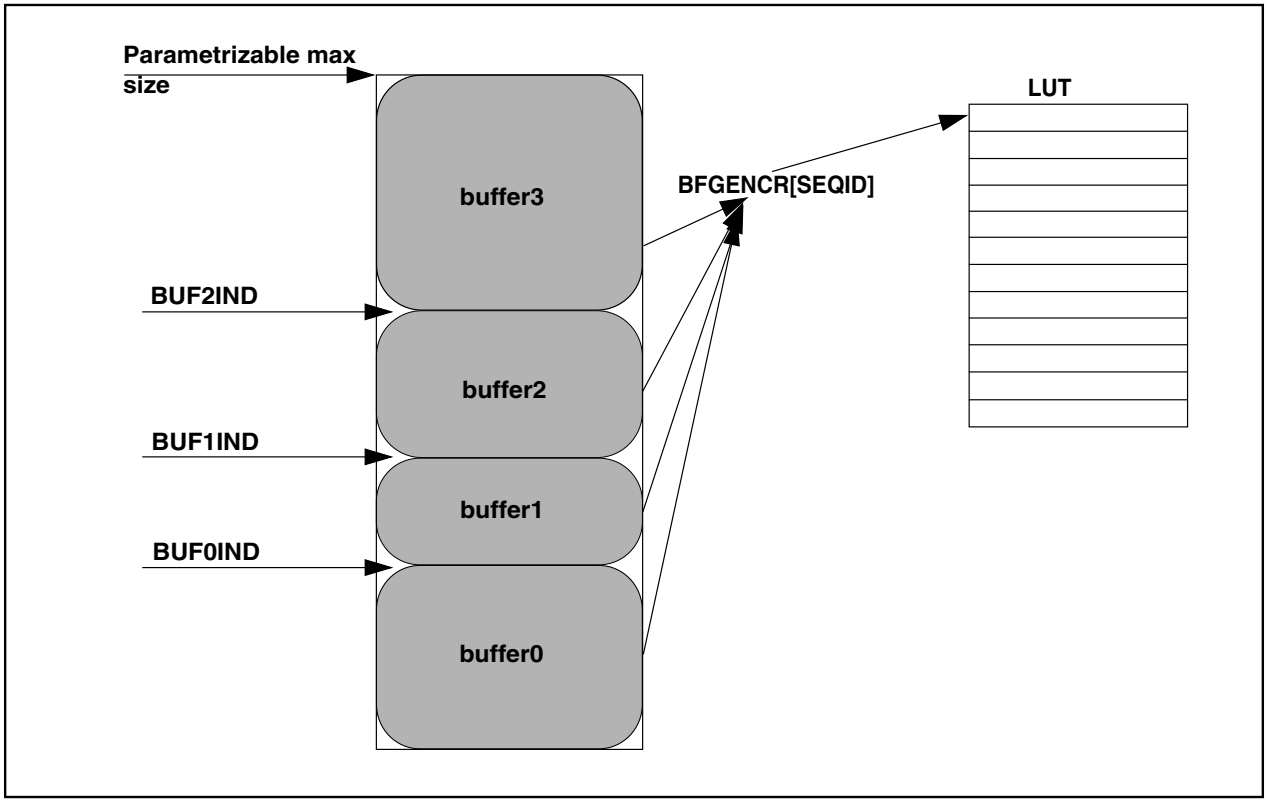


Figure 604. Flexible read AHB buffers

80.4.2.3 Abort mechanism during AHB read

Any ongoing read transaction is aborted if a request from the same master arrives for a location other than the location at which the transaction is going on. The abort can happen at any point of time.

80.4.2.4 HBURST support with AHB read

QuadSPI controller supports HBURST and HSIZE on the AHB read interface. HBURST indicates if the transfer forms part of a burst. Four, eight, and sixteen beat bursts are supported and the bursts might either be incrementing or wrapping. HSIZE indicates the size of the transfer, and supports 8-, 16-, 32-, and 64-bit data sizes. In case of WRAP accesses, QuadSPI generates aligned accesses to serial flash memory if there is no buffer hit for any incoming, non-sequential AHB read access. In case there is a buffer hit, the incoming address in the haddr line is latched as it is. If the total burst size is more than the data prefetch size, an error response is generated and the value of FR[AIBSEF] is configured as 1. The data prefetch size can be defined by BUFxCR[ADATSZ] or data size mentioned in the sequence pointed to by the SEQID field when ADATSZ is programmed as 0. In case of wrap burst, data prefetch size must be greater than or equal to the wrap burst size + 32 bytes. A few examples are shown in the figure below:

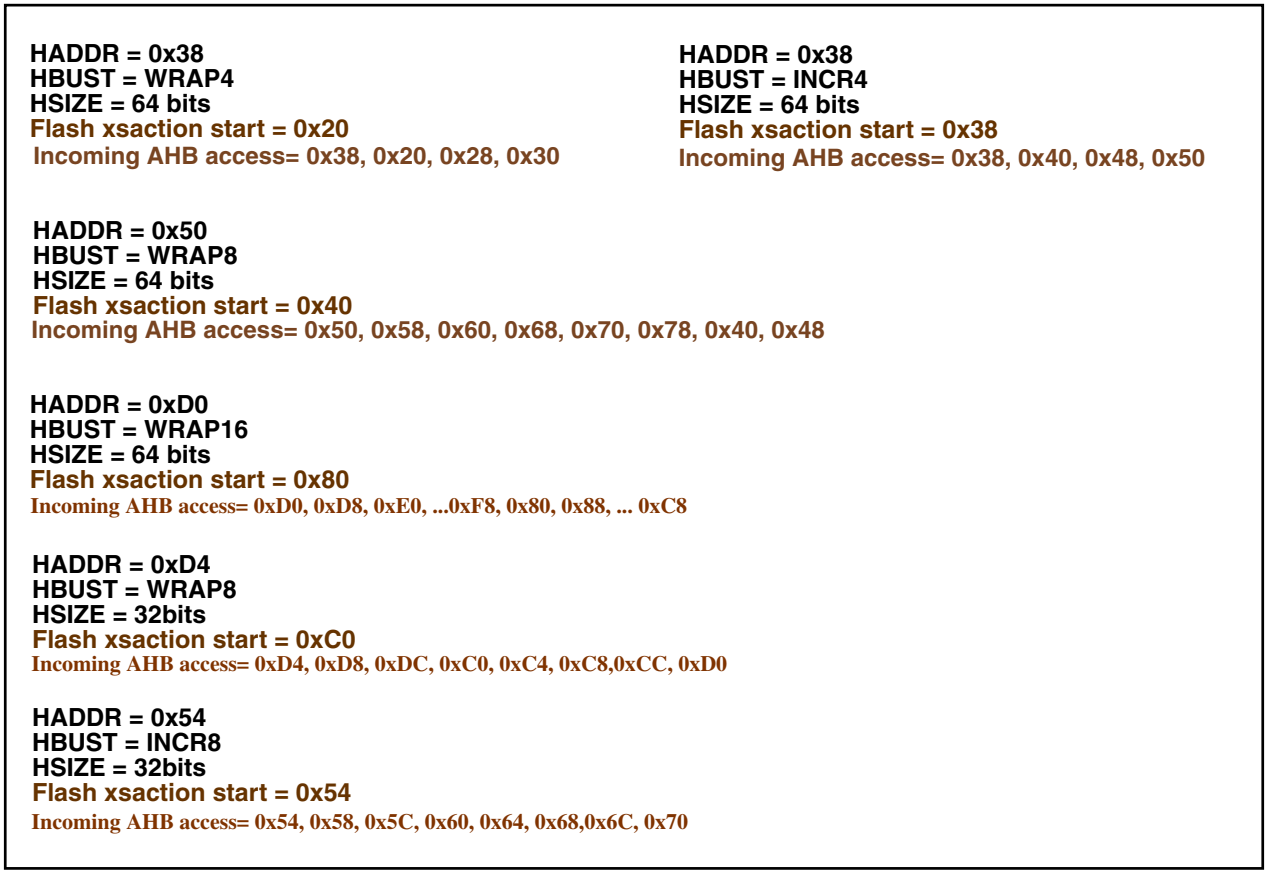


Figure 605. QuadSPI HBURST support

NOTE

The software must take care that the prefetch size should never be set less than the minimum data needed by any external interface to start processing.

NOTE

Whenever a core accesses QuadSPI memory with cache enabled, the prefetch size must be configured as equal or more than the cache line size; otherwise, FR[AIBSEF] error appears.

80.4.2.5 LUT

The LUT consists of a number of pre-programmed sequences. Each sequence is basically a sequence of instruction-operand pairs, which when executed sequentially, generate a valid serial flash memory transaction. Each sequence can have a maximum of 10 instruction-operand pairs. The LUT can hold a maximum of 16 sequences. The figure below shows the basic structure of the sequence in the LUT.

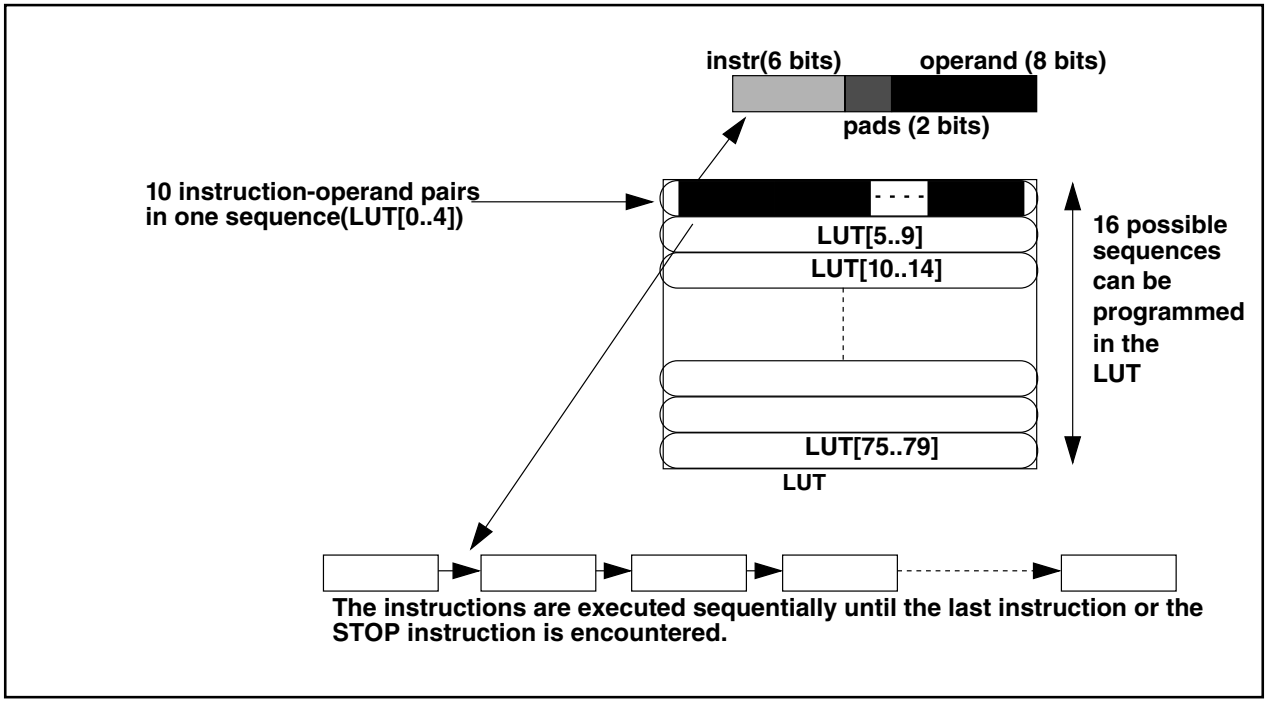


Figure 606. LUT and sequence structure

At reset, the index 0 of the LUT[0..4] is programmed with a basic read sequence as described in Reset sequence. After reset, the complete LUT may be reprogrammed according to the chip connected on board. To protect its contents, during a code runover, the LUT might be locked, after which a write to the LUT will not be successful until it has been unlocked again. The key for locking or unlocking the LUT is 5AF05AF0h, and the associated processes are as follows:

Locking the LUT

1. Write the key 5AF05AF0h into the LUT Key Register (LUTKEY).
2. Write 0b01 to the LUT Lock Configuration Register (LCKCR). Note that this IPS transaction should immediately follow the above IPS transaction (no other IPS transaction can be issued). A successful write to this register locks the LUT.

Unlocking the LUT

1. Write the key 5AF05AF0h into the LUT Key Register (LUTKEY).
2. Write 0b10 to the LUT Lock Configuration Register (LCKCR). Note that this IPS transaction should immediately follow the above IPS transaction (no other IPS transaction can be issued in between). A successful write to this register unlocks the LUT.

The lock status of the LUT can be read from the LCKCR[UNLOCK] and LCKCR[LOCK] fields.

Some example sequences are defined in Example sequences. After reset the instruction sequence 0 is populated with the default read sequence shown in the table below.

Table 690. Reset sequence

Instruction	Pad	Operand	Comment
CMD	0h	3h	Read data byte command on one pad
ADDR	0h	18h	24 address bits to be sent on one pad

Table continues on the next page...

Table 690. Reset sequence (continued)

Instruction	Pad	Operand	Comment
READ	0h	8h	Read 64 bits
JMP_ON_CS	0h	0h	Jump to instruction 0 (CMD)

NOTE

If DLL is disabled then JMP_ON_CS or STOP instruction can be used else only STOP instruction can be used.

80.4.2.6 Issuing SFM commands

Each access to the external device follows this sequence:

1. You must pre-populate the LUT with the serial flash memory command sequences that are required for the flash memory device being used.
2. The module executes the instructions in this sequence one by one. The transaction starts and the module configures the value of SR[BUSY].
3. Communication with the external serial flash memory device starts and the transaction executes.
4. After the transaction is complete (all transmit and receive operations with the external serial flash memory device are complete), the module resets SR[BUSY]. In case of an IP command, FR[TFF] is asserted.

For details, see Flash memory programming and Flash memory read.

You can trigger the processing of SFM commands in the QuadSPI module in one of the following ways:

Using IP commands

For IP commands, the required components need to be written into the following registers and in this sequence:

1. Write the serial flash memory address to be used as provided in the Serial Flash Address Register (SFAR). For IP commands not related to specific addresses, the base address of the related flash memory needs to be programmed. For example, for an instruction which does not require an address (that is, write enable instruction), the SFAR should be programmed with the base address of the memory the command is to be sent to.
2. Write the sequence ID and data size details in the IP Configuration Register (IPCR).
3. Note that writing a value to IPCR[SEQID] must be the last step of the sequence. It is possible to combine all the fields of the IPCR into one single write. See IP Configuration Register (IPCR) for details.

Using AHB commands

Any AHB memory-mapped access is routed to one of the buffers depending on the master ID of the request. If the access is a "miss," a new serial flash memory transaction is initiated. The transaction is based on the sequence pointed to by BFGENCR[SEQID] as described in Flexible read xAHB buffers.

An AHB access is considered memory mapped when the access is to the memory-mapped serial flash memories, as described in Memory Mapped Serial Flash Data - Individual Flash mode on Flash memory A.

80.4.2.7 Flash memory programming

In all NOR Flash devices memory sector to be written needs to be erased first. The programming sequence is then initiated in the following way:

1. Program the FRAD and MDAD registers.
2. Program the address related to the command in SFAR (with access attributes programmed in MDAD). If required, write the desired value to SFACR[CAS], otherwise write 0 to it. Also, write 1 to SFACR[WA] if the serial flash memory is a word addressable flash memory, or write 0 in case serial flash memory is byte addressable

3. Program the IPCR register (with access attributes programmed in MDAD). IPCR[SEQID] should point to an index of the LUT that has the flash memory program sequence pre-programmed. Write an appropriate value to IPCR[IDATSZ] to denote the size of the write in bytes.
4. Check FSM Status (FSMSTAT) register to know status of current transaction. Valid[31] bit should be '1' and domain ID [11:8] should match the ID with which SFAR and IPCR were written. Program the TX watermark in TBCT[WMRK] field and wait for STAT[1:0] bits to turn '01'.
5. Check that the TX buffer is empty. If you need to discard the data present in the TX buffer (SR[TXEDA]) field is set, then the TX buffer must be cleared by writing 1 to MCR[CLR_TXF].
6. Provide data for the program command into the circular buffer through the TBDR. Once the TX buffer is written till watermark level and SR[TXWA] flag is de-asserted this IP command will be triggered. FSMSTAT[STAT] will get set to 10.
7. Repeat step 3, depending on the amount of data required, until all of the required data is written to the TBDR. SR[TXFULL] can be used to check if the buffer is ready to receive more data. At any time, TBSR[TRCTR] can be read to check how many words have been written into the TX buffer.
8. Once the transaction completes FSMSTAT[VLD] bit will set to 0, SR[BUSY] is reset and FR[TFF] is asserted. Please refer to section Secure flash programming for more details.

After writing to IPCR[SEQID] , the module starts executing the programmed sequence when QuadSPI SFM is IDLE. The software ensures that the correct sequence is programmed into the LUT in accordance with the flash memory connected to the module. The data is fetched from the TX buffer. It consists of 256 entries of 32-bit sizes and is organized as a circular FIFO, the read pointer for which is incremented after each fetch. When all the data is transmitted, the QuadSPI module returns from the busy state to the idle state. However, this is not true for the external device because the internal programming is still ongoing. You may monitor the relevant status information available from the serial flash memory device and ensure that the programming is done appropriately.

80.4.2.8 Flash memory read

Host access to the data stored in the external serial flash memory device is performed in two steps. First, the data must be read into the internal buffers and in the second step, these internal buffers can be read by the host.

Reading serial flash memory data into the QuadSPImodule internal buffers

A read access to the external serial flash memory device can be triggered in two different ways:

- IP command read: For reading flash memory data into the RX buffer, you must provide the correct sequence ID in IPCR[SEQID]. The sequence ID points to a sequence in the LUT. The software needs to ensure that a correct read sequence is programmed in the LUT in accordance with the serial flash memory device connected on board. You must program the SFAR , SFACR[CAS], and IPCRs. All available read commands supported by the external serial flash memory are possible.

  Optionally, it is possible to clear the RX buffer pointer prior to triggering the IP command by writing a 1 to MCR[CLR_RXF]. This will invalidate the data currently present in the RX buffer and any new read data will overwrite the old one.

  Using these inputs, the complete transaction is built when IPCR[SEQID] is written to and if MDAD checks are passing (based on the access attributes while writing SFAR and IPCR). The transaction related to the read access starts when QuadSPI is IDLE and FSMSTAT[VLD] bit is 1. The data is fetched for the domain ID that is shown in FSMSTAT[11:8] bits when FSMSTAT[STAT] is set to 11 and the requested number of bytes is fetched from the external serial flash memory device into the RX buffer. As the read access is triggered by an IP command, the value of both SR[IP_ACC] and SR[BUSY] is set to 1.. A count of the number of entries currently in the Rx buffer can be obtained from RBSR[RDBFL].

  Communication with the external serial flash memory stops if the specified number of bytes are read (on successful completion of the transaction).

  NOTE

  In case of external DQS strobe based sampling, read data size (IDATSZ or LUT size) must be in multiples of 8 bytes.

- AHB command read: For reading flash memory data into the AHB buffer, you must:

- Set up a read access by a master to the address range in the system memory map, which the external serial flash memory devices are mapped to.
- Write a desired value to SFACR[CAS], if required, or write 0 to the field.
- Program the buffer registers corresponding to the AHB master initiating the request,and this depends on the configuration of RBCT[RXBRD].
- Provide the correct sequence ID in the BFGENCR. The software ensures that a correct read sequence is programmed in the LUT in accordance with the serial flash memory device connected on board. Flash memory device selection and access mode are determined by the address accessed in the AHB address space associated with the QuadSPI module (see Memory-mapped serial flash memory data—individual flash memory mode on flash memory A

On each AHB read access to the memory mapped area, the valid data in the AHB buffer is checked against the address requested in the actual read. When the AHB read request cannot be served from the content of the AHB buffer, the buffer is flushed and the controller executes the sequence pointed to by the sequence ID. The requested number of buffer entries defined in BUFxCR[ADATSZ] is then fetched from the external serial flash memory device into the internal AHB buffer. As the read access is triggered through the AHB bus, the value of SR[AHB_ACC] is set, driving SR[BUSY] in turn, until the transaction is complete. Communication with the external serial flash memory stops when the specified number of entries is filled.

Data transfer from the QuadSPI module internal buffers

The data read out from the external serial flash memory device by the QuadSPI module is stored in the internal buffers. The means of accessing the data from the buffer differs depending on which buffer the data is loaded to. See Block diagram for details on the two available buffers, the RX buffer and the AHB buffer, in this module. The buffer appears transparent to you and is non-memory mapped. See the "Flexible AHB Buffer" section for details.

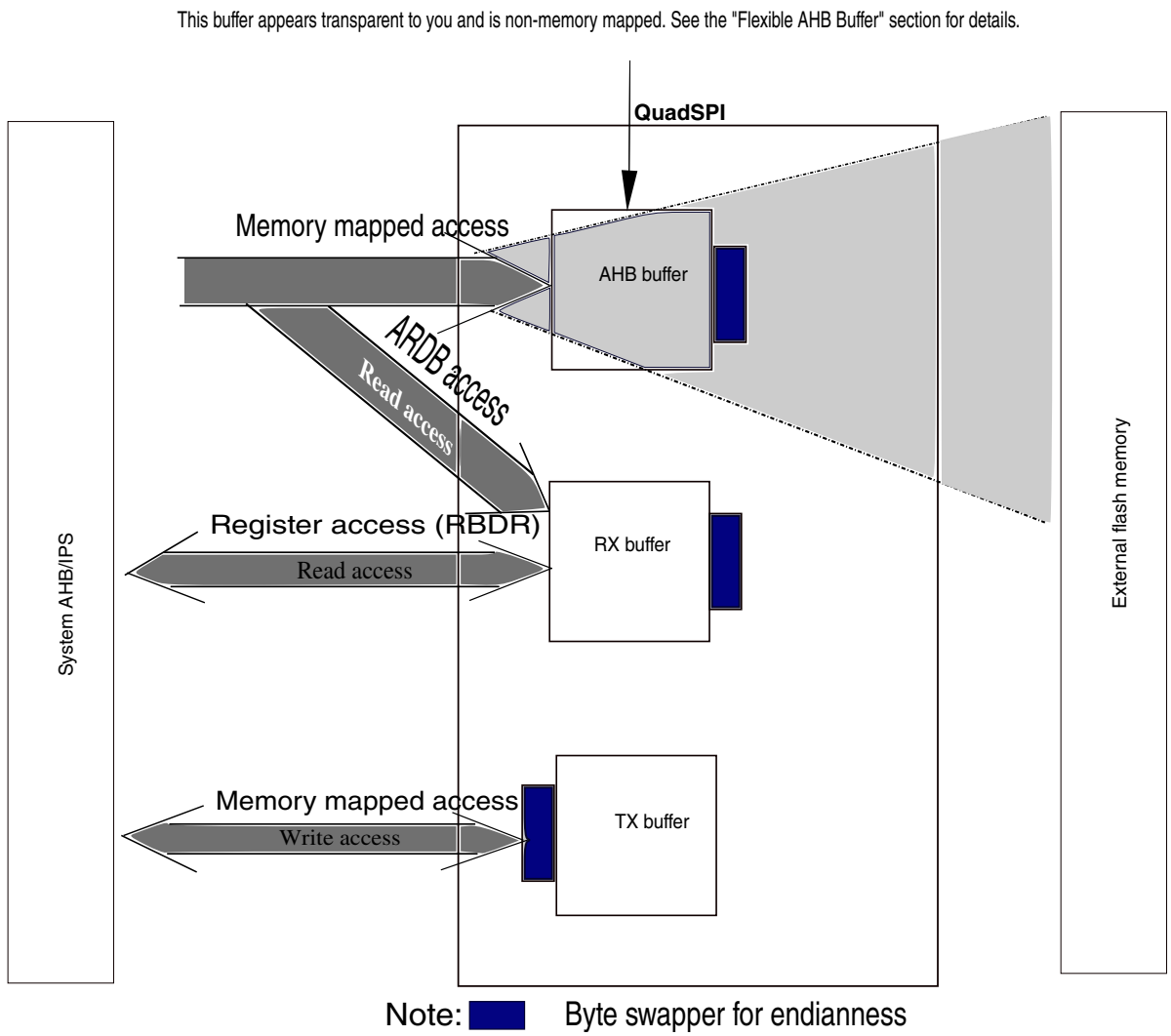


Figure 607. QuadSPI memory map

The RX buffer is implemented as FIFO of depth 32 entries of 4 bytes. Its content is accessible in two different address areas, both referring to identical data and the same physical memory:

- In the IPS address space in the area associated with RX Buffer Data Register (RBDR0 - RBDR31).
- In the AHB address space in the area associated with AHB RX Data Buffer Register (ARDB0 - ARDB31).Two successive entries are accessed with one single 64-bit AHB read operation.

The RX buffer operation can be summarized as follows:

- RBCT[WMRK] determines at which fill level SR[RXWE] is asserted and how many entries are removed from the RX buffer on each buffer POP operation.
- SR[RXWE] indicates that the configured number of data entries is available in the RX buffer and RBSR[RDBFL] indicates how many valid entries are available in total.
- The first entry (RBDR0 or ARDB0) always corresponds to the first valid entry in the RX buffer.

For details, see RX Buffer Data Register (RBDR0 - RBDR31) and AHB RX Data Buffer Register (ARDB0 - ARDB31).

- Flag-based data read of the RX buffer is performed by polling SR[RXWE]. When it is asserted, the valid entries can be read either via the IPS address space (RBDRn) or the AHB address space (ARDBn). A buffer POP operation must be

triggered by the application by writing a 1 to FR[RBDF]. This automatically updates the FIFO to point to the next entry as defined by RBCT[WMRK]. For example, if WMRK is set to 3, then the buffer discards 16 bytes of data.

- DMA-controlled data read of the RX buffer is performed by using the DMA module. The application must ensure that the DMA controller of the related chip is programmed appropriately, as described in DMA usage.
- DMA-controlled read out is triggered fully automatically by the assertion of SR[RXWE]. The related buffer POP operation is also handled completely inside the QuadSPI module. As in the case explained here, accessing the RX buffer content either on RBDRn or ARDBn related addresses is equivalent.
- AHB buffer data read via memory-mapped access: This kind of access is performed by reading one of the addresses assigned to the external serial flash memory device(s) within the range specified in Table 728. If this is not the case, a memory-mapped AHB command read is triggered as described above. If the requested data is already available in the AHB buffer, it is provided directly to the host.

When an AHB access is made to the flash memory mapped address, the data is fetched and returned to the AHB interface. The AHB interface is stalled until the data is fetched. As soon as the data from the requested address is read by the QuadSPI module, the AHB read access is served. Therefore, it is possible to run sequential reads from the AHB buffer at arbitrary speed without the need to monitor any information about the availability of the data. Nevertheless, this access scheme stalls the AHB bus for the time required to read the data from the serial flash memory device. If you know that the access is sequential, a better way is to have a prefetch enabled by programming the value of BUFxCR[ADATSZ] so that the data is fetched into the buffer before the next sequential AHB access.

As long as the host restricts its accesses to the data present in the buffer and to the data currently fetched from the serial flash memory, it is possible to run the host read from the AHB buffer simultaneously with the serial flash memory read into the AHB buffer.

80.4.2.9 AHB write

This module supports a single master AHB write with these burst types — INCR4, INCR8, INCR16, and INCR unspecified 4n bytes and single 4n bytes — and these burst types are supported with all Hsizes. An AHB write transaction size can be expressed in multiples of 4 bytes, and a single transaction must have a minimum of 4 bytes. In case of HyperRAM ,this limitation of minimum 4 bytes is not present. Also unspecified INCR and single transactions are supported without the limitation of 4n bytes in case of HyperRAM.

The following restrictions apply to the QuadSPI module with respect to AHB write transactions:

- AHB transactions of WRAP* types are not supported. For these unsupported access types, the controller returns an error response and does not initiate any flash memory transaction.
- Back to back, fixed address AHB write is not supported.
- Early burst termination is not supported for AHB transactions.

The QuadSPI controller queues back-to-back AHB writes with continuous address and sends them in a single flash memory transaction. However, in case the AHB address of a burst is not in continuous addressing sequence to previous write burst, a new flash memory transaction is initiated.

Following is the programming sequence for an AHB write:

1. Check that SR[BUSY] is deasserted or is 0 and check that the TX buffer is empty. If there is any residue data present in the TX buffer(SR[TXNE]), the buffer must be cleared by writing '1'1 to MCR[CLR_TXF].
2. Based on the type of flash memory device that is used for page programming, AWRCR[PPW_WR_DIS] and AWRCR[PPW_RD_DIS] need to be programmed.

   The default reset value for both the fields is 0 and allows writing to flash memory device assuming a very low T_{pp} (page program wait time) period. This period is very high for most of the flash memory devices. After any write to a flash memory device, the module waits for the write to finish before proceeding further.

   This is controlled by the AWRCR[PPW_WR_DIS] and AWRCR[PPW_RD_DIS] field configurations.
3. Program the BFGENCR[SEQID] to point to the LUT where flash memory write sequence is stored.

4. AHB write master can now enable the transactions to be written to the flash memory. The AHB master must ensure data throughout to avoid underflow.
5. When a flash memory write completes and flash memory CS is deasserted, the software must poll SR[BUSY] for the deasserted value, which is 0. This indicates that the AHB write is complete. In case an underflow has occurred, flash memory CS is deasserted with (SR[TXNE])to know that an AHB write is pending with some residue data in the TX buffer.
6. Whenever flash memory CS is deasserted after an AHB write sequence, FR[PPWF] is set if any of AWRCR[PPW_RD/WR_DIS] is enabled. FR[PPWF] disables any further flash memory read/write based on AWRCR[PPW_RD]/AWRCR[WR_DIS]. After FR[PPWF] is set, it returns every incoming AHB transaction with an error response.
7. The software must clear FR[PPWF] to resume AHB transactions after the expiry of T_{pp} period of flash memory. It can also send IPS read command to the flash memory for checking if T_{pp} is over.
8. The software must ensure that the correct read and write LUT sequences are selected corresponding to the AHB read and write transactions. QuadSPI would malfunction if flash memory read sequence is selected during AHB write or vice versa.

NOTE

An AHB error response occurs in case of AHB write if flash is not able to consume data at the rate master is writing in TX FIFO and TX FIFO eventually becomes full

80.4.2.10 Byte ordering of serial flash memory read data

The basic scheme is that the first byte read out of the serial flash memory device, which is addressed by SFAR[SFADR], corresponds to RBDR0[31:24] for IP command read. Similarly, to send a single byte it should be positioned in TBDR[0:7]. In contrast to that for AHB command read, the bytes are always positioned according to the byte ordering of the AHB bus.

- Byte ordering in individual flash memory mode

  The following table provides the byte ordering scheme of how the byte oriented data space of the serial flash memory device is mapped into one single 32-bit entry of the RX buffer or the AHB buffer. The table is valid within the following context:

  — Flash memory A in individual flash memory mode

  — All AHB data read commands with 32-bit access size

Table 691. Byte ordering in individual flash memory mode

Serial flash memory byte numbering	3	2	1	0
Buffer entry bit position [31:0] (32-bit data width)	[31:24]	[23:16]	[15:8]	[7:0]

NOTE

For IP commands, the read size can be specified as number of bytes. If this number is not a multiple of four, then the last buffer entry is not completely filled with the missing higher numbered bytes at undefined values.

  For AHB commands and reads, starting from an address not aligned to 32-bit boundaries, the requested bytes are given at the appropriate positions according to the AMBA AHB specification.

- Buffer entry ordering for 64-bit read access

  For read access via the AHB interface, a 64-bit access is possible. Each 64-bit access reads two 32-bit entries, simultaneously. The ordering of these 32-bit entries within the 64-bit word is provided in the following table.

Table 692. 64-bit read access buffer entry ordering

AHB read data bit position [63:0]	[63:32]	[31:0]
Buffer entry #	Odd (1, 3, 5, ...)	Even (0, 2, 4, ...)

80.4.2.11 Normal mode interrupt and DMA requests

The QuadSPI module has different flags that can only generate interrupt requests and one flag that can generate an interrupt as well as DMA requests. The following table lists the eight conditions. Note that the flags mentioned in the table are associated with the Flag Register (FR).

Table 693. Interrupt and DMA request conditions

Condition	Flag (FR)	DMA
Data learn pattern failure	DLPFF	-
TX buffer fill	TBFF	-
TX buffer underrun	TBUF	-
Illegal instruction error	ILLINE	-
RX buffer drain	RBDF	X
RX buffer overflow	RBOF	-
AHB buffer overflow	ABOF	-
AHB sequence error	ABSEF	-
AHB illegal transaction error	AITEF	-
AHB illegal burst size error	AIBSEF	-
IP command trigger could not be executed error	IPIEF	-
IP command related transaction finished	TFF	-

Each condition has a corresponding field in Flag Register (FR) and a request enable field in DMA Request Select and Enable Register (RSER). FR[RBDF] has separate enable fields for generating IRQ and DMA requests. Note that not all the fields have an individual IRQ line. See the chip's Interrupt Vector table for details.

- Transmit buffer fill interrupt request

  This indicates that the TX buffer can accept new data. The buffer is asserted if FR[TBFF] is asserted and if the value of the corresponding enable field, RSER[TBFIE], is 1. See TX buffer Operation for details on the assertion of FR[TBFF].

  Apart from IRQ, it is possible to handle the TX buffer fill by using the DMA. If the value of RSER[TBFDE] is 1, a DMA request is triggered when the number of available space in the TX buffer is more than the TBCT[WMRK] valid entries and value of SR[TXWA] is set. The application must configure the environment appropriately (for example, the DMA controller) for the DMA transfer.

  In SFP Enabled configurations, program RSER[TBFDE] bit to 1 only when arbitration is won and TBDR access is unlocked after checking STATE field of FSMSTAT register. After TBDR programming is completed by DMA, reset this bit otherwise, QuadSPI SFM state will remain busy and no further IPS accesses can be served by that Target queue.

- Receive buffer drain interrupt or DMA request

  This is derived from FR[RBDF], indicating that the RX buffer of the QuadSPI module has data available from the serial flash memory device to be read by the host. It remains set as long as RBSR[RXWE] is configured. Also, RSER[RBDIE] enables the related IRQ.

  Apart from the IRQ, it is possible to handle the RX buffer drain by using the DMA. If the value of RSER[RBDDE] is 1, a DMA request is triggered when the RX buffer contains more than RBCT[WMRK] valid entries. The application must set the environment appropriately (for example, the DMA controller) for the DMA transfers.

- Buffer overflow/underrun interrupt request

This is a combination of the following fields (all located in the Flag Register (FR) with the related enable bits in the DMA Request Select and Enable Register (RSER)):

- TBUF - TX buffer underrun, enabled by TBUIE
- RBOF - RX buffer overflow, enabled by RBOIE
- ABOF - AHB buffer overflow, enabled by ABOIE
- The transmit buffer underrun indicates that an underrun condition in the TX buffer has occurred. It is generated when a write instruction is triggered whilst the TX buffer is empty and the value of RSER[TBUIE] is 1.
- The receive buffer overflow indicates that an overflow condition in the RX buffer has occurred. It is generated when the RX buffer is full, an additional read transfer attempts to write into the RX buffer, and the value of RSER[RBOIE] is 1.
- The AHB buffer overflow indicates that an overflow condition in the AHB buffer has occurred. It is generated when the AHB buffer is full, an additional read transfer attempts to write into the AHB buffer and the value of RSER[ABOIE] is 1.
- The data from the transfers that generated the individual overflow conditions is ignored.

- Serial flash memory command error interrupt request
- Transaction finished interrupt request

  The IP command transaction finished IRQ indicates the completion of the current IP command. It is triggered by FR[TFF] and is masked by RSER[TFIE].

80.4.2.12 TX buffer operation

The TX buffer provides the data used for page programming. For proper operation, it is required to provide at least one entry in the TX buffer prior to starting the execution of the page programming command. The application must ensure that the required number of data bytes is written into the TX buffer fast enough as long as the command is executed without a TX buffer overflow or underrun.

The QuadSPI module sets the FR[TBFF] field as long as the TX buffer is not full and can accept more data. At the end of write through TX buffer, you must clear FR[TBFF] to avoid unnecessary last TX buffer fill interrupt. However, there would always be a pending request asserted from QuadSPI controller at the end of any DMA transfer. When external DMA finishes transfer iteration, this request from QuadSPI is kept asserted for the next iteration loop.

NOTE

Even if the generation of DMA requests for filling the TX buffer is disabled by using RSER[TBFDE], the TX buffer still accepts a DMA transfer because of the last asserted pending request.

Disabling of DMA transfer should be controlled by an external DMA master.

When the QuadSPI module tries to pull data out of an empty TX buffer, FR[TBUB] signals the TX buffer underrun. The TX buffer underrun flag is also asserted when the TX buffer contains less than 32-bits of data and the QuadSPI module tries to pull out data from it. The current IP command leading to the underrun condition is continued until the specified number of bytes is sent to the serial flash memory device. Also, the data that is transferred is in the Fs[41] format. This means, after the underrun flag is set under this condition, it returns Fs until the required number of bytes are not sent. This has been done to ensure that the software does not erase the whole sector after underrun and just reprogramming from failure point serves the purpose. When this sequence command is complete, FR[TBFF] is asserted, indicating that the TX buffer is ready to be written again.

The TX buffer overflow is not signaled explicitly, but TBSR[TRBFL] can monitor the TX buffer fill level.

For more information, see TX Buffer Status Register (TBSR) and Flag Register (FR).

80.4.2.13 Address scheme

Earlier, serial flash memories supported only a 24-bit address space, restricting the maximum memory size of the serial flash memory to 16 MB. The new memory specification supports two types of 32-bit addressing mode in addition to the legacy 24-bit

[41] Fs represents a value of FFFF_FFFF.

address mode. It also supports segregation of address programmed into Row address and Column address of the flash memory, as per the requirement.

Extended address mode

In this mode, the legacy 24-bit commands are converted to accept 32-bit address commands. The flash memory needs to be configured for the 32-bit address mode. Also, while programming the LUT sequence in QuadSPI for 32-bit mode, the ADDR and ADDR_DDR commands should be programmed with 32d as the operand value with SFACR[CAS] programmed to 0. If a flash memory needs some bits of the address as its column address, then it must be considered that a total of 12 bits are required by the flash memory; however, the number of bits should not exceed 32 because the maximum address supported by QuadSPI is 32 bits.. Each of the memory vendors have a different way of enabling this mode (see the memory specification from memory vendors). For example, the command B7h sent to the Macronix flash memory enables it for the 32-bit address mode.

Extended address register

In this mode, the upper 8 bits of the 32-bit register are provided by the Extended address register in the memory, which provides a specific register that is updated according to the address to be accessed. This effectively converts the legacy 24-bit address command into 32-bit address commands. The memories greater in size than 16 MB consist of banks of 16 MB each. The 8 bits occupied in the extended address register effectively enable a bank. For example, in Spansion memory, when the extended address register is updated with a value of 1h, with the help of the 17h command, it opens Bank1 of the memory. The consequent 24-bit address commands lead to Bank1. The extended address register needs to be updated with the respective value for access to other banks. This effectively converts the legacy 24-bit address command into 32-bit address commands.

Separation of address into rows and columns

This mode has been introduced for flash memories that need addresses segregated into rows and columns. The value in SFACR[CAS] defines the width of the column address required by a flash memory. The actual address to be provided is derived from the incoming address in case of AHB-initiated transactions and the value of SFAR in case of IPS-initiated transactions, if the value of SFACR[CAS] is 0. Otherwise, the actual address takes CAS into consideration. If the value of SFACR[CAS] is 3, then bits 26-3 of the programmed address are sent to the flash memory as its page address. This is in case the flash memory is operating in a 24-bit mode and bits 2-0 are sent as its column address. If a flash memory requirement for column address is less than the number of pads in which address has to be sent, then QuadSPI appends the remaining bits by 0. You must program the operand value in CADDR and CADDR_DDR command accordingly. It must be ensured that the total number of address bits requested by flash memory as its page and column address must not be more than 32 bits.

Word addressable mode for flash memory

This mode has been introduced for flash memories, which have a word-addressable memory. This means, each address of the flash memory contains one word (two bytes) of data. The value of SFACR [WA] is configured to 1 to enter this mode. QuadSPI internally divides the incoming address in the AHB bus or the address in the SFAR to map it to a valid flash memory location. For example, if the incoming address is 2004h, the controller re-maps this address to access the flash memory location 1002h. If not in this mode, the incoming address 2004h is mapped to flash memory location 2004h.

80.4.3 Module Disable mode

Module Disable mode is a block-specific mode that the QuadSPI can enter to disable serial flash memory clock and AHB command. This mode can be entered by:

- The host software: by writing a '1' to MCR[MDIS]

Below are the condition that must be fulfilled to enter the Module Disable mode:

- SR[BUSY] = 0
- SR[AHBTRN] = 0
- RBSR[RDBFL] = 0
- SR[RXDMA] = 0
- SR[TXDMA] = 0
- None of the flags in FR are enabled as interrupts is set

The conditions mentioned above ensures the following:

- There is no SFM command currently being executed.
- All the data read into the RX buffer from the serial flash memory have been fetched by the application.
- There is no current AHB access.
- There is no active DMA request.
- There is no enabled interrupt that is pending.

Certain read or write operations have a different effect when the QuadSPI is in the Module Disable mode. In the Module Disable mode, not all of the status and flag bits of the QuadSPI module are updated, and writing to them has no effect. Interrupt and DMA request signals cannot be cleared while in the Module Disable mode.

NOTE

It is illegal to issue a new SFM command starting two clock cycles prior to raising the request of entering the Module Disable mode until the QuadSPI stays in this mode.

80.4.4 Leaving Module Disable mode

In the Module Disable mode, the serial flash memory clock and AHB command to the QuadSPI module are switched off.

After the QuadSPI has left this mode and has returned to Normal mode, the execution of the first SFM command is deferred until the clock to drive that part of the module related to the serial flash memory device is available. Depending upon the point in time when the first SFM command is triggered, the actual execution of the command starts with a delay, respective with the re-enabling of the flash memory clock signal.

80.4.5 HyperRAM support

QuadSPI supports HyperRAM memories, and by virtue of this protocol, QuadSPI supports the following functionalities.

- Bidirectional data strobe/read write data strobe (RWDS)
  - If QuadSPI is configured to use the HyperRAM mode, the RWDS pad should be pulled down.
- Variable refresh latency
  - If the value of MCR[VAR_LAT_EN] is 1, based on the status of RWDS from HyperRAM during the command/address phase, QuadSPI includes an additional initial access latency. If RWDS is high, QuadSPI includes twice + 1 the latency mentioned in the dummy phase. If RWDS is low, latency mentioned in the dummy phase is not included.
  - If the value of MCR[VAR_LAT_EN] is not set, fixed latency mentioned in the dummy phase is included.
- Read data strobe to latch data from HyperRAM
- Programming considerations for HyperRAM support:
  - Data masking during the AHB write is enabled when MCR[DQS_OUT_EN] bit is programmed as ’1’.
  - It is suggested that while using Hyper RAM program the SPTRCLR[PREFETCH_DIS] bit as ‘1’ so that every time a new AHB read transaction starts it reads new data from external memory instead of reading the data already stored in AHB buffers. This will ensure that the data read back after an AHB write is not a stale data.
  - AHB write doesn’t supports wrap transactions (WRAP4, WRAP8, WRAP16) even with HyperRAM.
  - If there is multiple switching between AHB read and write transactions then software should program AWRCR[AWTRGLVL] cautiously. It should ensure that during AHB write the data written to memory is more than the AWRCR[AWTRGLVL] programmed before switching over to AHB read transactions. This will ensure that IP is not left waiting for sufficient write data to be collected.

80.5 Initialization/application information

This section provides the initialization and application information of the QuadSPI module.

80.5.1 Power up and reset

The serial flash memory devices connected to the QuadSPI module might require special voltage characteristics of their inputs during power up or reset. The application must ensure this.

CAUTION

Erase or program commands should be completed before issuing a reset or power cycle to avoid corrupted flash pages. The application shall ensure there is a backup of critical data stored at a different location to enable recovery from corrupted flash pages.

Example: Flash reset sequence

Use the following sequence to reset flash A:

1. Make sure that the flash supports a reset for the condition CS#=high and IOF[3]=low.
2. Set MCR[SWRSTSD] and MCR[SWRSTHD] fields and then clear them.
3. Set MCR[MDIS] field.
4. Reset MCR[ISD3FA] field for flash A.
5. Clear MCR[MDIS] field.
6. Set MCR[MDIS] field.
7. Set MCR[ISD3FA] field for flash A.
8. Clear MCR[MDIS] field.

80.5.2 Available status/flag information

This section provides an overview of the different flags and statuses available, and their interdependencies for different use cases. The SR and FR are the related registers.

80.5.2.1 IP commands

See IP Configuration Register (IPCR) for additional details not explicitly covered in this paragraph.

- IP commands—normal operation

  Writing to IPCR[SEQID] triggers the execution of a new IP command. Given that this is a legal command, SR[IPACC] and SR[BUSY] are asserted simultaneously, immediately after the execution starts.

  After the instruction on the serial flash memory device is complete, these field deassert and FR[TFF] is configured.

- IP commands—error situations

  See Overview_of_Error_Flags for details.

80.5.2.2 AHB commands

See the "Reading serial flash memory data into the QuadSPI module internal buffers" topic in theFlash Memory Read section for details.

- AHB commands—normal operation

  Memory-mapped read access to a serial flash memory address not contained in the AHB buffer triggers the execution of an AHB command. Given that this is a legal command, SR[AHB_ACC] and SR[BUSY] are asserted simultaneously, immediately after the execution starts. After the instruction on the serial flash memory device is complete, these fields are deasserted.

- IP commands—error situations

  See Overview of FR error flags for details.

80.5.2.3 SFM commands

An SFM command consists of an instruction code and all other parameters (for example, size or mode bytes) needed for that specific instruction code. Triggering a command either initiates a transaction on the external serial flash memory or results in an error. See Table 694 for details on errors.

80.5.2.4 Overview of error flags

The following table provides an overview of the different error flags in the FR and additional error-related details.

Table 694. Overview of FR error flags

Error category	Error flag in FR	Command execution on serial flash memory device TFF behavior (in case of IP commands only)	Description
AHB error flag	ABOF	Flash memory transaction continues until it finishes	Set when the module tries to push data into the AHB buffer that exceeds the size of the AHB buffer. Occurs only because of the wrong programming of BUFxCR[ADATSZ].
AHB error flag	AIBSEF	Flash memory transaction is aborted	Total burst size of the AHB transaction is greater than prefetch data size.
AHB error flag	AITEF	Flash memory transaction is aborted	No response is generated from QuadSPI to AHB bus in case of illegal transaction. Also, the watchdog timer expires.
Miscellaneous error flag	DLPFF	Flash memory transaction continues until it finishes	Set when the DATA_LEARN instruction is encountered in a sequence but no sampling point is found for the data learning pattern.
Miscellaneous error flag	ILLINE	Flash memory transaction aborted	Illegal instruction error flag - set when an illegal instruction is encountered by the controller in any of the sequences.
Command arbitration error	IPIEF	TFF not asserted in conjunction with that command	IP command error - caused when IP access is currently in progress (IP_ACC is set) and during: • Write attempt to RBCT register
Buffer-related error	RBOF	TFF is asserted on completion	• RX buffer overrun
Buffer-related error	TBUF	TFF is asserted on completion	• TX buffer underrun

Note that only the buffer-related errors are associated with a transaction on the external serial flash memory. All the other errors do not trigger an actual transaction.

80.5.2.5 IP bus and AHB access command collisions

There are following flags related to this topic: FR[IPIEF]. See the "Reading serial flash memory data into the QuadSPI module internal buffers" topic of the Flash Memory read section for a description of the flags.

80.5.3 Flash memory device selection

Regardless of the SFM command (IP or AHB), the access mode is selected by specifying the 32-bit address value for the following SFM command.

For IP commands, the access mode is selected with the address programmed into the SFAR register. See Serial Flash Address Register (SFAR) for details.

For AHB commands, the access mode is determined by the memory-mapped address. See AMBA Bus Register Memory Map for details.

80.5.4 DMA usage

For a complete description of the DMA module, see the related DMA Controller chapter. This section only provides QuadSPI-specific DMA usage details.

80.5.4.1 DMA usage in normal mode

80.5.4.1.1 Bandwidth considerations

Careful consideration of the throughput rate of the entire chain (serial flash memory -> AHB bus / IP bus -> DMA controller) involved in the read/write data process is essential for a proper operation. Such analysis must take into account not only the data rate provided by the serial flash memory but also the data rate of the AHB bus and the performance of the DMA controller in reading/writing data from/to the RX/TX buffer.

Two figures must match for a proper operation, which means that the data rate provided by the serial flash memory device must not exceed the average RX buffer readout data rate. Otherwise, the longer this state persists, it results into an RX buffer overflow. Similarly, the data consumed by the serial flash memory device must not exceed the average TX buffer fill rate. If this persists, it leads to an underrun.

AHB bus side (data read)

The total number of bus cycles for each DMA minor loop completion is added from the following components:

The following table provides certain examples for typical use cases:

Case 1: DMA needs to read 4 bytes from SRAM and provide to QuadSPI. It costs total four bus clock cycles. Then, DMA handshake adds additional six bus clock cycles, resulting in a total of [6 + 4 * (32/4) = 38] bus clock cycles.

Table 695. Access duration examples for bus clock side

TBCT[WMRK]	Number of bytes per DMA loop	Number of bus clock cycles for DMA minor loop	Time duration of DMA minor loop for 60 MHz bus clock frequency
3	16	6+(16/4)*4 = 22	~366ns
7	32	6+(32/4)*4 = 38	~633ns
11	48	6+(48/4)*4 = 54	~900ns
15	64	6+(64/4)*4 = 70	~1166ns

Case 2: DMA needs to read 32 bytes from SRAM and provide to QuadSPI. DMA handshake takes an additional six bus cycles, with 32 bytes DMA read from SRAM costs (8 + 3) core clock cycles. DMA writes 32 bytes to QuadSPI, takes 2 * (32/4) = 16 bus cycles with one additional CPU access to QuadSPI, costing two bus clock cycles. This results in a total 6 + (8+3)/2 + 2 * (32/4) +2 = 30 bus clock cycles.

Table 696. Access duration examples for bus clock side

TBCT[WMRK]	Number of bytes per DMA loop >	Number of bus clock cycles for DMA minor loop	Time duration of DMA minor loop for 80 MHz bus clock frequency
3	16	6 + (4+3) /2 + (16/4)*2 + 2 = 20	~333ns
7	32	6 + (8+3) /2 + (32/4)*2 + 2 = 30	~500ns
11	48	6 + (4+3)/2*3 + (48/4)*2 + 2 = 44	~733ns
15	64	6 + (8+3) + (64/4)*2 + 2 = 51	~810ns

NOTE

This table figure represents an ideal scenario; actual performance depends on how the chip integrates DMA and QuadSPI modules.

Serial flash memory device side (data read)

The number of serial flash memory cycles can be determined in the following way:

- Number of serial flash memory clock cycles is required to read 4 bytes, corresponding to one RX buffer entry (setup of command and address not considered): , two cycles for the Octal DDR mode in the individual flash memory mode, eight cycles for quad mode (SDR) instructions in individual flash memory mode, and so on.
- Overhead because of clock domain crossing: one cycle

The following table lists the number of clock cycles required to read the data from the serial flash memory corresponding to the different settings of RBCT[WMRK]:

Table 697. Access duration examples for serial flash memory side

RBCT[WMRK] setting	Num bytes per DMA loop [1]	Num SCKFx for 80 MHz SCKFx		Time duration of flash memory data readout for 80 MHz SCKFx (~12.5ns period)	
		IFM [2] quad	IFM quad DDR	IFM quad	IFM quad DDR
0	4	8	4	~100ns	~50ns
1	8	16	8	~200ns	~100ns
3	16	32	16	~400ns	~200ns
7	32	64	32	~800ns	~400ns
11	48	96	48	~1200ns	~600ns

1. DMA loop refers to one minor loop completion that is equivalent to one major loop iteration.
2. Individual flash memory mode

NOTE

The table figure represents an ideal scenario; actual performance depends on how the chip integrates with DMA and QuadSPI modules.

A complementary example is when the watermark is set to be too high. In such a case, the time taken by the DMA to read out the RX buffer entries should be lesser than the time taken by the controller to push in the remaining entries in the buffer.

IPS bus side (data write)

The total number of bus cycles for each DMA minor loop completion are added from the following components:

- Overhead for each minor loop, given by DMA controller: assume 10 cycles
- Overhead because to clock domain crossing: assume two cycles
- Number of bus clock cycles required for 16 bytes (128-bit write size): assume four cycles (read/write sequence of DMA controller)

Note that the size of the minor loop is determined by the size of TBCT[WMRK]; therefore, the overhead specified above distributes among (TBCT[WMRK]+1) write accesses of 32-bit each.

The following table provides some examples for typical use cases:

Table 698. Access duration examples for bus clock side

TBCT[WMRK]	Number of bytes per DMA loop [1]	Number of bus clock cycles for DMA minor loop	Time duration of DMA minor loop for 80 MHz bus clock frequency
3	16	12+4 = 16	~200ns
7	32	12+8 = 20	~250ns

1. DMA loop refers to one minor loop completion that is equivalent to one.

NOTE

The table figure represents an ideal scenario; actual performance depends on how the chip integrates with DMA and QuadSPI modules.

Serial flash memory device side (data write)

The number of serial flash memory cycles can be determined in the following way:

- Number of serial flash memory clock cycles required to write 16 bytes, corresponding to four TX buffer entry (setup of command and address not considered): Eight cycles for Octal DDR mode instructions in individual flash memory mode, 32 cycles for quad SDR writes in individual flash memory mode.
- Overhead due to clock domain crossing: one cycle

The following table lists the number of clock cycles required to read the data from the serial flash memory corresponding to the different settings of TBCT[WMRK]:

Table 699. Access duration examples for serial flash memory side

TBCT[WMRK] setting	Num bytes per DMA loop [1]	Num SCKFx		Time duration for consuming data at flash memory interface 100 MHz SCKFx (10 ns period)[2]		Time for FIFO to get empty[3]	
		IFM [4] quad	IFM octal DDR	IFM quad	IFM octal DDR	IFM quad	IFM octal DDR
3	16	32	8	320ns	80ns	2240ns	560ns
7	32	64	16	640ns	160ns	1920ns	480ns

1. DMA loop refers to one minor loop completion that is equivalent to one major loop iteration.
2. Not all flash memory devices support writes at 100 MH. See the flash memory data sheet for the actual page program frequency supported.
3. The assumption for these timings is that the TX Fifo is full when the transaction is initiated
4. Individual flash memory mode

NOTE

The tables mentioned above are only examples which must be correlated with the DMA in the system.

Considering the examples provided in the two tables above for TX FIFO, it is evident that depending on the relationship between the bus clock and serial flash memory clock frequencies, there are settings possible where the serial flash memory consumes data faster than the IPS bus can write data in TX buffer. In these cases, a TX buffer underrun situation occurs. To avoid TX buffer underrun, the data transaction size should be large enough.

80.5.5 Flash memory devices address mapping

QuadSPI is configured in Single mode for the supported flash memory port A

The sizes of the flash memory devices are mapped with the system memory space based on the configurations of the following registers:

- SFA1AD
- SFA2AD

The total memory region for the flash memory devices is mapped between QuadSPI_AMBA_BASE and TOP_ADDR_MEMA2 such that the corresponding CS is asserted based on SFA1AD and SFA2AD register configurations.

80.5.5.1 Single mode

For single-die flash memories, you must write the same value to SFA2AD register that you write to the SFA1AD register.

Following is a programming example for single mode single-die flash memory:

- QuadSPI_AMBA_BASE - 1000_0000h
- SFA1AD[TPADA1] - 2000_0000h
- SFA2AD[TPADA2] - 2000_0000h

The following figure illustrates the memory mapping for single mode QuadSPI configuration.

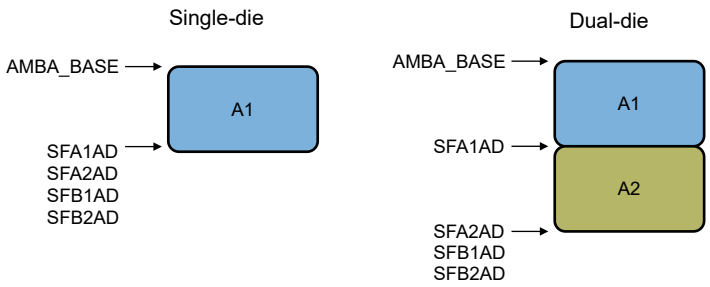


Figure 608. Memory map for Single mode

80.6 Byte ordering – endianness

The following topics show the byte ordering in 64-bit LE configuration for AHB buffer and 32-bit LE for TX/RX buffer.

80.6.1 Programming flash memory data

CPU writes instructions to the TBDR register, such as:

- Write TBDR: 4_03_02_01h
- Write TBDR: 8_07_06_05h

The following table shows the content against each TX buffer entry.

Table 700. Example of QuadSPI TX buffer

TX buffer entry	Content
0	4_03_02_01h
1	8_07_06_05h

Programming the TX buffer into the external serial flash memory device results in the following byte order to be sent to the serial flash memory:

- 01...02...03...04...05...06...07...08

80.6.2 Reading flash memory data into the RX buffer

Reading the content from the same address provides the following sequence of bytes, identical to the write case:

- 01...02...03...04...05...06...07...08

The following table shows the content against each TX buffer entry.

Table 701. Resulting RX buffer content

RX buffer entry	Content
0	4_03_02_01h
1	8_07_06_05h

80.6.2.1 Readout of the RX buffer through RBDRn

The RX buffer content appears at CPU read access through the peripheral bus interface in the following order:

- Read RBDR0: 4_03_02_01h
- Read RBDR1: 8_07_06_05h

80.6.2.2 Readout of the RX buffer through ARDBn

The RX buffer content appears at read access on the AMBA AHB interface at the QuadSPI module boundary:

- 32-bit access: Read ARDB0: 4_03_02_01h
- 32-bit access: Read ARDB1: 8_07_06_05h
- 64-bit access: Read ARDB0: 8_07_06_05_04_03_02_01h

80.6.3 Reading flash memory data into the AHB buffer

Reading the content from the same address as it was written to provides the following sequence of bytes, identical to the write case:

- 01...02...03...04...05...06...07...08

The following table shows the content against each TX buffer entry.

Table 702. Resulting AHB buffer content

AHB buffer entry	Content
0	8_07_06_05_04_03_02_01h

80.6.3.1 Readout of the AHB buffer through memory-mapped read

The AHB buffer content appears at read access on the AMBA AHB interface at the QuadSPI module boundary:

- 32-bit read access: 4_03_02_01h
- 32-bit read access: 8_07_06_05h
- 64-bit read access: 8_07_06_05_04_03_02_01h

80.7 Driving flash memory control signals in single and dual modes

In single and dual modes, the serial flash memory devices that can connect to the QuadSPI module expect additional control signals on the inputs, which are connected to IOFA[3], IOFA[2] in the quad mode. For easy interfacing, the outputs IOFA[3:2] for flash memory A are driven to the logic state given by the configuration fields MCR[ISD3FA], MCR[ISD2FA].

These outputs are driven all the time to the logic level programmed in the MCR except the time when quad commands of the serial flash memory are executed. See the specifications of the related serial flash memory device for details about the inactive level.

80.8 Serial flash memory devices

Several different vendors make flash memory devices with a QuadSPI interface. At present, there is no set standard for the QuadSPI instruction set. The most common commands currently have the same instruction code for all vendors; however, some commands are unique to specific vendors. Some of the example sequences are provided in the following sections.

80.8.1 Example sequences

This section provides the example sequences of the QuadSPI module.

Table 703. Exit 4 x I/O read enhance performance mode (XIP) (Macronix) and read status

Instruction	Pad	Operand	Description
CMD	0h	EBh	4xIO read command
ADDR	2h	18h	24-bit address to be sent on four pads
MODE	2h	0h	2 mode cycles (exit XIP)
DUMMY	2h	4h	4 dummy cycles
READ	2h	8h	Read 64 bits
CMD	0h	5h	Read Status register
READ	0h	1h	Status register data
STOP	0h	0h	Stop, instruction over

80.8.1.1 Read command (hyperflash memory/HyperRAM)

This section provides the read command sequences (hyperflash memory/HyperRAM) of the QuadSPI module.

Table 704. Read command (hyperflash memory/HyperRAM)

Instruction	Pad	Operand	Comment
CMD_DDR	3h	A0h	Read command with continuous burst type
ADDR_DDR	3h	18h	24-bit row address

Table continues on the next page...

Table 704. Read command (hyperflash memory/HyperRAM) (continued)

CADDR_DDR	3h	10h	16-bit column address with lower 3 bits valid and rest 0
Dummy	3h	0hF	15 dummy cycles
READ_DDR	3h	4h	32-bit data read on 8 pads
STOP	3h	0h	Stop, instruction over

Hyperflash memory/HyperRAM is a word addressable flash memory. This means that each address accesses a word-wide (two-byte) data value. The software should ensure that when Hyperflash memory/HyperRAM is connected to the controller, the value of SFACR[WA] must be 1. With this value, the controller remaps a byte addressable access to a word addressable access.

80.8.1.2 Read status register (hyperflash memory/HyperRAM)

This section provides details related to the read status register of the QuadSPI module.

Table 705. Read status register (hyperflash memory/HyperRAM)

Instruction	Instruction sequence	Pad	Operand	Description
CMD_DDR	Read Pre Command	3h	0h	Write command with wrapped burst type
ADDR_DDR		3h	18h	24-bit row address (0000AAh)
CADDR_DDR		3h	10h	16-bit column address with lower 3 bits valid and rest 0(0005h) treated as command
CMD_DDR		3h	0h	Write command with wrapped burst type
CMD_DDR		3h	70h	Write data to be sent to flash memory as pre-command
CMD_DDR	Command phase (fourth/final chip select phase)	3h	A0h	Read command with continuous burst type
ADDR_DDR		3h	18h	24-bit row address
CADDR_DDR		3h	10h	16-bit column address with lower 3 bits as valid and rest 0
DUMMY		3h	0hF	15 dummy cycles
READ_DDR		3h	4h	32-bit data read on 8 pads
STOP		3h	0h	Stop, instruction over

80.8.1.3 Word program (hyperflash memory/HyperRAM)

This section provides the word program (hyperflash memory/HyperRAM) of the QuadSPI module.

Table 706. Word program (hyperflash memory/HyperRAM)

Instruction	Instruction sequence	Pad	Operand	Description
CMD_DDR	Unlock sequence 1 (first chip select phase)	3h	0h	Write command with wrapped burst type
CMD_DDR		3h	0h	8-bit address 00h treated as command
CMD_DDR		3h	0h	8-bit address 00h treated as command
CMD_DDR		3h	AAh	8-bit address AAh treated as command
CADDR_DDR		3h	10h	16-bit column address with lower 3 bits valid and rest 0(0005h) treated as command
CMD_DDR		3h	0h	Write command with wrapped burst type
CMD_DDR		3h	AAh	Write data to be sent to flash memory as pre-command
CMD_DDR	Unlock sequence 2 (second chip select phase)	3h	0h	Write command with wrapped burst type
CMD_DDR		3h	0h	8-bit address 00h treated as command
CMD_DDR		3h	0h	8-bit address 00h treated as command
CMD_DDR		3h	55h	8-bit address 55h treated as command
CADDR_DDR		3h	10h	16-bit column address with lower 3-bits valid and rest 0(0002h) treated as command
CMD_DDR		3h	0h	Write command with wrapped burst type
CMD_DDR		3h	55h	Write data to be sent to flash memory as pre-command
CMD_DDR	Program setup phase (third chip select phase)	3h	0h	Write command with wrapped burst type
CMD_DDR		3h	0h	8-bit address 00h treated as command
CMD_DDR		3h	0h	8-bit address 00h treated as command

Table continues on the next page...

Table 706. Word program (hyperflash memory/HyperRAM) (continued)

CMD_DDR		3h	AAh	8-bit address AAh treated as command
CADDR_DDR		3h	10h	16-bit column address with lower 3 bits valid and rest 0(0005h) treated as command
CMD_DDR		3h	0h	Write command with wrapped burst type
CMD_DDR		3h	A0h	Write data to be sent to flash memory as pre-command
CMD_DDR	Command phase (fourth/final chip select phase)	3h	0h	Write command with wrapped burst type
ADDR_DDR		3h	18h	24-bit row address
CADDR_DDR		3h	10h	16-bit column address with lower 3 bits as valid and rest as 0
WRITE_DDR		3h	2h	2-byte data written on 8 pads (D1D2)
STOP		3h	0h	Stop, instruction over

80.8.1.4 Fast read sequence (Macronix/Numonyx/Spansion/Winbond)

The following table shows the fast read sequence for Macronix/Numonyx/Spansion/Winbond flash memories.

Table 707. Fast read sequence

Instruction	Pad	Operand	Description
CMD	0h	Bh	Fast read command = 0Bh
ADDR	0h	18h	24 address bits to be sent on one pad
DUMMY	0h	8h	Eight dummy cycles
READ	0h	4h	Read 32 bits on one pad
JMP_ON_CS	0h	0h	Jump to instruction 0 (CMD)

NOTE

If DLL is disabled then JMP_ON_CS or STOP instruction can be used else only STOP instruction can be used.

80.8.1.5 Fast dual I/O DT read sequence (Macronix)

The following table shows the fast dual I/O DT read sequence for Macronix flash memories.

Table 708. Fast dual I/O DT read sequence

Instruction	Pad	Operand	Description
CMD	0h	BDh	Fast dual I/O DT read command = BDh
ADDR_DDR	1h	18h	24 address bits to be sent on two pads in the DDR mode
MODE4_DDR	1h	0h	P2=P0 or P3=P1 is necessary. See the Macronix data sheet for details. One clock cycle for mode.
DUMMY	1h	6h	Six dummy cycles
READ_DDR	1h	4h	Read 32 bits on two pads in the DDR mode
JMP_ON_CS	0h	0h	Jump to instruction 0 (CMD)

NOTE

If DLL is disabled then JMP_ON_CS or STOP instruction can be used else only STOP instruction can be used.

80.8.1.6 Fast read quad output (Winbond)

The following table shows the fast read quad output sequence for Winbond memories

Table 709. Fast read quad output sequence

Instruction	Pad	Operand	Description
CMD	0h	6Bh	Fast read quad output command = 6Bh
ADDR	0h	18h	24 address bits to be sent on one pad
DUMMY	2h	8h	Eight dummy cycles
READ	2h	4h	Read 32 bits on four pads
JMP_ON_CS	0h	0h	Jump to instruction 0 (CMD)

NOTE

If DLL is disabled then JMP_ON_CS or STOP instruction can be used else only STOP instruction can be used.

80.8.1.7 4 x I/O read enhance performance mode (XIP) (Macronix)

The following table shows the 4 x I/O read enhance performance mode for Macronix flash memories. The enhanced performance mode is also known as XIP mode.

Table 710. Fast read quad output sequence

Instruction	Pad	Operand	Description
CMD	0h	EBh	4xI/O read command = EBh

Table continues on the next page...

Table 710. Fast read quad output sequence (continued)

Instruction	Pad	Operand	Description
ADDR	2h	18h	24 address bits to be sent on four pads
MODE	2h	A5h	Two mode cycles
DUMMY	2h	4h	Four dummy cycles
READ	2h	4h	Read 32 bits on four pads
JMP_ON_CS	0h	1h	Jump to instruction 1 (ADDR)

When in XIP mode, the software must ensure that all the flash memories connected to the controller are in this mode. As a part of initializing the controller, all the flash memories might be enabled with XIP by carrying out dummy reads.

80.8.1.8 Dual command page program (Numonyx)

The following table shows the dual command page program sequence for Numonyx flash memories.

Table 711. Dual command page program sequence

Instruction	Pad	Operand	Description
CMD	1h	2h	Dual command page program = 02h on 2 pads
ADDR	1h	18h	24 address bits to be sent on two pads
WRITE	1h	20h	Write 32 bytes on two pads
STOP	0h	0h	Stop, instruction over

80.8.1.9 Sector erase (Macronix/Numonyx/Spansion)

The following table shows the Sector erase sequence for the Macronix/Numonyx/Spansion flash memories.

Table 712. Sector erase sequence

Instruction	Pad	Operand	Description
CMD	0h	20h	Sector erase command = 20h
ADDR	0h	18h	24 address bits to be sent on one pad
STOP	0h	0h	Stop, instruction over

80.8.1.10 Read status register (Macronix/Numonyx/Spansion/Winbond)

The following table shows the read status register sequence for Macronix/Numonyx/Spansion/Winbond flash memories.

Table 713. Read status register sequence

Instruction	Pad	Operand	Description
CMD	0h	0h5	Read status register command = 05h
READ	0h	0h1	Read status register data
STOP	0h	0h	Stop, instruction over

80.8.1.11 Data learn instruction sequence

The following table shows the data learn sequence for 4 I/O flash memory.

Table 714. Data learn instruction sequence (4 I/O)

Instruction	Pad	Operand	Description
CMD	0h	6Bh	Fast read quad command = 6Bh
ADDR_DDR	2h	18h	24 address bits in the DDR mode to be sent on four pads
DUMMY	2h	8h	8-cycle dummy
DATA_LEARN	2h	1h	1-byte data learn
READ_DDR	2h	6h	Read 6 bytes in 4 pads[1]
JMP_ON_CS	0h	0h	Jump to Inst 0 (CMD)

1. Data learn instruction needs to be followed by a read DDR instruction of minimum 6 bytes in case of 4 I/O mode.

NOTE

If DLL is disabled then JMP_ON_CS or STOP instruction can be used else only STOP instruction can be used.

The following table shows the data learn sequence for 8 I/O (hyperflash memory) flash memory.

Table 715. Data learn instruction sequence (8 I/O)

Instruction	Pad	Operand	Description
CMD_DDR	3h	AOh	Read command for hyperflash memory
ADDR_DDR	3h	18h	24-bit row address[1]
CADDR_DDR	3h	10h	16-bit column address
DUMMY	3h	Fh	15-cycle dummy
DATA_LEARN	3h	1h	1-byte data learn
READ_DDR	3h	Ch	Read 12 bytes in 8 pads[2]
STOP	3h	0h	Stop, instruction over

1. The address needs to be aligned, which means, no latency should be there between the RWDS edges.
2. The data learn instruction needs to be followed by a read DDR instruction of minimum 12 bytes in case of 8 I/O mode.

The following table shows the data learn sequence for 4 I/O flash memory.

Table 716. Data learn instruction sequence (4 I/O)

Instruction	Pad	Operand	Description
CMD	0h	6Bh	Fast read quad command = 6Bh
ADDR_DDR	2h	18h	24 address bits in DDR mode to be sent on four pads
DUMMY	2h	8h	8 dummy cycles
DATA_LEARN	2h	1h	1-byte data learn
READ_DDR	2h	6h	Read 6 bytes in 4 pads
JMP_ON_CS	0h	0h	Jump to Inst 0 (CMD)

NOTE

If DLL is disabled then JMP_ON_CS or STOP instruction can be used else only STOP instruction can be used.

The following table shows the data learn sequence for 8 I/O (Hyperflash) flash memory.

Table 717. Data learn instruction sequence (8 I/O)

Instruction	Pad	Operand	Description
CMD_DDR	3h	AOh	Read command for hyperflash memory
ADDR_DDR	3h	18h	24-bit row address[1]
CADDR_DDR	3h	10h	16-bit column address
DUMMY	3h	Fh	15-cycle dummy
DATA_LEARN	3h	1h	1-byte data learn
READ_DDR	3h	8h	Read 8 bytes in 8 pads
STOP	3h	0h	Stop, instruction over

1. The address needs to be aligned, which means, no latency should be there between the RWDS edges.

NOTE

If DLL is disabled then JMP_ON_CS or STOP instruction can be used else only STOP instruction can be used.

80.9 Sampling of serial flash memory input data

80.9.1 Basic description

QuadSPI is used to read data from the serial flash memory device. Depending on the actual implementation, there is a delay between the internal clocking in the QuadSPI module and the external serial flash memory device. See the following figure for an overview of this scheme.

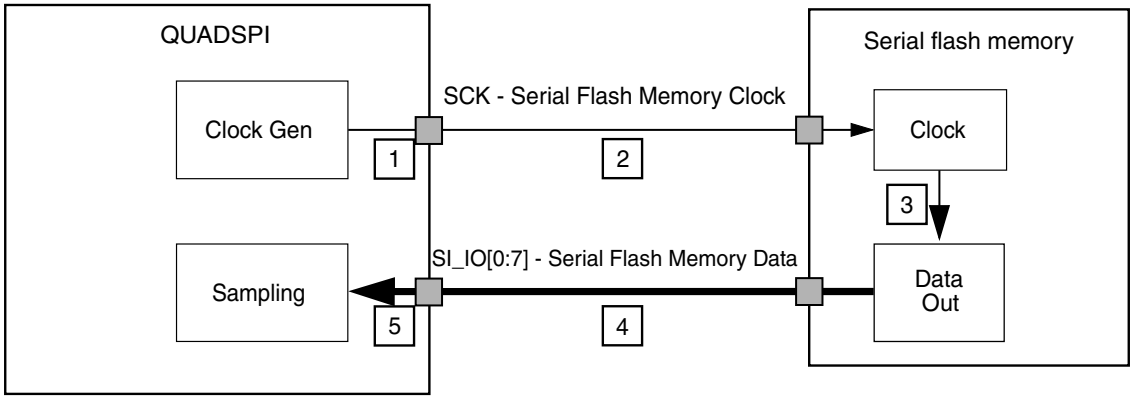


Figure 609. Serial flash memory sampling clock overview

The rising edge of the internal reference clock is taken as timing reference for the data output of the serial flash memory. After a time of t_{total_delay} the data arrives at the internal sampling stage of the QuadSPI module. Considering the figure provided here, the following parts of the delay chain contribute to t_{total_delay}:

- Output delay of the serial flash memory clock output of the device containing the QuadSPI module
- Wire delay of application/PCB from the device containing the QuadSPI module to the external serial flash memory device
- Clock to data out delay of the external serial flash memory device, including input and output delays
- Wire delay of application/PCB from the external serial flash memory device to the device containing the QuadSPI module
- Device delay corresponding to the input data

NOTE

The t_{total_delay} is specific to the characteristics of the actual implementation.

80.9.2 DQS sampling method

80.9.2.1 Basic description

In the DQS mode, the data strobe signal (DQS/RWDS) is used to sample the read data. Here, both DQS and the data sent by the flash memory move in the same direction; therefore, it is relatively easier to achieve at higher frequencies.

When using DQS for SDR reads, QuadSPI internally samples the incoming data on the rising edge of the strobe signal.

The next figure shows the sampling read data in the SDR mode using the DQS.

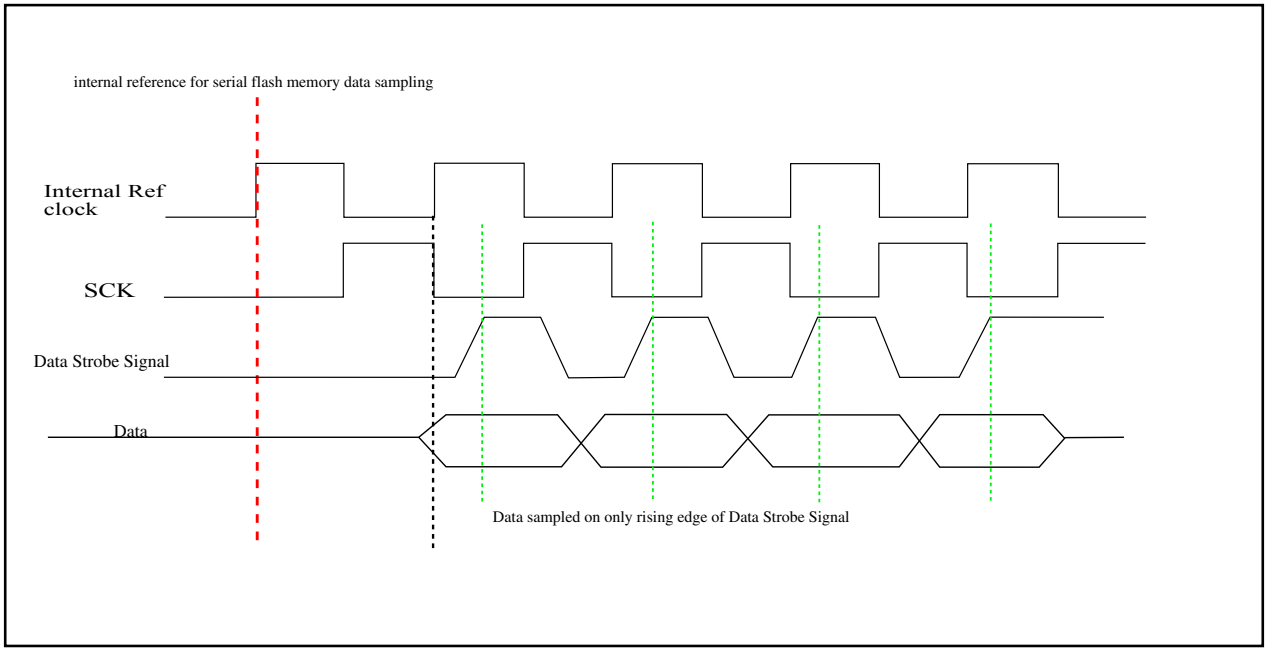


Figure 610. Data strobe functionality in SDR mode for read operation.

NOTE

Consider "Data Strobe Signal" as "Data Strobe Signal driven by memory" and "Data" as "Data from memory".

NOTE

Refer to the Datasheet for specific timing waveforms of QuadSPI

When using the DQS for DDR reads, QuadSPI internally samples the incoming data on both the edges of the strobe signal. See the next figure for details.

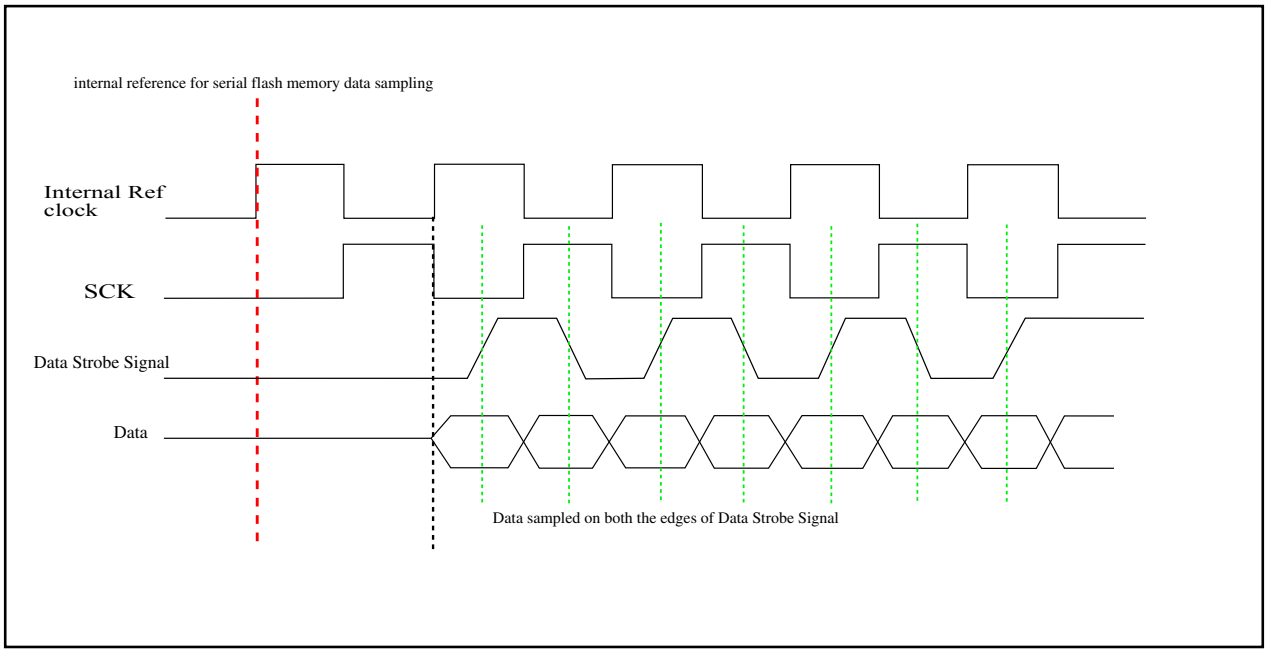


Figure 611. Data strobe functionality in DDR mode for read operation.

NOTE

Consider "Data Strobe Signal" as "Data Strobe Signal driven by memory" and "Data" as "Data from memory".

NOTE

For Specific details - Refer to the Data Sheet specification of QuadSPI module.

80.9.2.2 External DQS

In serial flash memories supporting DQS, the data strobe signal is an output from the flash memory device that indicates when data is being transferred from the flash memory to the host controller. The data is then captured by the controller on:

- Only one edge (either rising or falling edge) of DQS signal in the SDR mode
- Both rising/falling edges of the DQS signal in the DDR mode

This can be enabled by programming MCR[DQS_FA_SEL] = "11" for flash memory A. This mode supports the following configuration:

- Both high/low frequency delay chain manual programming using DLLCRA[SLV_DLY_COARSE] and DLLCRA[SLV_FLINE_OFFSET]
- DLL-assisted sampling only using and DLLCRB[DLLEN]
- DLL-assisted auto data learning using and DLLCRB[DLLEN] along with MCR{DLPEN]
- should be disabled as DLL is used

NOTE

This mode may not be available on the chip. See the "Supported read modes" section in the chip-specific QuadSPI information for the read modes that this chip supports.

80.9.2.3 Dummy Pad loopback

The internal clock is loop-backed from the dummy internal pad to compensate data pad delays. This can be enabled by configuring the value of MCR[DQS_FA_SEL] as "01" for flash memory A. This mode can be used with the following configuration:

- High/low frequency delay chain manual programming in bypass mode using DLLCRA[SLV_DLY_COARSE] and DLLCR[FREQEN].
- DLL-assisted sampling only using DLLCRA[DLLEN]

NOTE

Refer to chip-specific QuadSPI section or datasheet for 'Fixed sampling tap specific settings/details' without DLL (in bypass mode).

- DLL-assisted auto data learning using DLLCRA[DLLEN] and along with MCR[DLPEN]

NOTE

Refer to Auto-DataLearning (4x Sampling method) section with DLL for further details

NOTE

This mode may not be available on the chip. See the "Supported read modes" section in the chip-specific QuadSPI information for the read modes that this chip supports.

80.10 Data learning

80.10.1 Basic description

Data learning is used to manage varying data valid windows from the flash memory as well as any variations in the chip based on PVT conditions in the DDR mode. QuadSPI provides this feature via the DATA_LEARN instruction for all flash memories, irrespective of whether the flash memory supports it. The DATA_LEARN instruction accepts an operand that defines the number of bits of the known pattern for which the data learning has to be done. The known pattern is provided in the DLPR register.

QuadSPI supports the following data learning:

- QuadSPI supports data learning with DLL enabled only

The following sections explain data learning in detail.

80.10.2 DQS sampling method

The semi-automatic data learning is supported in the DQS sampling method. To start data learning:

1. Configure a known pattern in the Data Learn register inside flash memories that support data learning. The pattern should be selected to have multiple low and high transitions in the data bus.

   NOTE

   Certain flash memories provide data learning as a feature for DDR data reads.

2. Set up a QuadSPI DDR data read sequence, inserting a DATA_LEARN instruction before the READ_DDR instruction. The flash memory returns the data learning pattern in between dummy cycles in every read command. Each I/O gives the same DLP value for every clock edge.

   NOTE

   For flash memories that *do not* support data learning, configure a known location in flash memory with a known pattern. The pattern should not have 0h or FFh included. The pattern should be selected to have multiple low and high transitions in the data bus. Set up a QuadSPI DDR data read sequence, inserting a DATA_LEARN instruction. The address in the SFAR register should point to the known location within the pattern. Configure the known pattern in DLPR[DLPV]. See Programming the data learning pattern in flash memory for details on how the data has to be ordered in memory for correct operation.

3. Select a sampling point. See chip-specific QuadSPI information for selection of the sampling point.
4. Initiate the read via a peripheral transaction.
5. QuadSPI reads the data from the flash memory. It then encounters the DATA_LEARN instruction and samples the incoming data on both edges (rising and falling) of the DQS.

   NOTE

   If the data from the flash memory does not match the data learning pattern, the FR[DLPFF] flag is set. The QuadSPI module reports no sampling point automatically.

6. Repeat steps 2-7 with varying VT conditions for a particular process until FR[DLPFF] is set. The sampling points where no FR[DLPFF] is set signify a valid setting.

In the case of multiple valid settings, the software should select the middle point. The sampling point should be fixed within the above selected point for the next READ transactions.

NOTE

Ensure that QuadSPI is not accessed during calibration.

This feature might be used to auto-calibrate the sampling point for DDR reads, and auto-calibration might be triggered at fixed intervals, or depending on a change in PVT conditions.In case the sampling point needs to be changed based on initiating options (such as, DLL lock status, time period, or software forced interrupt), data learn instruction has to be re-initiated.

The following figure shows data learning in DQS mode.

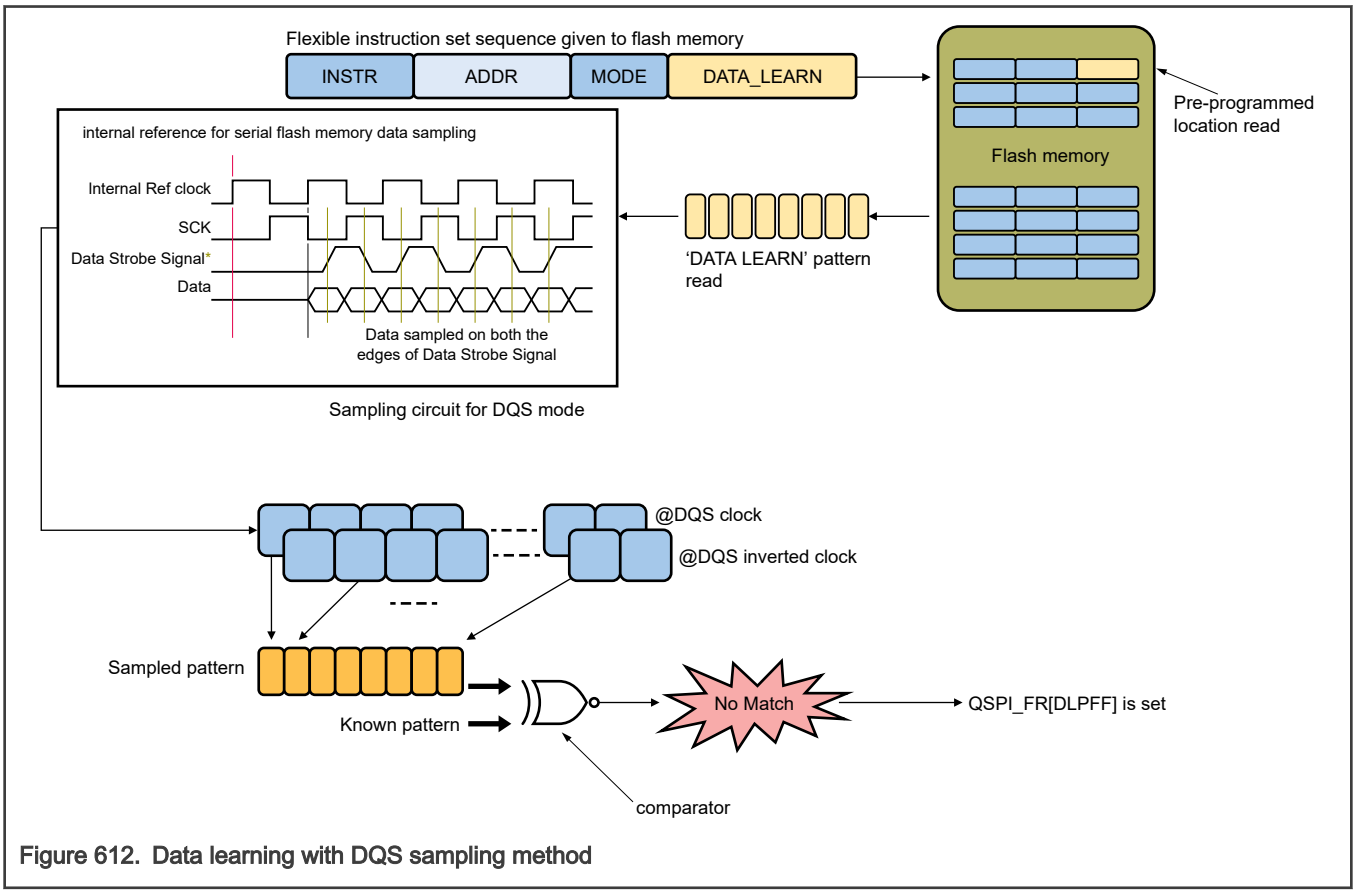


Figure 612. Data learning with DQS sampling method

NOTE

This mode might not be available on the chip. See the chip-specific QuadSPI information for the read modes that this chip supports.

80.10.3 Programming the data learning pattern in flash memory

Example scenario: If the value of DLPR[DLPV] is 43h, QuadSPI controller tries to match the sequence of bits sent on selected data lines with the pattern in DLPR[DLPV]. The following table shows the data programmed in flash memory with endianness taken into consideration.

Table 718. Programming the data learning pattern in flash memory

	Single Pad	Double Pad	Quad Pad	Octal Pad
DLPR IO1 pattern	0x349A	0x349A	0x3514	0x349A
DLPR IO3 pattern	NA	NA	0x349A	0x3514
Flash Pattern	0x2C59	0xF04CC226	0x0DF02D0D 0x00FFF020	0xF708f700 0xF70000FF 0x00FF0008 0x0000FFFF

80.11 DLL and delay chain usage

The DLL is a general-purpose, dynamically adaptive clock delay module. It provides the ability to select a quantized delay (in fractions of the clock period) regardless of on-chip variations such as process, voltage, and temperature (PVT). The DLL is suitable for applications where accurate delay adjustment is required, such as in case of DDR interfaces.

DLL working concept

The DLL control loop consists of a counter, reference delay line, and phase detector which operate on the ref_clock reference clock input. The reference clock (clk_ref) is fed into the reference delay line. After reset, a single delay tap is selected. A phase detector is used to detect the condition where a half shift has occurred. In addition to this, signals are generated to either increment or decrement the counter, which controls the delay line (if the half-phase detect condition is not met). Any changes in the delay of the individual elements of the delay chain (because of PVT) automatically cause the phase detector logic to determine if a change in the counter value is required. After the half-phase shift is detected, an internal lock signal is generated, and after a lock event occurs, the slave delay chain is ready to be updated based on a triggering event.

Slave delay chain programming sequence—

Following is the programming sequence for DLL bypass mode.

1. Program DLLCRA[SLV_EN]=1, DLLCRA[SLV_DLL_BYPASS]=1, and DLLCRA[SLAVE_AUTO_UPDT]=0.
2. Program the following fields to provide the desired DQS delay for sampling: DLLCRA[SLV_FINE_OFFSET], DLLCRA[SLV_DLY_COARSE], and DLLCR[FREQEN]. See the chip-specific QuadSPI information for the supported programming settings.
3. Program DLLCRA[SLV_UPD]=1 to load these values in the slave delay chain.
4. Check the slave delay chain update status by polling DLLSR[SLVA_LOCK]=1 and clear DLLCRA[SLV_UPD] after confirming the update state.

Following is the programming sequence for DLL auto update mode.

1. Program DLLCRA[SLV_EN]=1, DLLCRA[SLV_DLL_BYPASS]=0, and DLLCRA[SLAVE_AUTO_UPDT]=1.
2. Program the DLL configuration by using DLLCRA[DLL_REFCNTR] and DLLCRA[DLLRES]. See the chip-specific QuadSPI information for the supported DLL configuration settings.
3. Program the slave settings to delay DQS by using these fields: DLLCRA[SLV_FINE_OFFSET], DLLCRA[SLV_DLY_OFFSET], and DLLCR[FREQEN]. See the chip-specific QuadSPI information for the supported settings.
4. If offset delay needs to be updated on the slave chain, program DLLCRA[SLV_UPD]=1.
5. Enable DLL by programming DLLCRA[DLLEN]=1 and reset DLLCRA[SLV_UPD]=0. Slave delay chain is updated automatically and can be checked by polling DLLSR[SLVA_LOCK]==1

80.12 Data input hold requirement of flash memory

In the DDR mode, the data is valid only for half clock cycle. It is difficult to meet the data input hold time requirement for flash memory. QuadSPI internally delays the data sent to flash memory so that it becomes easy to meet the hold requirement. The FLSHCR[TDH] is used for this purpose. If FLSHCR[TDH] is configured to 0, then the data sent to flash memory is aligned with the internal reference clock of QuadSPI. If it is 1, then the data is aligned to 2x internal reference half clock.

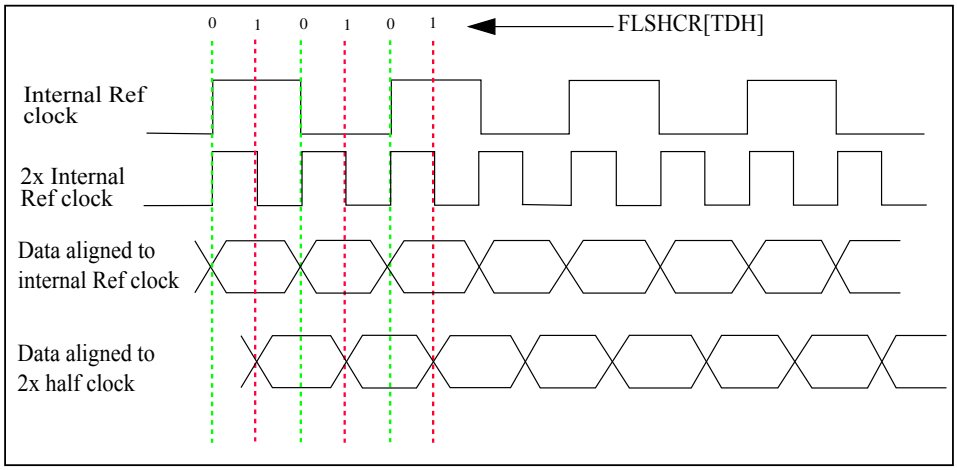


Figure 613. Data hold

80.13 Secure flash protection

This secure flash module enforces access control policies based on the MGID, privilege and secure attributes of the IPS transactions. All accesses throughout the flash device need to be monitored to determine the validity of all accesses. If transaction from a given master has appropriate access rights, it is forwarded to flash, else the access is denied, and an error is generated.

There are two level of checks present in this module, based on MDAD and FRAD descriptors programmed. First level checks the input transactions based on secure attribute and MGID associated with that transaction which are checked according to MDAD. Second level check selects the appropriate FRAD based on address range of transaction. And each FRAD allows the transaction to pass through only when secure, privilege and other MGID related attributes are matching. Else the transaction is not forwarded and IPS bus error/interrupt is generated. Flash regions can be programmed to cover the entire address space to provide a default set of access permissions. For flash read transactions only first level of check is enabled.

Software can bypass both or anyone of these checks by writing to MGC[GVLDFRAD], MGC[GVLDMDAD] and MGC[GVLD] fields.

The IPS masters should write on QuadSPI register (SFAR, IPCR and TBDR) addresses for generating transfers to flash. SFP block monitors these IPS transfers and checks if the write is being done on SFAR or IPCR registers and forwards them for MDAD and FRAD checks. If the transaction passes both checks then it is passed through to QuadSPI register else bus error or interrupt is generated. FRAD check is only done for flash write transactions not for read. Actual write on QuadSPI SFAR and IPCR register is done by SFP module only after the transaction passes MDAD and FRAD checks. There is only a single IPS slave interface which can be used for QuadSPI IPS register access and SFP IPS register access.

An IPS master transaction is secure if IPS_NONSECURE_ACCESS attribute is set to 0 for that transaction. An IPS master transaction is privileged if IPS_SUPERVISOR_ACCESS attribute is set to 1 for that transaction.

QuadSPI SFP related register sets are present here.

80.13.1 MDAD

These descriptors form the first level of checks on the input IPS transaction. There are two target group queues (TG0 and TG1) present in SFP block and each of these queues can be programmed with different set of MGAD descriptors checks in TG*n*MDAD registers. These registers are under access control and can only be programmed by privilege masters. These descriptors (one or both) should be programmed before start of any flash transaction else any IPS write on SFAR, IPCR or TBDR registers will generate an IPS bus error. After programming the target group descriptor the TG*n*MDAD[VLD] should be set to 1 for that register.

There are two target group queues (TG0 and TG1) so two transactions by different master ID can be stored inside SFP block while one of them is being processed by QuadSPI.

80.13.1.1 MDAD checks

- Secure check – This is decided by the TG*n*MDAD[SA] field of the MDAD descriptor. If the fields are set to 01 then queue is reserved for only non-secure transactions. If set to 10 then queue is reserved for only secure transactions. If the bits are set to 11 then this check is bypassed.
- MasterID check – This check compares themasterID of the input transaction with the MID match value set inTG*n*TG*n*MDAD[MIDMATCH]fields and allows only matching transactions inside the queue. There are 6 mask fields (TG*n*TG*n*MDAD[MASK]) inside the descriptor. If the mask type (TG*n*TG*n*MDAD[MASKTYPE]) is set to 0 then the input transactions master ID is ANDed with the mask bits before comparing with the MID match value. If the mask type is set to 1 then the input master ID is ORed with the masks bits and then compared with the MID match bits. Multiple master IDs can be allowed inside the queue using this mask.

When an IPS write is done to SFAR or IPCR registers then SFP block checks the attributes with MDAD descriptors of both the queues. If the attributes match with descriptor of any queue, then the value is written inside that queue and master ID is assigned to that queue. The queue is considered locked once the SEQID bits of IPCR register are written. So software should ensure that IPCR SEQID bits are written only after SFAR and other IPCR bits like DATSZ are written in that queue. The queue will be unlocked when flash transfer is completed for that transaction.

Once a master ID is assigned to a queue then transactions with only that master ID are allowed inside the queue. Any write of SFAR/IPCR is mapped to this queue even if other queue is free. So same master ID cannot have transaction on both queues at a time. The data in the queue is cleared once the flash transaction is finally completed by the QuadSPI.

The data path for input IPS writes to SFAR or IPCR registers are shown in the following figure.

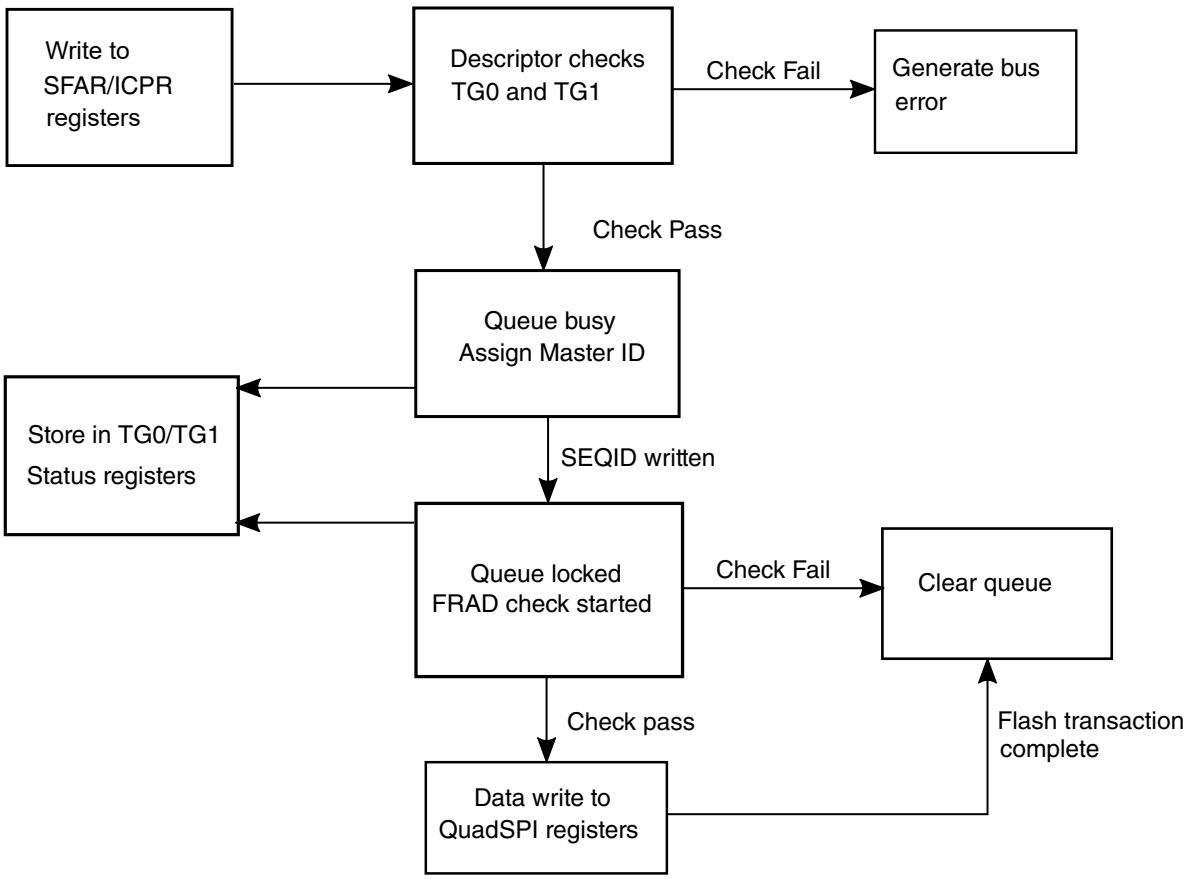


Figure 614. Data path for input IPS write to QuadSPI SFAR or IPCR registers

If the SFAR write passes first level of MDAD checks then the value is written in SFP register TG*n*SFAR and valid bit is set in TG*n*SFARS register and queue is considered as busy. Similarly when ICPR write passes the checks, its value is written into TG*n*IPRCS register and TG*n*IPRCS[VLD] field is set to 1 and queue is considered as locked. It is mandatory that IPCR is

written only after SFAR has been written for a queue and queue is busy. If IPCR is written before SFAR then it will result in IPS transfer error. Master should ensure that it completes the programming sequence for flash access request (write SFAR and IPCR with SEQID) so that target queue is not left after writing SFAR or IPCR without the SEQID. Both queues TG0 and TG1 are processed in round robin arbitration. The queue receiving the data first is processed first and next queue is processed after the first transfer completes.

NOTE

TBDR register write is not allowed until the SFAR and IPCR entries of that master has passed MDAD and FRAD checks and the transaction is queued for writing to QuadSPI. If TBDR registers are written before arbitration win, transfer error will be generated. IPS master can read FSMSTAT register to check the status of their transaction. TBDR access is allowed when FSMSTAT[VLD] field is set and for the master whose master ID matches with fields [11:8] of this register, and field [1:0] are set to 01 or 10. IPCR and SFAR registers are forwarded to QuadSPI only after the TX buffer is filled till watermark level in case of write transactions. IPCR should be written only after SFAR has been written successfully to a queue.

80.13.1.2 Error conditions

The error conditions for first level of MDAD checks and the response is given in table below. These error conditions can occur when SFAR, IPCR or TBDR registers are being written.

NOTE

Queue is considered busy if it has been written successfully once with any of the values SFAR, IDATSZ or PAR. Queue is considered locked when SEQID has been written successfully by passing MDAD checks.

Table 719. MDAD check error conditions

Error condition	Response	Common/Queue error
None of the queue descriptors are programmed	IPS transfer error is generated	Common error
Both queues are locked	IPS transfer error is generated	Common error
Both queues are busy and another master writes whose master ID is not matching with either queue.	IPS transfer error is generated.	Common error
Queue busy and same master writes SFAR or IPCR registers with wrong security attribute	IPS transfer error is generated and queue is cleared (SFAR and IPCR needs to be written again for transfer to start).	Queue error
Queue is locked and same master writes	IPS transfer error is generated	Common error
If master ID of transaction doesn't qualify MID check of any of the queues	IPS transfer error is generated	Common error
If both the queues are empty and security attribute of transaction doesn't match with any of the queues	IPS transfer error is generated	Common error
TBDR register is written before SFAR and IPCR SEQID qualifies MDAD checks	IPS transfer error is generated	-
If none of FRAD descriptors are programmed	IPS transfer error is generated	Common error

Table continues on the next page...

Table 719. MDAD check error conditions (continued)

Error condition	Response	Common/Queue error
IPCR is written before SFAR	IPS transfer error is generated	Common Error - If the transaction doesn't matches the security attribute check or MID check of any MDAD. No common or queue error - If it matches security and MID attribute of any queue.

When a common error is generated its details are latched in IPSERROR register and corresponding error field is set to 1. This register will tell if the transaction failed because of queue locked, MID mismatch or security failure along with the master ID of that transaction. This register will keep the last error transaction latched unless cleared by writing 1 to CLR bit of this register. Then from next cycle onwards this register can latch new errors. Common error will also be generated if none of the FRAD descriptors are programmed. In case a queue is busy and same master writes IPCR or SFAR with wrong security attributes the queue is cleared, the Target Group n SFAR Status (TG0SFARS - TG1SFARS) valid bit goes low. In this case the master should write the SFAR an IPCR again for proper transaction to start.

In case of queue error the details are latched in Target Group n IPCR Status (TG0IPCRS - TG1IPCRS) or Target Group n SFAR Status (TG0SFARS - TG1SFARS) registers. These registers will also keep the error status latched until cleared by writing 1 to CLR bit of respective registers.

80.13.2 FRAD

These descriptors form the second level check for IPS flash write and flash erase transactions. IPS read transaction are not processed by this level of check and are passed through after MDAD checks. There are 8 FRADs which can be programmed by privilege masters. So the access checks can be programmed for up to 8 unique address ranges. Each of the address range is equipped with different access attribute checks and based on this write access can be controlled for the flash region. These descriptors must be programmed before starting transactions on flash.

After programming the FRAD*n*_WORD0, FRAD*n*_WORD1, FRAD*n*_WORD2 and FRAD*n*_WORD3 registers, FRAD*n*_WORD3[VLD] field should be written 1. SFP block doesn't consider the FRAD descriptors which are not valid. If none of the FRAD are programmed, then error interrupt will be generated if enabled, and transaction is not forwarded to QuadSPI.

There is a descriptor lock feature to prevent spurious changes to the FRAD. FRAD*n*_WORD3[LOCK] can be programmed to make all FRAD registers as read only or to allow write access to all or some masters with specific master ID.

80.13.2.1 FRAD checks

- Address range checks – Start and end address for FRAD region are programmed in FRAD*n*_WORD0 and FRAD*n*_WORD1 registers. Start address of IPS flash transaction written in SFAR register and data size programmed in IPCR register, is used to check if the transaction lies within any of the FRAD address ranges. This address range match will be used to select the corresponding FRAD from which other access checks will be done. The start and end address are programmed around 64 KB boundary so 16 MSB are only used for range check..

  The data size should not be programmed as 0 in IPCR register for normal data transfers to flash and actual size should be programmed. In the cases where only flash instruction has to be send and no data has to be written in TBDR register, this DATSZ can be programmed as 0. In case the DATSZ is programmed as 0 in IPCR, SFP module blocks the write access to TBDR register and if any write is done then that generates IPS transfer error.

- Exclusive access lock – Exclusive master access lock can be enabled over any flash address defined under a FRAD. The master ID of the master which enables/owns the exclusive access is captured in FRAD*n*_WORD2[EALO] fields. Once enabled, the exclusive lock can be released only by the same master which enabled the lock by writing on FRAD*n*_WORD3[EAL] fields. The exclusive write access permissions of a flash region are decided as given in table below:

Table 720. Exclusive access lock

FRAD*n*_WORD3[EAL]	Write permissions
00	No lock. The write permissions are decided as set in FRAD*n*_WORD2[MDnACP] fields for respective master domain.
10	Write permissions are revoked for all masters. Any write transaction coming to this flash address region will not be forwarded through and will result in an error.
11	Write permissions are revoked for all masters except the master ID matching the ID specified by FRAD*n*_WORD2[EALO] fields.

- Flash region privilege checks – If the FRAD*n*_WORD3[EAL] fields are set to 00 then flash write access permissions for any IPS master is decided based on the settings done in FRAD*n*_WORD2[MDnACP] fields as given in table below. MD0ACP permission checks are done for transaction coming through target group 0 queue (TG0) and MD1ACP permission checks are for transactions coming through target group 1 queue (TG1).

Table 721. Flash region privilege checks

MDxACP value	Privilege access	Secure access	Write access
111	No	No	Not allowed
	No	Yes	Not allowed
	Yes	No	Allowed
	Yes	Yes	Allowed
110	No	No	Allowed
	No	Yes	Allowed
	Yes	No	Allowed
	Yes	Yes	Allowed
101	No	No	Not allowed
	No	Yes	Not allowed
	Yes	No	Not allowed
	Yes	Yes	Allowed
100	No	No	Not allowed
	No	Yes	Allowed
	Yes	No	Not allowed
	Yes	Yes	Allowed
0xx	-	-	Not allowed

If any transaction fails FRAD check then error interrupt is generated if enabled.

FRAD status registers keep the details of last transaction which lie within the address range of that respective FRAD and will be updated only when a new transaction comes which falls within the same address range.

Flash Region Compare Address Status (FRAD0_WORD4 - FRAD7_WORD4) register stores the flash start address that was compared and Flash Region Compare Status Data (FRAD0_WORD5 - FRAD7_WORD5) contains the master ID, privilege and secure attributes of the transaction. The transaction details are stored in FRAD register for which the address compare check passed. These status registers are not updated in case of read transfers or when FRAD check is disabled. For example, if the transaction address lies in the range set in FRAD2_WORD0 and FRAD2_WORD1 then the transaction details will be stored in

FRAD2_WORD4 and FRAD2_WORD5 registers and valid field [30] will be set. If transaction fails, the security or privilege attribute check for the corresponding FRAD then error field [29] is set in FRADx_WORD5 status register. This bit and other transaction details will remain latched unless cleared by writing '1' to W1C bit of corresponding FRAD in ERRSTAT register.

If transaction address doesn't match any of the FRAD address range or if matches with multiple FRAD address ranges, then also error interrupt is generated. But for no FRAD match, the details will not be stored in any of the FRAD status registers.

FRAD checks are done only for flash write transactions, flash read transactions are passed through to QuadSPI if MDAD checks are passed. At least one FRAD region should be made valid (if the FRAD check is enabled from MGC register) for flash read instructions to go through even when FRAD check is not done for read instructions. SFP module checks if a transaction is read or write from the SEQID written in IPCR register and LUT table programmed inside QuadSPI. Master Read Command (MRC) register shows the read command code which SFP block identifies. There are two command codes which are predefined READ_DDR and READ commands. Software can program two other command code as per its convenience by writing into fields [21:16] or [29:24] and then writing respective valid bit as 1.

80.13.2.2 Error conditions

Any transaction passing the MDAD checks will be checked for FRAD checks and can lead to following error scenarios.

Table 722. Error conditions

Error condition	Response
None of the FRAD are programmed	IPS transfer error will be generated and status will be latched in IPS_ERROR register
Transaction address doesn't fall within any of the FRAD address range	Error interrupt will be generated if enabled
Transaction match with multiple FRAD address range	Error interrupt will be generated if enabled. Error bit will be set, and status will be stored in FRADx_WORD5 status registers for whom the address check passed
Transaction passes FRAD address check but fails privilege or security checks	Error interrupt will be generated if enabled. Error bit will be set, and status will be stored in FRADx_WORD5 status registers for whom the address check passed
Transaction passes FRAD address check but range was locked by EAL bits	Error interrupt will be generated if enabled. Error bit will be set, and status will be stored in FRADx_WORD5 status registers for whom the address check passed
Read transaction	No FRAD check will be done and no error will be generated for FRAD failure. But if FRAD check is enabled in MGC then at least one FRAD should be valid else it will give error during SFAR/IPCR write

80.13.2.3 Atomic commands considerations

For security reasons, the atomic commands (where flash's internal configuration region is accessed) like flash erase etc. should always be programmed in last 6 SEQID locations of LUT. FRAD0 has access to all the LUT locations including these last 6 SEQID. Remaining FRAD regions will not allow write access if the IPCR SEQID is set for any of the last 6 locations of LUT. It will result in FRAD access error and it will set in FRAD status registers. Also the software must set the FRAD0 MDACP to 101 so that write access is allowed only for secure privilege masters. This is done to ensure that no other master can use the atomic commands like flash erase to change the contents of flash. So when any master wants to use these atomic command programmed in last 6 locations of LUT it will have to write FRAD0 start address in SFAR and keep IPCR DATSZ such that it falls under FRAD0 address region and MDACP programmed in FRAD0 are checked.

For flash configuration in case of dual-die the software needs to change the address range of FRAD0 accordingly so that address goes to second die. Similar consideration to be taken in case of dual flash where Port A and B are being used.

80.13.3 TBDR register write lock

SFP module keeps the TBDR write locked for IPS transactions by default. When a IPS master writes SFAR and IPCR transactions and this transaction passes MDAD and FRAD checks then the accesses are unlocked for that master ID. Lock and unlock procedure is shown with an example in figure below:

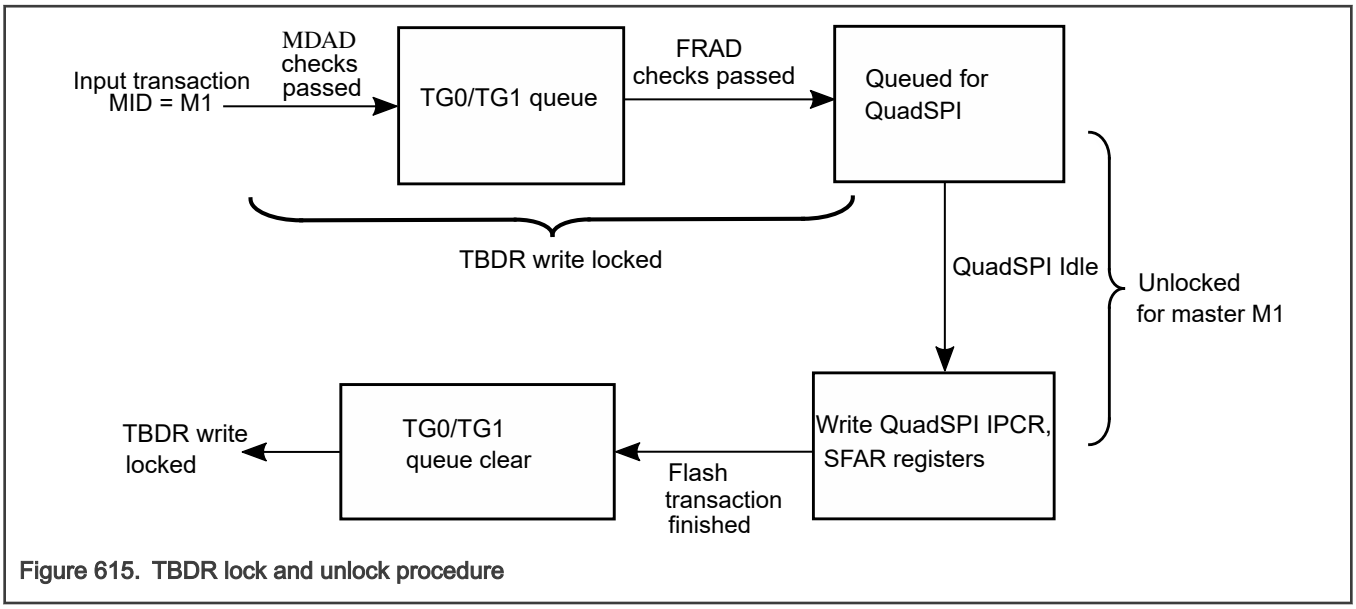


Figure 615. TBDR lock and unlock procedure

If any master writes on TBDR register when it is not unlocked for that master ID it will result in IPS transfer error. IPS master should ensure that it writes the TBDR register once QuadSPI registers have been written by the SFP module. This can be checked by reading FSM Status (FSMSTAT). Bits [11:8] of this register tells which master ID is currently active, and if the value of bits [1:0] is 01 or 10 and bit 31 is set as 1, then the TBDR lock is open for write transactions. It is advisable that for write transactions where IDATSZ is non zero, master clears the TBDR buffer from any residue data and program the TBCT[WMRK] watermark once its request is granted in arbitration (FSMSTAT bit [1:0] are 01). In case of transfers having IDATSZ programmed as 0 the TBDR register remains locked and data can't be written to this register. In case DMA is being used to fill the TBDR buffer, program RSER[TBFDE] field to 1 only when write access is granted and TBDR access is unlocked after checking FSMSTAT[STATE] field. Once DMA completes the TBDR write reset, this field is set back to 0. After this, the SFP will write SFAR and IPCR to QuadSPI triggering the flash transfer. It should be made sure that the DMA should have same master ID as the master which won the arbitration.

80.13.4 Transaction status registers

SFP module has two registers (FSM Status (FSMSTAT) and FlashSeq Request (FLSEQREQ)) which shows the current and last transaction status. These registers are updated only after MDAD and FRAD check are passed.

- FSM Status (FSMSTAT) register shows the current transaction which is queued for QuadSPI when valid field [31] is set. Field [16] of this register if set to 1 then it is a non-read instruction sequence and it is set to 0 then it means that this is a read sequence. Fields [11:8] show the master ID from which this transaction is generated. Fields [1:0] show the current state of active transaction when valid field [31] is set.

  The figure below shows the IPS transaction flow inside SFP block along with various values of bits [1:0]:

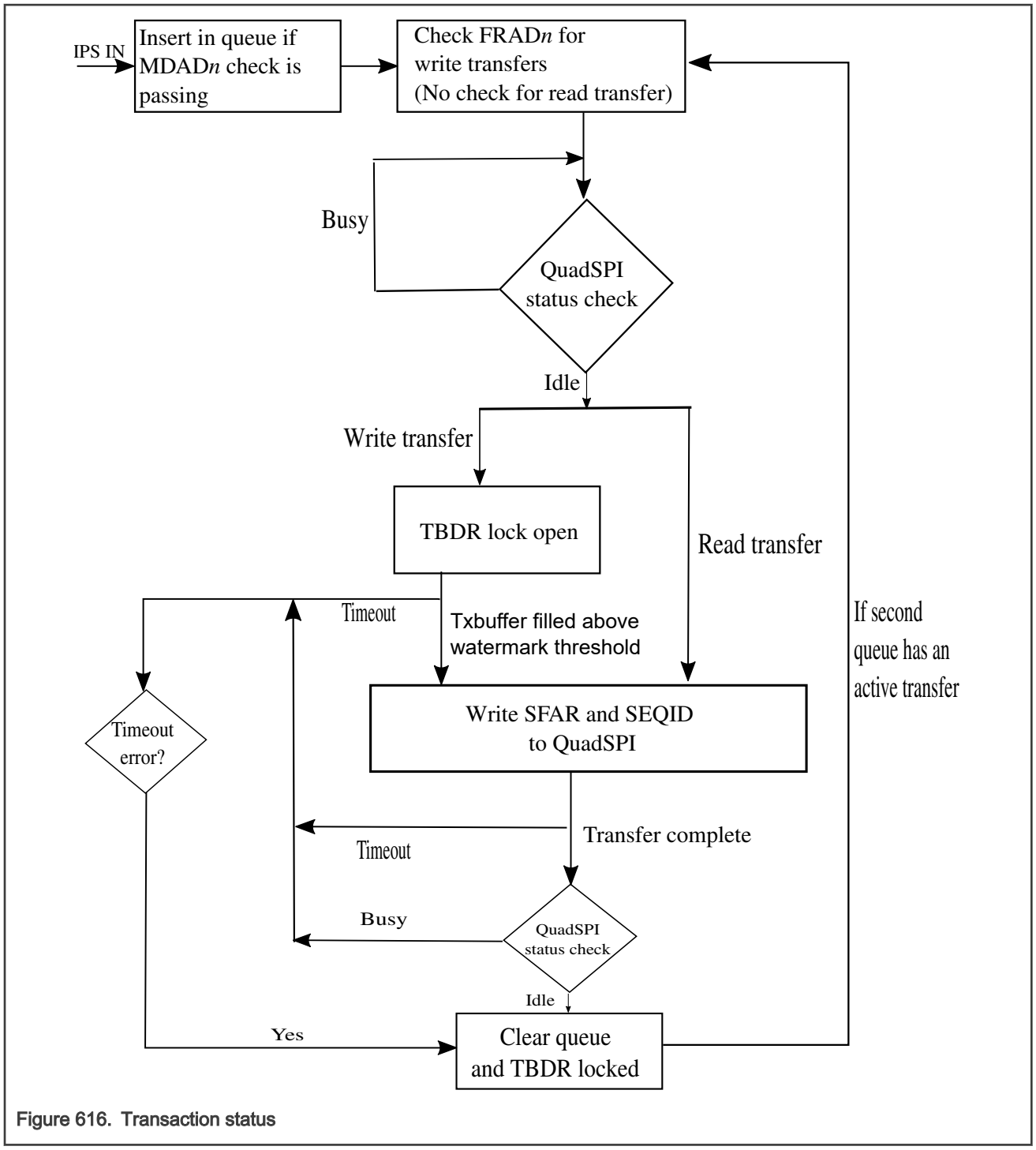


Figure 616. Transaction status

NOTE

If the DATSZ programmed in TG0/TG1 IPCR register is more than the TX buffer watermark threshold value (256-Watermark programmed in TBCT) then it waits for threshold to cross before writing the SFAR and IPCR registers to QuadSPI. Else SFP block waits for one entry to be written to TBDR register and after that it writes the SFAR and IPCR to QuadSPI thus triggering the transfer. In case of read transfers, SFAR and IPCR are written as soon as QSPI is IDLE.

NOTE

QuadSPI is considered IDLE if transaction is finished at flash, No DMA and interrupt pending and RX data is completely read. In case RX data is pending it can be cleared by writing to MCR[CLR_RXF]. Refer to section Timeout error for more details.

FSM state values in FSM Status (FSMSTAT) for different states are in the following table:

Table 723. FSMSTAT register field details

FSMSTAT register fields	
VLD	0 - No IPS transfer is queued for launch to QuadSPI 1 - IPS transfer is queued or running in QuadSPI
STAT	00 - QuadSPI is busy with AHB transfer, any DMA transfer is pending, RDBFL has residue data or any interrupt is pending. 01 - TBDR lock is open. QuadSPI considers IPS transfer. AHB transfer should not start. 10 - TX buffer filled above threshold. Write transfer is triggered. SEQID is written. 11 - Read transfer is triggered. SEQID is written.

For flash write transfers which passes MDAD and FRAD checks and QuadSPI is not busy with any previous transfer, TBDR lock is opened and bits [1:0] shows value of 01. Once the IPS master fills the TX buffer till the level where free entries in TX buffer are less than the watermark threshold set in TX Buffer Control Register (TBCT) and SR[TXWA] flag is de-asserted, SFP block writes the SFAR and IPCR entries to QuadSPI registers and transaction is triggered. To avoid underrun, program the watermark accordingly for size of the data to be transferred. This programming can be done when TBDR access is allowed after arbitration is granted. TBCT Watermark can be programmed as 256-(IDATSZ/4-1) in most of the scenarios. If the DATSZ entry written in IPCR is less such that TX buffer can never be filled till watermark threshold, in such cases SFP block does not wait for the TBCT[WMRK] to trigger and writes the SFAR and ICPR registers as soon as one data entry is written to TBDR register. When the SFAR and IPCR register are written, bits [1:0] are set to 10. In case of flash memory read transfers SFAR and IPCR entries are written to QuadSPI as soon as QuadSPI is IDLE and bits [1:0] are set to 11. QuadSPI is considered IDLE only if no AHB/IPS transfer is ongoing, any DMA transfer is not pending, RDBFL doesn't have residue data and any interrupt is not pending (FR[TFF], FR[TBFF], FR[TBUF], FR[RBDF], FR[RBOF], FR[ABOF], FR[AIBSEF], FR[AITEF], , , FR[IPIEF], , FR[ILLINE], ,). Valid bit [31] goes to 0 once the IPS transfer is completed. IPS master should clear the TX buffer before writing to TBDR register to ensure that no data from previous transaction is left in TX buffer.

If the IPS transaction has passed the MDAD and FRAD checks but QuadSPI is busy with some AHB transfer, then the bits [1:0] are set to 00. Other than ongoing AHB transfer QuadSPI can be busy because of other reasons also like if any TXDMA or RXDMA pending, if read buffer has data pending or if any QuadSPI interrupt is enabled and pending for servicing. So IPS master should ensure that no interrupt is pending or previous read transfer is completed. If the QuadSPI remains busy for a longer time it may result in timeout error.

Software must take care that no AHB transaction is launched when any IPS transaction is ongoing, TBDR lock is open or IPS transaction is getting executed on QuadSPI. It can be checked by reading this FSM status register. if the valid bit is 1 and bits [1:0] are set to 01, 10 or 11 then no AHB transfer should be generated towards QuadSPI.

For any IPS initiated RW transaction which needs two separate transactions at flash interface, like Write-Enable transaction followed by Write-data transaction (Data-Learn flash transaction followed by Read-data transaction) at flash interface must be joined together with JMP_2_SEQ instruction.

- FlashSeq Request (FLSEQREQ) register holds the details of transaction which was last send to QuadSPI. After a flash transaction is completed this register is updated and its valid field [31] is set to 1. This register holds the command type (read or write), transaction master ID (fields [3:0]), target group queue (TG0 or TG1) from which this transaction passed in field [4], privilege and secure attributes for the transaction, SEQID (fields [19:16]) and number of flash descriptor FRAD within whose address range the transaction lies (fields [14:12]).

This register also contains a timeout error field [27] which is set when a timeout error occurs, and transaction is aborted. When the error occurs this register keeps the status latched unless it is cleared by writing 1 to clear field [29].

80.13.5 Timeout error

MTO register can be programmed with a timeout value above which the transaction should be aborted. When the transaction passes MDAD and FRAD level checks and QuadSPI is idle (no AHB transaction is ongoing, no DMA transfer is pending, RDBFL doesn't have any residue data from last transfer and (FR[TFF], FR[TBFF], FR[TBUF], FR[RBDF], FR[RBOF], FR[ABOF], FR[AIBSEF], FR[AITEF], , , FR[IPIEF], , FR[ILLINE], ,) interrupt is not pending) this counter is started. If the transaction is not completed before this timeout counter reaches the value programmed in MTO register the transaction is considered aborted by SFP and an error interrupt is generated if enabled. The error bit is also set in FLSEQREQ register along with the transaction details. After the timeout error, next transaction is written to QuadSPI register which was queued in another target group queue once SR[BUSY] flag goes low.

80.13.6 Arbitration lock

The arbitration lock feature is used to lock the arbitration for a particular queue. This lock can be requested by a master by writing '1' into IPCR[ARB_LOCK] field. Once the transaction passes both the checks (MDAD & FRAD) and wins the arbitration, this lock will be granted. After this, the transaction from the other queue will not be granted unless the arbitration is unlocked by previous queue. The master which locked the arbitration can unlock it by writing '1' to IPCR[ARB_UNLOCK] field. Once the transaction with unlock bit 1 passes the MDAD and FRAD checks, it will unlock the arbitration. After this transaction is finished, the other queue will be granted the arbitration which was waiting.

This arbitration lock feature can be used by software while doing any transaction to flash which may result in a waiting period. For example, in case of NOR flash, after a write is issued to flash there is a waiting period (TPP) for which the flash is inaccessible. In this case, the software should ensure that while writing this SEQID to IPCR register it should lock the arbitration so that transaction coming to other queue is not passed to flash controller which may result in failure. Once the software ensures that waiting period at flash is over, it can read the flash configuration/status registers to confirm. And after getting confirmation, it can send another read command to same configuration register with IPCR[ARB_UNLOCK] field set to '1'. This will ensure that the transaction waiting in another queue are granted. If the flash being used does not have a waiting period attached with transactions, then this ARB_LOCK field can be always kept to 0.

In case software uses this LOCK functionality RWW support will not be available. Because in this case, all the transaction from other queue which was blocked from arbitration will be blocked irrespective of read or write access. So, RWW support (read can go through even when flash is in waiting state) will not be available. The master which has arbitration lock granted can still send read accesses to flash during the waiting period in case the flash supports it.

80.13.7 Soft reset consideration with SFP

If there is any pending transaction in MDAD queue, do not assert QuadSPI reset bits unless you observe unexpected behavior like no response from the module. In that case, assert QSPI reset twice.

In case the soft reset is being used for QSPI, software should take some considerations so that correct functionality is maintained. if the soft reset is asserted when a transaction is being executed by SFP (FSM_STATE [1:0] bits are 01, 10 or 11) then this transaction will be aborted. Different conditions that can occur in case of soft reset are listed in table below:

Table 724. Soft reset conditions

Condition at time of soft reset	FSM state register at time of soft reset	Result	Timeout scenario
Some AHB transaction was ongoing and SFP/IPS is in waiting state.	FSM_STATE[1:0] = 00	After the soft reset if de-asserted the SFP will schedule its transaction over QSPI. FSM_STATE[1:0] will change to other values than 00. Software can fill TBDR in case it is a write transfer or start reading from RBDR.	In this case software doesn’t writes to TBDR or read from RBDR it will result in timeout error.

Table continues on the next page...

Table 724. Soft reset conditions (continued)

Condition at time of soft reset	FSM state register at time of soft reset	Result	Timeout scenario
QSPI was IDLE and SFP transaction has been arbitrated. TBDR is being filled and SFAR, IPCR are not currently written to QSPI.	FSM_STATE[1:0] = 01	Currently TBDR was being filled after soft reset all the entries in TBDR are flushed. So it is expected from software that it will start filling TBDR from start after the reset has de-asserted. SFP will write SFAR and IPCR to QSPI once its normal conditions are met (when number of available spaces in the TX buffer is greater than or equal to the value provided by TBCT[WMRK] or single TBDR write in case watermark check is disabled)	Timeout will occur if TBDR is not filled again after the soft reset is lifted.
SFP has written just SFAR to QSPI IPCR is not written yet. (For a read transfer or write transfer with data size 0)	FSM_STATE[1:0] = 01	After the soft reset is lifted the SFP will write ICPR to QSPI module and FSM_STATE will change to 11 (read) or 10(write). Transaction will finish normally.	Timeout conditions will be same as that for normal transfer.
SFP has written just SFAR to QSPI IPCR is not written yet. (Write data size is non 0)	FSM_STATE[1:0] = 01	After soft reset is lifted the SFP will write IPCR to QSPI module once software fill TBDR (from start) and FSM_STATE will change to 10.	Timeout conditions will be same as that for normal transfer.
SFP has written SFAR and IPCR to QSPI.	FSM_STATE[1:0] = 10 or 11	After the soft reset is de-asserted the current transaction will be deemed aborted. FSM_STATE valid will go low as transfer has finished.	No timeout.

So to conclude in case the soft reset is asserted when FSM_STATE[31] bit is 1 and state bits are 10 or 11 current transaction will be aborted & the next transaction will proceed as normal. In case the state bits are 00 or 11 then it is advisable that software doesn't writes into TBDR after the reset is de-asserted and waits for timeout error to be generated to know when current ongoing SFP transaction is aborted. After clearing the timeout error a new transaction can be launched to SFP or if already a new transaction is present in another queue it will be arbitrated.

80.13.8 Error Interrupt Enable

INT_EN register allow software to disable or enable the interrupt signal generation in case of any of the listed error conditions. This interrupt is generated on 'ipi_int_ored' interface signal of QuadSPI.

- Time out error (INT_EN[TO_ERR])
- IPCR register write error (INT_EN[TG*n*IPCR])
- SFAR register write error (INT_EN[TG*n*SFAR])
- IPS common error (INT_EN[IPS_ERR])
- FRAD access error (INT_EN[FRAD*n*ACC])
- No FRAD address range match error (INT_EN[FRADMTCH])

If the respective field is set to 1 for any of the error conditions, then the interrupt signal is set to 1 when that error occurs and it remains set until the error is cleared by writing 1 to error clear bit as listed in register descriptions.

80.14 Memory map and register definition

This section provides the memory map and register definitions for the QuadSPI module.

80.14.1 Register write access

Following are the write access restriction terms that apply to all the registers:

- Register write access restriction

  For each register field, the write access conditions are specified in the detailed register description.

  The following table provides a description of the write access conditions. If, for a specific register bit or field, none of the given write access conditions is fulfilled, any write attempt to this register bit or field is ignored without any notification. The values of the bits or fields are not changed.

  The condition term [A or B] indicates that the register or field can be written to if at least one of the conditions is fulfilled.

Table 725. Register write access restrictions

Condition	Description
Anytime	No write access restriction
Disabled mode	Write access only if MCR[MDIS] = 1
Normal mode	Write access only if the module is in the normal mode

- Register write access requirements

  You can access all registers using 8-bit, 16-bit, and 32-bit wide operations. For some of the registers, at least a 16-bit or 32-bit wide write access is required to ensure correct operation. This write access requirement is stated in the detailed register description for each affected register.

80.14.2 QuadSPI register descriptions

This section provides the memory map and register definitions for the QuadSPI module.

Access to the following addresses does not result in a transfer error:

- 64h
- 138h
- 168h
- 188h
- 18Ch
- 198h

80.14.2.1 QuadSPI memory map

QuadSPI base address: 404C_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration Register (MCR)	32	RW	000F_404Ch
8h	IP Configuration Register (IPCR)	32	RW	0000_0000h
Ch	Flash Memory Configuration Register (FLSHCR)	32	RW	0000_0303h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
10h	Buffer 0 Configuration Register (BUF0CR)	32	RW	0000_0003h
14h	Buffer 1 Configuration Register (BUF1CR)	32	RW	0000_0002h
18h	Buffer 2 Configuration Register (BUF2CR)	32	RW	0000_0001h
1Ch	Buffer 3 Configuration Register (BUF3CR)	32	RW	8000_0000h
20h	Buffer Generic Configuration Register (BFGENCR)	32	RW	0000_0000h
24h	SOC Configuration Register (SOCCR)	32	RW	0000_0000h
30h	Buffer 0 Top Index Register (BUF0IND)	32	RW	0000_0000h
34h	Buffer 1 Top Index Register (BUF1IND)	32	RW	0000_0000h
38h	Buffer 2 Top Index Register (BUF2IND)	32	RW	0000_0000h
50h	AHB Write Configuration Register (AWRCR)	32	RW	0000_0000h
60h	DLL Flash Memory A Configuration Register (DLLCRA)	32	RW	0120_0000h
6Ch	Parity Configuration Register (PARITYCR)	32	RW	0000_0000h
100h	Serial Flash Memory Address Register (SFAR)	32	RW	0000_0000h
104h	Serial Flash Memory Address Configuration Register (SFACR)	32	RW	0000_0800h
108h	Sampling Register (SMPR)	32	RW	FF00_0000h
10Ch	RX Buffer Status Register (RBSR)	32	R	0000_0000h
110h	RX Buffer Control Register (RBCT)	32	RW	0000_0000h
120h	AHB Write Status Register (AWRSR)	32	R	0000_0000h
12Ch	DLL Status Register (DLLSR)	32	R	8000_8000h
130h	Data Learning Configuration Register (DLCR)	32	RW	40FF_40FFh
134h	Data Learning Status Flash Memory A Register (DLSR_FA)	32	R	0000_0000h
150h	TX Buffer Status Register (TBSR)	32	R	0000_0000h
154h	TX Buffer Data Register (TBDR)	32	RW	0000_0000h
158h	TX Buffer Control Register (TBCT)	32	RW	0000_0000h
15Ch	Status Register (SR)	32	R	0200_3800h
160h	Flag Register (FR)	32	RW	0800_0000h
164h	Interrupt and DMA Request Select and Enable Register (RSER)	32	RW	0000_0000h
16Ch	Sequence Pointer Clear Register (SPTRCLR)	32	RW	0100_0000h
180h	Serial Flash Memory A1 Top Address Register (SFA1AD)	32	RW	7000_0000h
184h	Serial Flash Memory A2 Top Address Register (SFA2AD)	32	RW	7000_0000h
190h	Data Learn Pattern Register (DLPR)	32	RW	AA55_3443h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
194h	Flash Memory A Failing Address Status Register (FAILA_ADDR)	32	R	FFFF_FFFFh
200h - 27Ch	RX Buffer Data Register (RBDR0 - RBDR31)	32	R	0000_0000h
300h	LUT Key Register (LUTKEY)	32	RW	5AF0_5AF0h
304h	LUT Lock Configuration Register (LCKCR)	32	RW	0000_0002h
310h	LUT Register (LUT0)	32	RW	0818_0403h
314h	LUT Register (LUT1)	32	RW	2400_1C08h
318h - 44Ch	LUT Register (LUT2 - LUT79)	32	RW	0000_0000h
800h	Flash Region Start Address (FRAD0_WORD0)	32	RW	0000_0000h
804h	Flash Region End Address (FRAD0_WORD1)	32	RW	0000_FFFFh
808h	Flash Region Privileges (FRAD0_WORD2)	32	RW	0000_0000h
80Ch	Flash Region Lock Control (FRAD0_WORD3)	32	RW	0000_0000h
810h	Flash Region Compare Address Status (FRAD0_WORD4)	32	R	0000_0000h
814h	Flash Region Compare Status Data (FRAD0_WORD5)	32	R	0000_0000h
820h	Flash Region Start Address (FRAD1_WORD0)	32	RW	0000_0000h
824h	Flash Region End Address (FRAD1_WORD1)	32	RW	0000_FFFFh
828h	Flash Region Privileges (FRAD1_WORD2)	32	RW	0000_0000h
82Ch	Flash Region Lock Control (FRAD1_WORD3)	32	RW	0000_0000h
830h	Flash Region Compare Address Status (FRAD1_WORD4)	32	R	0000_0000h
834h	Flash Region Compare Status Data (FRAD1_WORD5)	32	R	0000_0000h
840h	Flash Region Start Address (FRAD2_WORD0)	32	RW	0000_0000h
844h	Flash Region End Address (FRAD2_WORD1)	32	RW	0000_FFFFh
848h	Flash Region Privileges (FRAD2_WORD2)	32	RW	0000_0000h
84Ch	Flash Region Lock Control (FRAD2_WORD3)	32	RW	0000_0000h
850h	Flash Region Compare Address Status (FRAD2_WORD4)	32	R	0000_0000h
854h	Flash Region Compare Status Data (FRAD2_WORD5)	32	R	0000_0000h
860h	Flash Region Start Address (FRAD3_WORD0)	32	RW	0000_0000h
864h	Flash Region End Address (FRAD3_WORD1)	32	RW	0000_FFFFh
868h	Flash Region Privileges (FRAD3_WORD2)	32	RW	0000_0000h
86Ch	Flash Region Lock Control (FRAD3_WORD3)	32	RW	0000_0000h
870h	Flash Region Compare Address Status (FRAD3_WORD4)	32	R	0000_0000h
874h	Flash Region Compare Status Data (FRAD3_WORD5)	32	R	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
880h	Flash Region Start Address (FRAD4_WORD0)	32	RW	0000_0000h
884h	Flash Region End Address (FRAD4_WORD1)	32	RW	0000_FFFFh
888h	Flash Region Privileges (FRAD4_WORD2)	32	RW	0000_0000h
88Ch	Flash Region Lock Control (FRAD4_WORD3)	32	RW	0000_0000h
890h	Flash Region Compare Address Status (FRAD4_WORD4)	32	R	0000_0000h
894h	Flash Region Compare Status Data (FRAD4_WORD5)	32	R	0000_0000h
8A0h	Flash Region Start Address (FRAD5_WORD0)	32	RW	0000_0000h
8A4h	Flash Region End Address (FRAD5_WORD1)	32	RW	0000_FFFFh
8A8h	Flash Region Privileges (FRAD5_WORD2)	32	RW	0000_0000h
8ACh	Flash Region Lock Control (FRAD5_WORD3)	32	RW	0000_0000h
8B0h	Flash Region Compare Address Status (FRAD5_WORD4)	32	R	0000_0000h
8B4h	Flash Region Compare Status Data (FRAD5_WORD5)	32	R	0000_0000h
8C0h	Flash Region Start Address (FRAD6_WORD0)	32	RW	0000_0000h
8C4h	Flash Region End Address (FRAD6_WORD1)	32	RW	0000_FFFFh
8C8h	Flash Region Privileges (FRAD6_WORD2)	32	RW	0000_0000h
8CCh	Flash Region Lock Control (FRAD6_WORD3)	32	RW	0000_0000h
8D0h	Flash Region Compare Address Status (FRAD6_WORD4)	32	R	0000_0000h
8D4h	Flash Region Compare Status Data (FRAD6_WORD5)	32	R	0000_0000h
8E0h	Flash Region Start Address (FRAD7_WORD0)	32	RW	0000_0000h
8E4h	Flash Region End Address (FRAD7_WORD1)	32	RW	0000_FFFFh
8E8h	Flash Region Privileges (FRAD7_WORD2)	32	RW	0000_0000h
8ECh	Flash Region Lock Control (FRAD7_WORD3)	32	RW	0000_0000h
8F0h	Flash Region Compare Address Status (FRAD7_WORD4)	32	R	0000_0000h
8F4h	Flash Region Compare Status Data (FRAD7_WORD5)	32	R	0000_0000h
900h	Target Group n Master Domain Access Descriptor (TG0MDAD)	32	RW	0000_0000h
904h	Target Group n SFAR Address (TG0SFAR)	32	R	0000_0000h
908h	Target Group n SFAR Status (TG0SFARS)	32	RW	0000_0000h
90Ch	Target Group n IPCR Status (TG0IPCRS)	32	RW	0000_0000h
910h	Target Group n Master Domain Access Descriptor (TG1MDAD)	32	RW	0000_0000h
914h	Target Group n SFAR Address (TG1SFAR)	32	R	0000_0000h
918h	Target Group n SFAR Status (TG1SFARS)	32	RW	0000_0000h

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Offset	Register	Width (In bits)	Access	Reset value
91Ch	Target Group n IPCR Status (TG1IPCRS)	32	RW	0000_0000h
920h	Master Global Configuration (MGC)	32	RW	A800_0000h
924h	Master Read Command (MRC)	32	RW	0050_0E07h
928h	Master Timeout (MTO)	32	RW	FFFF_FFFFh
92Ch	FlashSeq Request (FLSEQREQ)	32	RW	0000_0000h
930h	FSM Status (FSMSTAT)	32	R	0000_0000h
934h	IPS Error (IPSERROR)	32	RW	0000_0000h
938h	Error Status (ERRSTAT)	32	RW	0000_0000h
93Ch	Interrupt Enable (INT_EN)	32	RW	0000_0000h

80.14.2.2 Module Configuration Register (MCR)

Offset

Register	Offset
MCR	0h

Function

This register holds configuration data associated with the QuadSPI operation.

NOTE

When out of reset, after first initial MCR programming and exiting module disable mode (that is, when the value of MCR[MDIS] is 0), you must write 1 to MCR[SWRSTSD] and release it after six (three system and three flash memory) clock cycles.

Special write-access is permitted in different modes:

- DQS_FA_SEL: Disabled mode
- ISD3FA, ISD2FA: Disabled mode
- All other fields: Anytime

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved	Reserved	Reserved		Reserved	Reserved	DQS_FA_SEL		Reserved	Reserved	0		Reserved	Reserved	ISD3FA	ISD2FA
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	MDIS	Reserved	DLPEN	0	0	0	VAR_LAT...	DDR_EN	DQS_EN	Reserved	DQS_OUT...	Reserved		SWRSTHD	SWRSTSD
W					CLR_TXF	CLR_RXF										
Reset	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0

Fields

Field	Function
31 —	Reserved
30 —	Reserved
29-28 —	Reserved
27 —	Reserved
26 —	Reserved
25-24 DQS_FA_SEL	DQS clock for sampling read data at flash memory A Selects DQS clock for sampling read data at flash memory A QuadSPI port 00b - Reserved 01b - Pad loopback 10b - Reserved 11b - External DQS **NOTE** In case of an padloopback selection to access port A, port B cannot be programmed for external DQS and vice-versa.
23 —	Reserved

Table continues on the next page...

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Field	Function
22 —	Reserved
21-20 —	Reserved
19 —	Reserved
18 —	Reserved
17 ISD3FA	Idle signal drive IOFA[3] flash memory A Determines the logic level that the IOFA[3] output of the QuadSPI module is driven to in the inactive state. See Driving flash memory control signals in single and dual modes for details. 0b - IOFA[3] is driven to logic L 1b - IOFA[3] is driven to logic H
16 ISD2FA	Idle signal drive IOFA[2] flash memory A Determines the logic level that the IOFA[2] output of the QuadSPI module is driven to in the inactive state. See Driving flash memory control signals in single and dual modes for details. 0b - IOFA[2] is driven to logic L. 1b - IOFA[2] is driven to logic H.
15 —	Reserved
14 MDIS	Module disable Allows the clock to the non-memory mapped logic in the QuadSPI to be stopped. 0b - Enable QuadSPI clocks 1b - Allow external logic to disable QuadSPI clocks
13 —	Reserved
12 DLPEN	Data learning pattern enable Write 1 to this field to enable data learning mechanism.
11 CLR_TXF	Clear TX FIFO/buffer This is a self-clearing field that invalidates the TX buffer content.

Table continues on the next page...

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Field	Function
	NOTE Software must wait for at least five system cycles and three flash cycles after writing '1' to this field. 0b - No action 1b - Read and write pointers of the TX buffer are reset to 0 and TBSR[TRCTR] is reset to 0.
10 CLR_RXF	Clear RX FIFO This is a self-clearing field that invalidates the RX buffer content. 0b - No action 1b - Read and write pointers of the RX buffer are reset to 0 and RBSR[RDBFL] is reset to 0.
9 —	Reserved
8 VAR_LAT_EN	Variable latency Is used to enable the variable latency feature in the controller. This field is valid for HyperRAM where data strobe acts as an output from the memory during the command and address (CA) cycles of a read or write transaction. This is to indicate whether additional initial access latency is needed to perform a dynamic memory refresh operation. For details, see HyperRAM support. 0b - Fixed latency: Twice + 1 latency enable 1b - Variable latency: "Once" or "twice + 1" the initial latency based on data strobe during the CA phase. If enabled, you need to ensure that the value of FLSHCR[TCSS] is >= 2.
7 DDR_EN	DDR mode enable Enables the DDR mode 0b - 2x clock disabled for SDR instructions only 1b - 2x clock enabled for DDR instructions. Note: 2x clock - This is twice the SCKF clock used to shift the TX data by 90 degree.
6 DQS_EN	DQS enable Is valid for both the SDR and DDR modes. For details, see DQS sampling method. 0b - Reserved. Do not program 0 to this field. 1b - DQS enabled. The incoming data is sampled on both the edges of the DQS input when the value of MCR[DDR_EN] is 1; else, on only one edge when MCR[DDR_EN] is 0.
5 —	Reserved
4 DQS_OUT_EN	DQS as an output

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Is valid when data strobe is also used as an output from controller during the write data phase. This is valid for HyperRAM where the data strobe acts as a Read Write Data Strobe (RWDS). For details, see HyperRAM support. 0b - DQS as an output from controller is disabled. 1b - DQS as an output from controller is enabled.
3-2 —	Reserved
1 SWRSTHD	Software reset for AHB domain 0b - De-assert Software reset 1b - AHB domain flops are reset. This field does not reset configuration registers. It is advisable to reset both the serial flash memory domain and AHB domain at the same time. Resetting only one domain might lead to side effects. **NOTE** The software resets need the clock to be running to propagate to the design. The value of MCR[MDIS] should be 0 when the software reset bits are asserted. Also, before they can be deasserted again (by setting MCR[SWRSTHD] to 0), it is recommended to set the value of MCR[MDIS] to 1. After the software resets have been deasserted, the normal operation can be started by setting MCR[MDIS] to 0. **NOTE** Software must wait for at least three system cycles and three flash cycles after changing the value of this field.
0 SWRSTSD	Software reset for serial flash memory domain 0b - De-assert Software reset 1b - Serial flash memory domain flops are reset. This field does not reset configuration registers. It is advisable to reset both the serial flash memory domain and AHB domain at the same time. Resetting only one domain might lead to side effects. **NOTE** The software resets need the clock to be running to propagate to the design. The value of MCR[MDIS] should therefore be 0 when the software reset bits are asserted. Also, before they can be deasserted again (by specifying 0 as the value for MCR[SWRSTSD]), it is recommended to specify 1 as the value for MCR[MDIS]. After the software resets are deasserted, the normal operation can be started by specifying 0 as the value for MCR[MDIS]. **NOTE** Software must wait for at least three system cycles and three flash cycles after changing the value of this field.

80.14.2.3 IP Configuration Register (IPCR)

Offset

Register	Offset
IPCR	8h

Function

This register provides all the configuration required for an IP-initiated command, which can be triggered by writing in the SEQID field of this register. If the SEQID field is written successfully, a new command to the external serial flash memory is initiated per the sequence pointed to by this field. See Normal mode for details on command triggering and command execution.

Special write-access is permitted if:

- SR[IP_ACC]=0

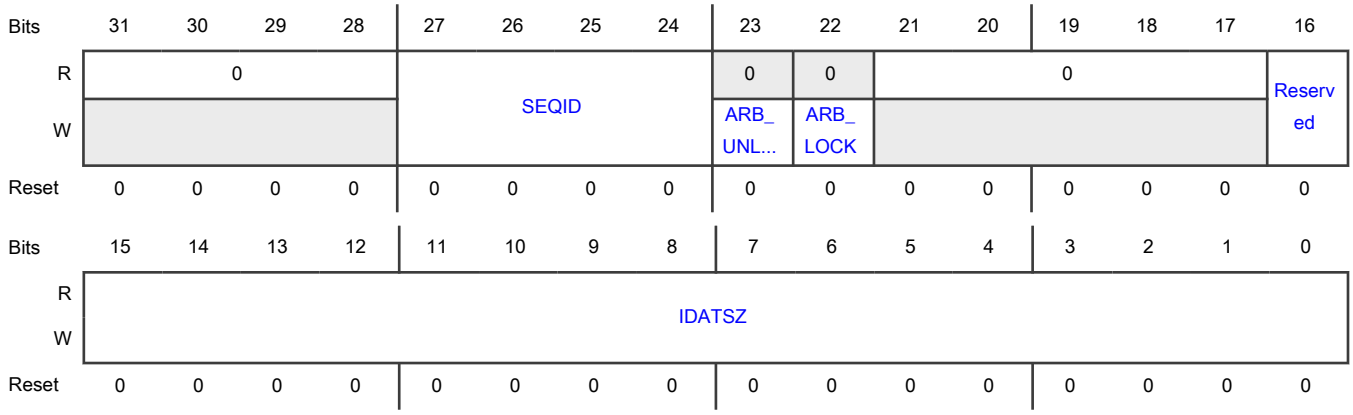
NOTE

Only one of the fields should be written '1' at a time out of ARB_LOCK and ARB_UNLOCK. If both the fields are written '1' at same time then it will invert the lock status. If the arbitration was already locked, it will unlock it and vice-versa.

NOTE

If MDAD and FRAD checks are enabled in MGC register but none of the MDAD and FRAD descriptors are valid, then any write on this register will generate a bus transfer error

Diagram



Fields

Field	Function
31-28 —	Reserved
27-24 SEQID	Points to a sequence in the LUT This field contains the sequence index of the LUT. See LUT for details.

Table continues on the next page...

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Field	Function
	Each sequence index can accommodate up to 10 instructions (2 instructions per register). In case of read command, a write to this field triggers a transaction on the serial flash memory interface if QSPI SFM is IDLE. In case of write command, a write to this fields unlocks the TBDR access if QSPI SFM is not busy. Refer to section Secure flash protection for more details
23 ARB_UNLOCK	Arbitration Unlock Writing 1 to this bit unlocks the arbitration. Writing 0 will have no effect. The arbitration unlock will be done only if the transaction passes both MDAD and FRAD checks. To lock the arbitration write 1 to ARB_LOCK bit. This bit is always read as 0.
22 ARB_LOCK	Arbitration Lock Writing 1 to this bit locks the arbitration for that specific target queue. Writing 0 will have no effect. The arbitration lock will be granted only if the transaction passes both MDAD and FRAD checks. To unlock the arbitration write 1 to ARB_UNLOCK bit. This bit is always read as 0.
21-17 —	Reserved
16 —	Reserved
15-0 IDATSZ	IP data transfer size This field defines the data transfer size, in bytes, of the IP command.

80.14.2.4 Flash Memory Configuration Register (FLSHCR)

Offset

Register	Offset
FLSHCR	Ch

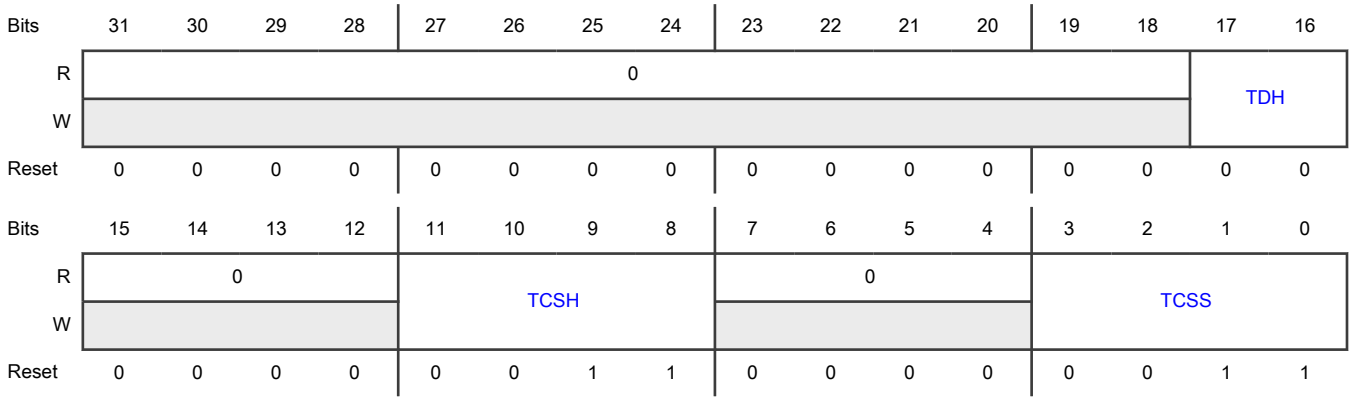
Function

This register contains the timings that are specific to the flash memory device. The QuadSPI controller must meet these timings for the device to function correctly.

Special write-access is permitted if:

- SR[AHB_ACC] = 0
- SR[IP_ACC] = 0

Diagram



Fields

Field	Function
31-18 —	Reserved
17-16 TDH	Serial flash memory data in hold time This field helps in meeting the data in hold time requirement of a flash memory. It is valid only in the DDR mode. **NOTE** This field should be set to 0x00 in the SDR mode (MCR[DDR_EN]=0). See Data input hold requirement of flash memory for details. The valid TDH programming options are shown below and the other combinations are invalid. 00b - Data aligned with the posedge of internal reference clock of QuadSPI 01b - Data aligned with 2x serial flash memory half clock
15-12 —	Reserved
11-8 TCSH	Serial flash memory CS hold time This hold time is in terms of serial flash memory clock cycles, and it must be greater than or equal to two flash memory clock cycles . Refer the chip datasheet for the exact value.
7-4 —	Reserved
3-0 TCSS	Serial flash memory CS setup time This setup time is in terms of serial flash memory clock cycles, and it must be greater than or equal to two flash memory clock cycles. Refer the chip Datasheet for the exact value.

80.14.2.5 Buffer 0 Configuration Register (BUF0CR)

Offset

Register	Offset
BUF0CR	10h

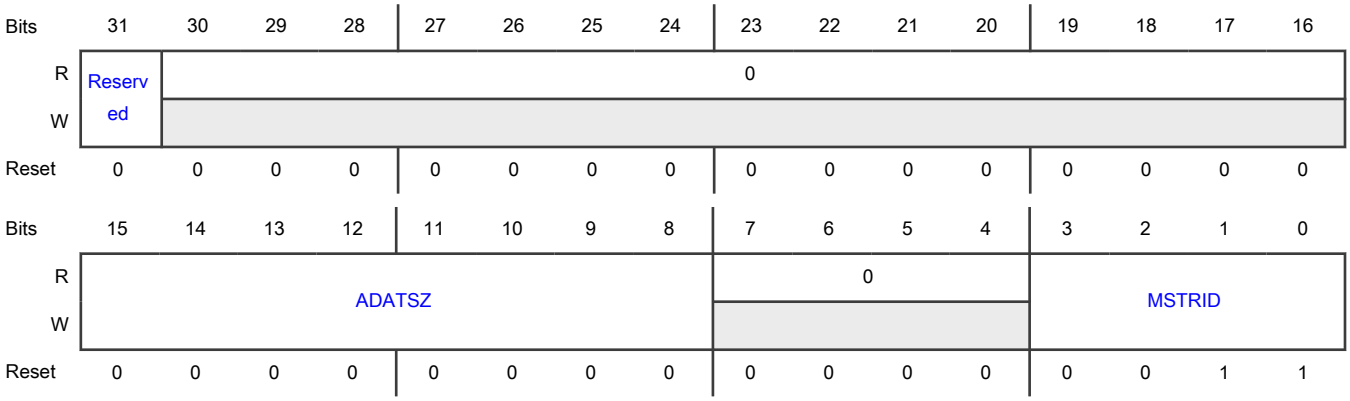
Function

This register provides the configuration for any read access routed to buffer0, which happens when the master ID of the incoming AHB request matches BUF0CR[MSTRID]. Any buffer "miss" leads to a serial flash memory transaction being triggered per the sequence pointed to by BFGENCR[SEQID].

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31 —	Reserved
30-16 —	Reserved
15-8 ADATSZ	AHB data transfer size Defines the read data transfer size in 8 bytes of an AHB triggered read access to serial flash memory. For example, a value of 0x2 sets transfer size to 16 bytes. When ADATSZ = 0, the data size mentioned in the sequence pointed to by the SEQID field overrides this value. The software should ensure that this transfer size is not greater than the size of the buffer.
7-4 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
3-0 MSTRID	Master ID ID of the AHB master associated with BUFFER 0 Any AHB read access with this master ID is routed to this buffer. You must ensure that the master IDs associated with all buffers are different. **NOTE** See the chip-specific QuadSPI information for details about master IDs and their corresponding components.

80.14.2.6 Buffer 1 Configuration Register (BUF1CR)

Offset

Register	Offset
BUF1CR	14h

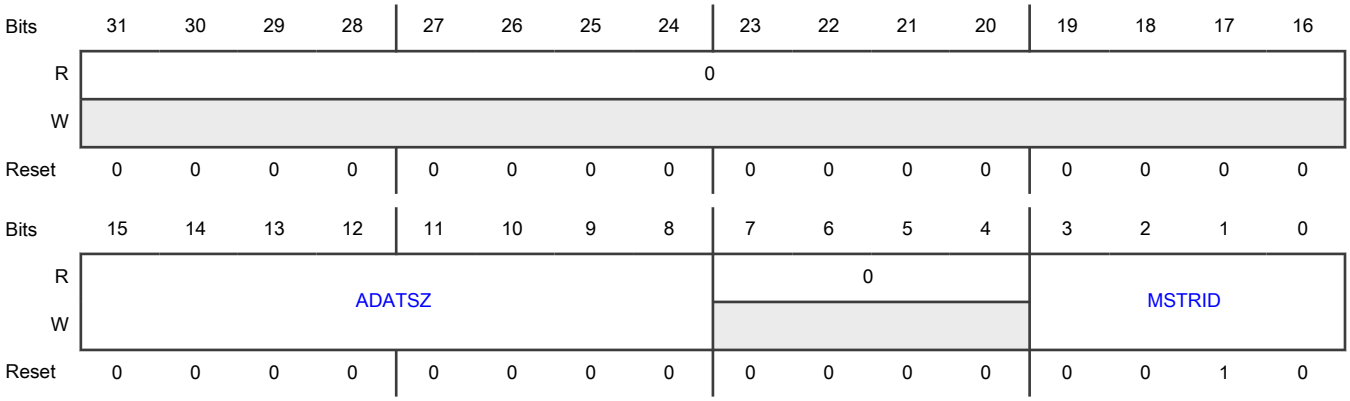
Function

This register provides the configuration for any access routed to buffer 1, which happens when the master ID of the incoming AHB request matches the MSTRID field of this register. Any buffer "miss" leads to the buffer being flushed and a serial flash memory transaction being triggered per the sequence pointed to by BFGENCR[SEQID].

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-16	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
15-8 ADATSZ	AHB data transfer size This field defines the read data transfer size in 8 bytes of an AHB triggered read access to serial flash memory. For example, a value of 0x2 sets the transfer size to 16 bytes. When ADATSZ = 0, the data size mentioned in the sequence pointed to by the SEQID field overrides this value. Software should ensure that this transfer size is not greater than the size of this buffer.
7-4 —	Reserved
3-0 MSTRID	Master ID ID of the AHB master associated with BUFFER 1 Any AHB read access with this master ID is routed to this buffer. You must ensure that the master IDs associated with all buffers are different. **NOTE** See the chip-specific QuadSPI information for details about master IDs and their corresponding components.

80.14.2.7 Buffer 2 Configuration Register (BUF2CR)

Offset

Register	Offset
BUF2CR	18h

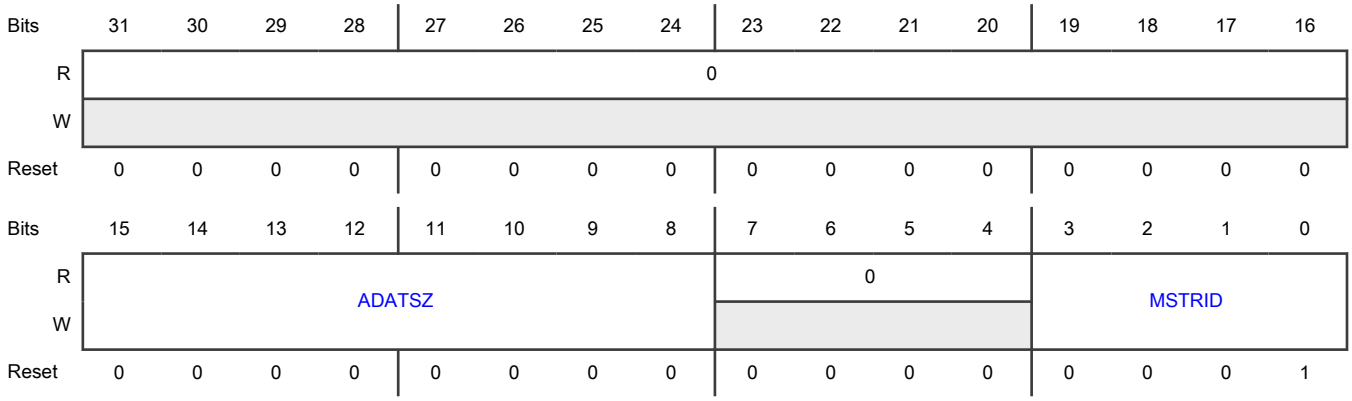
Function

This register provides the configuration for any access routed to buffer 2, which happens when the master ID of the incoming AHB request matches the MSTRID field of this register. Any buffer "miss" leads to the buffer being flushed and a serial flash memory transaction being triggered per the sequence pointed to by BFGENCR[SEQID].

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-16 —	Reserved
15-8 ADATSZ	AHB data transfer size This field defines the read data transfer size in 8 bytes of an AHB triggered read access to the serial flash memory. For example, a value of 0x2 sets transfer size to 16 bytes. When ADATSZ = 0, the data size mentioned in the sequence pointed to by the SEQID field overrides this value. The software should ensure that this transfer size is not greater than the size of this buffer.
7-4 —	Reserved
3-0 MSTRID	Master ID The ID of the AHB master associated with BUFFER2. Any AHB read access with this master ID is routed to this buffer. It must be ensured that the master IDs associated with all buffers are different. **NOTE** See the chip-specific QuadSPI information for details about master IDs and their corresponding components.

80.14.2.8 Buffer 3 Configuration Register (BUF3CR)

Offset

Register	Offset
BUF3CR	1Ch

Function

This register provides the configuration for any access to buffer 3.

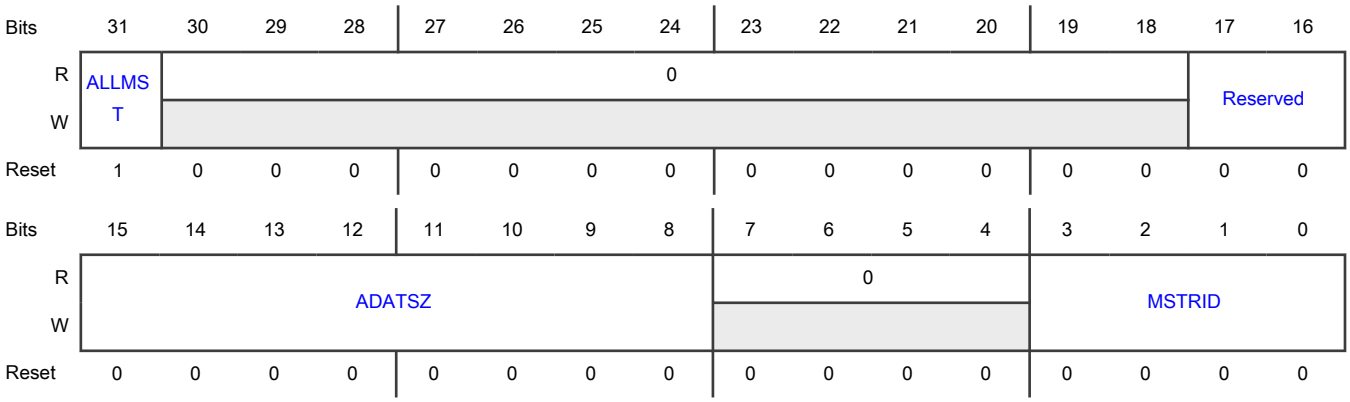
An access is routed to buffer 3 when the master ID of the incoming AHB request matches the MSTRID field of BUF3CR. Any buffer "miss" leads to the buffer being flushed and a serial flash memory transaction being triggered per the sequence pointed to by BFGENCR[SEQID].

In case the value of the ALLMST field is not 1, any such transaction (where master ID does not match any of the MSTRID fields) is returned with an ERROR response.

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31 ALLMST	All master enable When set, buffer3 acts as an all-master buffer. Any AHB access with a master ID not matching with the master ID of buffer0, buffer1, or buffer2 is routed to buffer3. When set, the MSTRID field of this register is ignored.
30-18 —	Reserved
17-16 —	Reserved
15-8 ADATSZ	AHB data transfer size Defines the read data transfer size in 8 bytes of an AHB triggered read access to serial flash memory. When ADATSZ = 0, the data size mentioned in the sequence pointed to by the SEQID field overrides this value.
7-4 —	Reserved
3-0 MSTRID	Master ID ID of the AHB master associated with BUFFER 3. Any AHB read access with this master ID is routed to this buffer. You must ensure that the master IDs associated with all buffers are different.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE See the chip-specific QuadSPI information for details about master IDs and their corresponding components.

80.14.2.9 Buffer Generic Configuration Register (BFGENCR)

Offset

Register	Offset
BFGENCR	20h

Function

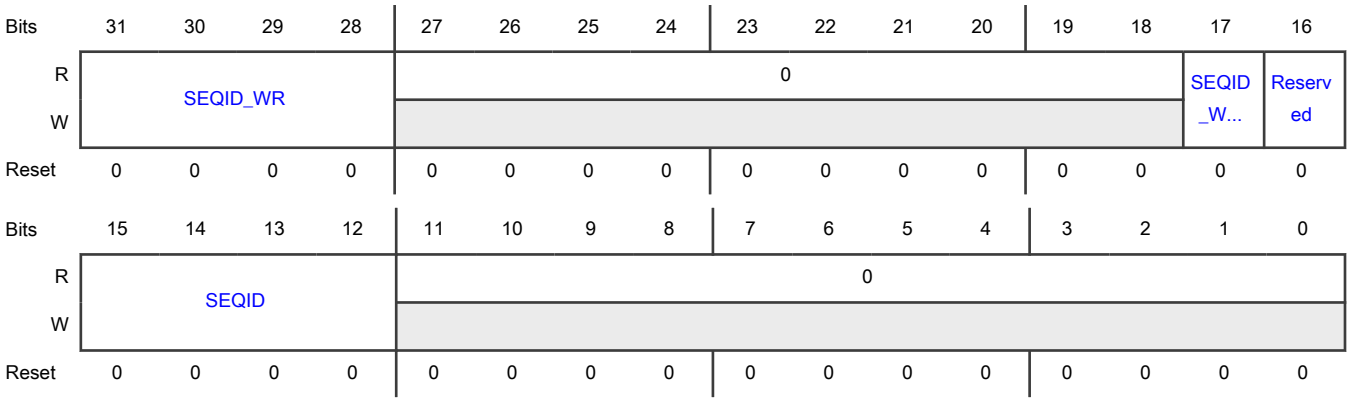
This register provides generic configuration to any of the buffer accesses. Any buffer "miss" leads to the buffer being flushed and a serial flash memory transaction being triggered per the sequence pointed to by the SEQID field.

Special write-access is permitted if:

- SR[AHB_ACC] = 0

This register is access controlled and can only be programmed by privilege masters.

Diagram



Fields

Field	Function
31-28 SEQID_WR	Write Sequence ID This field points to write seq-id of LUT and would be selected in case of AHB write transaction, if SEQID_WR_EN==1.
27-18	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
17 SEQID_WR_EN	Enable Write Sequence ID
16 —	Reserved
15-12 SEQID	Points to a sequence in the LUT. This field contains the sequence index of the LUT. and would be selected in case of AHB read transaction (and AHB write transactions if SEQID_WR_EN==0).. See LUT. **NOTE** If the sequence pointer differs in the new and the previous sequences, you should reset it. See sequence pointer clear register for more information.
11-0 —	Reserved

80.14.2.10 SOC Configuration Register (SOCCR)

Offset

Register	Offset
SOCCR	24h

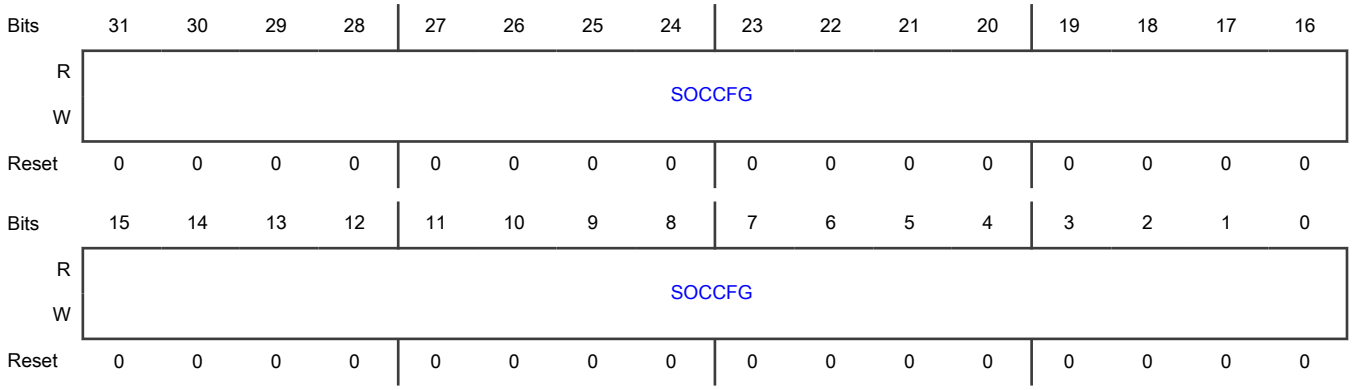
Function

This register is programmed at the chip level for QuadSPI configuration. For details, see chip-specific QuadSPI information.

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-0 SOCCFG	SOC configuration This field configuration is specific to chip. For details, see chip-specific QuadSPI information.

80.14.2.11 Buffer 0 Top Index Register (BUF0IND)

Offset

Register	Offset
BUF0IND	30h

Function

This register specifies the top index for buffer 0, which defines its size. Note that the three LSBs of this register are set to 0. This ensures that the buffer is 64-bit aligned because each buffer entry is 64-bits long.

The register value should be set to the desired number of bytes. For example, setting BUF0IND[31:3] to 0 gives 0 bytes, setting the value to 1 gives 8 bytes, and so on.

The size of buffer 0 is the difference between BUF0IND and 0.

The software must ensure that the value of TPINDX0 is not greater than the size of buffer 0.

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0				TPINDX0									0		
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-11 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
10-3 TPINDX0	Top index of buffer 0
2-0 —	Reserved

80.14.2.12 Buffer 1 Top Index Register (BUF1IND)

Offset

Register	Offset
BUF1IND	34h

Function

This register specifies the top index of buffer 1, which defines its size. Note that the three LSBs of this register are set to 0. This ensures that the buffer is 64-bit aligned because each buffer entry is 64-bits long.

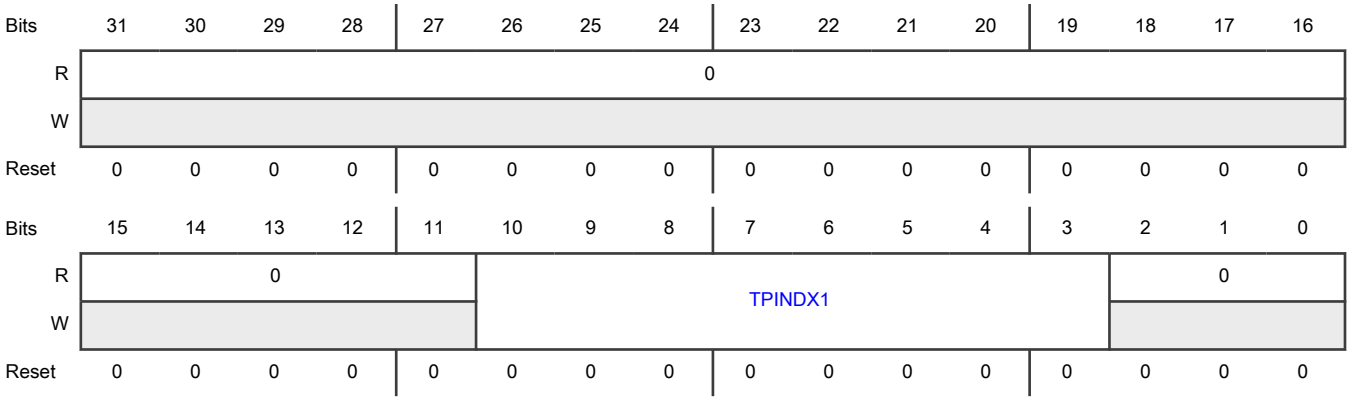
The size of buffer 1 is the difference between BUF1IND and BUF0IND. The register value should be entered in bytes. For example, if BUF0IND = 0x100, then setting BUF1IND = 0x130 sets the size of buffer 1 to 0x30 bytes.

The software must ensure that the value of TPINDX1 is not greater than the size of buffer 1.

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-11	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
10-3 TPINDX1	Top index of buffer 1
2-0 —	Reserved

80.14.2.13 Buffer 2 Top Index Register (BUF2IND)

Offset

Register	Offset
BUF2IND	38h

Function

This register specifies the top index of buffer 2, which defines its size. Note that the three LSBs of this register are set to 0. This ensures that the buffer is 64-bit aligned because each buffer entry is 64-bits long.

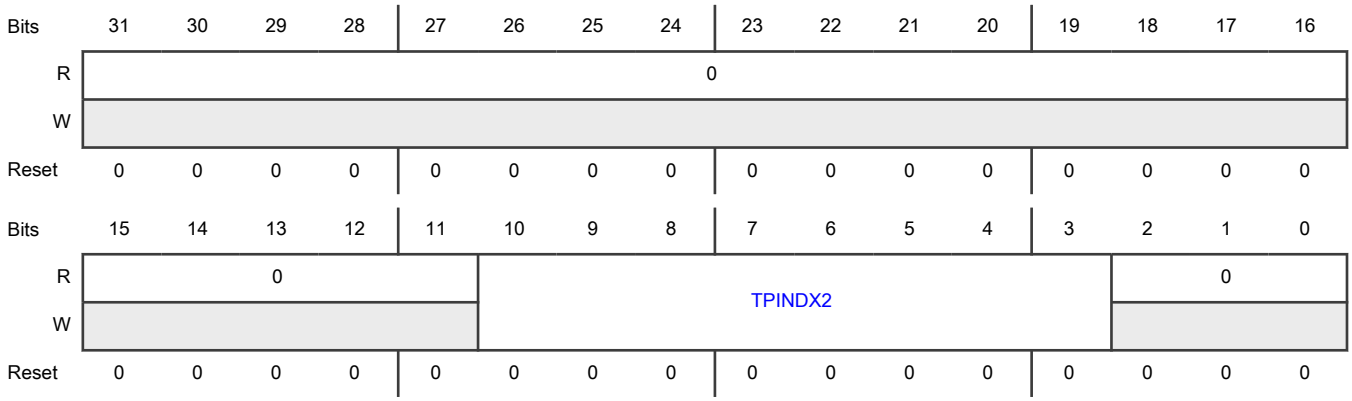
The size of buffer 2 is the difference between BUF2IND and BUF1IND. The register value should be entered in bytes. For example, if BUF1IND = 0x130 then setting BUF2IND = 0x180 sets the size of buffer 2 to 0x50 bytes.

The software must ensure that the value of TPINDX2 is not greater than the size of buffer 2.

Special write-access is permitted if:

- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-11 —	Reserved
10-3 TPINDX2	Top index of buffer 2
2-0 —	Reserved

80.14.2.14 AHB Write Configuration Register (AWRCR)

Offset

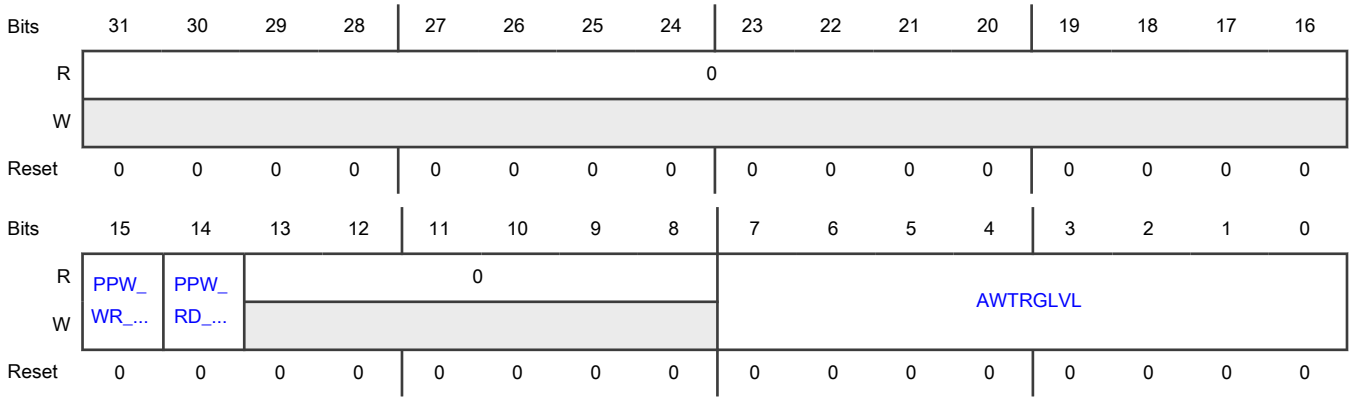
Register	Offset
AWRCR	50h

Function

Special write-access is permitted if:

- SR[AWRACC] = 0

Diagram



Fields

Field	Function
31-16 —	Reserved
15	Page program wait write disabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
PPW_WR_DIS	0b - Enables subsequent writes 1b - Disables subsequent writes to the flash memory. After the first write transaction, AHB write is returned with an error response.
14 PPW_RD_DIS	Page program wait read disabled 0b - Enables subsequent reads 1b - Disables subsequent reads to the flash memory. After the first write transaction, AHB read is returned with an error response.
13-8 —	Reserved
7-0 AWTRGLVL	AHB write trigger level Defines a trigger level of TX FIFO in terms of a 4-byte entry. AHB write to the flash memory is triggered when either of the following happens: • TX FIFO crosses the level defined by this field • AHB transaction completes This is done to prevent an under run in the flash memory. For HyperRAM, this field must be set to 0. For details, see HyperRAM support

80.14.2.15 DLL Flash Memory A Configuration Register (DLLCRA)

Offset

Register	Offset
DLLCRA	60h

Function

This register configures DLL and slave delay chain for flash memory A.

The value of the DLLEN field must be 1 after all reference (FREQEN, DLL_REFCNTR, DLLRES, SLAVE_AUTO_UPDT) delay chain configurations are programmed.

See DLL and delay chain usage for the programming sequence.

NOTE

See the chip data sheet for information on programming register fields.

NOTE

Please see the chip specific section of QuadSPI DLLCRA register for delay elements data

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DLLEN	FREQEN	0		DLL_REFCNTR				DLLRES				SLV_FINE_OFFSET			
W																
Reset	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	SLV_DLY_OFFSET			SLV_DLY_COARSE				Reserved			DLL_CDL8	SLAVE_A...	SLV_EN	SLV_DLL...	SLV_UPD
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DLLEN	DLL enable 0b - DLL reference logic remains in reset and should be 0 for at least three flash memory clock cycles for reset. 1b - Enables DLL logic. Set it to 1 after all the configuration for DLLCR reference settings is complete.
30 FREQEN	Frequency enable 0b - Selects delay chain for low frequency of operation 1b - Selects delay chain for high frequency of operation
29-28 —	Reserved
27-24 DLL_REFCNTR	DLL reference counter Select the "n+1" interval of DLL phase detection and reference delay updating interval (minimum recommended value = 1).
23-20 DLLRES	DLL resolution Minimum resolution for DLL phase detector to remain locked/unlocked based on flash memory clock jitter. The minimum value is 2, and should be programmed to a more suitable value, such as 6.
19-16 SLV_FINE_OFFSET	Fine offset delay elements in incoming DQS This field sets the number of fine offset delay elements up to 16 in incoming DQS, and the default must be 1 element.
15 —	Reserved
14-12	T/16 offset delay elements in incoming DQS This field sets the number of T/16 offset delay elements in incoming DQS; default is 0.

Table continues on the next page...

Table continued from the previous page...

Field	Function
SLV_DLY_OFFSET	
11-8 SLV_DLY_COARSE	Delay elements in each delay tap This field sets the number of delay elements in each delay tap. The field is used to overwrite DLL-generated delay values and works when the value of SLV_DLL_BYPASS is 1. Note : Please refer to the QuadSPI datasheet for more details.
7-5 —	Reserved
4 DLL_CDL8	DLL CDL8 Enable 0b - DLL is implemented to support within 2x variation 1b - DLL is implemented to support within 3x variation (BCS -> WCS)
3 SLAVE_AUTO_UPDT	Slave chain update This field automatically updates the slave chain as soon as DLL is locked. 0b - Auto-update feature is disabled. 1b - Auto-update feature is enabled.
2 SLV_EN	Slave enable 0b - DLL slave logic remains in reset, and its value should be 0 for at least three flash memory clock cycles for reset. 1b - Enables DQS slave delay chain, and should be 1 before any slave configuration settings take place.
1 SLV_DLL_BYPASS	Slave DLL bypass This field enables selection of the number of delays in each slave delay tap. 0b - Disables manual selection of coarse delays in the slave delay chain. 1b - Enables selection of number of delays in each slave delay tap, based on DLLCRA[SLV_DLY_COARSE].
0 SLV_UPD	Slave update You must program this field only after slave delay chain configuration takes place. 0b - Disables any further update on DQS slave delay chain. 1b - Updates the DQS slave delay chain with either ref-delay or bypass slave delay value, and should be set in the absence of the DQS clock.

80.14.2.16 Parity Configuration Register (PARITYCR)

Offset

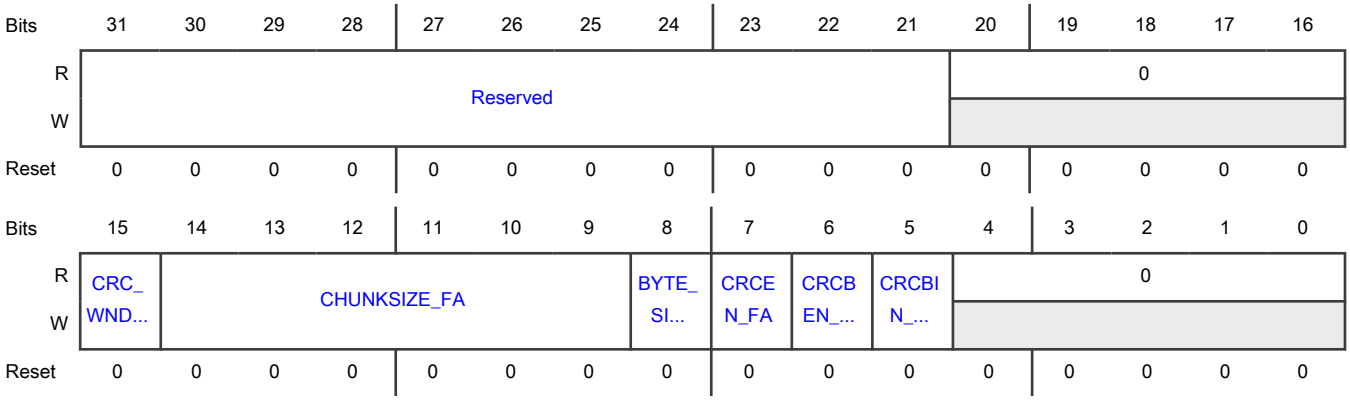
Register	Offset
PARITYCR	6Ch

Function

This register replicates the parity related configuration programming performed on the flash memory configuration registers.

You must write 1 to PARITYCR[CRCEN_FA] and PARITYCR[CRCEN_FB] after all parity configuration bits are programmed. However, you can program PARITYCR[BYTE_SIZE_FA] and PARITYCR[BYTE_SIZE_FB] at any time.

Diagram



Fields

Field	Function
31-21 —	Reserved
20-16 —	Reserved
15 CRC_WNDW_FA	CRC address window configuration 0b - Calculates parity (CRC) over fixed address window within the denoted flash memory A chunk size boundary. 1b - Calculates parity (CRC) over incremental window of flash memory A chunk size, irrespective of address.
14-9 CHUNKSIZE_FA	Chunk size for flash memory A Defines the chunk size (in terms of 4 bytes) after parity is inserted and compared by the QuadSPI controller for flash memory A. Values 0x1, 0x2, and so on indicate 4 bytes, 8 bytes, and so on.
8	Byte size for flash memory A

Table continues on the next page...

Table continued from the previous page...

Field	Function
BYTE_SIZE_FA	This field can be programmed any time. It enables single-byte, read/write parity with flash memory A configuration register. The field overrides the chunk size used for flash memory data array. You must write 1 to this field before any read/write operation on the flash memory internal registers. And you must write 0 to this field before reading flash memory data array.
7 CRCEN_FA	CRC parity checker logic 0b - Disables parity mechanism. In case of parity error, set it to 0 to clear parity error. Only supported for DDR Octal commands. 1b - CRC parity checker logic for flash memory A read paths. Configure this field after programming CHUNK_SIZEA, CRCBEN_FA and CRCBIN_FA.
6 CRCBEN_FA	Adds CRC bar parity from flash memory A output to QuadSPI controller
5 CRCBIN_FA	Adds CRC bar parity to flash memory A input from QuadSPI controller
4-0 —	Reserved

80.14.2.17 Serial Flash Memory Address Register (SFAR)

Offset

Register	Offset
SFAR	100h

Function

The module automatically translates this address on the memory map to the address on the flash memory. When operating in a 24-bit mode, only bits 23-0 are sent to the flash memory. In the 32-bit mode, bits 27-0 are used with bits 31-28 driven to 0 when the value of SFACR[CAS] is 0. For example, if the value of SFACR[CAS] is 3, then bits 26-3 are sent to the flash memory as its page address in case flash memory is operating in a 24-bit mode. The total number of address bits requested by the flash memory, as its page and column address, must not be more than 32 bits. See Table 727 for the mapping between the access mode and the SFAR content and Normal mode for details on command triggering and command execution. The software must ensure that the serial flash memory address provided in the SFAR register lies in the valid flash memory address range, as defined in Table 727.

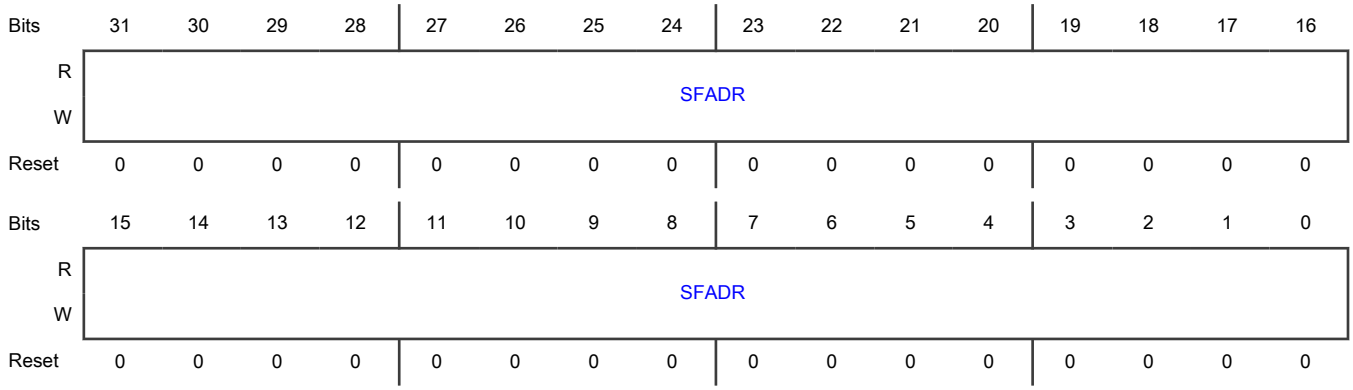
Special write-access is permitted if:

- SR[IP_ACC] = 0

NOTE

If MDAD and FRAD checks are enabled in MGC register but none of the MDAD and FRAD descriptors are valid, then any write on this register will generate a bus transfer error

Diagram



Fields

Field	Function
31-0 SFADR	Serial flash memory address

80.14.2.18 Serial Flash Memory Address Configuration Register (SFACR)

Offset

Register	Offset
SFACR	104h

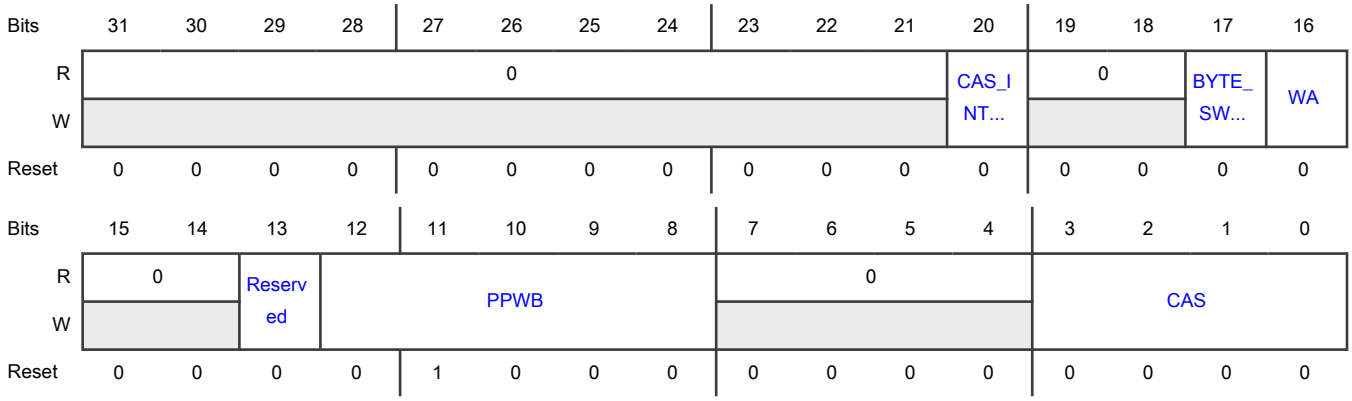
Function

This register contains the address requirements that are specific to serial flash memory. These requirements must be configured according to the connected flash memory, for the controller to function properly. The module automatically translates the address of SFAR on the memory map or the incoming address on the AHB bus to the column address on the flash memory. For example, if a flash memory needs 3 bits as its column address, then only the lower three bits of the SFAR/AHB address are sent to the flash memory as its column address. The software should ensure that the serial flash memory address provided in SFAR or the incoming AHB address lies in the valid flash memory address range.

Special write-access is permitted if:

- SR[IP_ACC] = 0
- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-21 —	Reserved
20 CAS_INTRLVD	CAS Interleaving 0b - CAS interleaving is disabled 1b - CAS interleaving is enabled
19-18 —	Reserved
17 BYTE_SWAP	Byte swapping In case of Octal DDR mode, this field controls whether a word unit composed of 2 bytes from posedge and negedge of a single DQS cycle needs to be swapped. 0b - One word of two bytes at [nth, n+1th] address 1b - One word of two bytes at [n+1th, nth] address
16 WA	Word addressable Defines whether the serial flash memory is a byte addressable flash memory or a word addressable flash memory. According to the configuration of this field, the address is remapped to the flash memory interface. See Address scheme for details. 0b - Byte addressable serial flash memory mode 1b - Word (2-byte) addressable serial flash memory mode
15-14 —	Reserved
13 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
12-8 PPWB	Page program boundary Flash memory-specific page program boundary size should be programmed in Log2 (size in bytes) format. The default is 8 = log2(256) for a 256-byte page program size.
7-4 —	Reserved
3-0 CAS	Column address space Defines the width of the column address. If the column address is, for example, [2:0] of SFAR/AHB address, then CAS must be 3. If there is no column address separation in any serial flash memory, the value of this field must be specified as 0.

80.14.2.19 Sampling Register (SMPR)

Offset

Register	Offset
SMPR	108h

Function

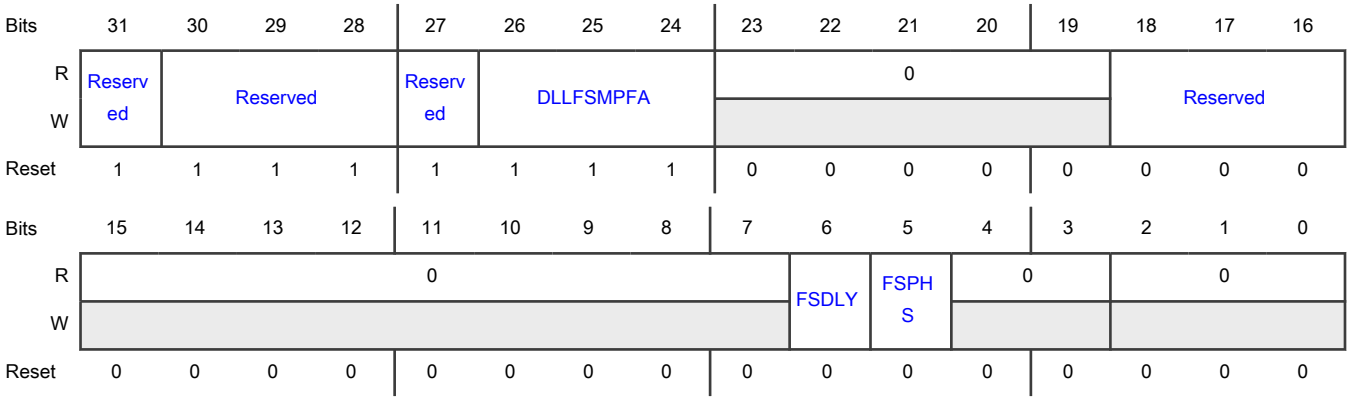
This register allows configuration of how the incoming data from the external serial flash memory devices is sampled in the QuadSPI module.

NOTE

See the chip data sheet for programming the register fields.

Special write-access is permitted in the disabled mode.

Diagram



Fields

Field	Function
31 —	Reserved
30-28 —	Reserved
27 —	Reserved
26-24 DLLFSMPFA	Selects the nth tap provided by slave delay chain for flash memory A The value of *n* can vary from 0 to 7, with each tap delay based on the DLLCRA register.
23-19 —	Reserved
18-16 —	Reserved
15-7 —	Reserved
6 FSDLY	Full-speed delay selection for internal/pad loop back DQS sampling This field selects the delay in accordance with the reference edge for the valid sample point. 0b - Same DQS 1b - Half-cycle early DQS
5 FSPHS	Full-speed phase selection for SDR instructions This field selects the edge of the sampling clock valid for full-speed commands. 0b - Select sampling at non-inverted clock 1b - Select sampling at inverted clock
4-3 —	Reserved
2-0 —	Reserved

80.14.2.20 RX Buffer Status Register (RBSR)

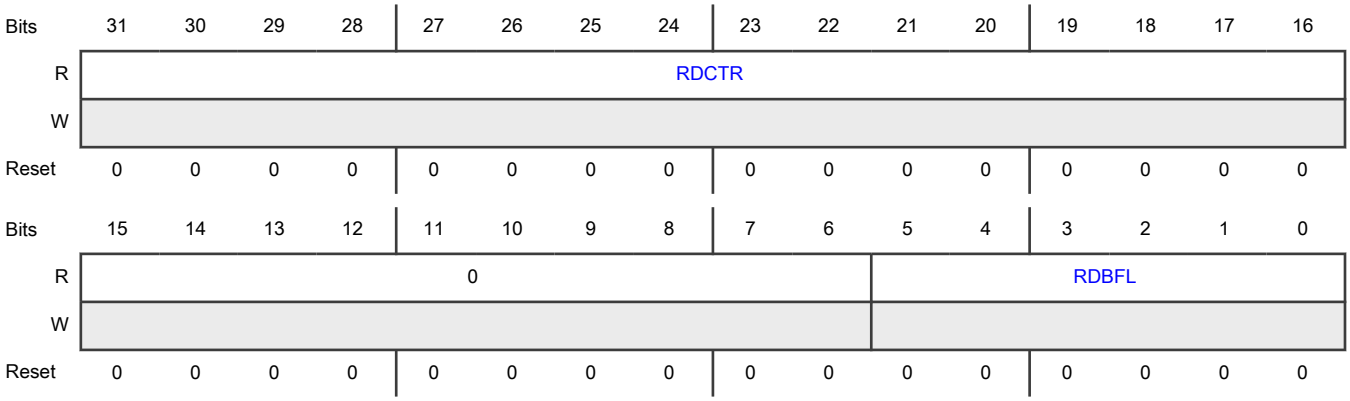
Offset

Register	Offset
RBSR	10Ch

Function

This register contains information related to the receive data buffer.

Diagram



Fields

Field	Function
31-16 RDCTR	Read counter Indicates the number of 4-byte entries removed from the RX buffer. For example, a value of 0x2 indicates that 8 bytes have been removed. It is incremented by the number (RBCT[WMRK] + 1) on RX buffer POP event. The RX buffer can be popped using DMA or FR[RBDF]. The RSER[RBDDE] defines which pop should be pursued. For details, see AHB RX Data Buffer Register (ARDB0 - ARDB31) and Data Transfer from the QuadSPI Module Internal Buffers.
15-6 —	Reserved
5-0 RDBFL	RX buffer fill level Indicates the number of 4-byte entries available in the RX buffer. For example, a value of 0x2 indicates 8 bytes are available.

80.14.2.21 RX Buffer Control Register (RBCT)

Offset

Register	Offset
RBCT	110h

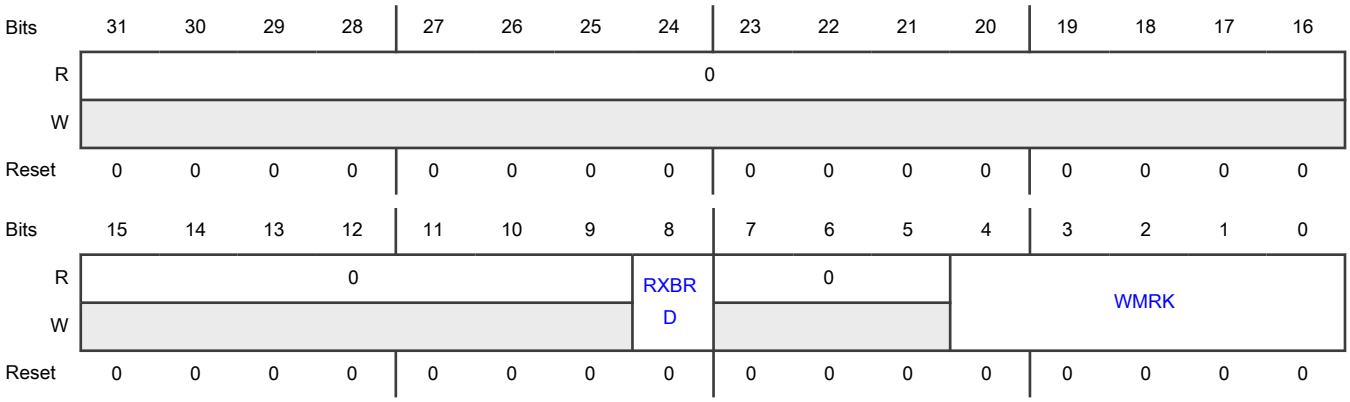
Function

This register contains control data related to the receive data buffer.

Special write-access is permitted if:

- SR[IP_ACC] = 0

Diagram



Fields

Field	Function
31-9 —	Reserved
8 RXBRD	RX buffer readout This field specifies the access scheme for the RX buffer readout. 0b — RX buffer content is read using the AHB bus registers. See AHB RX Data Buffer Register (ARDB0 - ARDB31). 1b — RX buffer content is read using the IP bus registers. See RX Buffer Data Register (RBDR0 - RBDR31).
7-5 —	Reserved
4-0 WMRK	RX buffer watermark

Table continues on the next page...

Table continued from the previous page...

Field	Function
	This field determines when the readout action of the RX buffer is triggered. When the number of valid entries in the RX buffer is equal to or greater than the number provided by (WMRK+1), the SR[RXWE] flag is asserted. The value should be entered as the number of 4-byte entries minus 1. For example, a value of 0x0 sets the watermark to 4 bytes, 1 to 8bytes, 2 to 12 bytes, and so on. For details, see DMA usage. **NOTE** This field should never be programmed above 31 because there are only 32 memory mapped RBDR registers. If watermark is programmed above 31, data above 32 words will be lost.

80.14.2.22 AHB Write Status Register (AWRSR)

Offset

Register	Offset
AWRSR	120h

Function

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0													SEQAUJO...	0	0
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-3 —	Reserved
2	Sequence auto join

Table continues on the next page...

Table continued from the previous page...

Field	Function
SEQAUJOIN	Asserted when the LUT sequences are automatically joined using the JMP_TO_SEQ command. This remains asserted as long as you do not encounter the STOP/JMP_ON_CS command.
1 —	Reserved
0 —	Reserved

80.14.2.23 DLL Status Register (DLLSR)

Offset

Register	Offset
DLLSR	12Ch

Function

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved				0				Reserved							
W																
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	DLLA_LO...	SLVA_LO...	DLLA_RA...	DLLA_FI...	0				DLLA_SLV_FINE_VAL				DLLA_SLV_COARSE_VAL			
W																
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-28 —	Reserved
27-24 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
23-16 —	Reserved
15 DLLA_LOCK	DLL A lock status
14 SLVA_LOCK	Slave high lock status High-frequency slave delay chain locked. The field is configured when the slave decoder is updated with DLLCRA[SLV_UPD] and is reset after you configure SLV_UPD to 0.
13 DLLA_RANGE_ERR	DLL master delay chain The value 1 indicates that DLL master delay chain is working out of delay range because of incorrect DLL configuration.
12 DLLA_FINE_UNDERFLOW	Fine delay chain underflow The value 1 indicates that fine delay chain underflow has occurred.
11-8 —	Reserved
7-4 DLLA_SLV_FINE_VAL	Fine delay cells in slave delay chain This value indicates the total number of fine delay cells (1 delay unit) selected in the slave delay chain.
3-0 DLLA_SLV_COARSE_VAL	Coarse delay cells in slave delay chain This value indicates the total number of coarse delay cells (16 delay units) selected in the slave delay chain.

80.14.2.24 Data Learning Configuration Register (DLCR)

Offset

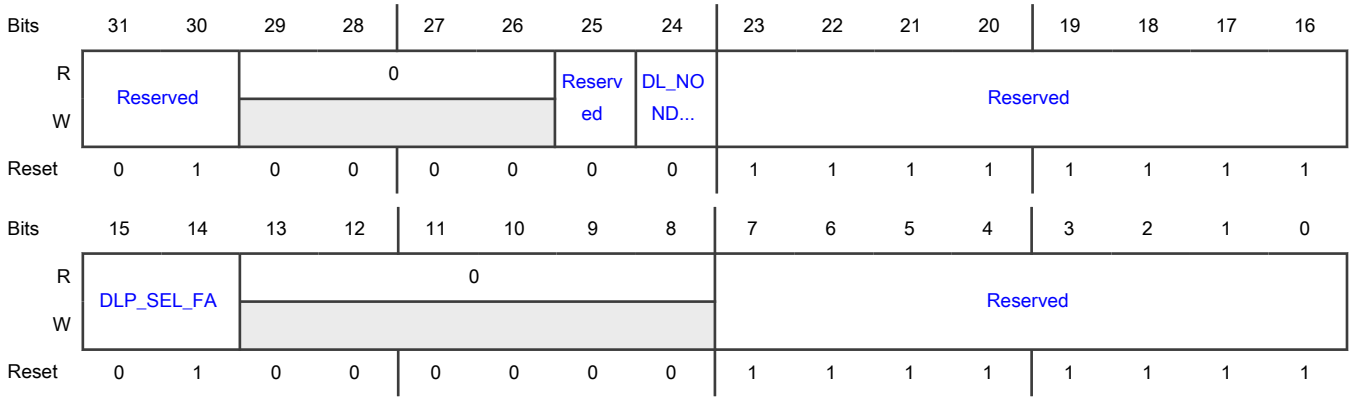
Register	Offset
DLCR	130h

Function

This register is used for programming the data learning settings.

- A flash memory device that supports data learning but cannot provide more than 10 bits of data learn pattern must be considered as non-DLP Flash. For Non-DLP flash devices, you must read at least 16 bits data learn pattern from a known location.
- You must program different learning pattern on the two data pins–IO1 and IO3. This is required to accommodate pessimistic data skew between the different IO lines.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-26 —	Reserved
25 —	Reserved
24 DL_NONDLP_FLSH	Data learning enabled for non-DLP flash memory Configure the value of this field as 1 to enable data learning for flash memories that do not provide a data learning pattern. For a non-DLP flash memory, execute a one-time data learning through the IPS to select a tap before an AHB read operation.
23-16 —	Reserved
15-14 DLP_SEL_FA	Selects pattern matching IO pads 00b - Pattern matching is ignored. This is only for debugging purpose and should not be programmed. 01b - IO1 is used for matching 10b - IO3 is used for matching. This is only for debugging purpose and should not be programmed. 11b - Both IO1 and IO3 are used for pattern matching
13-8 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
7-0 —	Reserved

80.14.2.25 Data Learning Status Flash Memory A Register (DLSR_FA)

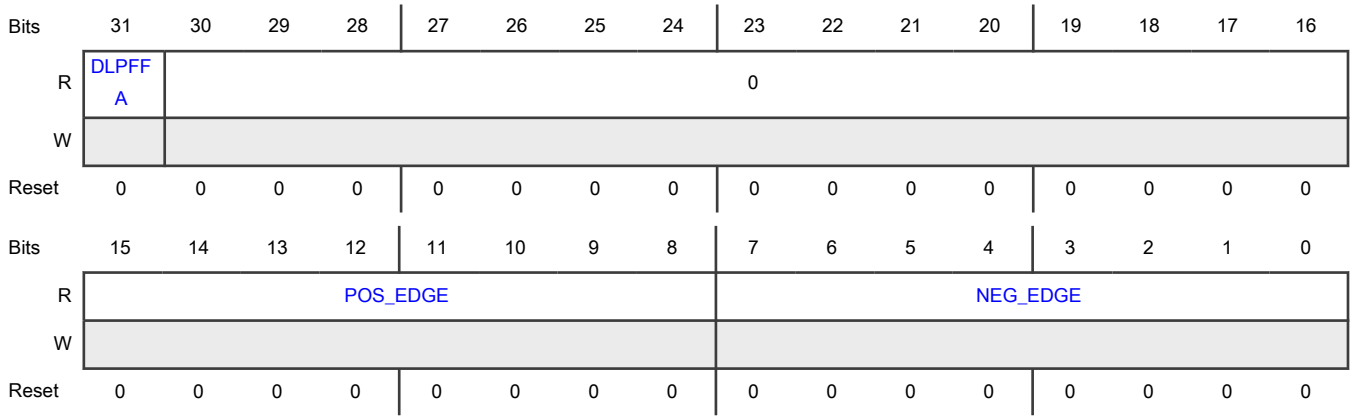
Offset

Register	Offset
DLSR_FA	134h

Function

This register shows sampling point selected by data learning algorithm when the value of DLSR_FA[DLPFFA] is 0. Otherwise, it shows the pattern matching outline.

Diagram



Fields

Field	Function
31 DLPFFA	Data learning pattern fail This field asserts when data learning fails at flash memory A.
30-16 —	Reserved
15-8 POS_EDGE	DLP positive edge match signature for flash memory A
7-0 NEG_EDGE	DLP negative edge match signature for flash memory A

80.14.2.26 TX Buffer Status Register (TBSR)

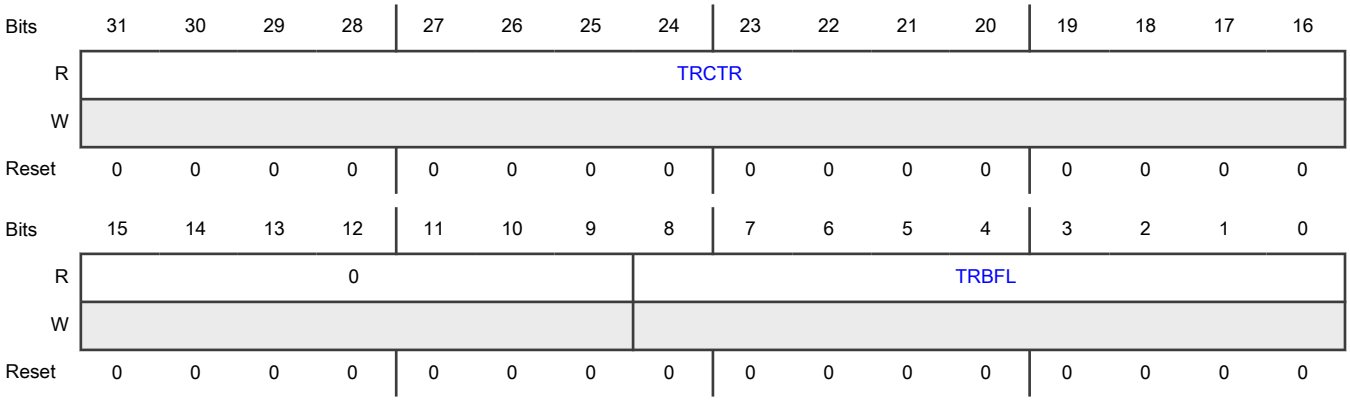
Offset

Register	Offset
TBSR	150h

Function

This register contains information related to the transmit data buffer.

Diagram



Fields

Field	Function
31-16 TRCTR	Transmit counter This field indicates how many entries of 4 bytes have been written into the TX buffer by host accesses. It is reset to 0 when a 1 is written to MCR[CLR_TXF]. It is incremented on each write access to the TBDR register when another word has been pushed onto the TX buffer. When it is not cleared, the TRCTR field wraps around to 0. See TX Buffer Data Register (TBDR) for details.
15-9 —	Reserved
8-0 TRBFL	TX buffer fill level This field contains the number of entries of 4 bytes each available in the TX buffer for the QuadSPI module to transmit to the serial flash memory device. The value of this field can reach maximum up to the total TX buffer size.

80.14.2.27 TX Buffer Data Register (TBDR)

Offset

Register	Offset
TBDR	154h

Function

This register provides access to the circular TX buffer of depth 256, so the total size is 256 * 4 bytes. This buffer provides the data written into it as write data for the page programming commands to the serial flash memory device. See Table 691 for the byte ordering scheme. A write transaction on the flash memory with data size of less than 32 bits leads to the removal of one data entry from the TX buffer. The valid bits are used and the rest of the bits are discarded.

Special write-access is permitted if:

- SR[TXFULL] = 0

NOTE

This register can only be written when write access is granted by SFP block else bus transfer error is generated on write. Please refer to section TBDR register write lock

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TXDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TXDATA															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 TXDATA	TX data On write access, the data is written to the next available entry of the TX buffer and TBSR[TRBFL] is updated accordingly. On a read access, the last data written to the register is returned.

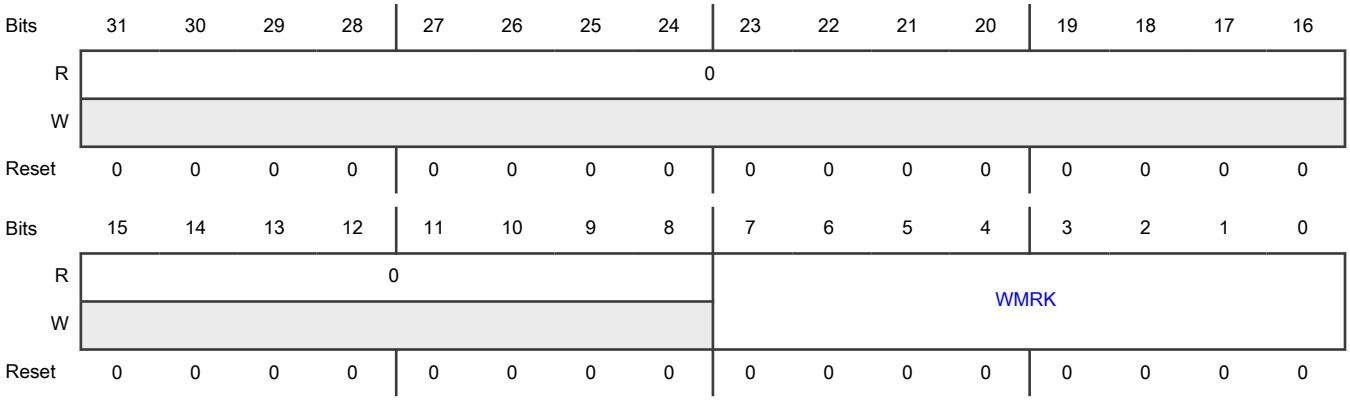
80.14.2.28 TX Buffer Control Register (TBCT)

Offset

Register	Offset
TBCT	158h

Function
This register contains control information for transmit data buffer.

Diagram



Fields

Field	Function
31-8 —	Reserved
7-0 WMRK	Watermark for TX buffer Determines the watermark for the TX buffer When the number of available space in the TX buffer is greater than or equal to the number provided by WMRK (number of 4-byte entries), SR[TXWA] is asserted. For example, a value of 0x1 sets the watermark to 4 bytes, 0x2 sets it to 8 bytes, 0x3 sets it to 12 bytes, and so on. For details, see DMA usage. WMRK = 0 is invalid. **NOTE** For IPS write with SFP enabled, this field must be programmed as per formula to prevent TX underflow: If data size in words >1, watermark=(TX FIFO size in words - data size in words) +1, If data size in words =1, watermark=(TX FIFO size in words - data size in words)

80.14.2.29 Status Register (SR)

Offset

Register	Offset
SR	15Ch

Function

This register provides all the available status information about SFM command execution and arbitration, the RX buffer, TX buffer, and the AHB buffer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0			0	TXFULL	TXDMA	TXWA	TXNE	RXDMA	0			RXFULL	0		RXWE
W																
Reset	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	AHB3FUL	AHB2FUL	AHB1FUL	AHB0FUL	AHB3NE	AHB2NE	AHB1NE	AHB0NE	AHBTRN	Reserved	AWRACC	Reserved	AHB_ACC	IP_ACC	BUSY
W																
Reset	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-29 —	Reserved
28 —	Reserved
27 TXFULL	TX buffer full Asserted when the FIFO level reaches TX buffer size
26 TXDMA	TX DMA Asserted when the TXFIFO fill via DMA is active and DMA is requested or running
25 TXWA	TX buffer watermark available Asserted when the number of available spaces in the TX buffer is greater than or equal to the value provided by TBCT[WMRK] Example: When TBCT[WMRK]=1, SR[TXWA] is de-asserted when TX FIFO has 256 entries.

Table continues on the next page...

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Field	Function
24 TXNE	TX buffer not empty Asserted when TX buffer contains data
23 RXDMA	RX buffer DMA Asserted when RX buffer read out via DMA is active; that is, when DMA is requested or running
22-20 —	Reserved
19 RXFULL	RX buffer full Asserted when the RX buffer is full; that is, when RBSR[RDBFL] is equal to 32
18-17 —	Reserved
16 RXWE	RX buffer watermark exceeded Asserted when the number of valid entries in the RX buffer exceeds the number provided in RBCT[WMRK]
15 —	Reserved
14 AHB3FUL	AHB 3 buffer full Asserted when AHB 3 buffer is full
13 AHB2FUL	AHB 2 buffer full Asserted when AHB 2 buffer is full
12 AHB1FUL	AHB 1 buffer full Asserted when the AHB 1 buffer is full
11 AHB0FUL	AHB 0 buffer full Asserted when the AHB 0 buffer is full
10 AHB3NE	AHB 3 buffer not empty Asserted when the AHB 3 buffer contains data
9 AHB2NE	AHB 2 buffer not empty Asserted when the AHB 2 buffer contains data
8 AHB1NE	AHB 1 buffer not empty Asserted when the AHB 1 buffer contains data
7	AHB 0 buffer not empty

Table continues on the next page...

Table continued from the previous page...

Field	Function
AHB0NE	Asserted when the AHB 0 buffer contains data
6 AHBTRN	AHB access transaction pending Asserted when there is a pending request on the AHB interface. See Flash memory mapped AMBA bus.
5 —	Reserved
4 AWRACC	AHB write access Asserted when AHB write access is enabled
3 —	Reserved
2 AHB_ACC	AHB read access Asserted when the currently executed transaction is initiated by the AHB bus
1 IP_ACC	IP access Asserted when transaction currently executed is initiated by the IP bus
0 BUSY	Module busy Asserted when module is currently busy handling a transaction to an external flash memory device

80.14.2.30 Flag Register (FR)

Offset

Register	Offset
FR	160h

Function

This register provides all available flags about SFM command execution and arbitration, which may serve as the source for the generation of interrupt service requests. Note that the error flags in this register do not relate directly to the execution of the transaction in the serial flash memory device itself but only to the behavior and conditions visible in the QuadSPI module.

Special write-access is permitted in the enabled mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DLPFF	0	Reserved	DLLABRT	TBFF	TBUF	0	DLLUNLCK	ILLINE	0		0	0		RBOF	RBDF
W	W1C			W1C	W1C	W1C		W1C	W1C						W1C	W1C
Reset	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	AAEF	AITEF	AIBSEF	ABOF	Reserved	CRCAEF	Reserved	PPWF	0	IPIEF	0	0	0			TFF
W	W1C	W1C	W1C	W1C	W1C	W1C		W1C		W1C						W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DLPFF	Data learning pattern failure flag This field is set when the DATA_LEARN instruction is encountered in a sequence, but no sampling point is found for the data learning pattern.
30 —	Reserved
29 —	Reserved
28 DLLABRT	DLL abort 1b - This field is set whenever DLL is unlocked while reading data from the flash memory.
27 TBFF	TX buffer fill flag Before writing to the TX buffer, this field should be cleared. Then, it should be read back. If it is set, the TX buffer can include more data. If the field remains cleared, the TX buffer can be considered as full. See TX buffer operation for details.
26 TBUF	TX buffer underrun flag This field is set if the module tries to pull data when the TX buffer is empty.. The IP command leading to the TX buffer underrun is continued (data sent to the serial flash memory device is undefined). Here, a valid underrun means that it should have occurred during the transaction so that few bytes (that is, less than 4 bytes) are left in FIFO and the remaining are filled with "FFFFh". This field does not set if transfer is less than 128 bits. The application must clear the TX buffer in response to this event by writing a 1 to MCR[CLR_TXF]. The application must clear the TX buffer in response to this event by writing a 1 to MCR[CLR_TXF].
25 —	Reserved
24	DLL unlock

Table continues on the next page...

Table continued from the previous page...

Field	Function
DLLUNLCK	1b - This field is set whenever DLL unlock event occurs, irrespective of flash memory access.
23 ILLINE	Illegal instruction error flag This field is set when an illegal instruction is encountered by the controller in any of the sequences. As soon as the field is set, you must assert MCR[SWRSTSD] and MCR[SWRSTHD]. That is, reset the flash memory and AHB domain after reconfiguring the correct sequence instruction. See Table 689 for a list of legal instructions.
22-21 —	Reserved
20 —	Reserved
19-18 —	Reserved
17 RBOF	RX buffer overflow flag This field is set when no more data can be pushed into the RX buffer from the serial flash memory device. The IP command leading to this condition is continued until the number of bytes in IPCR[IDATSZ] are read from the serial flash memory device. The content of the RX buffer remains unchanged.
16 RBDF	RX buffer drain flag This field is set if SR[RXWE] is asserted. Writing 1 to this field triggers one of the following actions: • If the RX buffer has up to RBCT[WMRK] valid entries, then the flag is cleared. • If the RX buffer has more than RBCT[WMRK] valid entries and the RSER[RBDDE] field is not set (flag driven mode), an RX buffer POP event is triggered. The flag remains set if the RX buffer contains more than RBCT[WMRK] valid entries after the RX buffer POP event is complete. The flag is cleared if the RX buffer contains less than or equal to RBCT[WMRK] valid entries after the RX buffer POP event is complete. See the "Receive Buffer Drain Interrupt or DMA Request" section in Normal mode interrupt and DMA requests for details.
15 AAEF	AHB abort error flag This flag can be set when AHB transaction in ongoing and any of the below conditions occur which may result in AHB error response (HRESP) generation: • When Software abort is asserted from SPTRCLT[ABRT_CLR] during AHB read.

Table continues on the next page...

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Field	Function
	• During data learning pattern failure if any AHB transaction is ongoing. (FR[DLPFF]) • CRC or ECC error from flash memory during AHB transaction. (FR[CRCAEF]) • If AIBSEF flag is set during the AHB transfer. (FR[AIBSEF]) Software should clear this flag and other related flags in FR register (mentioned in points above) before initiating any new AHB transfer.
14 AITEF	AHB illegal transaction error flag This is set whenever there is no response generated from QuadSPI to AHB bus in case of an illegal transaction and the watchdog timer expires. The timer value is considered as a parameter.
13 AIBSEF	AHB illegal burst size error flag This is set whenever the total burst size (size x beat) of an AHB transaction is greater than the prefetch data size, which is defined by BUFxCR[ADATSZ] or data size mentioned in the sequence pointed to by the SEQID field in case ADATSZ = 0. See HBURST support with AHB read details on HBURST feature.
12 ABOF	AHB buffer overflow flag This is set when the size of the AHB access exceeds the size of the AHB buffer. This condition can occur only if BUFxCR[ADATSZ] is programmed incorrectly. The AHB command leading to this condition is continued until the number of entries according to BUFxCR[ADATSZ] have been read from the serial flash memory device. The content of the AHB buffer is not changed.
11 —	Reserved
10 CRCAEF	Sets when there is CRC or ECC error for flash memory A 0b - CRCEF interrupt is not generated. 1b - CRCEF interrupt is generated.
9 —	Reserved
8 PPWF	Page-program wait flag after flash memory write flag This field indicates page-program wait flag after flash memory write.
7 —	Reserved
6 IPIEF	IP command trigger could not be executed error flag This is set when the SR[IP_ACC] and SR[AWRACC] fields are set (that is, an IP triggered command is currently executing) and any of the following conditions occurs: • Write access to the RBCT
5	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
4 —	Reserved
3-1 —	Reserved
0 TFF	IP command transaction finished flag This field is set after the QuadSPI module completes a running IP command. If an error occurs, and the related error flags are valid in the same clock cycle, the TFF flag is asserted.

80.14.2.31 Interrupt and DMA Request Select and Enable Register (RSER)

Offset

Register	Offset
RSER	164h

Function

This register provides enables and selectors for the interrupts in the QuadSPI module.

NOTE

Each field of the FR enabled as source for an interrupt prevents the QuadSPI module from entering the Stop mode or Module Disable mode when this flag is set.

Special write-access is permitted in the "Anytime" mode.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DLPFIE	Reserved		0	TBFIE	TBUIE	TBFDE	DLLULIE	ILLINIE	Reserved	RBDDE	Reserved	0		RBOIE	RBDIE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	AAIE	AITIE	AIBSIE	ABOIE	Reserved	CRCAIE	Reserved	PPWIE	Reserved	IPIEIE	0	Reserved	0			TFIE
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DLPFIE	Data learning pattern failure interrupt enable Triggered by DLPFF flag in FR. 0b - No DLPFF interrupt is generated. 1b - DLPFF interrupt is generated.
30-29 —	Reserved
28 —	Reserved
27 TBFIE	TX buffer fill interrupt enable flag This field indicates the TX buffer fill interrupt enable flag. This interrupt should not be enabled when using SFP functionality because it causes QSPI BUSY SFM to go high and keeps SFP to generate any transaction over to QSPI. 0b - No TBFF interrupt is generated. 1b - TBFF interrupt is generated.
26 TBUIE	TX buffer underrun interrupt enable flag This field indicates the TX buffer underrun interrupt enable flag. 0b - No TBUF interrupt is generated 1b - TBUF interrupt is generated
25 TBFDE	TX buffer fill DMA enable Enables generation of DMA requests for TX buffer fill. When the value of this field is 1, DMA requests are generated as long as number of available spaces in the TX buffer is greater than or equal to the value provided by TBCT[WMRK]. 0b - No DMA request is generated 1b - DMA request is generated
24 DLLULIE	DLL unlock interrupt enable 1b - Write 1 to this to enable generation of interrupt on DLL unlock event.
23 ILLINIE	Illegal instruction error interrupt enable Triggered by the ILLINE flag in FR 0b - No ILLINE interrupt is generated. 1b - ILLINE interrupt is generated.
22	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
21 RBDDE	RX buffer drain DMA enable This field enables generation of DMA requests for RX buffer drain. When the value of this field is 1, the DMA requests are generated as long as SR[RXWE] is set. 0b - No DMA request is generated. 1b - DMA request is generated.
20 —	Reserved
19-18 —	Reserved
17 RBOIE	RX buffer overflow interrupt enable This field indicates the RX buffer overflow interrupt enable flag. 0b - No RBOF interrupt is generated. 1b - RBOF interrupt is generated.
16 RBDIE	RX buffer drain interrupt enable This field enables generation of IRQ requests for RX buffer drain. When the value of this field is 1, the interrupt is asserted as long as SR[RBDF] is set. 0b - No RBDF interrupt is generated. 1b - RBDF Interrupt is generated.
15 AAIE	AHB abort error interrupt enable Triggered by AAEF flags in FR. 0b - No AAEF interrupt is generated 1b - AAEF interrupt is generated
14 AITIE	AHB illegal transaction interrupt enable flag This field indicates the AHB illegal transaction interrupt enable flag. 0b - No AITEF interrupt is generated. 1b - AITEF interrupt is generated.
13 AIBSIE	AHB illegal burst size interrupt enable flag This field indicates the AHB illegal burst size interrupt enable flag. 0b - No AIBSEF interrupt is generated. 1b - AIBSEF interrupt is generated.

Table continues on the next page...

Table continued from the previous page...

Field	Function
12 ABOIE	AHB buffer overflow interrupt enable flag This field indicates the AHB buffer overflow interrupt enable flag. 0b - No ABOF interrupt is generated. 1b - ABOF interrupt is generated.
11 —	Reserved
10 CRCAIE	CRC and ECC interrupt enable for flash memory A 0b - CRCAEF interrupt is not generated. 1b - CRCAEF interrupt is generated.
9 —	Reserved
8 PPWIE	Page-program wait interrupt flag This field indicates page-program wait interrupt. 0b - No PPWIE interrupt is generated 1b - PPWIE interrupt is generated
7 —	Reserved
6 IPIEIE	IP command trigger during IP access error interrupt enable flag This field indicates IP command trigger during IP access error interrupt enable flag. 0b - No IPIEF interrupt is generated 1b - IPIEF interrupt is generated
5 —	Reserved
4 —	Reserved
3-1 —	Reserved
0 TFIE	Transaction finished interrupt enable flag This field indicates the transaction finished interrupt enable flag. 0b - No TFF interrupt is generated.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - TFF interrupt is generated.

80.14.2.32 Sequence Pointer Clear Register (SPTRCLR)

Offset

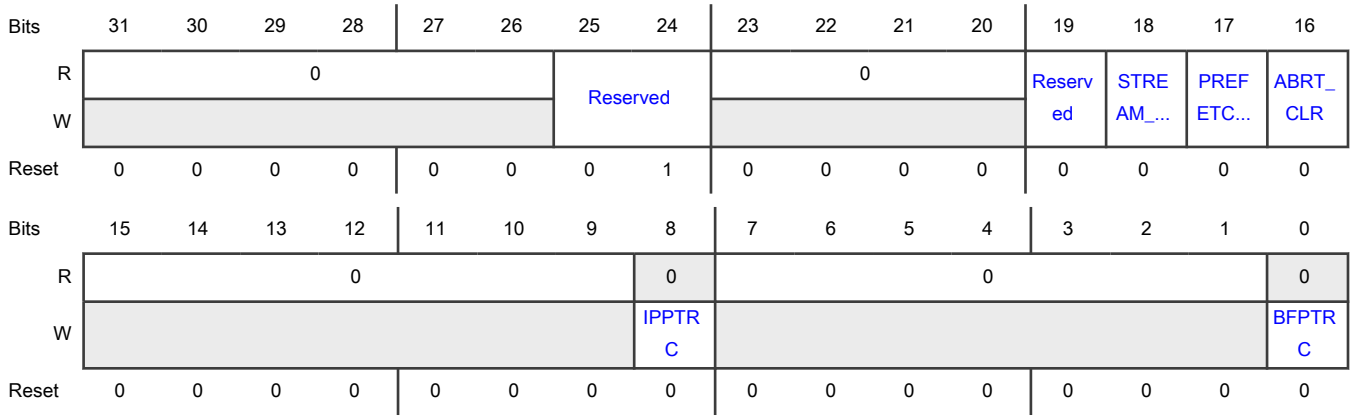
Register	Offset
SPTRCLR	16Ch

Function

This register provides fields to reset the IP and buffer sequence pointers. The sequence pointer contains the index of instructions within the LUT entry that is to be executed next. For example, if the LUT entry ends on a JMP_ON_CS value of 2, the index is stored as 2.

The software should reset the sequence pointers defined by JMP_ON_CS operand whenever the sequence ID is required to be changed by updating the SEQID field in the IPCR or BFGENCR.

Diagram



Fields

Field	Function
31-26 —	Reserved
25-24 —	Reserved
23-20	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
19 —	Reserved
18 STREAM_EN	Enable Streaming Port 1b - Enables AHB read as streaming port with 64K prefetch size.
17 PREFETCH_DIS	Prefetch disable This field should be configured to disable the prefetch mechanism of receiver. It is not based on dynamic programming. Therefore, it should be programmed initially at once. When this field is set, then during an ongoing flash memory read, any subsequent AHB read is checked for buffer hit. However, after the end of flash memory read, as soon as chip select is deasserted, any subsequent AHB read results in flushing of the current AHB buffer data and issues fresh flash memory transaction if the AHB buffer data is not updated with the flash memory.
16 ABRT_CLR	Flash memory Abort/AHB buffer clear This is a dynamic field. Writing a 1 to it, irrespective of the prefetch disable, clears the AHB buffer pointers and also aborts any ongoing flash memory transaction (if any) and rejects any ongoing AHB read with an error response (if any). QuadSPI sets this field to 0 after clearing the AHB buffer pointers.
15-9 —	Reserved
8 IPPTRC	IP pointer clear This is a self-clearing field. 1b - Clears the sequence pointer for IP accesses as defined in IPCR.
7-1 —	Reserved
0 BFPTRC	Buffer pointer clear This is a self-clearing field. 1b - Clears the sequence pointer for AHB read accesses as defined in BFGENCR.

80.14.2.33 Serial Flash Memory A1 Top Address Register (SFA1AD)

Offset

Register	Offset
SFA1AD	180h

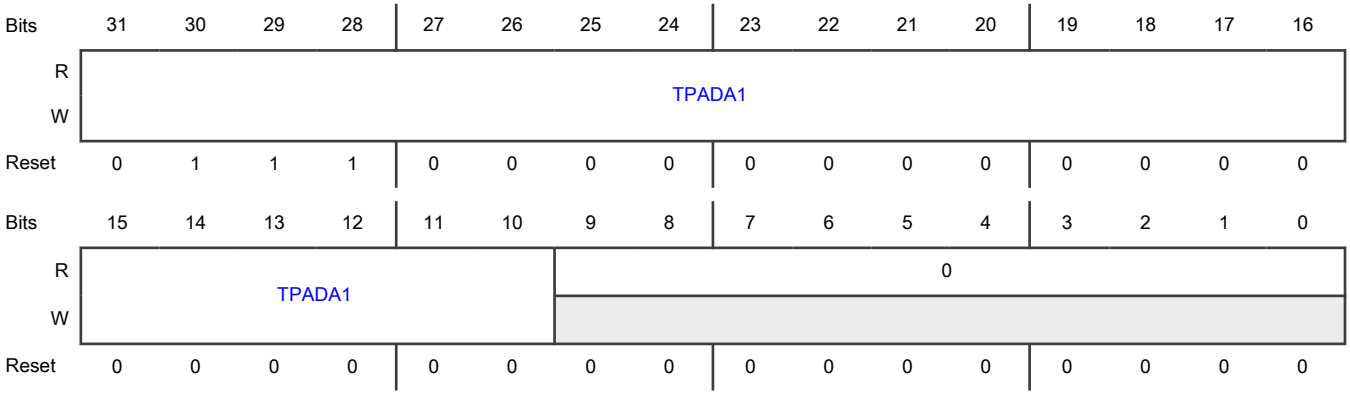
Function

This register provides the address mapping for serial flash memory A1. The difference between SFA1AD[TPADA1] and AMBA_BASE defines the size of the memory map for serial flash memory A1.

Special write-access is permitted if:

- SR[IP_ACC] = 0
- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-10 TPADA1	Top address for serial flash memory A1 In effect, TPADxx is the first location of the next memory.
9-0 —	Reserved

80.14.2.34 Serial Flash Memory A2 Top Address Register (SFA2AD)

Offset

Register	Offset
SFA2AD	184h

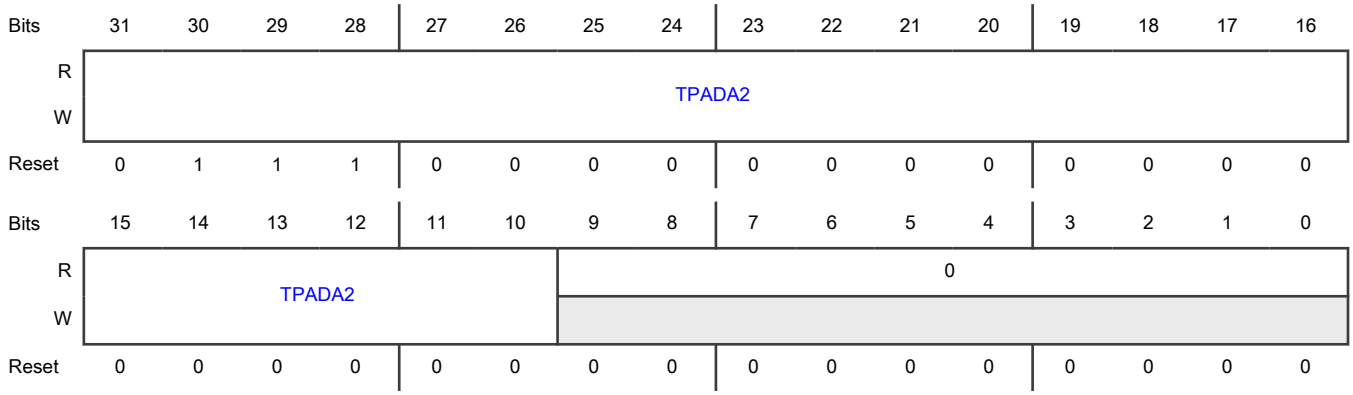
Function

This register provides the address mapping for serial flash memory A2. The difference between SFA2AD[TPADA2] and SFA1AD[TPADA1] defines the size of the memory map for serial flash memory A2.

Special write-access is permitted if:

- SR[IP_ACC] = 0
- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-10 TPADA2	Top address for serial flash memory A2 In effect, TPxxAD is the first location of the next memory.
9-0 —	Reserved

80.14.2.35 Data Learn Pattern Register (DLPR)

Offset

Register	Offset
DLPR	190h

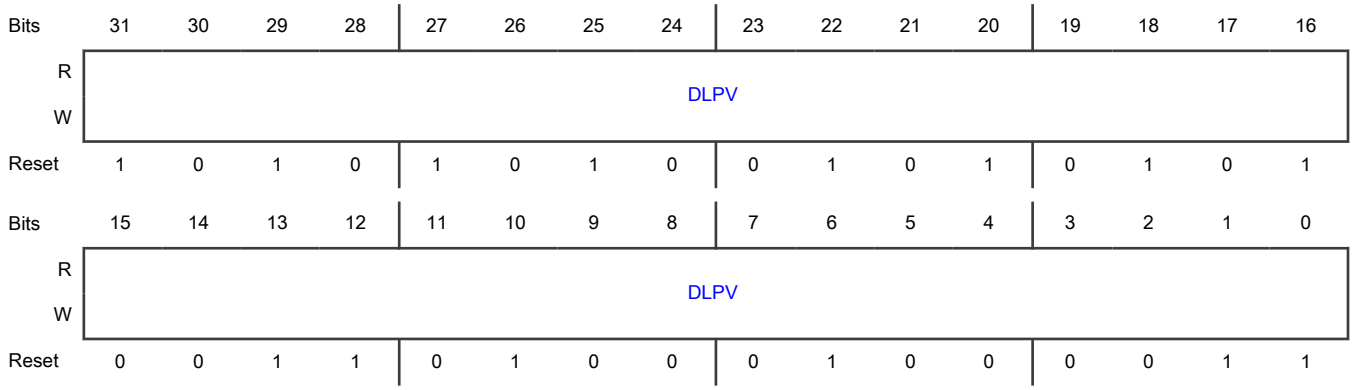
Function

This register contains the information of the data to be used for data learning.

Special write-access is permitted if:

- SR[IP_ACC] = 0
- SR[AHB_ACC] = 0

Diagram



Fields

Field	Function
31-0 DLPV	Data learning pattern value This value is used for data learning in the DDR and DQS modes. For example, if you request for more than 32 bits of data learning, the value is repeated in the register. For example, if 64-bit data learning is requested by any flash memory and the value of DLPR is aa55_3443, then the 64-bit value is aa55_3443_aa55_3443. This value is used for data learning in SDR/DDR modes along with DATA_LEARN instruction. Different patterns can be matched at selected IOs. That is, IO1 and IO3 using DLCR[DLP_SEL_FA], DLPR[31:16] for IO3, and DLPR[15:0] for IO1. DLP pattern for IO1 and IO3 should be stored, bit-wise, in the little endian format. For details, see Data learning.

80.14.2.36 Flash Memory A Failing Address Status Register (FAILA_ADDR)

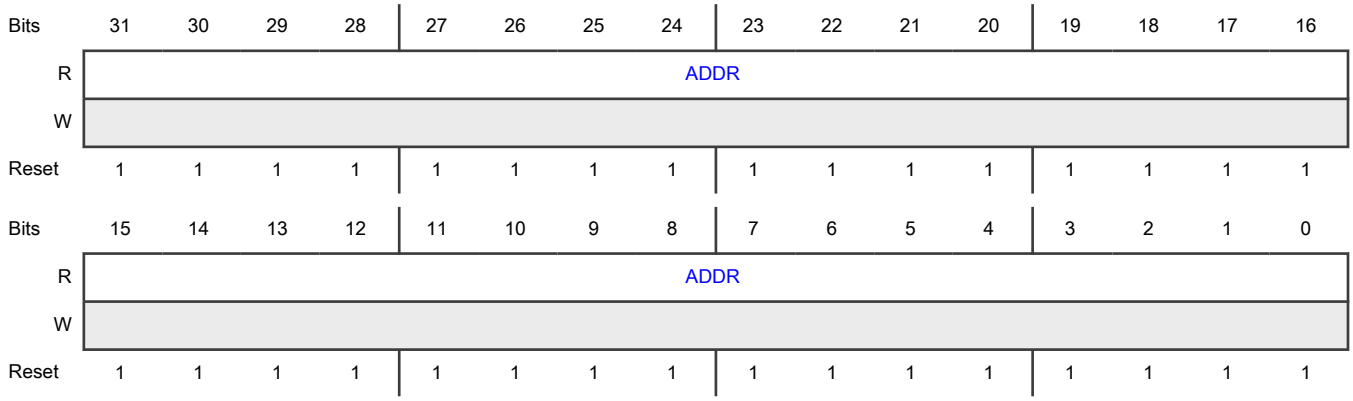
Offset

Register	Offset
FAILA_ADDR	194h

Function

This register provides the flash memory address where data learning or parity error has occurred.

Diagram



Fields

Field	Function
31-0 ADDR	Failing address for flash memory A

80.14.2.37 RX Buffer Data Register (RBDR0 - RBDR31)

Offset

For a = 0 to 31:

Register	Offset
RBDRa	200h + (a × 4h)

Function

These registers provide access to individual entries in the RX buffer. See Table 691 for the byte ordering scheme.

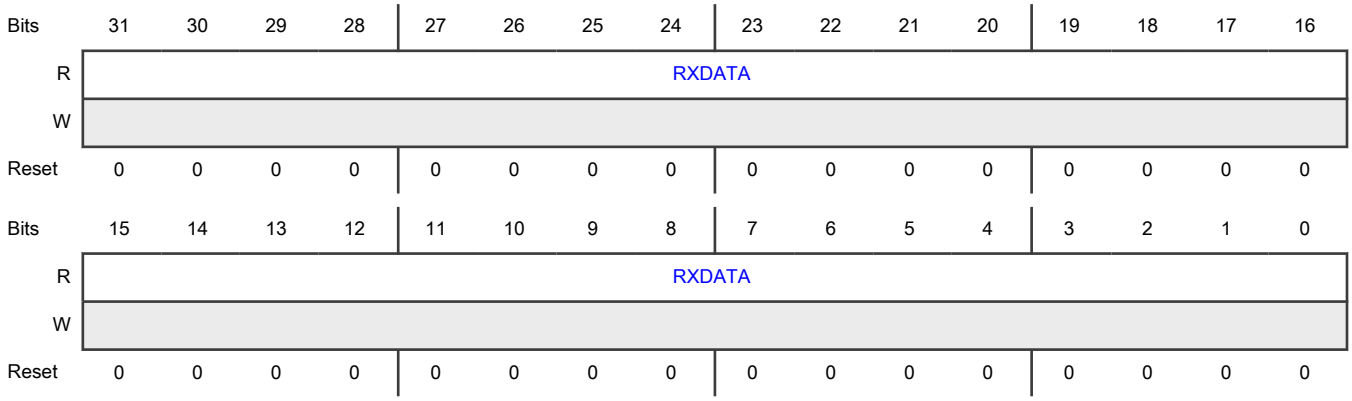
RBDR0 corresponds to the actual position of the read pointer within the RX buffer. The number of valid entries available depends on the number of RX buffer entries implemented and on the number of valid buffer entries available in the RX buffer.

Example 1 - RX buffer filled completely with 32 words: In this case, the address range for valid read access extends from RBDR0 to RBDR31 RBDR63.

Example 2 - RX buffer filled with five valid words: RX buffer fill level of RBSR[RDBFL] is 5. In this case, access to RBDR4 provides the last valid entry.

Any access beyond the range of valid RX buffer entries provides undefined results.

Diagram



Fields

Field	Function
31-0 RXDATA	RX data This field contains the data associated with the related RX buffer entry. For data format and byte ordering, see Byte ordering of serial flash memory read data.

80.14.2.38 LUT Key Register (LUTKEY)

Offset

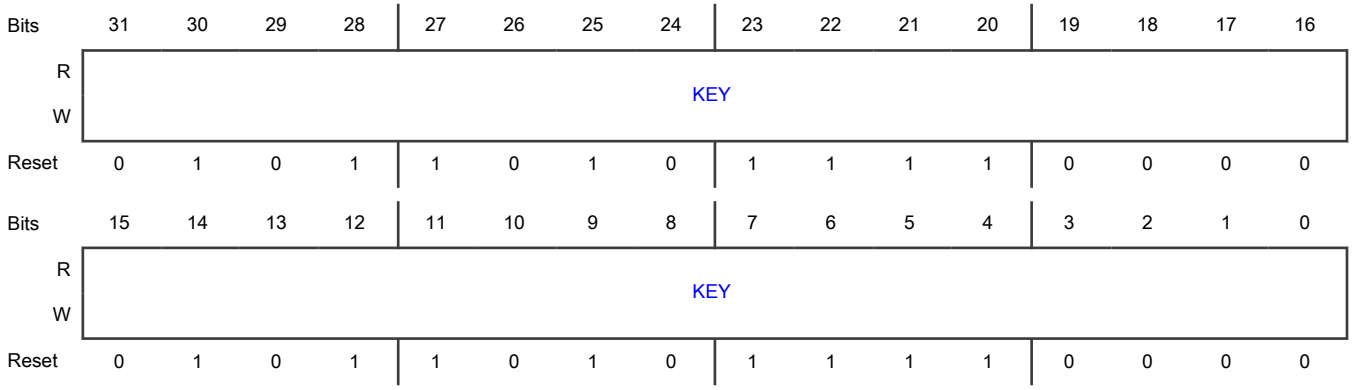
Register	Offset
LUTKEY	300h

Function

This register contains the key to lock and unlock the LUT. See LUT for details.

Special write-access is permitted in the "Anytime" mode.

Diagram



Fields

Field	Function
31-0 KEY	Key to lock or unlock the LUT The key is 0x5AF05AF0 and the read value is always 0x5AF05AF0.

80.14.2.39 LUT Lock Configuration Register (LCKCR)

Offset

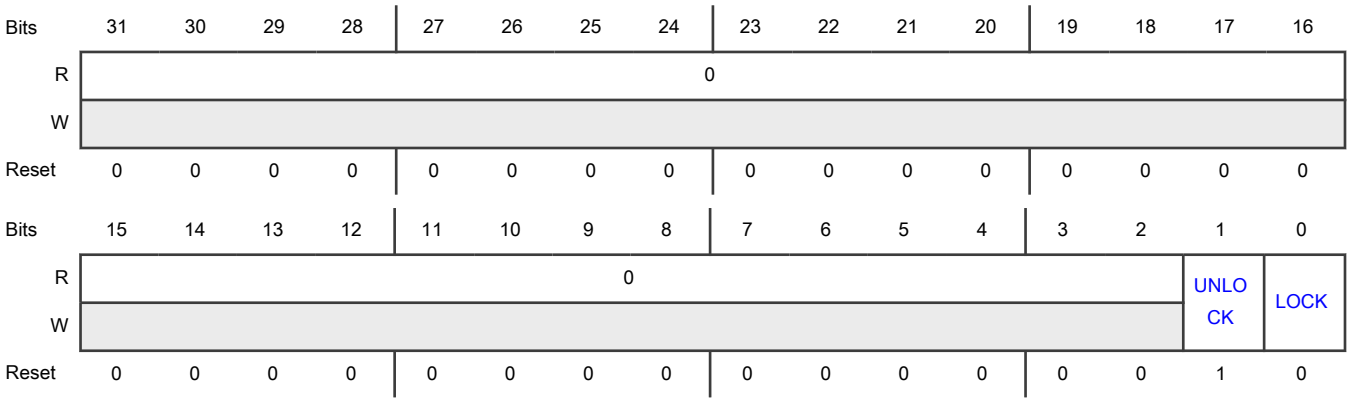
Register	Offset
LCKCR	304h

Function

This register is used along with the LUTKEY register to lock or unlock the LUT. This register should be written immediately after the LUTKEY register for the lock or unlock operation to be successful. See LUT for details. Setting both the LOCK and UNLOCK bits as "00" or "11" is not allowed.

Special write access is permitted after writing the LUT key register.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 UNLOCK	Unlock LUT Unlocks the LUT when the following two conditions are met: • This register is written just after the LUT Key Register (LUTKEY). • The LUT key register was written with the 0x5AF05AF0 key.

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 LOCK	Lock LUT Locks the LUT when the following conditions are met: • This register is written just after the LUT Key Register (LUTKEY). • The LUT key register is written with the 0x5AF05AF0 key.

80.14.2.40 LUT Register (LUT0)

Offset

Register	Offset
LUT0	310h

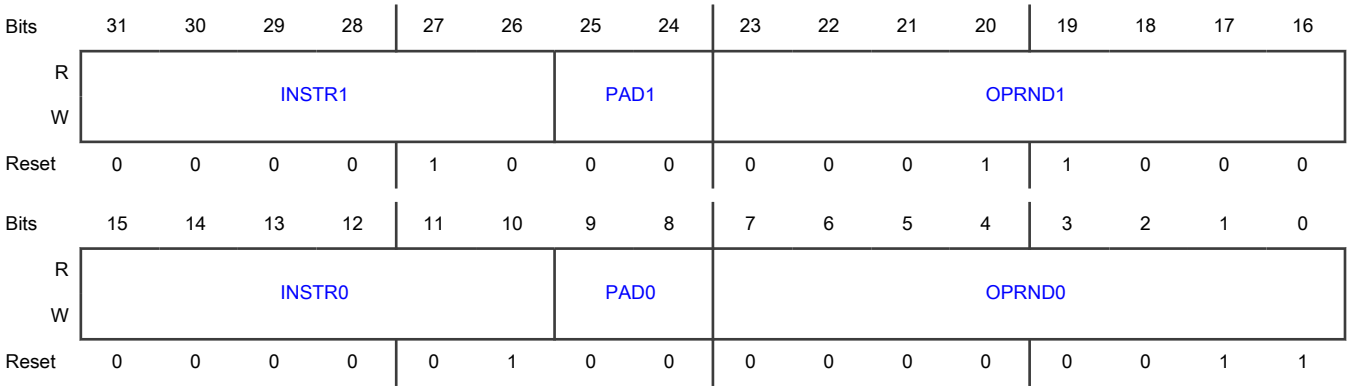
Function

A sequence of instruction-operand pairs may be pre-populated in the LUT according to the device connected on board. Each instruction-operand pair is of 16 bits (2 bytes) each. Every sequence preprogrammed by Program Sequence Engine in the LUT is referred to by its index. The LUT registers act as lookup tables for sequences of instructions. The programmable sequence engine executes the instructions in these sequences to generate a valid serial flash memory transaction. There are a total of 80 LUT registers. These 80 registers are divided into groups of 5 registers that make a valid sequence. Therefore, LUT[0], LUT[5], LUT[10] ..... LUT[75] are the starting registers of a valid sequence. Each of these sets of 5 registers can have a maximum of 10 instructions. Reset value of the register shown below is only applicable to LUT2 to LUT79. A maximum of 16 sequences can be defined at one time. See LUT that describes the LUT registers in detail.

Special write-access is permitted if the LUT is unlocked.

This register is access controlled and can only be programmed by privilege masters. Last six LUT SEQID locations should be used for programming SEQID for atomic commands (where flash's internal config region is accessed) like flash erase etc. where data transfer is not required. These 6 SEQID can be send to QSPI using only FRAD0 and can't be qualified using any other FRAD. For details, see Atomic commands considerations.

Diagram



Fields

Field	Function
31-26 INSTR1	Instruction 1
25-24 PAD1	Pad information for INSTR1 00b - 1 Pad 01b - 2 Pads 10b - 4 Pads 11b - 8 Pads
23-16 OPRND1	Operand for INSTR1
15-10 INSTR0	Instruction 0
9-8 PAD0	Pad information for INSTR0 00b - 1 Pad 01b - 2 Pads 10b - 4 Pads 11b - 8 Pads
7-0 OPRND0	Operand for INSTR0

80.14.2.41 LUT Register (LUT1)

Offset

Register	Offset
LUT1	314h

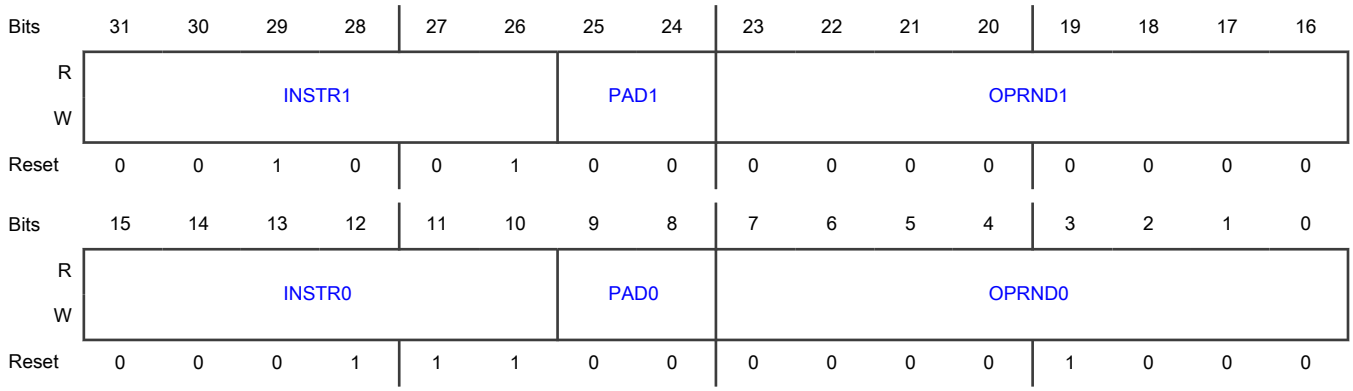
Function

A sequence of instruction-operand pairs may be pre-populated in the LUT according to the device connected on board. Each instruction-operand pair is of 16 bits (2 bytes) each. Every sequence preprogrammed by Program Sequence Engine in the LUT is referred to by its index. The LUT registers act as lookup tables for sequences of instructions. The programmable sequence engine executes the instructions in these sequences to generate a valid serial flash memory transaction. There are a total of 80 LUT registers. These 80 registers are divided into groups of 5 registers that make a valid sequence. Therefore, LUT[0], LUT[5], LUT[10] ..... LUT[75] are the starting registers of a valid sequence. Each of these sets of 5 registers can have a maximum of 10 instructions. Reset value of the register shown below is only applicable to LUT2 to LUT79. A maximum of 16 sequences can be defined at one time. See LUT that describes the LUT registers in detail.

Special write-access is permitted if the LUT is unlocked.

This register is access controlled and can only be programmed by privilege masters. Last six LUT SEQID locations should be used for programming SEQID for atomic commands (where flash's internal config region is accessed) like flash erase etc. where data transfer is not required. These 6 SEQID can be send to QSPI using only FRAD0 and can't be qualified using any other FRAD. For details, see Atomic commands considerations.

Diagram



Fields

Field	Function
31-26 INSTR1	Instruction 1
25-24 PAD1	Pad information for INSTR1 00b - 1 Pad 01b - 2 Pads 10b - 4 Pads 11b - 8 Pads
23-16 OPRND1	Operand for INSTR1
15-10 INSTR0	Instruction 0
9-8 PAD0	Pad information for INSTR0 00b - 1 Pad 01b - 2 Pads 10b - 4 Pads 11b - 8 Pads
7-0 OPRND0	Operand for INSTR0

80.14.2.42 LUT Register (LUT2 - LUT79)

Offset

For a = 2 to 79:

Register	Offset
LUTa	310h + (a × 4h)

Function

A sequence of instruction-operand pairs may be pre-populated in the LUT according to the device connected on board. Each instruction-operand pair is of 16 bits (2 bytes) each. Every sequence preprogrammed by Program Sequence Engine in the LUT is referred to by its index. The LUT registers act as lookup tables for sequences of instructions. The programmable sequence engine executes the instructions in these sequences to generate a valid serial flash memory transaction. There are a total of 80 LUT registers. These 80 registers are divided into groups of 5 registers that make a valid sequence. Therefore, LUT[0], LUT[5], LUT[10] ..... LUT[75] are the starting registers of a valid sequence. Each of these sets of 5 registers can have a maximum of 10 instructions. Reset value of the register shown below is only applicable to LUT2 to LUT79. A maximum of 16 sequences can be defined at one time. See LUT that describes the LUT registers in detail.

Special write-access is permitted if the LUT is unlocked.

This register is access controlled and can only be programmed by privilege masters. Last six LUT SEQID locations should be used for programming SEQID for atomic commands (where flash's internal config region is accessed) like flash erase etc. where data transfer is not required. These 6 SEQID can be send to QSPI using only FRAD0 and can't be qualified using any other FRAD. For details, see Atomic commands considerations.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	INSTR1						PAD1		OPRND1							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	INSTR0						PAD0		OPRND0							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-26 INSTR1	Instruction 1
25-24 PAD1	Pad information for INSTR1 00b - 1 Pad

Table continues on the next page...

Table continued from the previous page...

Field	Function
	01b - 2 Pads 10b - 4 Pads 11b - 8 Pads
23-16 OPRND1	Operand for INSTR1
15-10 INSTR0	Instruction 0
9-8 PAD0	Pad information for INSTR0 00b - 1 Pad 01b - 2 Pads 10b - 4 Pads 11b - 8 Pads
7-0 OPRND0	Operand for INSTR0

80.14.2.43 Flash Region Start Address (FRAD0_WORD0 - FRAD7_WORD0)

Offset

For n = 0 to 7:

Register	Offset
FRADn_WORD0	800h + (n × 20h)

Function

This register is access controlled and can only be programmed by privilege masters.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	STARTADR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-16 STARTADR	Start Address Specifies the specific flash memory region starting address (around 64 KB boundary)
15-0 —	Reserved

80.14.2.44 Flash Region End Address (FRAD0_WORD1 - FRAD7_WORD1)

Offset

For n = 0 to 7:

Register	Offset
FRADn_WORD1	804h + (n × 20h)

Function

This register is access controlled and can only be programmed by privilege masters.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	ENDADR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved															
W																
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-16 ENDADR	End Address Specifies the specific flash memory region end address (around 64 KB boundary)
15-0 —	Reserved

80.14.2.45 Flash Region Privileges (FRAD0_WORD2 - FRAD7_WORD2)

Offset

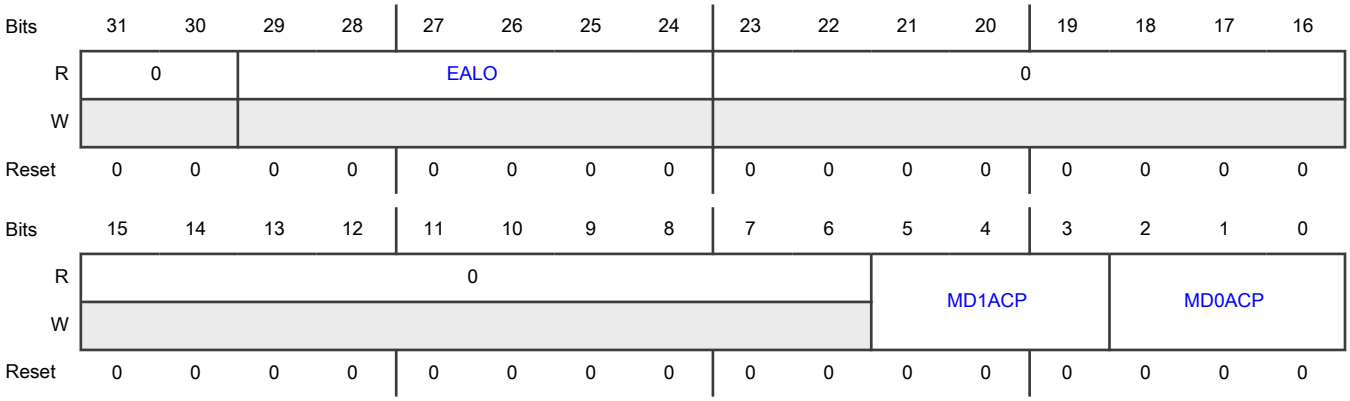
For n = 0 to 7:

Register	Offset
FRADn_WORD2	808h + (n × 20h)

Function

This register is access controlled and can only be programmed by privilege masters.

Diagram



Fields

Field	Function
31-30 —	Reserved
29-24 EALO	Exclusive Access Lock Owner When FRAD*n*_WORD3[EAL] = 11, this field indicates the domain/master ID that owns the exclusive access lock.
23-6	Reserved

Table continues on the next page...

<table>
<tr><th>Field</th><th>Function</th></tr>
<tr><td>—</td><td></td></tr>
<tr><td>5-3: MD1ACP
2-0: MD0ACP</td><td>Master Domain Access Control Policy
This field define the access restrictions for respective Master Domain 0 and 1 corresponding to this FRAD region. Write permissions are decided based on secure and privilege attributes of current transaction. Read access is not restricted. This field can not be programmed if MDAD registers are not valid. If EAL is being written in same cycle (10 or 11), or if FRAD_WORD3 [LOCK] bits are written as 11. If LOCK bits are written as 10 then this field can be programmed only if Master ID matches the ID check of respective MDAD queue. If MDAD descriptor is not valid then respective MDxACP also becomes read-only.
Table 726. Field value mapping
<table>
<tr><th>Policy</th><th>Secure privilege</th><th>Secure user</th><th>Non secure privilege</th><th>Non secure user</th></tr>
<tr><td>111</td><td>Read/Write</td><td>Read</td><td>Read/Write</td><td>Read</td></tr>
<tr><td>110</td><td>Read/Write</td><td>Read/Write</td><td>Read/Write</td><td>Read/Write</td></tr>
<tr><td>101</td><td>Read/Write</td><td>Read</td><td>Read</td><td>Read</td></tr>
<tr><td>100</td><td>Read/Write</td><td>Read/Write</td><td>Read</td><td>Read</td></tr>
<tr><td>0xx</td><td>Read</td><td>Read</td><td>Read</td><td>Read</td></tr>
</table>
NOTE
The software must program the value 101 for MDACP fields for FRAD0 as this FRAD has access to all the atomic instructions. For details, see Atomic commands considerations.</td></tr>
</table>

80.14.2.46 Flash Region Lock Control (FRAD0_WORD3 - FRAD7_WORD3)

Offset

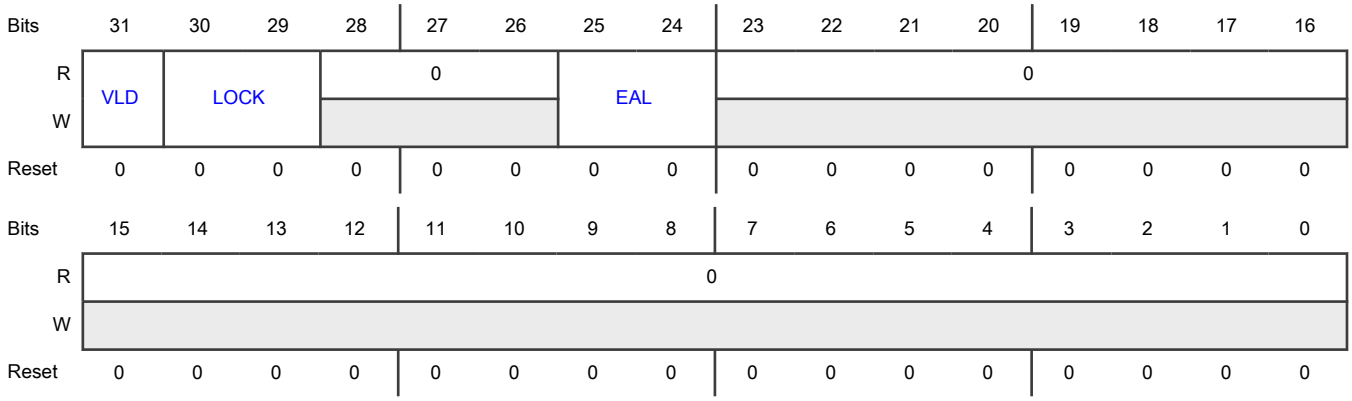
For n = 0 to 7:

Register	Offset
FRADn_WORD3	80Ch + (n × 20h)

Function

This register is access controlled and can only be programmed by privilege masters.

Diagram



Fields

Field	Function
31 VLD	Valid This field indicates whether the FRAD Descriptor for a specific flash region is valid. This field can not be written in same cycle if EAL field is being written as 10 or 11. **NOTE** You must enable this field after programming FRAD0_WORD0, FRAD0_WORD1, FRAD0_WORD2 and FRAD0_WORD3 registers. 0b - FRAD-Assignment is invalid 1b - FRAD-Assignment is valid
30-29 LOCK	Descriptor Lock This field enables masking of accidental write on FRAD registers. Lock is enabled/disabled by Secure/ Privileged master. Lock functionality does not affects the EAL bits of FRAD. They can still be written even if FRAD descriptors are locked. 00b-01b - Lock disabled. Descriptor registers can be written by any master 10b - Lock enabled. Descriptors are read-only. MDnACP fields can be programmed only by the master with ID matching the MID check of their respective Target group MDAD. If the Target group MDAD is not valid then MDnACP fields also become read-only. 11b - Lock enabled. Descriptor registers are read-only.
28-26 —	Reserved
25-24 EAL	Exclusive Access Lock This field provides exclusive write lock over a FRAD region based on MD*n*ACP. 00b - No lock. Write permissions available for all masters based on their MDxACP evaluation. 01b - NA

Table continues on the next page...

Table continued from the previous page...

Field	Function
	10b - Lock enabled. Write permissions revoked for all domains. It can only be changed to 11b and can't directly be changed to 00b. 11b - Lock enabled. Exclusive write permission for master with master ID given in FRADn_WORD3[EALO] fields based on its MDxACP evaluation. Write disabled for other masters. Exclusive lock can be taken by a master only if it its ID matches the master ID check of any of the MDAD target queue, which is valid. MDxACP field corresponding to that target queue is not programmed as 0b. when a master writes 11b on this field it will be written only if above condition is met and then the master ID will be stored in FRADn_WORD3[EALO]. No transfer error will be generated in case the master does not satisfies the check.
23-0 —	Reserved

80.14.2.47 Flash Region Compare Address Status (FRAD0_WORD4 - FRAD7_WORD4)

Offset

For n = 0 to 7:

Register	Offset
FRADn_WORD4	810h + (n × 20h)

Function

This register is access controlled and can only be programmed by privilege masters.

NOTE

Any write access to these registers will result in bus transfer error

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CMP_ADDR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	CMP_ADDR															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CMP_ADDR	Capture Address This field indicates the 32-bit start address of the last transaction which lies inside the address range of this FRAD descriptor.

80.14.2.48 Flash Region Compare Status Data (FRAD0_WORD5 - FRAD7_WORD5)

Offset

For n = 0 to 7:

Register	Offset
FRADn_WORD5	814h + (n × 20h)

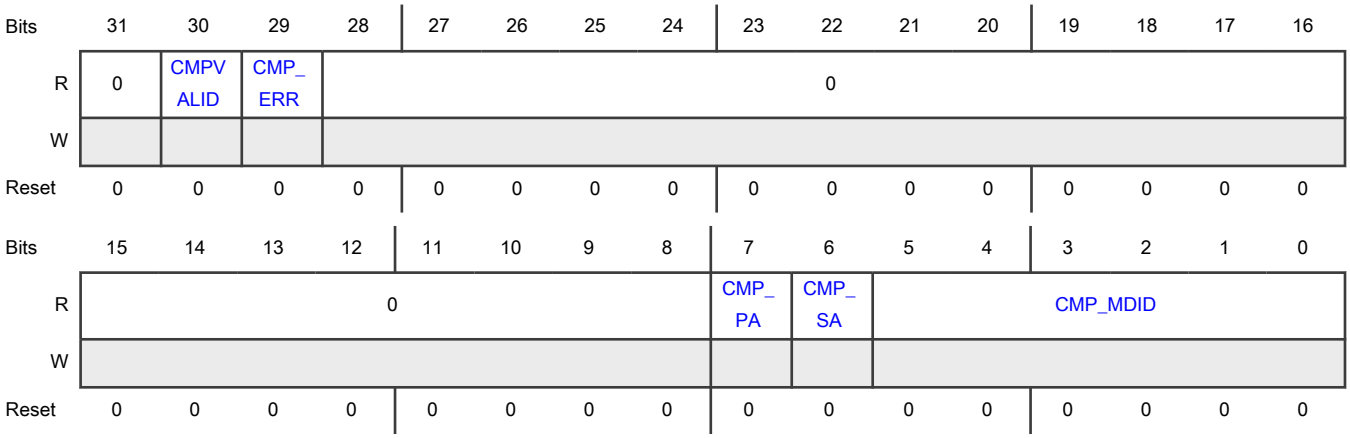
Function

This register is access controlled and can only be programmed by privilege masters.

NOTE

Any write access to these registers will result in bus transfer error

Diagram



Fields

Field	Function
31 —	Reserved
30 CMPVALID	Comparison Valid This field indicates the validity of flash region specific comparison check.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Access result/status not available 1b - Access result/status is available
29 CMP_ERR	Comparison Error This field indicates the error status (based on secure/privilege attributes checked with MDxACP permissions or exclusive access lock as programmed in FRAD) for flash region specific comparison check for last transaction. When this field is set, it can be cleared by writing '1' to W1C field of ERRSTAT register. It will update new value only after the error field has been cleared. 0b - No error 1b - Access error
28-8 —	Reserved
7 CMP_PA	Capture Privilege Attribute Capture Privilege attribute of last transaction which passed the address check for this FRAD. 0b - Non-privilege transaction 1b - Privilege transaction
6 CMP_SA	Capture Secure Attribute Capture Secure attribute of last transaction which passed the address check for this FRAD. 0b - Non-secure transaction 1b - Secure transaction
5-0 CMP_MDID	Capture MDID Value Capture master ID (MDID) value of the last transaction which passed the address check for this FRAD.

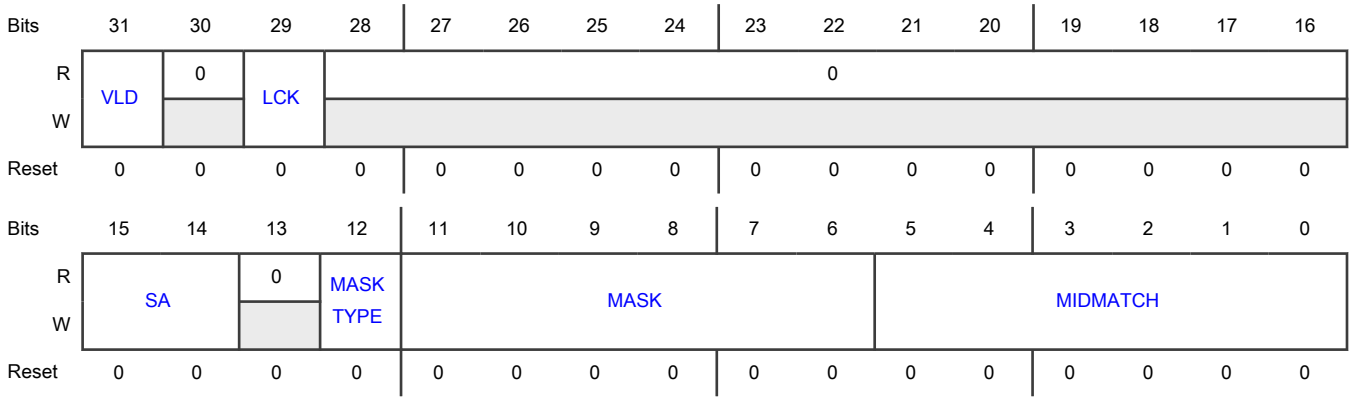
80.14.2.49 Target Group n Master Domain Access Descriptor (TG0MDAD - TG1MDAD)

Offset

Register	Offset
TG0MDAD	900h
TG1MDAD	910h

Function
This register is access controlled and can only be programmed by privilege masters.

Diagram



Fields

Field	Function
31 VLD	Valid Indicates whether MDAD Descriptor for the target group *n* is valid. 0b - MDAD-Assignment is invalid 1b - MDAD-Assignment is valid
30 —	Reserved
29 LCK	Descriptor Lock This field provides a means to make the MDAD descriptor read-only. 0b - Lock disabled. Registers can be written. 1b - Lock enabled. Registers are read-only.
28-16 —	Reserved
15-14 SA	Secure Attribute Defines the secure attribute selection criteria for entry into descriptor queue.. 00b - NA. This option should not be used. Allows the bus attribute for this master to non-secure only 01b - Allow the bus attribute for this master to non-secure only 10b - Allow the bus attribute for this master to secure only 11b - Allow the bus master's attribute: Both secure and non-secure
13 —	Reserved
12	Mask Type

Table continues on the next page...

Table continued from the previous page...

Field	Function
MASKTYPE	0b - ANDed mask 1b - ORed mask
11-6 MASK	Mask Defines the 6-bit mask value for the ID-Match comparison
5-0 MIDMATCH	Master ID Reference Specifies the reference value of the Master-ID (MID) for MID-comparison

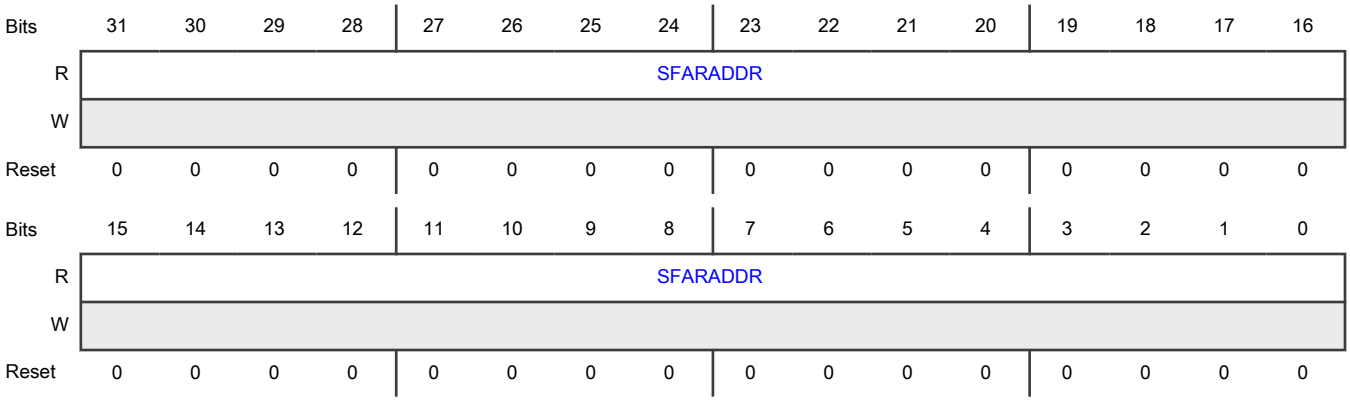
80.14.2.50 Target Group n SFAR Address (TG0SFAR - TG1SFAR)

Offset

Register	Offset
TG0SFAR	904h
TG1SFAR	914h

Function
Flash memory start address of the transaction in this target group queue.

Diagram



Fields

Field	Function
31-0 SFARADDR	SFAR Address Flash memory start address of the transaction which qualified into this target group queue.

80.14.2.51 Target Group n SFAR Status (TG0SFARS - TG1SFARS)

Offset

Register	Offset
TG0SFARS	908h
TG1SFARS	918h

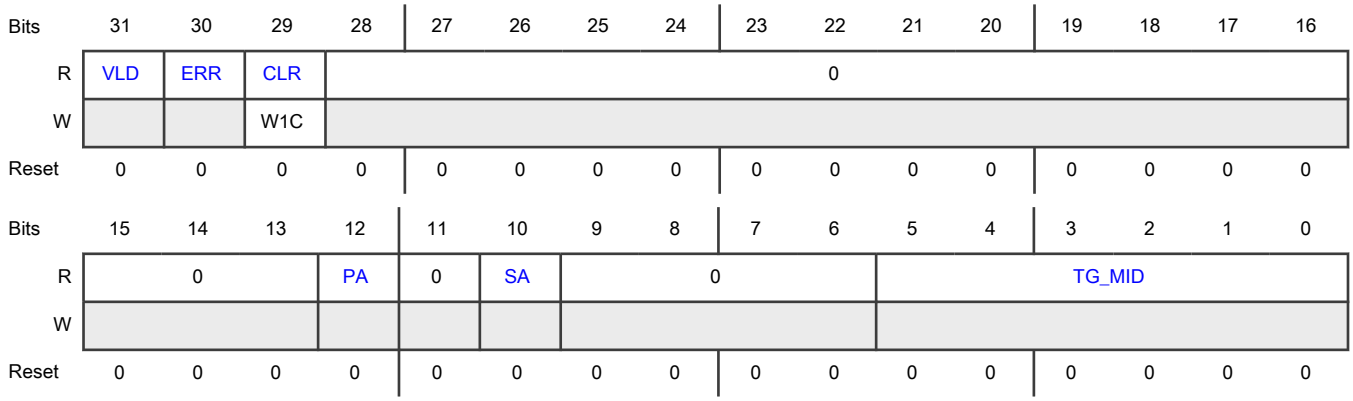
Function

Target group *n* SFAR status.

NOTE

This register can only be read if the master reading the register passes the security checks set in TGnMDAD[SA] fields or if MDAD descriptor is not valid. Else this register will be read as 0. It will also read as 0 if TGnMDAD[SA] bits in descriptor are set as 00.

Diagram



Fields

Field	Function
31 VLD	Valid Indicates whether the SFAR Address for the target group *n* is valid and queue is busy. This bit will not be set when ERR bit is set. 0b - SFAR-Assignment is invalid 1b - SFAR-Assignment is valid
30 ERR	Error Indicates whether the SFAR address stored by a Master is with required access attributes for this target group descriptor. 0b - SFAR with required attributes 1b - SFAR without required attributes

Table continues on the next page...

Table continued from the previous page...

Field	Function
29 CLR	Clear Clears the SFAR Status register. This register can only be cleared by the master having security attribute defined by TG*n*MDAD[SA]. After clearing if there is any valid transaction present in MDAD queue, it will again get updated in this register else it will be cleared. It will not be cleared if TGxMDAD[SA] bits are set to 00.
28-13 —	Reserved
12 PA	Privileged Attribute Privilege attribute of the master which wrote the SFAR register. 0b - Non-privileged 1b - Privileged
11 —	Reserved
10 SA	Secure Attribute Secure attribute of the master which wrote the SFAR register. 0b - Non-secure 1b - Secure
9-6 —	Reserved
5-0 TG_MID	Transaction Master ID Indicates the Master-ID of a transaction which programmed the SFAR registers with required attributes.

80.14.2.52 Target Group n IPCR Status (TG0IPCRS - TG1IPCRS)

Offset

Register	Offset
TG0IPCRS	90Ch
TG1IPCRS	91Ch

Function
Target group *n* IPCR status.

NOTE

This register can only be read if the master reading the register passes the security checks set in TGnMDAD[SA] fields or if MDAD descriptor is not valid. Else this register will be read as 0. It will also read as 0 if TGnMDAD[SA] bits in descriptor are set as 00.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	VLD	ERR		CLR	0					ARB_UNL...	ARB_LOCK	PAR	SEQID			
W				W1C												
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	IDATSZ															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 VLD	Valid Indicates whether the IPCR-IDATZ, IPCR-SEQID and PAR stored in this target group queue is valid and queue is locked. This bit will not be set in case ERR is set. 0b - IPCR-assignment is invalid 1b - IPCR-assignment is valid and queue is locked.
30-29 ERR	Error Indicates whether the IPCR stored by a Master with required access attributes wrt target group MDAD 00b - IPCR programming with required attributes 01b - IPCR-DATZ programming without required attributes 10b - IPCR-SEQID programming without required attributes 11b - IPCR-DATZ and SEQID both programming without required attributes
28 CLR	Clear Clears the status in IPCR Status register. This register can only be cleared by the master having security attribute defined by TGnMDAD[SA]. After clearing if there is any valid transaction present in MDAD queue it will again get updated in this register else it will be cleared. It will not be cleared if TGxMDAD[SA] bits are set to 00.
27-23 —	Reserved
22	Arbitration Unlock

Table continues on the next page...

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Field	Function
ARB_UNLOCK	Specifies if the arbitration unlock is requested for TGn. 0b - No effect 1b - Arbitration unlock is requested
21 ARB_LOCK	Arbitration Lock Specifies if the arbitration lock is requested for TGn. 0b - No effect 1b - Arbitration lock is requested
20 PAR	Parallel Mode Enable Value Indicates the parallel mode enable value programmed in the target group queue.
19-16 SEQID	SEQID Value Indicates the SEQID value programmed in target group queue.
15-0 IDATSZ	IDATSZ Value Indicates the IDATSZ value programmed in target group queue.

80.14.2.53 Master Global Configuration (MGC)

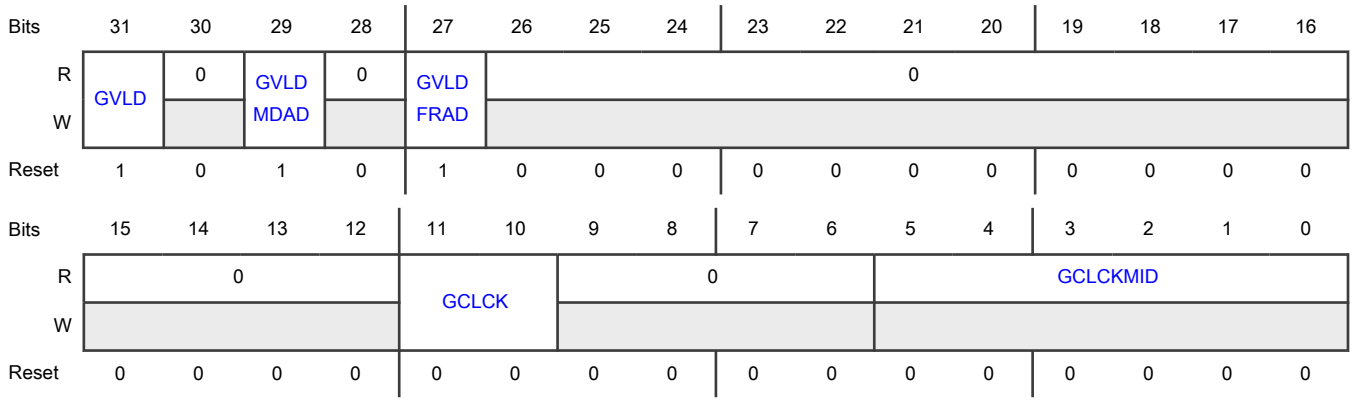
Offset

Register	Offset
MGC	920h

Function

This register is access controlled. It can only be programmed by master with master ID equal to 000011b. For MGC, MRC and MTO registers access checks master ID is being used. For transaction level checks inside MDAD and FRAD domain IDs are being used.

Diagram



Fields

Field	Function
31 GVLD	Global Valid access control 0b - Access controls are disabled. No descriptor comparison check. All transactions are allowed. 1b - Access controls are enabled.
30 —	Reserved
29 GVLDMDAD	Global Valid MDAD 0b - MDADs are disabled 1b - MDADs are enabled
28 —	Reserved
27 GVLDFRAD	Global Valid FRAD 0b - FRADs are disabled 1b - FRADs are enabled
26-12 —	Reserved
11-10 GCLCK	Global Configuration Lock This field provides a mechanism to limit write access to descriptors specific registers (MGC, MRC and MTO registers). 00b - Global Lock disabled. Registers can be written based on individual register access attribute. 01b - NA 10b - Lock enabled. Only the global configuration lock owner can write to the registers. 11b - Lock enabled. All registers are read only until unlocked
9-6 —	Reserved
5-0 GCLCKMID	Global configuration Lock Owner Status This fields specifies the 6-bit Master-ID of Global configuration Lock owner (which set MGC[GCLCK]=10). Input value of Global Master-ID is provided by sideband signals.

80.14.2.54 Master Read Command (MRC)

Offset

Register	Offset
MRC	924h

Function

This register is access controlled. It can only be programmed by master with master ID equal to 000011b.

NOTE

In case of Sequence Auto Join instruction in LUT, SFP will parse only first sequence. Second sequence will not be parsed for checking Read commands.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0	VLDCMD03	READ_CMD3						0	VLDCMD02	READ_CMD2					
W																
Reset	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		READ_CMD1						0		READ_CMD0					
W																
Reset	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1

Fields

Field	Function
31 —	Reserved
30 VLDCMD03	Valid command 0b - READ_CMD3 value invalid 1b - READ_CMD3 value valid
29-24 READ_CMD3	Read Command 3 Programmes the additional READ Instruction/Command encoding information, if applicable
23 —	Reserved
22 VLDCMD02	Valid command 0b - READ_CMD2 value invalid 1b - READ_CMD2 value valid
21-16 READ_CMD2	Read Command 2 Stores the existing instruction—DATA_LEARN command encoding information. Can be overwritten with additional read command, if required.
15-14 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
13-8 READ_CMD1	Read Command 1 Stores the existing instruction—READ_DDR command encoding information.
7-6 —	Reserved
5-0 READ_CMD0	Read Command 0 Stores the existing instruction—READ command encoding information.

80.14.2.55 Master Timeout (MTO)

Offset

Register	Offset
MTO	928h

Function

This register is access controlled. It can only be programmed by master with master ID equal to 000011b.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	WRITE_TO															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	WRITE_TO															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

Field	Function
31-0 WRITE_TO	Write Timeout Maximum timeout value to abort the ongoing write or read command. The timeout counter starts after the access from any target queue has won the arbitration and QSPI is IDLE (FSM_STAT state field is not 00). SFP queue is cleared once this timeout value has been reached and interrupt is generated if enabled.

80.14.2.56 FlashSeq Request (FLSEQREQ)

Offset

Register	Offset
FLSEQREQ	92Ch

Function
This register is access controlled and can only be programmed by privilege masters.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	VLD	0	CLR	0	TIMEOUT	0			0	CMD	0		SEQID			
W			W1C													
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	FRAD			0	ARB_LOCK	PA	SA	0	REQ_TG	REQ_MID					
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 VLD	Valid Indicates whether the FlashSeq request status is valid 0b - Status is invalid 1b - Status is valid
30 —	Reserved
29 CLR	Clear Clears the status
28 —	Reserved
27 TIMEOUT	Timeout Error Status Timeout error status of last executed FlashSeq request.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Instruction completed without timeout error 1b - Instruction aborted after timeout error
26-25 —	Reserved
24-23 —	Reserved
22 CMD	Instruction Type Instruction type of last executed FlashSeq request. 0b - Read Instruction Sequence 1b - Non-Read Instruction Sequence
21-20 —	Reserved
19-16 SEQID	Sequence ID Sequence ID of last executed FlashSeq request.
15 —	Reserved
14-12 FRAD	Flash Region Descriptor Number Flash Region specific number (FRAD) of last executed FlashSeq request. This will remain 0 in case of read transfers.
11 —	Reserved
10 ARB_LOCK	Arbitration Lock Arbitration lock status for last completed request. 0b - Arbitration was not locked 1b - Arbitration was locked
9 PA	Privilege Attribute Privilege attribute of last executed FlashSeq request. 0b - Non-privilege Transaction 1b - Privilege Transaction
8	Secure Attribute

Table continues on the next page...

Table continued from the previous page...

Field	Function
SA	Secure attribute of last executed FlashSeq request. 0b - Non-secure Transaction 1b - Secure Transaction
7 —	Reserved
6 REQ_TG	FlashSeq Request Target Group Target group queue from which last executed transaction passed. 0b - TG0 1b - TG1
5-0 REQ_MID	FlashSeq Request Master ID Indicates the master-ID of last executed FlashSeq request.

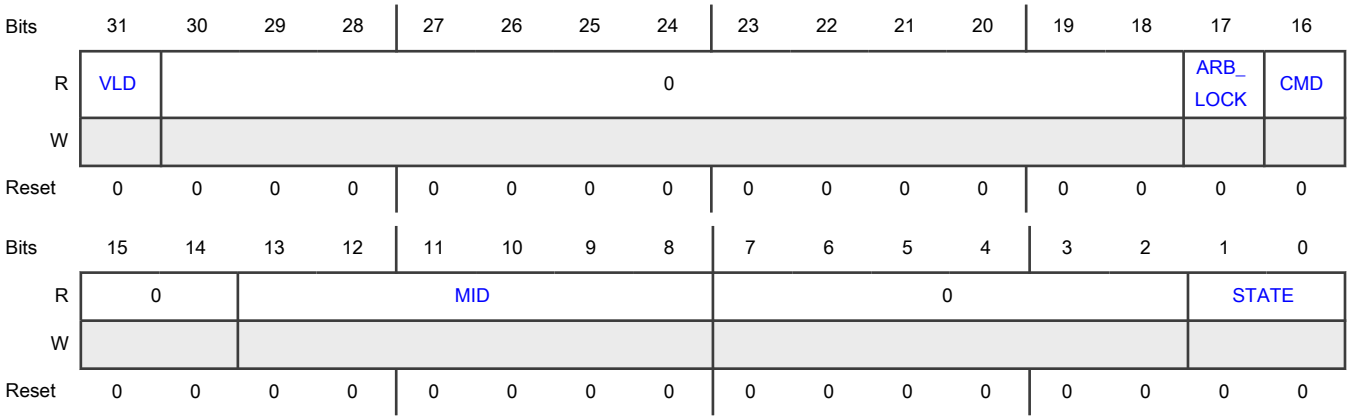
80.14.2.57 FSM Status (FSMSTAT)

Offset

Register	Offset
FSMSTAT	930h

Function
This register is access controlled and can only be programmed by privilege masters.

Diagram



Fields

Field	Function
31 VLD	Valid Indicates whether the FSM Status is valid. 0b - Status is invalid. No IPS transfer is queued. 1b - Status is valid. IPS transfer is queued or execution on QuadSPI.
30-18 —	Reserved
17 ARB_LOCK	Arbitration Lock Arbitration lock status for present request. 0b - Arbitration not locked 1b - Arbitration locked
16 CMD	Command Instruction type of currently initiated Flash transaction on QuadSPI. 0b - Read instruction sequence 1b - Non-read instruction sequence
15-14 —	Reserved
13-8 MID	Master ID Indicates the Master-ID of the currently initiated FlashSeq transaction on QuadSPI.
7-2 —	Reserved
1-0 STATE	FSM State Status 00b - Transaction is Queued, but QuadSPI is busy with AHB transfer, any previous DMA transaction is ongoing, any residue data left in RDBFL or if any interrupt is pending.. 01b - TBDR lock is open. IPS master can write in TBDR. 10b - Write transfer is triggered. SEQID is written to QuadSPI. 11b - Read transfer is triggered. SEQID is written to QuadSPI.

80.14.2.58 IPS Error (IPSERROR)

Offset

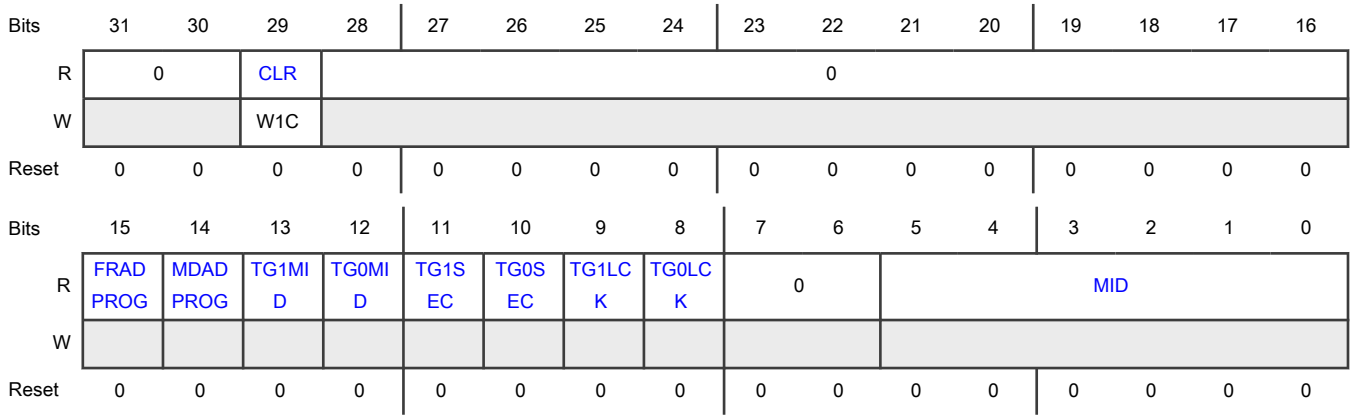
Register	Offset
IPSERROR	934h

Function

This register contains the error status of IPS write on SFAR or IPCR registers if they are not qualified for any of the target group queues.

This register is access controlled and can only be programmed by privilege masters.

Diagram



Fields

Field	Function
31-30 —	Reserved
29 CLR	Clear Clear the status of IPS Error register.
28-16 —	Reserved
15 FRADPROG	FRAD Descriptor Program Status 0b - Some or all of the FRAD descriptors are programmed 1b - None of the FRAD descriptors are programmed
14 MDADPROG	TG/MDAD Descriptor Program Status 0b - One or both of target group descriptors programmed 1b - None of the target group descriptors are programmed and valid
13-12 TGnMID	TGn Master-ID Status 0b - TGn master-ID check passed 1b - TGn master-ID check failed
11-10 TGnSEC	TGn Security Status 0b - Security attribute check passed for TGn

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Security attribute check failed for TGn
9-8 TGnLCK	TGn Lock 0b - TGn queue SEQID is not written yet. 1b - TGn queue SEQID is written and queue is locked
7-6 —	Reserved
5-0 MID	IPS DID Master ID IPS Master ID for the transaction which generated this IPS transfer error.

80.14.2.59 Error Status (ERRSTAT)

Offset

Register	Offset
ERRSTAT	938h

Function
This register is access controlled and can only be programmed by privilege masters.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	TO_ERR	TG1IPCR	TG0IPCR	TG1SFAR	TG0SFAR	IPS_ERR	FRAD7ACC	FRAD6ACC	FRAD5ACC	FRAD4ACC	FRAD3ACC	FRAD2ACC	FRAD1ACC	FRAD0ACC	FRADMTCH
W								W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-15	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
14 TO_ERR	Timeout Error This field is set if any flash transaction generated on QuadSPI results in timeout error and is aborted by SFP module. This field can be cleared by writing 1 to FLSEQREQ[CLR]. 0b - No timeout Error generated 1b - Timeout error is generated
13-12 TGnIPCR	TGn IPCR Error This field is set if any IPCR write generates error while being written to Target group queue. This field can be cleared by writing 1 to TG*n*IPCRS[CLR]. 0b - No Error generated 1b - Error is generated
11-10 TGnSFAR	TGn SFAR Error This field is set if any SFAR write generates error while being written to Target group queue. This field can be cleared by writing 1 to TG*n*SFARS[CLR]. 0b - No Error generated 1b - Error is generated
9 IPS_ERR	IPS Error Some common error occurred and IPS bus transfer error is also generated. The details of the IPS error can be found in IPSERROR register. This field can be cleared by writing 1 to IPSERROR[CLR]. 0b - No Error generated 1b - Error is generated
8-1 FRADnACC	FRADn Access Error This bit is set when the transaction address lies within the address range of this FRAD but it does not qualify the access permission checks for this FRAD or this FRAD was under exclusive lock (FRAD*n*_WORD3[EAL] = 10 or 11) by another master. It may also be set if the transaction address qualifies for multiple FRAD regions. 0b - No valid Error transaction 1b - Transaction is with error and target queue is cleared
0 FRADMTCH	No FRAD Match Error Transaction address does not lie within address range of any FRAD descriptor. 0b - No Error generated

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Transaction does not lie within any FRAD address range and error is generated

80.14.2.60 Interrupt Enable (INT_EN)

Offset

Register	Offset
INT_EN	93Ch

Function

This register is access controlled and can only be programmed by privilege masters.

NOTE

In case Queue Specific Error Interrupt bits (TG0SFAR,TG1SFAR,TG0IPCR,TG1IPCR) are enabled, ensure that the core executing interrupt handler can clear the Queue specific TGxSFARS and TGxIPCRS registers only when core's security attribute matches the queue. In case there is a mismatch in security attribute, you must change the TGMDADx.SA attribute of that queue to match the core SA attribute. After that, core can clear the error and then revert the changes in TGMDADx.SA field.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0	TO_ERR	TG1IPCR	TG0IPCR	TG1SFAR	TG0SFAR	IPS_ERR	FRAD7ACC	FRAD6ACC	FRAD5ACC	FRAD4ACC	FRAD3ACC	FRAD2ACC	FRAD1ACC	FRAD0ACC	FRADMTCH
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-15 —	Reserved
14 TO_ERR	Timeout Error Interrupt Enable 0b - Interrupt disabled 1b - Interrupt enabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
13-12 TGnIPCR	TGn IPCR Error Interrupt Enable 0b - Interrupt disabled 1b - Interrupt enabled
11-10 TGnSFAR	TGn SFAR Error Interrupt Enable 0b - Interrupt disabled 1b - Interrupt enabled
9 IPS_ERR	IPS Error Interrupt Enable 0b - Interrupt disabled 1b - Interrupt enabled
8-1 FRADnACC	FRADn Access Error Interrupt Enable 0b - Interrupt disabled 1b - Interrupt enabled
0 FRADMTCH	No FRAD Match Error Interrupt Enable 0b - Interrupt disabled 1b - Interrupt enabled

80.14.3 Serial flash memory address assignment

The serial flash memory address assignment can be modified by writing into Serial Flash Memory A1 Top Address Register (SFA1AD) and Serial Flash Memory A2 Top Address Register (SFA2AD) for device A

Table 727. Serial flash memory address assignment

Parameter	Function	Access mode
QuadSPI_AMBA_BASE ((31:10) - 22 bits)	QuadSPI AHB base address First address of the serial flash memory device as presented to the QuadSPI controller. This might be the base of the serial flash memory in the system address map or it may be a remapping, for instance to 0h, performed by the system. (See the system address map file attached to this document)	
QuadSPI_ARDB_BASE	First address of the QuadSPI Rx buffer on system memory map	

Table continues on the next page...

Table 727. Serial flash memory address assignment (continued)

Parameter	Function	Access mode
TOP_ADDR_MEMA1(TPADA1)	Top address for the external flash memory A1 (the first of the two independent flash memories sharing the IOFA)	Any access to the address space between TOP_ADDR_MEMA1 and QuadSPI_AMBA_BASE is routed to serial flash memory A1.
TOP_ADDR_MEMA2(TPADA2)	Top address for the external flash memory A2 (the second of the two independent flash memories sharing the IOFA)	Any access to the address space between TOP_ADDR_MEMA2 and TOP_ADDR_MEMA1 is routed to serial flash memory A2.

80.15 Flash memory mapped AMBA bus

QuadSPI_AMBA_BASE defines the address to be used as the start address of the serial flash memory device, as defined by the system memory map. Note that this may be a remapping of the physical address of the serial flash memory in the system. See the system address map for details.

Table 728. QuadSPI AMBA bus memory map

Address	Register name
QuadSPI_AMBA_BASE to (TOP_ADDR_MEMA2 - 1h)	• See Memory-mapped serial flash memory data—individual flash memory mode on flash memory A. • For information about byte ordering, see Table 691 and Table 692.
QuadSPI_ARDB_BASE to... (32 * 4 Byte) QuadSPI_ARDB_BASE + 1FFh	• See AHB RX Data Buffer Register (ARDB0 - ARDB31). • For information about the byte ordering, see Table 691.

NOTE

Any read access to non-implemented addresses provides undefined results.

In individual flash memory modes, the 3/4 address bytes (as programmed in the instruction/operand in the sequence) available for the flash memory address are determined by SFADR[23:0] or SFADR[31:0] as provided in the table shown above.

80.15.1 AHB bus access read considerations

Note that all logic in the QuadSPI module implementing the AHB bus access is designed to read the content of an external serial flash memory device. Therefore, the following restrictions apply to the QuadSPI module with respect to accesses to the AHB bus:

- AHB bus read access types—NONSEQ and BUSY—are fully supported.
- AHB read access type—SEQ—is treated in the same way as NONSEQ. See Flash memory mapped AMBA bus for details.
- Early burst termination is not supported for AHB transactions.
- An AHB error response is provided on occurrence of:
  - Parity error
  - ECC error from flash memory
  - Data learning failure

  Also, interrupts (if enabled) are provided along with the AHB error response.

- An AHB error response occurs when FR[AITEF] bit is set
- An AHB bus stall along with error response occurs when FR[AAEF] bit is set

80.15.2 Memory-mapped serial flash memory data—individual flash memory mode on flash memory A

Starting with address QuadSPI_AMBA_BASE, the content of the first external serial flash memory device is mapped into the address space of the device containing the QuadSPI module. Serial flash memory byte address 0h corresponds to bus address, QuadSPI_AMBA_BASE, in an increasing order. . See the following table for the address mapping. The byte ordering for 32-bit access is provided in Table 691 and for 64-bit read access, the byte ordering is provided in Table 692.

Table 729. Memory-mapped individual flash memory mode—flash memory A address scheme

Memory-mapped address 32-bit access	Memory-mapped address 64-bit access	Serial flash memory byte address	Flash memory device
QuadSPI_AMBA_BASE + 0h	QuadSPI_AMBA_BASE + 0h	0h to 3h	A1
QuadSPI_AMBA_BASE + 4h		4h to 7h	
...	...	...	
TOP_ADDR_MEMA1 - 8h	TOP_ADDR_MEMA1 - 8h	(TOP_ADDR_MEMA1- 8h) to (TOP_ADDR_MEMA1 - 0h4 -0h1)	
TOP_ADDR_MEMA1 - 4h		(TOP_ADDR_MEMA1 - 4h) to (TOP_ADDR_MEMA1 - 0h1)	
TOP_ADDR_MEMA1 + 4h	TOP_ADDR_MEMA1 + 0h	0h to 3h	A2
TOP_ADDR_MEMA1 + 0h4		4h to 7h	
...	...	...	
TOP_ADDR_MEMA2 - 8h	TOP_ADDR_MEMA2 - 8h	(TOP_ADDR_MEMA2 - 8h) to (TOP_ADDR_MEMA2 - 4h - 1h)	
TOP_ADDR_MEMA2 - 4h		(TOP_ADDR_MEMA2 - 4h) to (TOP_ADDR_MEMA2 - 1h)	

The available address range depends on the size of the external serial flash memory device. Any access beyond the size of the external serial flash memory provides undefined results.

For details concerning the read process, see Flash memory read.

80.15.3 ARDB register descriptions

NOTE

See the system memory map in this document for the base address of the QuadSPI AHB RX data buffer.

80.15.3.1 ARDB memory map

QuadSPI_ARDB base address: 6800_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h - 7Ch	AHB RX Data Buffer Register (ARDB0 - ARDB31)	32	R	0000_0000h

80.15.3.2 AHB RX Data Buffer Register (ARDB0 - ARDB31)

Offset

For a = 0 to 31:

Register	Offset
ARDBa	0h + (a × 4h)

Function

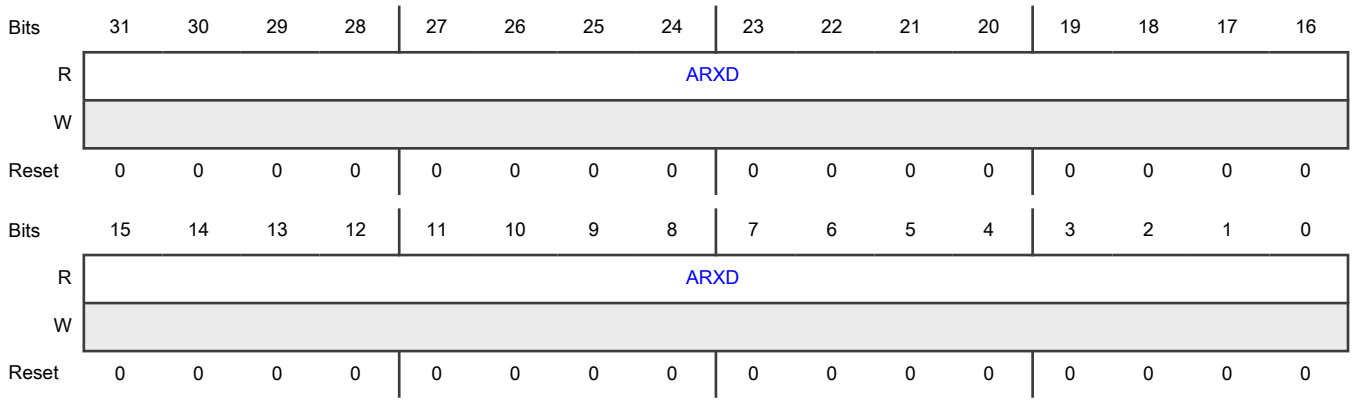
This register is used to read the buffer content of the RX buffer from successive addresses. ARDB0 corresponds to the RX buffer register entry corresponding to the current value of the read pointer in an increasing order.

The increment of the read pointer depends on the access scheme (DMA or flag-driven). See Flash memory read, RX buffer, data read through register interface, and AHB read for the description of successive accesses to the RX buffer content. See Byte Ordering of Serial Flash Memory Read Data for the byte ordering scheme.

Valid address range accessible in the ARDB*n* range depends on the number of RX buffer entries implemented and on the number of valid buffer entries available in the RX buffer.

- Example 1 - RX buffer filled completely with 32 words: In this case, the address range for valid read access extends from ARDB0 to ARDB31 .
- Example 2 - RX buffer filled with five valid words; RX buffer fill level RBSR[RDBFL] is 5. In this case, an access to ARDB4 provides the last valid entry.

Diagram



Fields

Field	Function
31-0 ARXD	ARDB provided RX buffer data Byte order (endianness) is identical to the RX buffer data registers.

80.16 Glossary

AHB Advanced high-performance bus, a version of AMBA

AMBA Advanced microcontroller bus architecture

APB Advanced peripheral bus

BE Big endian byte ordering

CRS Center aligned read strobe

CS Chip select

FRAD Flash region access descriptor

I/O Input output, I/O lines are also referred to as pads in this chapter

IFM Individual flash memory mode

LE Little endian

MDAD Master domain access descriptors

MGID Master-Group identifier

PCS Peripheral chip select

SCK Serial communications clock

SFM Serial flash memory

Chapter 81
Zipwire

81.1 Chip-specific Zipwire information

81.1.1 Zipwire instances and configuration

This section summarizes the module configuration in the controller. For a comprehensive description of SIPI and LFAST, please refer the specific dedicated chapters for SIPI and LFAST.

The SIPI and LFAST are connected to one another and appear as a single unit. The LFAST portion of the two modules allows for high speed inter-device communications. The SIPI allows memory to be shared between devices which have SIPI and LFAST communication modules (see Figure 617). Zipwire is official brand for the combination of LFAST and SIPI.

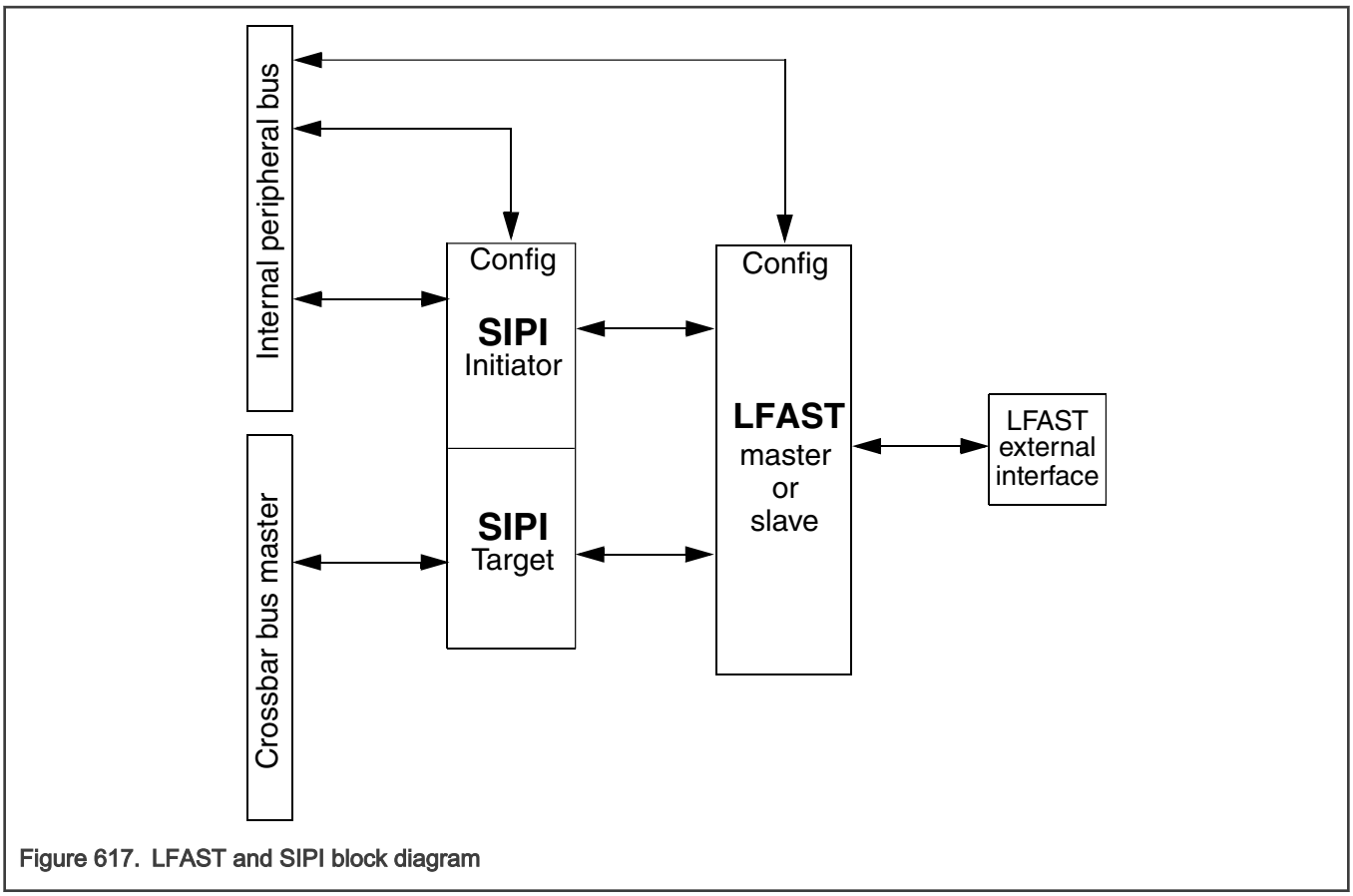


Figure 617. LFAST and SIPI block diagram

SIPI chip ID value:

Each SIPI instance has a 32-bit-wide chip ID. The chip ID value indicates the Zipwire instance.

Table 730. SIPI chip ID value

SIPI instance	Bits 31–0
SIPI_0	098D801D

DCM.DCMRWF1 and DCM.DCMRWF3 registers need to be configured. See the "Device Configuration Module General-Purpose Registers (DCM_GPR)" chapter for details.

81.2 Overview

The Serial Inter Processor Interface (SIPI) and LVDS Fast Asynchronous Serial Transmission Interface (LFAST) modules work together as a single unit called Zipwire. The LFAST portion of the two modules allows for high-speed, inter-device communications. The SIPI module allows memory to be shared between devices having SIPI and LFAST communication modules.

The LFAST module can operate in either slave or master mode configurations. The node running in the master mode controls the serial link, but SIPI, in both the master and slave modes, can act as an initiator and a target for SIPI commands simultaneously. Please see the SIPI and LFAST chapters for detailed information on module configuration and functionality.

81.3 Introduction

Zipwire is a group of modules that allow one MCU to have a fast, low pin count, serial communication link directly into the memory mapped peripherals and/or memories of another MCU or smart ASIC. Zipwire is implemented in hardware, so there is no CPU load for the initiator or target node. Zipwire supports 8-bit, 16-bit, or 32-bit reads and writes to any 32-bit address at the target node.

Zipwire architecture is fully pipelined and support multiple outstanding commands to allow maximum use of the serial link bandwidth.

The serial link runs at a high speed using the LVDS physical layer. One LVDS pair for Tx and another pair for Rx, with a separate LFAST reference clock for a total of five pins.

Zipwire also supports a streaming mode for the transfer of large blocks of data.

In the streaming mode, Zipwire has a high transfer rate.

81.4 Zipwire block diagram

The next diagram shows two MCUs with Zipwire connected using a five wire interface. Both MCUs support Target and Initiator modes of Zipwire. The SIPI Bus Master Interface is used for all Target mode transactions. The SIPI Register Interface is used for all Initiator Transactions and initial setup. The LFAST Register Interface is used for Initial Setup.

The following diagram shows the LFAST reference clock is coming from MCU B clock system. The Ref_Clock can come from either MCU. It is user configurable, but it must be the same clock that drives both LFAST modules.

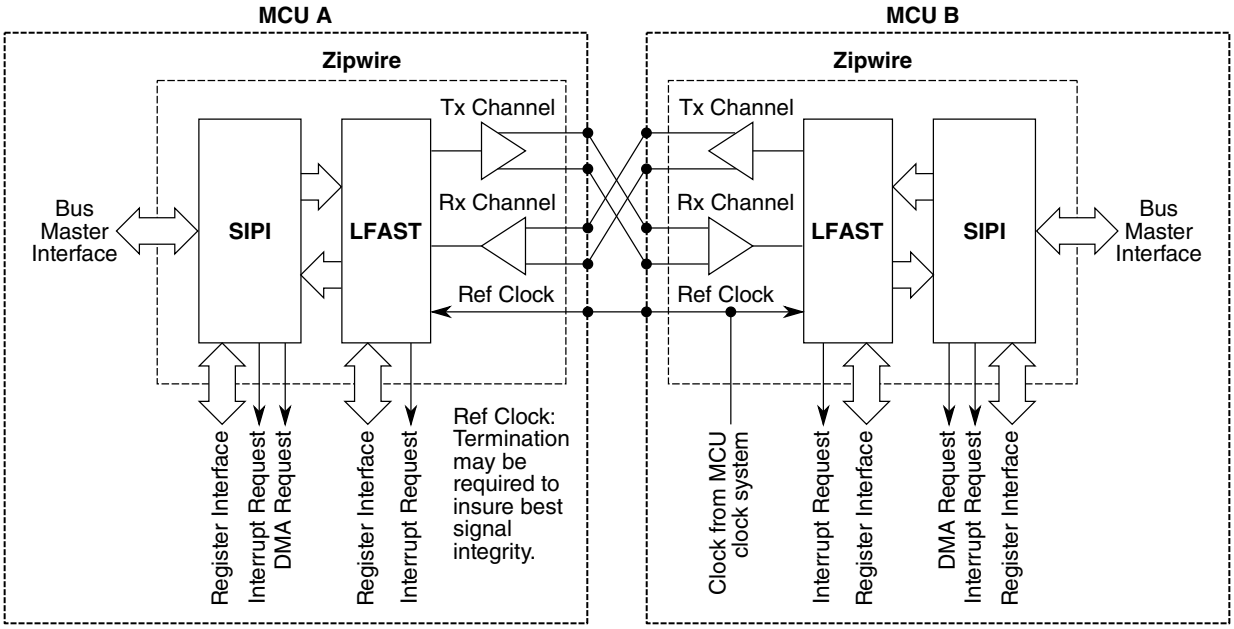


Figure 618. Zipwire connection diagram

81.5 Architecture

Zipwire consists of several modules and system resources. The physical layer is LVDS with common mode voltage and defined swing.

The transport layer is a protocol called LFAST, which is an asynchronous protocol, using non-return to zero encoding. The LFAST protocol consists of the following:

- A fixed 16-bit sync frame to allow the receiver to detect the optimal point to sample the incoming data
- An 8-bit LFAST header, which defines the channel number and the size of the LFAST payload
- The payload, which can be between 8 and 288 bits

The application layer protocol is called SIPI. SIPI runs on top of LFAST and is fully encapsulated within the LFAST payload. SIPI uses four fixed sizes of LFAST payload in Zipwire:

- 32-bit
- 64-bit
- 96-bit
- 288-bit

The SIPI protocol implements a suite of commands initiated by one MCU, for reading and writing any 32-bit address location in another connected MCU. The SIPI protocol allows either or both MCUs to initiate commands. The protocol also supports interrupt requests from one MCU to the other.

The SIPI module implements both the initiator part of the protocol and the recipient part of the protocol. The module implements four SIPI Initiator channels that can run independently of each other and can run simultaneously. The SIPI module is a bus master on the low speed XBAR. As the target MCU for a command from the initiating MCU, SIPI can perform read and write accesses to any address location within the target MCU. The software running on the local MCU, should configure the system MPU to allow/deny memory accesses to MCU memory and resources as required.

The initiator part of the module is connected to the DMA controller and is able to generate DMA requests as a command is completed. This allows a series of read or write commands to be queued in the Initiator MCU and executed by DMA and SIPI without CPU intervention at either Initiator or Target MCU.

81.6 Zipwire interconnections

LFAST includes the following connections:

- Tx and Rx configuration is controlled by LFAST Control registers
- Peripheral Bridge interface (PBRIDGE) — Allows software to read and write configuration registers
- Tx Data Port/Rx Data Port — Directly connected to the SIPI module and allows received data to be efficiently transferred to SIPI and transmit data to be transferred from SIPI
- Interrupt Request connections — Allows the module to flag to the CPU when it requires servicing

SIPI includes the following connections:

- Peripheral Bridge interface (PBRIDGE) — Allows the software to read and write configuration registers and SIPI Interface Registers.
- DMA connections — Allows SIPI command sequences to be queues and initiated without CPU intervention
- Crossbar master port — Allows SIPI to execute requested commands to read and write MCU address space
- Tx Data Port/Rx Data Port — Directly connected to the LFAST module and allows received data to be efficiently transferred from LFAST and transmit data to be transferred to LFAST
- Interrupt Request connections — Allows the module to flag to the CPU when it requires servicing

81.7 Zipwire performance

Two aspects of performance are considered:

- Bandwidth — The rate at which data can be read or written between two nodes. It assumes that read or write commands from the Initiator node can be sent continuously at the highest speed at which the Target node can consume those commands.
- Latency — The time from the Initiator node sending a read or write command to the Initiator node receiving the read data or write acknowledge.

81.7.1 Read performance

A Zipwire read operation consists of three stages:

- Initiator sends SIPI Read command to Target.
- Target parses the received command and runs a master bus cycle to read the data.
- Target sends the SIPI Read response back to the Initiator.

A SIPI Read command consists of:

- 16-bit header
- 32-bit read address
- 16-bit CRC
- 64 bits total

A SIPI Read response consists of:

- 16-bit header
- 32-bit read data
- 16-bit CRC

- 64 bits total

The SIPI message is encapsulated in an LFAST frame where the LFAST payload is the size of the SIPI message.

The LFAST frame consists of:

- 16-bit synchronisation header
- 8-bit header
- 64-bit payload
- 1-bit stop bit
- 89 bits total

LFAST Baud rate is *c* Mbaud that yields a bit time of *d* ns

Therefore, an 89-bit LFAST transmission of a SIPI 64-bit Read command or 64-bit Read response takes 89*d* ns.

The SIPI module takes thirteen system clock cycles to parse a command and create a Read response, in addition to the time to run the master bus cycle. The time to run the master bus cycle varies depending on the memory being read.

Assumptions:

- Average of *n* × XBAR cycles to read different memories
- XBAR clocked at *x* MHz
- SIPI clocked at *y* MHz

Therefore, time for SIPI to read an address location is:

(13 × *y* MHz clocks) + (*n* × *x* MHz clocks) = *z* ns

81.7.1.1 Read bandwidth

The Zipwire target node has a three-message deep receive FIFO and a three-message deep transmit FIFO. So, the Target node can simultaneously receive a command, process a command, and send the Read response.

The time to transmit a command or response is less than the time to process the command. Therefore, the bandwidth is limited by the time to process the message.

Read Bandwidth = 4 bytes in *z* ns = 4 × *z* MB/second

81.7.1.2 Read latency

The latency is the time taken to send a Read command, process the command, and send a Read response.

Read Latency = 89*d* ns + *z* ns + 89*d* ns = *z* + 178*d* ns

81.7.2 Write performance

A Zipwire write operation consists of three stages:

- Initiator sends a SIPI Write command to Target.
- Target parses the received command and runs a master bus cycle to write the data.
- Target sends the SIPI Write response back to the Initiator.

A SIPI Write command consists of:

- 16-bit header
- 32-bit write address
- 32-bit write data
- 16-bit CRC

- 96 bits total

A SIPI Write acknowledge consists of:

- 16-bit header
- 16-bit CRC
- 32 bits total

The SIPI message is encapsulated in an LFAST frame where the LFAST payload is the size of the SIPI message.

The LFAST frame consists of:

- 16-bit synchronisation header
- 8-bit header
- 96-bit payload (command) or 32-bit (acknowledge)
- 1-bit stop bit
- 121 bits total (command) or 57 bits (acknowledge)

LFAST Baud rate is c Mbaud that yields a bit time of d ns

Therefore, the time for an LFAST transmission is:

- 121-bit LFAST transmission of a SIPI 96-bit Write Command takes $121d$ ns
- 57-bit LFAST transmission of a SIPI 32-bit Write Acknowledge takes $57d$ ns

The SIPI module takes thirteen system clock cycles to parse a command and create a Write response, in addition to the time to run the master bus cycle. This time varies depending on the memory being written.

Assumptions:

- Average of m × slow XBAR cycles to write different memories
- Slow XBAR clocked at x MHz
- SIPI clocked at y MHz

Therefore, the time for SIPI to write an address location is:

(13 × y MHz clocks) + (m × x MHz clocks) = v ns

81.7.2.1 Write bandwidth

The Zipwire target node has a three-message deep receive FIFO and a three-message deep transmit FIFO. So, the Target node can simultaneously receive a command, process a command, and send the Write Acknowledge response.

The time to transmit the command is longer than the time to process the command, or the time to transmit the Write Acknowledge. Therefore, the bandwidth is limited by the time to transmit the command.

Write Bandwidth = 4 bytes in v ns = 4 × v MB/second

81.7.2.2 Write latency

The latency is the time taken to send a Write command, process the command, and send a Write Acknowledge.

Write Latency = $121d$ ns + v ns + $57d$ ns = v + $178d$ ns

Chapter 82
Serial Interprocessor Interface (SIPI)

82.1 Chip-specific SIPI information

82.1.1 SIPI instances and configuration

S32K396 supports one instance of SIPI.

Table 731. SIPI instances

Configuration	S32K396
Number of supported channels	4
Number of outstanding frames allowed	4

82.2 Overview

SIPI is an application-layer protocol that runs on top of the LVDS Fast Asynchronous Serial Transmission (LFAST) module. The local device uses it to access the shared memory of a remote device.

SIPI defines point-to-point, full-duplex communication between two devices, where LFAST works as a physical medium of communication between both the devices.

An instance of SIPI can act as an initiator, or target, or both. SIPI can access the shared memory directly through its AHB master interface or through its DMA interface. The AHB master interface is used when the node acts as target and the DMA interface is used when the node acts as an initiator. SIPI includes four channels, with channel 2 having data streaming capability. Payload width for channel 0, 1, and 3 is 32 bits, and for channel 2, data widths can be 32 bits, or 256 bits when streaming. You can use any of these channels for DMA access or bus interface access, depending on the setting of the SIPI_CCR*n*. The Cyclic Redundancy Check (CRC) encoder calculates CRC on the command frame. Then, the SIPI initiator appends the CRC to the end of the frame before transmission.

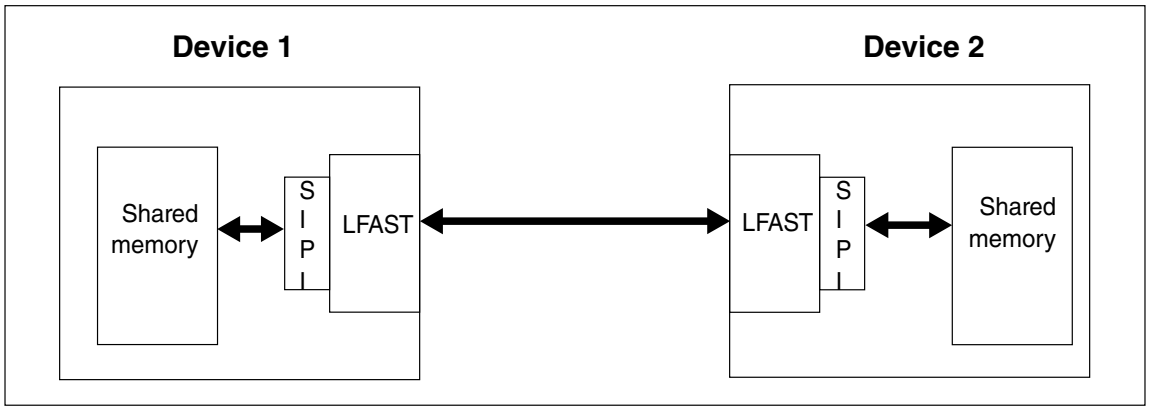


Figure 619. Interprocessor communication diagram

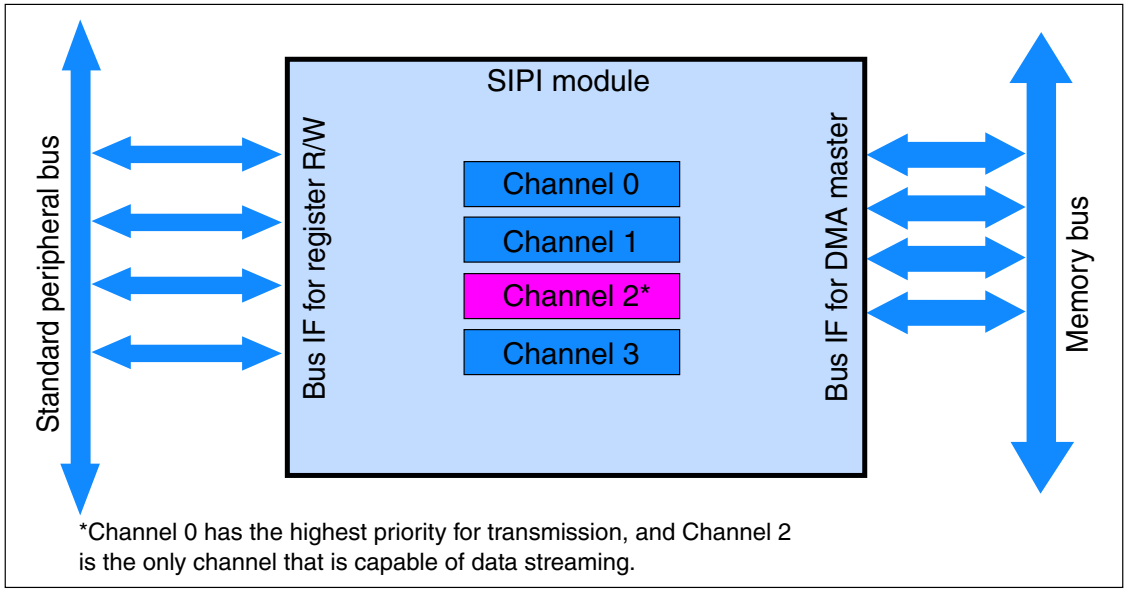
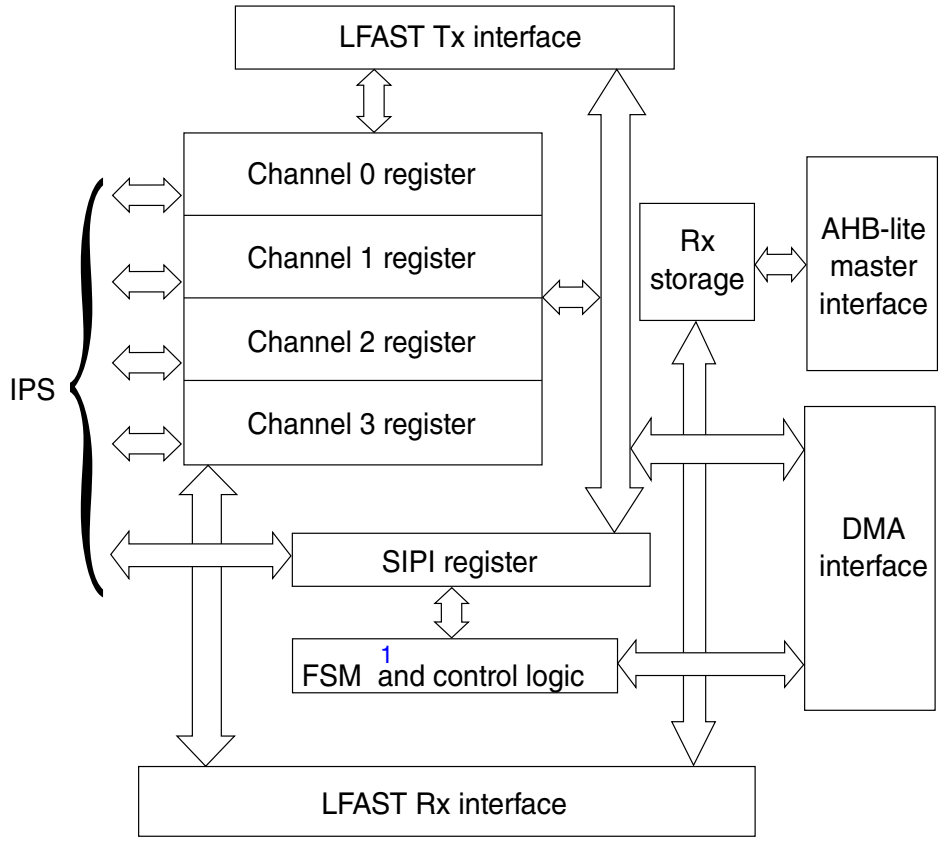


Figure 620. SIPI module

82.3 SIPI block diagram



1 Finite State Machine

Figure 621. SIPI block diagram

82.4 Feature description

This section describes the features of the SIPI module.

82.4.1 Main features

- Point-to-point communication between two devices
- Full-duplex communication
- Four channels, including one channel with data streaming capability
- Configurable DMA access for each channel
- CRC protection mechanism
- Timeout protection mechanism
- Fixed-priority channel selection
- Data size up to 256 bits on streaming channel
- Common tag pool for assigning sequential transfer IDs to every new transfer
- AHB master interface that is used by the target node to access shared memory
- Target node containing a set of nine 32-bit internal registers to store commands

- Support for up to 4 outstanding requests at initiator

82.4.2 Standard features

- IPS bus interface (PBRIDGE)
- SPP DMA2x bus interface
- AHB master interface
- LFAST Tx/Rx interfaces
- CRC error detection (CRC16)

82.5 SIPI operation from reset

When the SIPI module exits reset, it becomes operational, and the Target mode is enabled without the need to configure the control registers.

82.6 Functional description

82.6.1 External signals

The SIPI module does not include any chip external signals.

82.6.2 Frame format

All frames have the same general format:

- 16-bit header
- Address, address and data, or nothing
- 16-bit CRC

There are two main groups of command: read and write. Within the two groups are these read/write formats:

- 32-bit
- 16-bit
- 8-bit
- 256-bit

Each command generates one of these three different responses:

- Read data
- Write acknowledge
- Error

There is an additional command that requests the module ID from the Target node. The sections below illustrate the four different frame formats that are used to implement all the commands and responses.

The number of frames depends on the data buffers (associated with every channel); the frame data is stored in data buffers at the initiator. The address and data are both transmitted in the same order in which they are stored.

82.6.2.1 Register read request

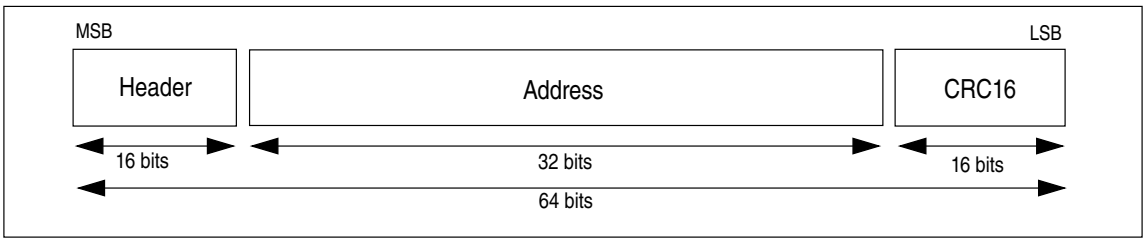


Figure 622. SIPI register read request

82.6.2.2 Register read response, ID request response

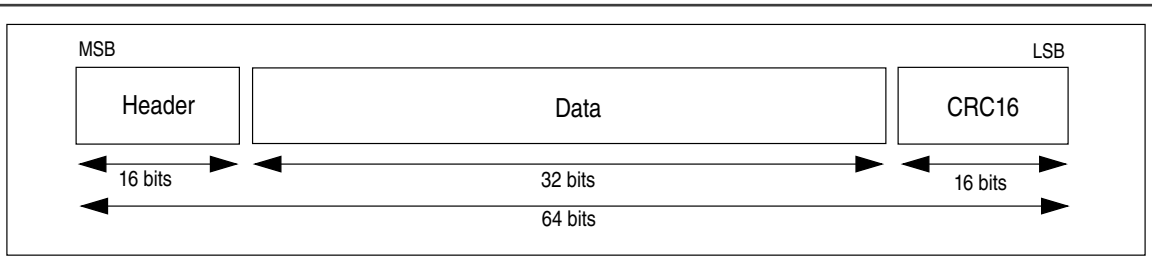


Figure 623. SIPI read response

82.6.2.3 Register write request

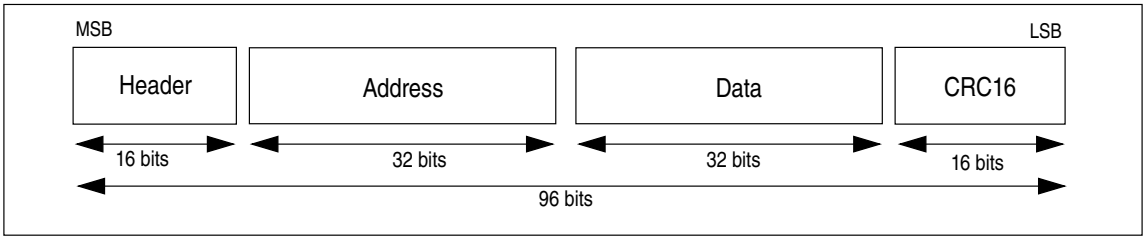


Figure 624. SIPI register write request

82.6.2.4 Trigger transfer, ID transfer, write acknowledge, and streaming write acknowledge

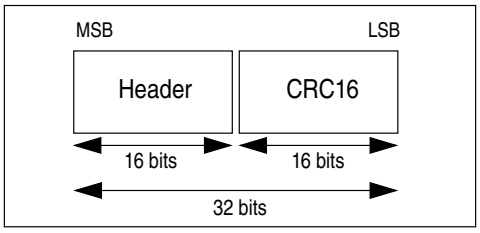


Figure 625. SIPI write acknowledge

82.6.2.5 Streaming write request

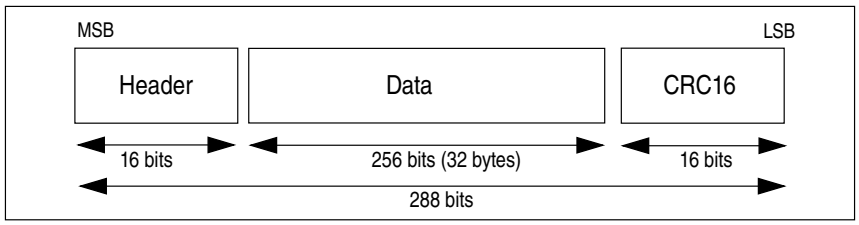


Figure 626. Streaming write request format

NOTE

SIPI uses direct write operations to set the streaming address, and performs streaming data write using the format shown in the figure above.

82.6.2.6 Header field

The Header field contains 16 bits of configuration information, and MSB is transmitted first.

82.6.2.6.1 SIPI header coding

See Figure 627, Table 732, Figure 628, and Table 733 that show how the SIPI header bits are coded.

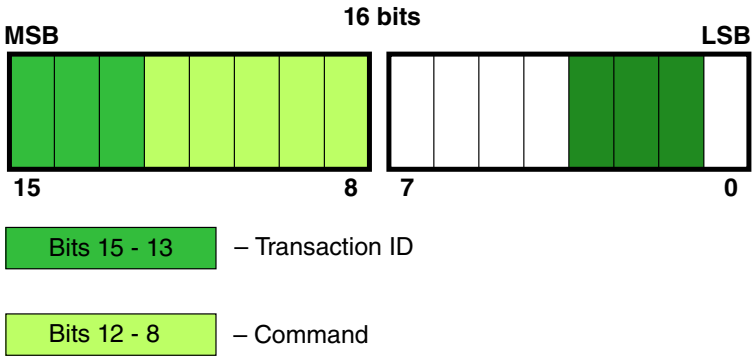


Figure 627. SIPI header coding

The following table shows the command coding for the bits[12:8] of the header.

Table 732. SIPI header command coding

b[12:8] (hex)	Command	Payload size
00	Read 8 bits	64
01	Read 16 bits	64
02	Read 32 Bits	64
03	Reserved	-
04	Write 8 bits with ACK	96

Table continues on the next page...

Table 732. SIPI header command coding (continued)

b[12:8] (hex)	Command	Payload size
05	Write 16 bits with ACK	96
06	Write 32 bits with ACK	96
07	Reserved	-
08	ACK - OK	32
09	ACK - Fault	32
0A	Read Answer - OK	64
0B	Reserved	-
0C	Trigger command with ACK	32
0D	Reserved	-
...	...	...
11	Reserved	-
12	ID Register Read Request	32
13	Reserved	-
...	...	...
16	Reserved	-
17	Stream Data with ACK (32 bytes)	288
18	Reserved	-
...	...	...
1F	Reserved	-

See Figure 628 that shows the Channel Number field in the header, and see Table 733 that shows the channel number coding.

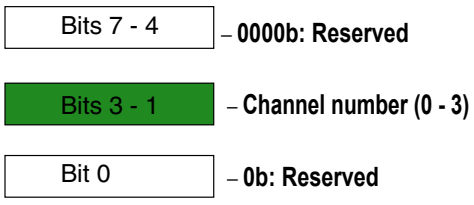


Figure 628. SIPI header channel field

Table 733. SIPI header channel number coding

SIPI channel name	Channel number coding in header(s)		Comment
	SIPI channel coding select field (MCR[CHNSB])		
	Code table I (MCR[CHNSB]=1)	Code table II (MCR[CHNSB]=0)	
0 (Channel A)	000b	100b	In use
1 (Channel B)	001b	101b	In use
2 (Channel C)	010b	110b	In use
3 (Channel D)	011b	111b	In use
4 (Channel E)	100b	000b	Reserved
5 (Channel F)	101b	001b	Reserved
6 (Channel G)	110b	010b	Reserved
7 (Channel H)	111b	011b	Reserved

82.6.2.7 Address field

The Address field is 32-bit wide with the MSB transmitted first.

82.6.2.8 Payload field

See the following table that shows the payload sizes of the LFAST frames.

Table 734. Payload sizes of the LFAST channel frames

LFAST code	SIPI code	LFAST payload size (bits)	LFAST payload size (bytes)
000b	-	8	1
001b	-	32	4
010b	010b	64	8
011b	011b	96	12
100b	100b	128	16
101b	101b	256	32
110b	110b	512	64
111b	111b	288	36

See the following table that shows the converted coding of LFAST for a given SIPI code.

Table 735. Converted coding of the LFAST channel code for SIPI headers

LFAST code	SIPI code	Channel (hex)[1]
0100b	100b	A
0101b	101b	B
0110b	110b	C
0111b	111b	D
1000b	000b	E (not used by SIPI)
1001b	001b	F (not used by SIPI)
1010b	010b	G (not used by SIPI)
1011b	011b	H (not used by SIPI)

1.
- SIPI channel 0 sends all commands to LFAST channel A. The commands are processed and the response is sent to LFAST channel A.
- SIPI channel 1 sends all commands to LFAST channel B. These commands are processed and the response is sent to LFAST channel B.
- SIPI channel 2 sends all commands to LFAST channel C. These commands are processed and the response is sent to LFAST channel C.
- SIPI channel 3 sends all commands to LFAST channel D. These commands are processed and the response is sent to LFAST channel D.

82.6.2.9 CRC field

The CRC field is 16-bit wide with calculation always enabled using the CRC-16-CCITT syndrome (x16 + x12 + x5 + 1). MSB is sent first in the data stream.

82.6.2.9.1 CRC field examples

82.6.2.9.1.1 Example 1-32 bit write on channel 1 with ID1

- Header = 260Ah
- Address = 1122_3344h
- Data = CCDD_EEFFh
- CRC = BF7Dh

82.6.2.9.1.2 Example 2-32 bit read on channel 2 with ID2

- Header = 420Ch
- Address = 89AB_CDEFh
- CRC = 6B80h

82.6.2.9.1.3 Example 3-event command on channel 3 with ID3

- Header = 6C0Eh
- CRC = B286h

82.6.3 Clocking

This module has no clocking considerations.

82.6.4 SIPI Initialization procedure

SIPI requires a sequence of operations before it can be used for communication.

1. Enable SIPI module by writing MCR[MOEN] = 1
2. Enter in the Initialization mode by writing MCR[INIT]=1
3. Set up the (SIPI Module Configuration Register (MCR)) as required
4. Configure timeout counter prescaler MCR[PRSCLR] and channel timeout value CTORn[TOR]
5. Exit the Initialization mode by writing MCR[INIT]=0
6. SIPI is ready to send channel command

82.7 SIPI register descriptions

82.7.1 SIPI memory map

SIPI base address: 404F_0000h

Offset	Register	Width (In bits)	Access	Reset value
0h	SIPI Channel Control Register 0 (CCR0)	32	RW	0000_0000h
4h	SIPI Channel Status Register 0 (CSR0)	32	RW	0000_0000h
Ch	SIPI Channel Interrupt Register 0 (CIR0)	32	RW	0000_0000h
10h	SIPI Channel Timeout Register 0 (CTOR0)	32	RW	FFFF_FFFFh
14h	SIPI Channel CRC Register 0 (CCRC0)	32	R	0000_0000h
18h	SIPI Channel Address Register 0 (CAR0)	32	RW	0000_0000h
1Ch	SIPI Channel Data Register 0 (CDR0)	32	RW	0000_0000h
20h	SIPI Channel Control Register 1 (CCR1)	32	RW	0000_0000h
24h	SIPI Channel Status Register 1 (CSR1)	32	RW	0000_0000h
2Ch	SIPI Channel Interrupt Register 1 (CIR1)	32	RW	0000_0000h
30h	SIPI Channel Timeout Register 1 (CTOR1)	32	RW	FFFF_FFFFh
34h	SIPI Channel CRC Register 1 (CCRC1)	32	R	0000_0000h
38h	SIPI Channel Address Register 1 (CAR1)	32	RW	0000_0000h
3Ch	SIPI Channel Data Register 1 (CDR1)	32	RW	0000_0000h
40h	SIPI Channel Control Register 2 (CCR2)	32	RW	0000_0000h
44h	SIPI Channel Status Register 2 (CSR2)	32	RW	0000_0000h
4Ch	SIPI Channel Interrupt Register 2 (CIR2)	32	RW	0000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
50h	SIPI Channel Timeout Register 2 (CTOR2)	32	RW	FFFF_FFFFh
54h	SIPI Channel CRC Register 2 (CCRC2)	32	R	0000_0000h
58h	SIPI Channel Address Register 2 (CAR2)	32	RW	0000_0000h
5Ch - 78h	SIPI Channel Data Register 2 (CDR2_0 - CDR2_7)	32	RW	0000_0000h
7Ch	SIPI Channel Control Register 3 (CCR3)	32	RW	0000_0000h
80h	SIPI Channel Status Register 3 (CSR3)	32	RW	0000_0000h
88h	SIPI Channel Interrupt Register 3 (CIR3)	32	RW	0000_0000h
8Ch	SIPI Channel Timeout Register 3 (CTOR3)	32	RW	FFFF_FFFFh
90h	SIPI Channel CRC Register 3 (CCRC3)	32	R	0000_0000h
94h	SIPI Channel Address Register 3 (CAR3)	32	RW	0000_0000h
98h	SIPI Channel Data Register 3 (CDR3)	32	RW	0000_0000h
9Ch	SIPI Module Configuration Register (MCR)	32	RW	0040_0020h
A0h	SIPI Status Register (SR)	32	RW	4000_0000h
A4h	SIPI Max Count Register (MAXCR)	32	RW	FFFF_FFFCh
A8h	SIPI Address Reload Register (ARR)	32	RW	0000_0000h
ACh	SIPI Address Count Register (ACR)	32	RW	0000_0000h
B0h	SIPI Error Register (ERR)	32	RW	0000_0000h
B4h	SIPI Debug Register (DEBUG)	32	R	0000_0001h
B8h	SIPI Performance Monitor register (PMR)	32	R	0000_0000h

82.7.2 SIPI Channel Control Register 0 (CCR0)

Offset

Register	Offset
CCR0	0h

Function

NOTE

Back to back transactions are not supported on a single channel (for example, if the channel busy bit, SIPI_CSR0[CB] = 1, is configured for a channel, it cannot be triggered for another transfer until the data buffers are empty and the channel is free, SIPI_CSR0[CB] = 0).

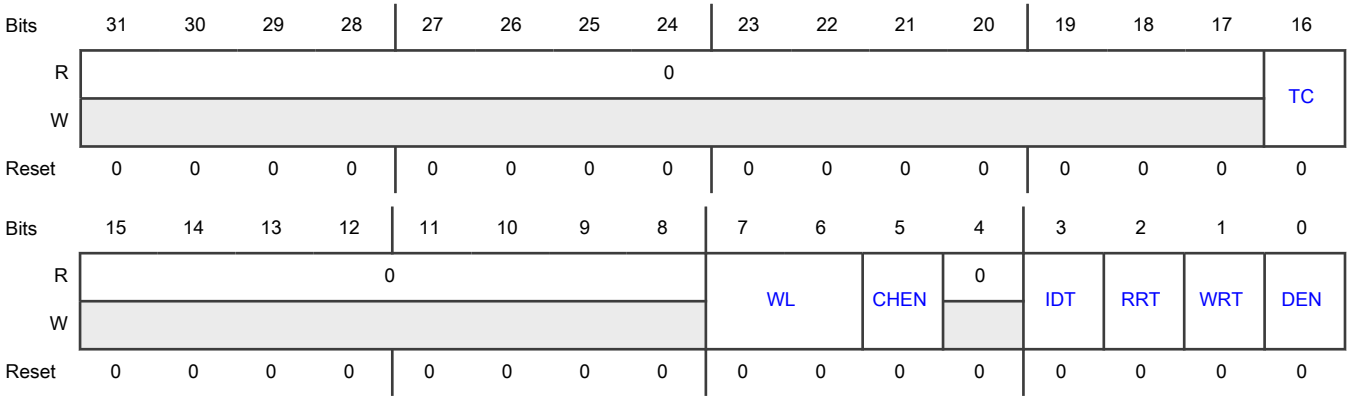
PRIORITY SCHEDULING: The channel whose SIPI_CAR*n* is written first will gain access first irrespective of its priority at the start of the transfer. As more transfers are requested, priority will be resolved as per the priority scheme (for example, channel 0-channel 1-channel 2-channel 3). Scheduling will occur each time the LFAST is not ready to receive data and no channel is pending for data transmission. The reason for the scheduling is that a common CRC module is shared by all channels. If the LFAST is ready to receive data during the entire process, it will happen only in the beginning and later on priority will be resolved as per the priority scheme.

NOTE

The CHEN bit of this register is writable in Initialization mode (SIPI_MCR[INIT] = 1). Also, the command bits can be written only when the corresponding Channel busy bit is not asserted (SIPI_CSR*n*[CB] = 1 (see SIPI Channel Status Register 0 (CSR0)). Software will need to poll the respective channel busy bits before attempting to change the command type.

Only one channel at a time can transmit. Therefore, only one channel can remain busy. Maximum time allowed to transmit a full command is nine clock cycles. The Command type of a channel can only be changed when it is no longer busy. Also, to send a command, we need to write to the corresponding SIPI_CAR*n* (see SIPI Channel Address Register 0 (CAR0)).

Diagram



Fields

Field	Function
31-17 —	Reserved
16 TC	Send Trigger Command. A Trigger Command requires that only this bit to be set by software, the trigger does not depend on settings in SIPI_CAR0. 0b - Trigger command not sent

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Trigger command sent
15-8 —	Reserved
7-6 WL	Word Length Transfer. For Streaming write, WL bits should be written 10. 00b - 8-bit 01b - 16-bit 10b - 32-bit 11b - not used
5 CHEN	Channel Enable. If all channel enables are simultaneously written to enable the channels, channel 0 will be given the highest priority for transmission. For channels, the lowest channel number is given highest priority. 0b - Channel is disabled 1b - Channel is enabled
4 —	Reserved
3 IDT	ID Read Request Transfer. This request returns the value of the CHIP ID. **NOTE** LEGACY_MODE_BIT must be set to '1' for chip ID read request. 0b - ID read request not sent 1b - ID read request sent
2 RRT	Read Request Transfer. 0b - Read request will not be sent 1b - Read request transfer by the initiator. This bit can not be written if SIPI_CCR0[IDT] = 1.
1 WRT	Write Request Transfer. **NOTE** The order of priority for writing to IDT, WRT and RRT must be in this order: 1. IDT 2. RRT 3. WRT

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - No write request will be sent 1b - Write request transfer by the initiator. This bit can not be written if SIPI_CCR0[IDT] = 1 or SIPI_CCR0[RRT] = 1.
0 DEN	DMA Enable. 0b - Reserved 1b - Channel will be used for DMA access

82.7.3 SIPI Channel Status Register 0 (CSR0)

Offset

Register	Offset
CSR0	4h

Function

CSR0 contains the status bits for the current transfer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0						WRITE_RX	READ_RX	RAR	TID			ACKR	CB	0	
W							W1C	W1C	W1C				W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-10 —	Reserved
9 WRITE_RX	WRITE_RX Write frame Reception.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Write frame not received 1b - Write frame received
8 READ_RX	READ_RX Read Frame Reception. 0b - Read frame not received 1b - Read frame received
7 RAR	RAR Read Answer Reception. 0b - Read answer not received 1b - Read answer received
6-4 TID	Transaction ID of transmitted frame. Transaction ID is a random number associated with every Tx frame to match the received response/ack with the command.
3 ACKR	ACKR Acknowledge Received. 0b - Acknowledge not received 1b - Acknowledge received
2 CB	Channel Busy. Indicates channel 0 status. 0b - Channel 0 free 1b - Channel 0 busy
1-0 —	Reserved

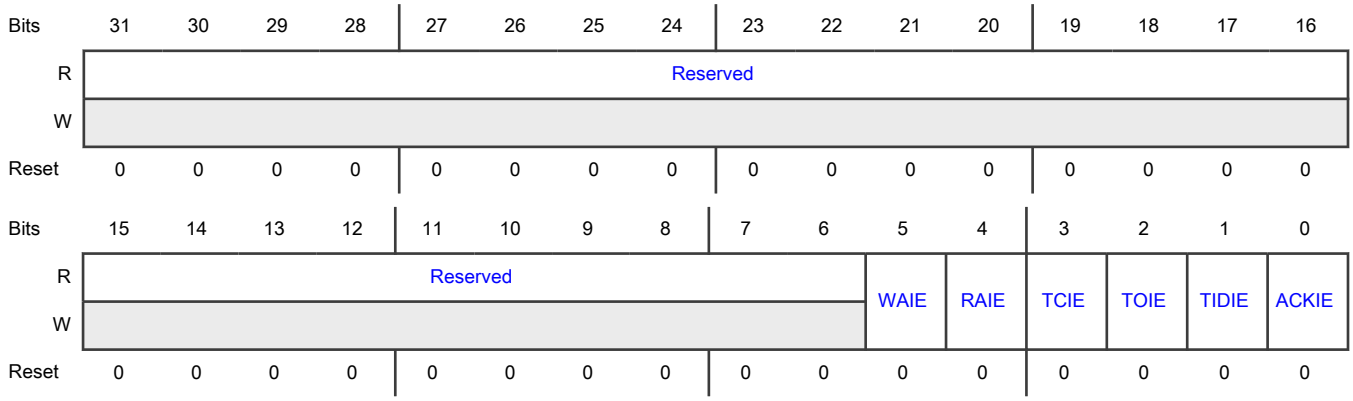
82.7.4 SIPI Channel Interrupt Register 0 (CIR0)

Offset

Register	Offset
CIR0	Ch

Function
SIPI_CIR0 contains the interrupt enable bits for channel 0.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 WAIE	Write Acknowledge Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
4 RAIE	Read Answer Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
3 TCIE	Trigger Command Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
2 TOIE	Timeout Error Interrupt Enabled. 0b - Interrupt is disabled 1b - Interrupt is enabled
1 TIDIE	Transaction ID Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
0 ACKIE	Acknowledge Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled

82.7.5 SIPI Channel Timeout Register 0 (CTOR0)

Offset

Register	Offset
CTOR0	10h

Function

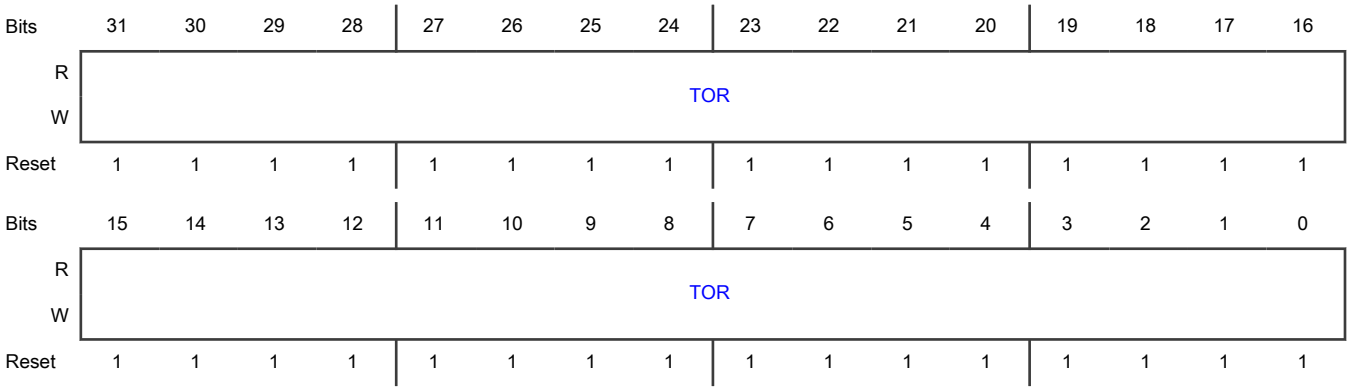
SIPI_CTOR0 contains the timeout value for Tx requests.

The timeout values are used to determine the amount of time to wait for an ACK response for transmitted frames, and if a timeout happens, the frame will be deleted from the outstanding transaction. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR].

The user must configure this value correctly. If this value is too small, a timeout will happen while waiting for ACK for an outstanding frame which will result in the outstanding transaction being cleared early.

If this value is too large (Reset Value 0xFFFFFFFF), the corresponding outstanding transaction will not clear in case another node is not available for ACK response and the upper threshold limit will be reached. It will prevent to next transfer until the outstanding transaction clears after a timeout.

Diagram



Fields

Field	Function
31-0 TOR	Timeout value for transmitted requests. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR]. **NOTE** • Field can only be written during Initialization mode (SIPI_MCR[INIT] = 1). • Only 32-bit write access is allowed. • Write to any CTORx[TOR] register, updates all the CTORx registers with same value.

82.7.6 SIPI Channel CRC Register 0 (CCRC0)

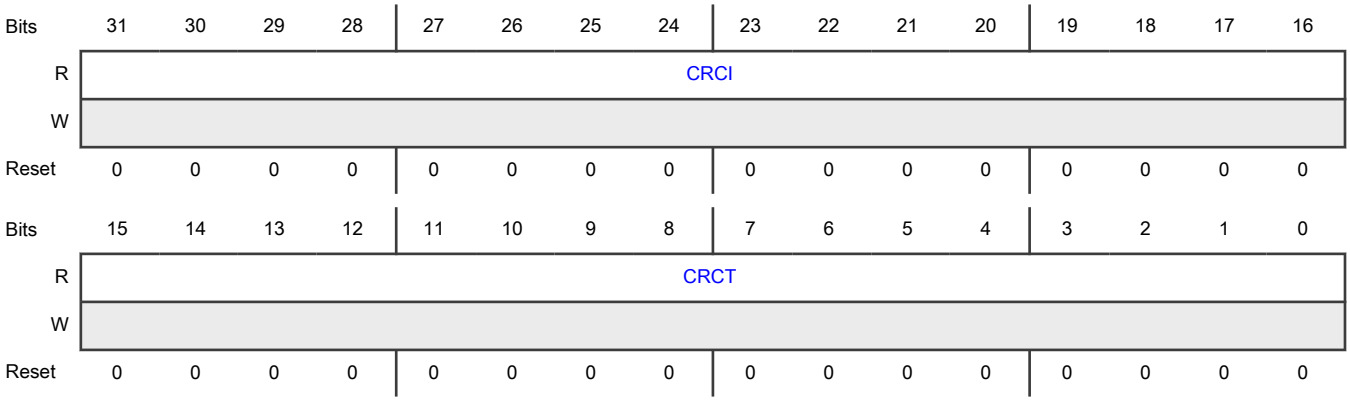
Offset

Register	Offset
CCRC0	14h

Function

SIPI_CCRC*n* is a read only which returns the CRC calculated value on the header, address and data bits.

Diagram



Fields

Field	Function
31-16 CRCI	CRCI Reflects received CRC value at initiator
15-0 CRCT	CRCT Reflects received CRC value at target

82.7.7 SIPI Channel Address Register 0 (CAR0)

Offset

Register	Offset
CAR0	18h

Function

SIPI_CAR0 is the address target for data transmission.

NOTE

The memory address must be 32bit word aligned. Unaligned memory access is not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CAR	CAR These bits contain the address of the target node.

82.7.8 SIPI Channel Data Register 0 (CDR0)

Offset

Register	Offset
CDR0	1Ch

Function

SIPI_CDR0 contains the data to be transmitted, and can be written anytime by software or the DMA. The data can be written in 8, 16 or 32 bit formats.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CDR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CDR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CDR	CDR Data register bits. Contains the data that will be transmitted, or received.

82.7.9 SIPI Channel Control Register 1 (CCR1)

Offset

Register	Offset
CCR1	20h

Function

NOTE

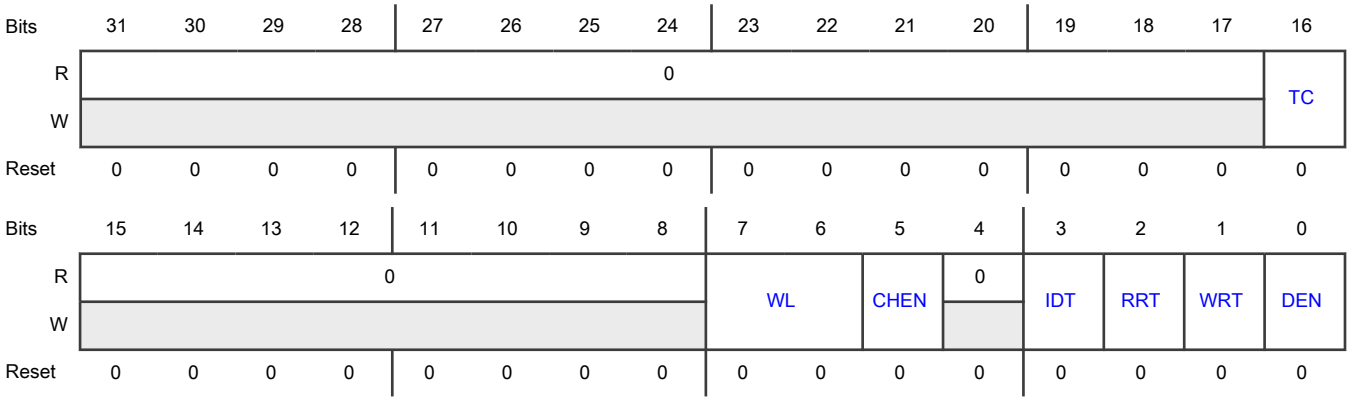
Back to back transactions are not supported on a single channel (for example, if the channel busy bit, SIPI_CSR1[CB] = 1, is configured for a channel, it cannot be triggered for another transfer until the data buffers are empty and the channel is free, SIPI_CSR1[CB] = 0).

NOTE

(see SIPI Channel Status Register 1 (CSR1)).

(see SIPI Channel Address Register 1 (CAR1)).

Diagram



Fields

Field	Function
31-17 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
16 TC	Send Trigger Command. 1. 0b - Trigger command not sent 1b - Trigger command sent
15-8 —	Reserved
7-6 WL	Word Length Transfer. For Streaming write WL bits should be written 10. 00b - 8-bit 01b - 16-bit 10b - 32-bit 11b - not used
5 CHEN	Channel Enable. 0b - Channel is disabled 1b - Channel is enabled
4 —	Reserved
3 IDT	ID Read Request Transfer. **NOTE** LEGACY_MODE_BIT must be set to '1' for chip ID read request. 0b - ID read request not sent 1b - ID read request sent
2 RRT	RRT Read Request Transfer. 0b - Read request will not be sent 1b - Read request transfer by the initiator. This bit can not be written if SIPI_CCR1[IDT] = 1.
1 WRT	Write Request Transfer. 0b - No write request will be sent 1b - Write request transfer by the initiator. This bit can not be written if SIPI_CCR1[IDT] = 1 or SIPI_CCR1[RRT] = 1.
0	DMA Enable.

Table continues on the next page...

Table continued from the previous page...

Field	Function
DEN	0b - Reserved 1b - Channel will be used for DMA access

82.7.10 SIPI Channel Status Register 1 (CSR1)

Offset

Register	Offset
CSR1	24h

Function

CSR1 contains the status bits for the current transfer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0						WRITE_RX	READ_RX	RAR	TID			ACKR	CB	0	
W							W1C	W1C	W1C				W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-10 —	Reserved
9 WRITE_RX	WRITE_RX Write frame Reception. 0b - Write frame not received 1b - Write frame received
8	READ_RX

Table continues on the next page...

Table continued from the previous page...

Field	Function
READ_RX	Read Frame Reception. 0b - Read frame not received 1b - Read frame received
7 RAR	RAR Read Answer Reception. 0b - Read answer not received 1b - Read answer received
6-4 TID	TID Transaction ID of transmitted frame. Transaction ID is a random number associated with every Tx frame to match the received response/ack with the command.
3 ACKR	ACKR Acknowledge Received. 0b - Acknowledge not received 1b - Acknowledge received
2 CB	Channel Busy. Indicates channel 1 status. 0b - Channel 1 free 1b - Channel 1 busy
1-0 —	Reserved

82.7.11 SIPI Channel Interrupt Register 1 (CIR1)

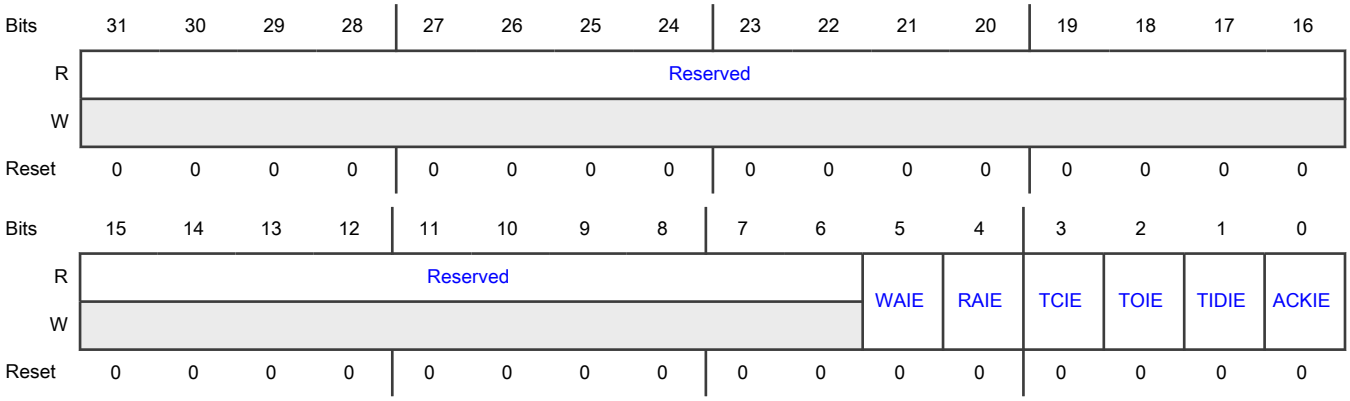
Offset

Register	Offset
CIR1	2Ch

Function

The CIR1 contains the interrupt enable bits for channel 1.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 WAIE	WAIE Write Acknowledge Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
4 RAIE	RAIE Read Answer Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
3 TCIE	TCIE Trigger Command Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
2 TOIE	TOIE Timeout Error Interrupt Enabled. 0b - Interrupt is disabled 1b - Interrupt is enabled
1 TIDIE	TIDIE Transaction ID Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 ACKIE	ACKIE Acknowledge Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled

82.7.12 SIPI Channel Timeout Register 1 (CTOR1)

Offset

Register	Offset
CTOR1	30h

Function

SIPI_CTOR1 contains the timeout value for Tx requests.

The timeout values are used to determine the amount of time to wait for an ACK response for transmitted frames, and if a timeout happens, the frame will be deleted from the outstanding transaction. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR].

The user must configure this value correctly. If this value is too small, a timeout will happen while waiting for ACK for an outstanding frame which will result in the outstanding transaction being cleared early.

If this value is too large (Reset Value 0xFFFFFFFF), the corresponding outstanding transaction will not clear in case another node is not available for ACK response and the upper threshold limit will be reached. It will prevent to next transfer until the outstanding transaction clears after a timeout.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TOR															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TOR															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

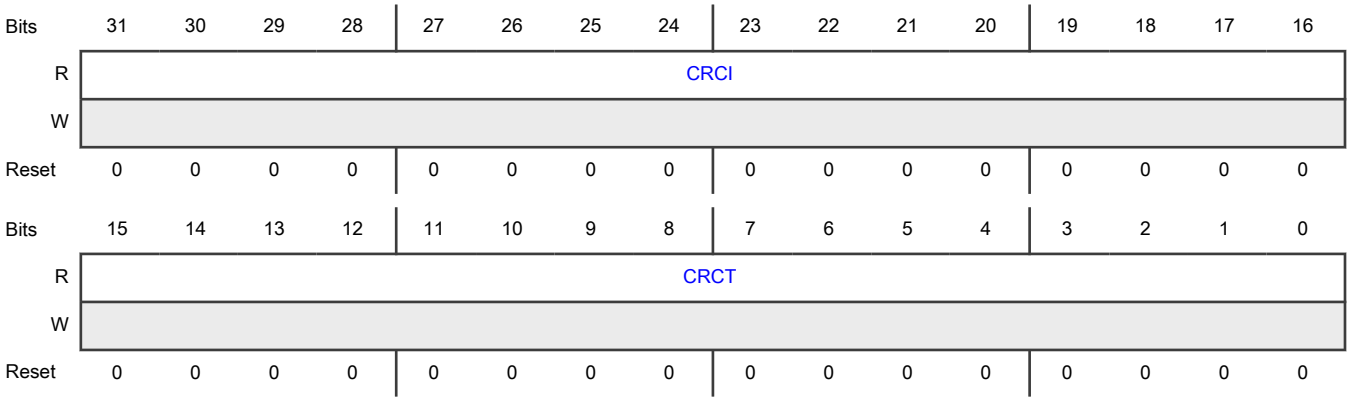
Field	Function
31-0 TOR	Timeout value for transmitted requests. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR]. **NOTE** • Field can only be written during Initialization mode (SIPI_MCR[INIT] = 1). • Only 32-bit write access is allowed. • All CTORx[TOR], gets updated with same value

82.7.13 SIPI Channel CRC Register 1 (CCRC1)

Offset

Register	Offset
CCRC1	34h

Diagram



Fields

Field	Function
31-16 CRCI	CRCI Reflects received CRC value at initiator
15-0 CRCT	CRCT Reflects received CRC value at target

82.7.14 SIPI Channel Address Register 1 (CAR1)

Offset

Register	Offset
CAR1	38h

Function

SIPI_CAR1 is the address target for data transmission.

NOTE

The memory address must be 32bit word aligned. Unaligned memory access is not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CAR	CAR These bits contain the address of the target node.

82.7.15 SIPI Channel Data Register 1 (CDR1)

Offset

Register	Offset
CDR1	3Ch

Function

SIPI_CDR1

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CDR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CDR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CDR	CDR Data register bits. Contains the data that will be transmitted, or received.

82.7.16 SIPI Channel Control Register 2 (CCR2)

Offset

Register	Offset
CCR2	40h

Function

NOTE

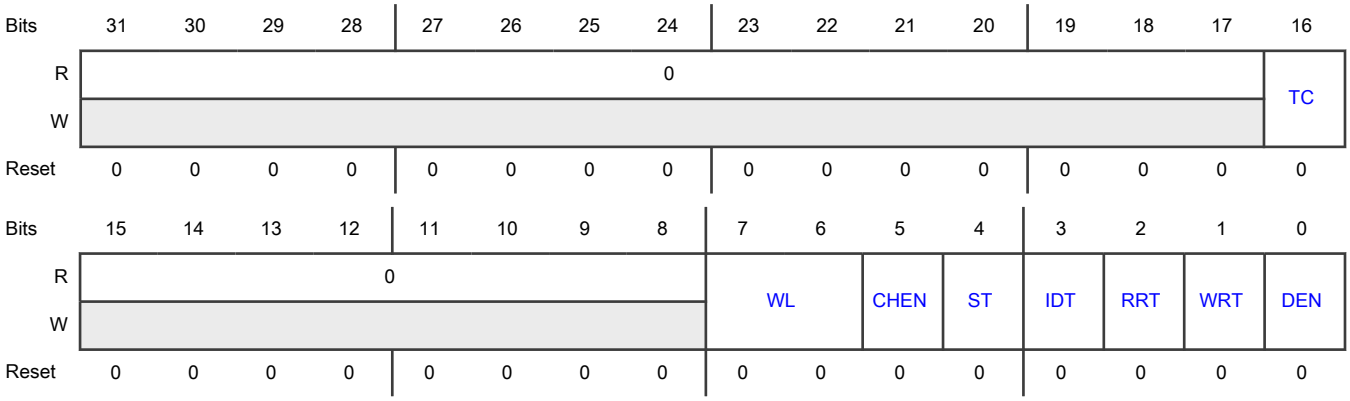
Back to back transactions are not supported on a single channel (for example, if the channel busy bit, SIPI_CSR2[CB] = 1, is configured for a channel, it cannot be triggered for another transfer until the data buffers are empty and the channel is free, SIPI_CSR2[CB] = 0).

NOTE

(see SIPI Channel Status Register 2 (CSR2)).

(see SIPI Channel Address Register 2 (CAR2)).

Diagram



Fields

Field	Function
31-17 —	Reserved
16 TC	Send Trigger Command. 2. 0b - Trigger command not sent 1b - Trigger command sent
15-8 —	Reserved
7-6 WL	Word Length Transfer. For Streaming write, WL bits should be written 10. 00b - 8-bit 01b - 16-bit 10b - 32-bit 11b - not used
5 CHEN	Channel Enable. 0b - Channel is disabled 1b - Channel is enabled
4 ST	ST **NOTE** This field can only be configured after WRT bit is set 0b - Streaming transfer is disabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Streaming transfer is enabled
3 IDT	ID Read Request Transfer. **NOTE** LEGACY_MODE_BIT must be set to '1' for chip ID read request. 0b - ID read request not sent 1b - ID read request sent
2 RRT	Read Request Transfer. 0b - Read request will not be sent 1b - Read request transfer by the initiator. This bit can not be written if SIPI_CCR2[IDT] = 1.
1 WRT	Write Request Transfer. 0b - No write request will be sent 1b - Write request transfer by the initiator. This bit can not be written if SIPI_CCR2[IDT] = 1 or SIPI_CCR2[RRT] = 1.
0 DEN	DMA Enable. 0b - Reserved 1b - Channel will be used for DMA access

82.7.17 SIPI Channel Status Register 2 (CSR2)

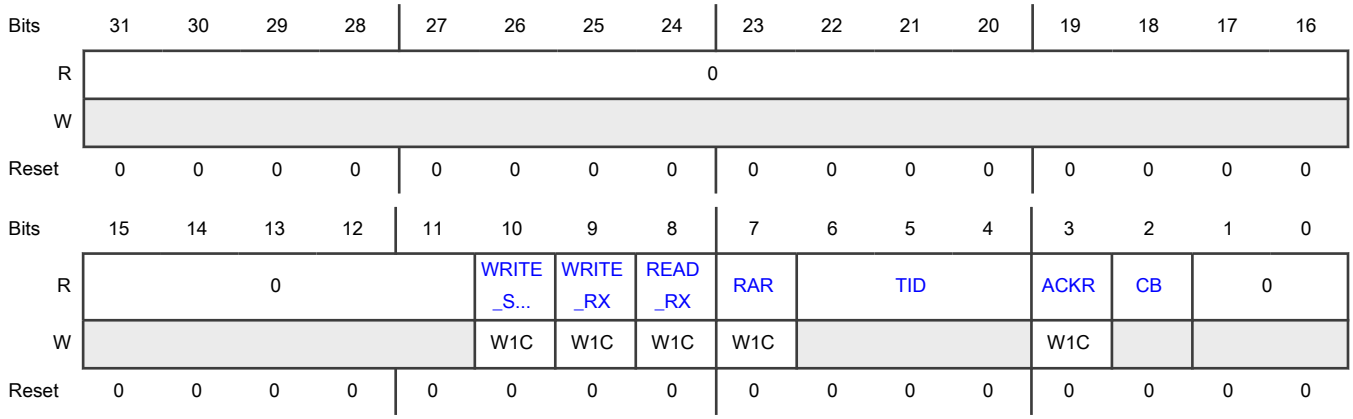
Offset

Register	Offset
CSR2	44h

Function

SIPI_CSR2 contains the status bits for the current transfer.

Diagram



Fields

Field	Function
31-11 —	Reserved
10 WRITE_STR_RX	WRITE_STR_RX Stream Write frame Reception. 0b - Stream Write frame not received 1b - Stream Write frame received
9 WRITE_RX	WRITE_RX Write frame Reception. 0b - Write frame not received 1b - Write frame received
8 READ_RX	READ_RX Read Frame Reception. 0b - Read frame not received 1b - Read frame received
7 RAR	RAR Read Answer Reception. 0b - Read answer not received 1b - Read answer received
6-4 TID	Transaction ID of transmitted frame. Transaction ID is a random number associated with every Tx frame to match the received response/ack with the command.

Table continues on the next page...

Table continued from the previous page...

Field	Function
3 ACKR	ACKR Acknowledge Received. 0b - Acknowledge not received 1b - Acknowledge received
2 CB	Channel Busy. Indicates channel 2 status. 0b - Channel 2 free 1b - Channel 2 busy
1-0 —	Reserved

82.7.18 SIPI Channel Interrupt Register 2 (CIR2)

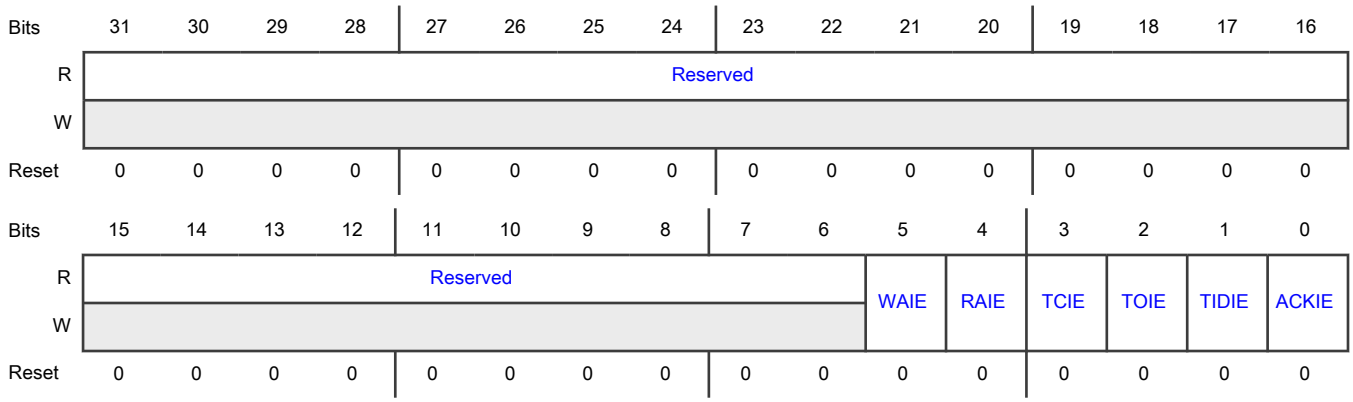
Offset

Register	Offset
CIR2	4Ch

Function

The SIPI_CIR2 contains the interrupt enable bits for channel 2.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 WAIE	WAIE Write Acknowledge Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
4 RAIE	RAIE Read Answer Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
3 TCIE	TCIE Trigger Command Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
2 TOIE	TOIE Timeout Error Interrupt Enabled. 0b - Interrupt is disabled 1b - Interrupt is enabled
1 TIDIE	TIDIE Transaction ID Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
0 ACKIE	ACKIE Acknowledge Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled

82.7.19 SIPI Channel Timeout Register 2 (CTOR2)

Offset

Register	Offset
CTOR2	50h

Function

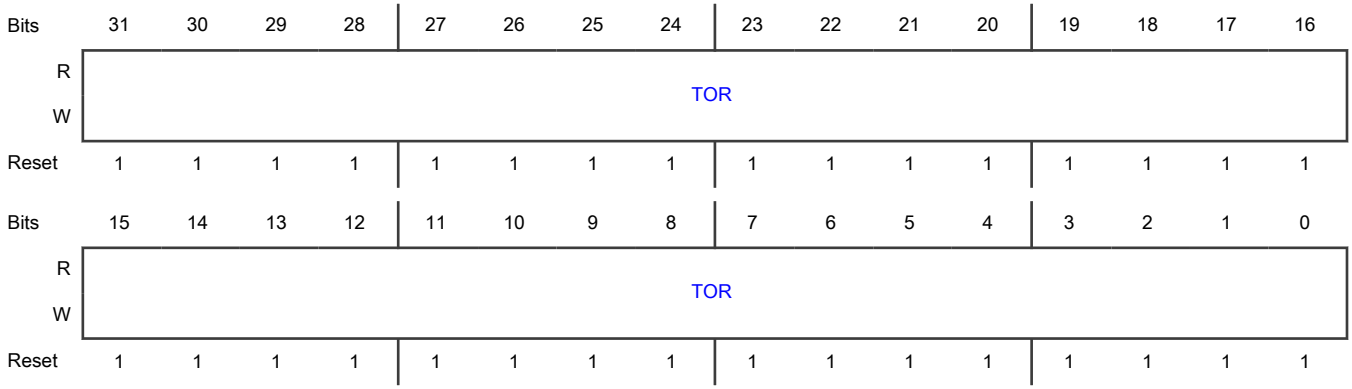
SIPI_CTOR2 contains the timeout value for Tx requests.

The timeout values are used to determine the amount of time to wait for an ACK response for transmitted frames, and if a timeout happens, the frame will be deleted from the outstanding transaction. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR].

The user must configure this value correctly. If this value is too small, a timeout will happen while waiting for ACK for an outstanding frame which will result in the outstanding transaction being cleared early.

If this value is too large (Reset Value 0xFFFFFFFF), the corresponding outstanding transaction will not clear in case another node is not available for ACK response and the upper threshold limit will be reached. It will prevent to next transfer until the outstanding transaction clears after a timeout.

Diagram



Fields

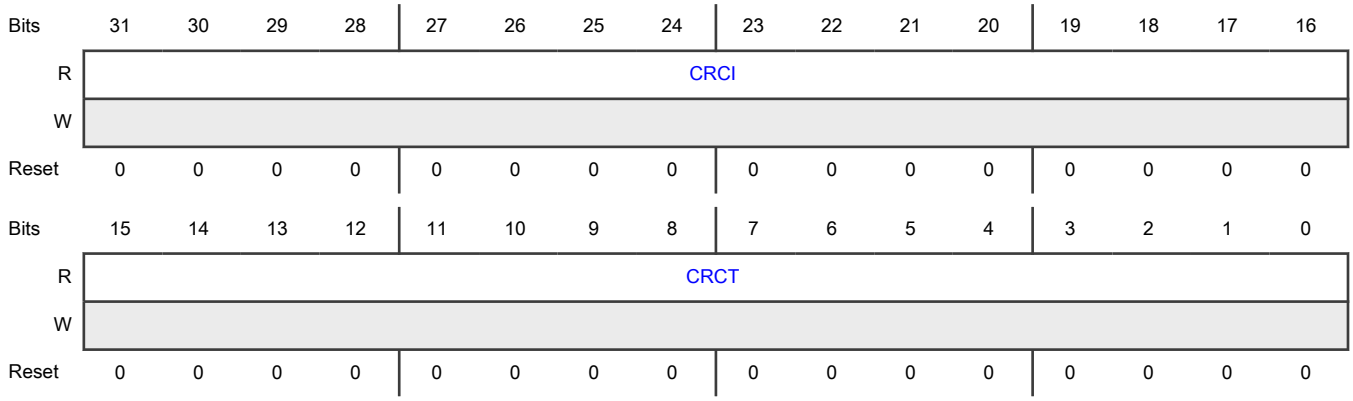
Field	Function
31-0 TOR	Timeout value for transmitted requests. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR]. **NOTE** • Field can only be written during Initialization mode (SIPI_MCR[INIT] = 1). • Only 32-bit write access is allowed. • All CTORx[TOR], gets updated with same value

82.7.20 SIPI Channel CRC Register 2 (CCRC2)

Offset

Register	Offset
CCRC2	54h

Diagram



Fields

Field	Function
31-16 CRCI	CRCI Reflects received CRC value at initiator
15-0 CRCT	CRCT Reflects received CRC value at target

82.7.21 SIPI Channel Address Register 2 (CAR2)

Offset

Register	Offset
CAR2	58h

Function

SIPI_CAR2 is the address target for data transmission. For streaming operations this register is the start address.

NOTE

The memory address must be 32bit word aligned. Unaligned memory access is not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CAR	CAR These bits contain the address of the target node.

82.7.22 SIPI Channel Data Register 2 (CDR2_0 - CDR2_7)

Offset

For a = 0 to 7:

Register	Offset
CDR2_a	5Ch + (a × 4h)

Function

SIPI_CDR2_*n*

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CDR2															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CDR2															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CDR2	CDR2 Data register bits. Contains the data that will be transmitted, or received.

82.7.23 SIPI Channel Control Register 3 (CCR3)

Offset

Register	Offset
CCR3	7Ch

Function

NOTE

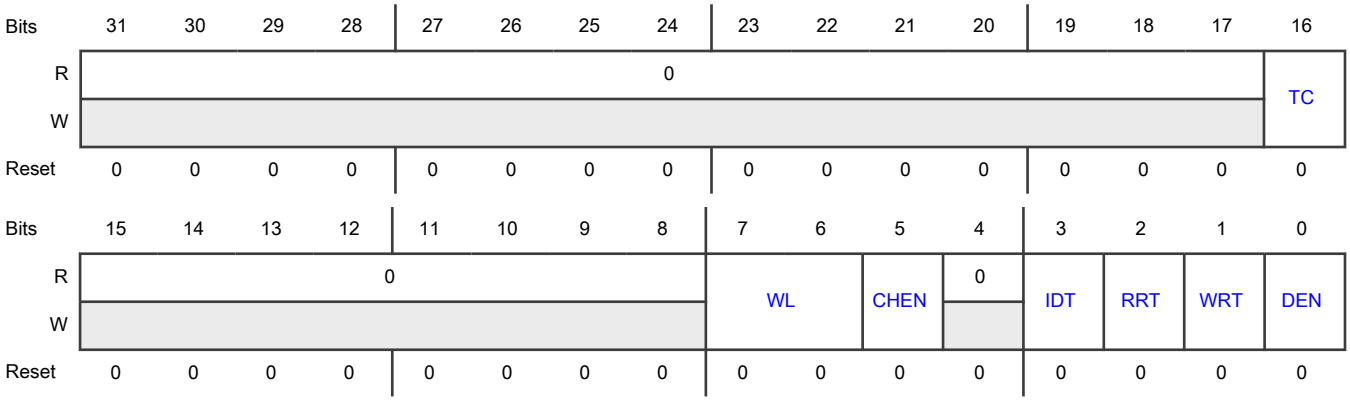
Back to back transactions are not supported on a single channel (for example, if the channel busy bit, SIPI_CSR3[CB] = 1, is configured for a channel, it cannot be triggered for another transfer until the data buffers are empty and the channel is free, SIPI_CSR3[CB] = 0).

NOTE

(see SIPI Channel Status Register 3 (CSR3)).

(see SIPI Channel Address Register 3 (CAR3)).

Diagram



Fields

Field	Function
31-17 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
16 TC	Send Trigger Command. 3. 0b - Trigger command not sent 1b - Trigger command sent
15-8 —	Reserved
7-6 WL	Word Length Transfer. For Streaming write WL bits should be written 10. 00b - 8-bit 01b - 16-bit 10b - 32-bit 11b - not used
5 CHEN	Channel Enable. 0b - Channel is disabled 1b - Channel is enabled
4 —	Reserved
3 IDT	ID Read Request Transfer. **NOTE** LEGACY_MODE_BIT must be set to '1' for chip ID read request. 0b - ID read request not sent 1b - ID read request sent
2 RRT	Read Request Transfer. 0b - Read request will not be sent 1b - Read request transfer by the initiator. This bit can not be written if SIPI_CCR3[IDT] = 1.
1 WRT	Write Request Transfer. 0b - No write request will be sent 1b - Write request transfer by the initiator. This bit can not be written if SIPI_CCR3[IDT] = 1 or SIPI_CCR3[RRT] = 1.
0 DEN	DMA Enable. 0b - Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Channel will be used for DMA access

82.7.24 SIPI Channel Status Register 3 (CSR3)

Offset

Register	Offset
CSR3	80h

Function

SIPI_CSR3 contains the status bits for the current transfer.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0						WRITE_RX	READ_RX	RAR	TID			ACKR	CB	0	
W							W1C	W1C	W1C				W1C			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-10 —	Reserved
9 WRITE_RX	WRITE_RX Write frame Reception. 0b - Write frame not received 1b - Write frame received
8 READ_RX	READ_RX Read Frame Reception.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Read frame not received 1b - Read frame received
7 RAR	RAR Read Answer Reception. 0b - Read answer not received 1b - Read answer received
6-4 TID	Transaction ID of transmitted frame. Transaction ID is a random number associated with every Tx frame to match the received response/ack with the command.
3 ACKR	ACKR Acknowledge Received. 0b - Acknowledge not received 1b - Acknowledge received
2 CB	Channel Busy. Indicates channel 3 status. 0b - Channel 3 free 1b - Channel 3 busy
1-0 —	Reserved

82.7.25 SIPI Channel Interrupt Register 3 (CIR3)

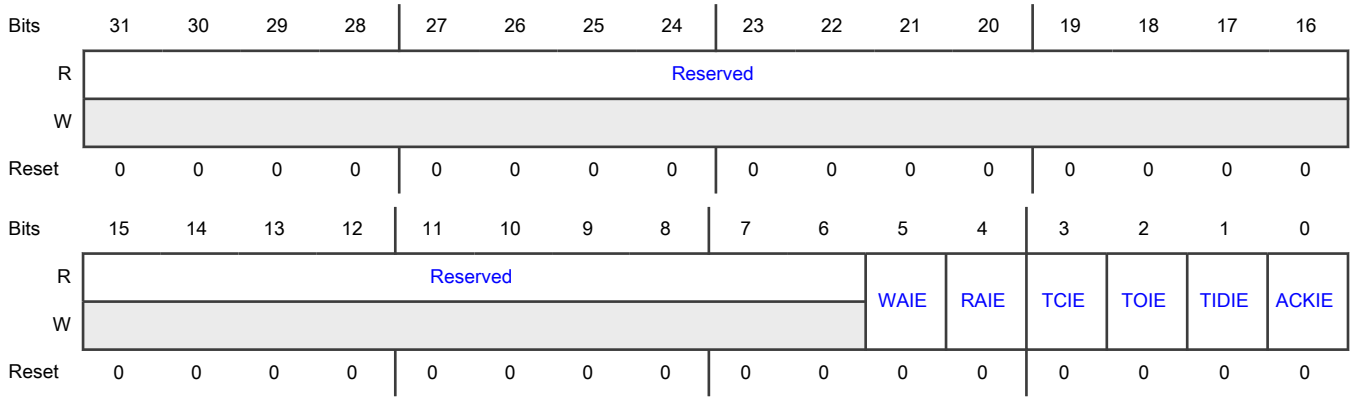
Offset

Register	Offset
CIR3	88h

Function

SIPI_CIR3 contains the interrupt enable bits for channel 3.

Diagram



Fields

Field	Function
31-6 —	Reserved
5 WAIE	WAIE Write Acknowledge Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
4 RAIE	RAIE Read Answer Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
3 TCIE	TCIE Trigger Command Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
2 TOIE	TOIE Timeout Error Interrupt Enabled. 0b - Interrupt is disabled 1b - Interrupt is enabled
1 TIDIE	TIDIE Transaction ID Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 ACKIE	ACKIE Acknowledge Error Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled

82.7.26 SIPI Channel Timeout Register 3 (CTOR3)

Offset

Register	Offset
CTOR3	8Ch

Function

SIPI_CTOR3 contains the timeout value for Tx requests.

The timeout values are used to determine the amount of time to wait for an ACK response for transmitted frames, and if a timeout happens, the frame will be deleted from the outstanding transaction. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR].

The user must configure this value correctly. If this value is too small, a timeout will happen while waiting for ACK for an outstanding frame which will result in the outstanding transaction being cleared early.

If this value is too large (Reset Value 0xFFFFFFFF), the corresponding outstanding transaction will not clear in case another node is not available for ACK response and the upper threshold limit will be reached. It will prevent to next transfer until the outstanding transaction clears after a timeout.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	TOR															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	TOR															
Reset	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Fields

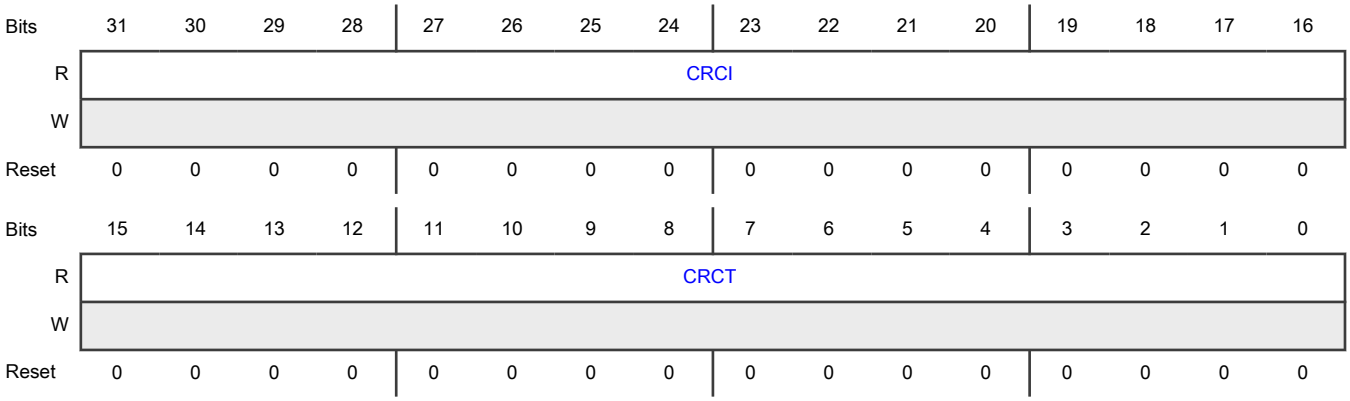
Field	Function
31-0 TOR	Timeout value for transmitted requests. Timeout counter runs on the prescaled peripheral clock. Prescaler is defined by SIPI_MCR[PRSCLR]. **NOTE** • Field can only be written during Initialization mode (SIPI_MCR[INIT] = 1). • Only 32-bit write access is allowed. • All CTORx[TOR], gets updated with same value

82.7.27 SIPI Channel CRC Register 3 (CCRC3)

Offset

Register	Offset
CCRC3	90h

Diagram



Fields

Field	Function
31-16 CRCI	CRCI Reflects received CRC value at initiator
15-0 CRCT	CRCT Reflects received CRC value at target

82.7.28 SIPI Channel Address Register 3 (CAR3)

Offset

Register	Offset
CAR3	94h

Function

SIPI_CAR3 is the address target for data transmission.

NOTE

The memory address must be 32bit word aligned. Unaligned memory access is not supported.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	CAR															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 CAR	CAR These bits contain the address of the target node.

82.7.29 SIPI Channel Data Register 3 (CDR3)

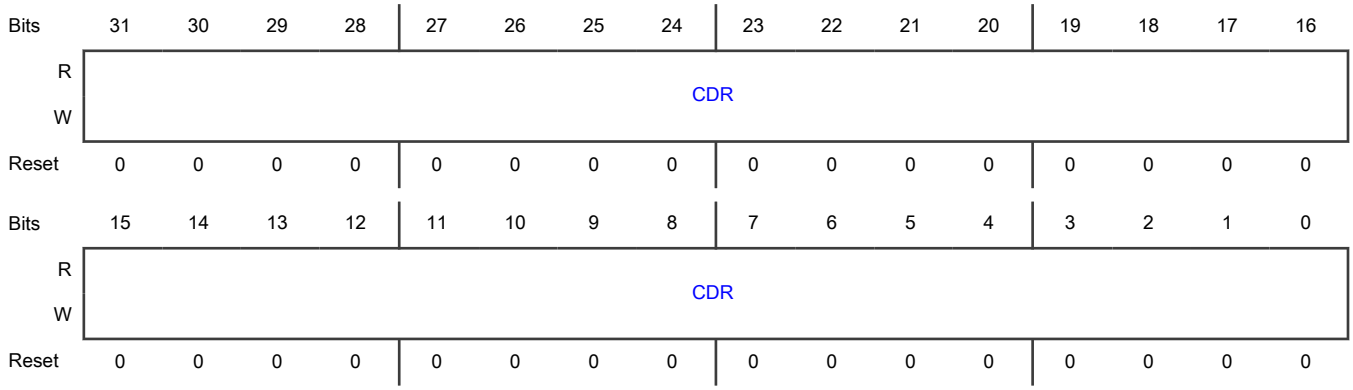
Offset

Register	Offset
CDR3	98h

Function

SIPI_CDR3

Diagram



Fields

Field	Function
31-0 CDR	CDR Data register bits. Contains the data that will be transmitted, or received.

82.7.30 SIPI Module Configuration Register (MCR)

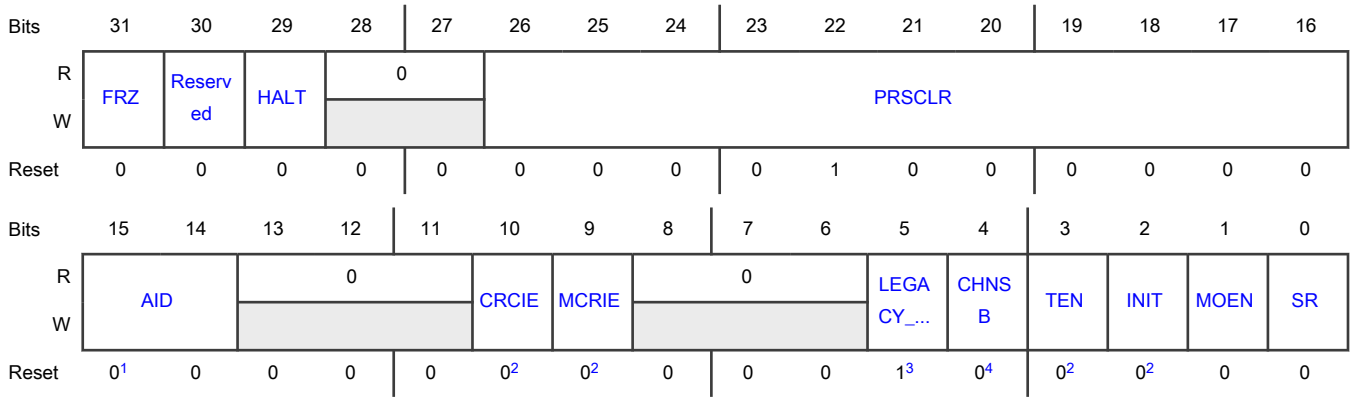
Offset

Register	Offset
MCR	9Ch

Function

The SIPI_MCR is a global 32-bit configuration register.

Diagram



1. Can be written in initialization mode only (SIPI_MCR[INIT] = 1).
2. Can only be written when SIPI_MCR[MOEN] = 1.
3. Can be written only once after reset in init mode.
4. Can be written only once after reset.

Fields

Field	Function
31 FRZ	Freeze Enable The FRZ bit specifies the SIPI behavior when Debug mode is requested at the MCU level. When FRZ is asserted, the SIPI is enabled to enter Freeze mode. Negation of this bit field causes SIPI to exit Freeze mode. **NOTE** Can only be written when SIPI_MCR[MOEN] = 1. 0b - Not enabled to enter Freeze mode 1b - Enabled to enter Freeze mode
30 —	Reserved **IMPORTANT** Always write the default value to this field.
29 HALT	Halt Mode Enable Assertion of this bit puts SIPI into Freeze mode. No Rx or Tx is performed in the SIPI until this bit is cleared. If this bit is enabled in during Tx or Rx communications, the current activity will finish, then the SIPI will enter Freeze mode. **NOTE** Can only be written when SIPI_MCR[MOEN] = 1. 0b - No Freeze mode request 1b - Enters Freeze mode if FRZ bit is asserted.
28-27 —	Reserved
26-16 PRSCLR	Timeout counter prescaler The timeout counter runs on the prescaled system clock. Default value is 64 (040h). The allowed programmable values are (all other values are ignored): 01000000b - 64(default) 10000000b - 128 000100000000b - 256 001000000000b - 512 010000000000b - 1024 **NOTE** This field should be programmed by software during initialization mode, SIPI_MCR[INIT] = 1. Writes during other times are ignored. **NOTE** Writes to SIPI_MCR[PRSCLR] can only be accomplished with 16-bit or 32-bit writes.

Table continues on the next page...

Table continued from the previous page...

Field	Function
15-14 AID	Address Increment/Decrement These bits define the type of address change at the target node. **NOTE** This bits should be programmed by software in initialization mode, SIPI_MCR[INIT] = 1. Writes during other times are ignored. 00b - no change. address stays same 01b - address increments by 4 10b - address decrements by 4 11b - not used
13-11 —	Reserved
10 CRCIE	CRC Error Interrupt Enable 0b - Interrupt is disabled 1b - Interrupt is enabled
9 MCRIE	Max Count Reached Interrupt Enable 0b - Interrupt is disabled 1b - Interrupt is enabled
8-6 —	Reserved
5 LEGACY_MODE_BIT	Legacy_mode select bit. 0b - The write command is triggered with CDR update and read command with CAR update. 1b - The write command and read command, both are triggered with CAR update
4 CHNSB	Channel coding select bit. 0b - Code Table II (see Table 733) 1b - Code Table I (see Table 733)
3 TEN	Target Enable Setting this bit enables the target functionality at SIPI. This bit can be read or written anytime. This bit is automatically negated by hardware when target detects an error in "streaming without ACK" mode. This bit has to be enabled for the transmission operations also.
2 INIT	Initialization Mode Setting this bit puts the module in initialization mode. This bit should be cleared by software. Most register bits are configured using this bit. The SIPI_MCR[MOEN] bit needs to be set first, and then the INIT bit can be set and both bits can't be enabled together.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Normal Mode 1b - Initialization Mode
1 MOEN	Module Enable This bit should be set or cleared by software. When this bit is negated, future SIPI Tx transfers are disabled.
0 SR	Soft Reset Setting this bit clears all status and error registers, and FSMs are moved to idle state. This bit is automatically cleared by hardware once the reset operation is complete.

82.7.31 SIPI Status Register (SR)

Offset

Register	Offset
SR	A0h

Function

The SIPI_SR is the global status register of SIPI.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	FRZACK	LPMACK	Reserved													
W																
Reset	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved		INVALID...	READ_OK...	ACK_TX	GCRCE	MCR	FRAME_TX	TE				STATE			
W			W1C	W1C	W1C	W1C	W1C	W1C	W1C							
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 FRZACK	FRZACK

Table continues on the next page...

Table continued from the previous page...

Field	Function
	Freeze Mode Acknowledge. This read-only bit indicates that SIPI is in Freeze mode. The Freeze mode request cannot be granted until current transmission or reception processes have finished. The software can poll the FRZACK bit to find when the SIPI has actually entered Freeze mode. If Freeze mode is requested while SIPI is in any of the low power modes, then the FRZACK bit will only be set when the low power mode is exited. 0b - SIPI not in Freeze mode 1b - SIPI in Freeze mode
30 LPMACK	Low Power Mode Acknowledge. This read-only bit indicates that SIPI is in Disable Modeor Doze mode. Disable mode The low power modes can not be entered until all current transmission or reception processes have finished. The CPU can poll the LPMACK bit to know when SIPI has actually entered low power mode. **NOTE** Reset value will be 1 for only one clock cycle. 0b - SIPI is not in low power mode 1b - SIPI is in Disable Mode or Doze mode.
29-14 —	Reserved
13 INVALID_FRAME_RX	INVALID_FRAME_RX Indicates if the received frame is invalid, i.e. the SIPI header command is unknown or streaming write is done on channel other than 2 . 0b - No invalid frame received 1b - Invalid frame received
12 READ_OK_TX	READ_OK_TX READ or ID ACK Transmit Bit. 0b - No Read or ID ACK Transmitted 1b - Read or ID ACK Transmitted
11 ACK_TX	ACK_TX ACK Transmit Bit. 0b - No ACK Transmitted 1b - ACK Transmitted
10 GCRCE	GCRCE Global CRC Error Bit. 0b - No CRC error

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - CRC error occurred
9 MCR	Maximum Count Reached. This bit will be set whenever SIPI_ACR[ADCNT] = SIPI_MAXCR[MXCNT]. An interrupt will be generated when this bit is set only if SIPI_MCR[MCRIE] = 1. This it should be cleared by software.
8 FRAME_TX	FRAME_TX . This bit will be set whenever a frame is transmitted from the initiator side. 0b - No frame transmitted 1b - Any frame type transmitted
7-4 TE	TE Trigger Event on Respective Channels. This field enables interrupts for target nodes. 1xxxb - TE3 = 1 - Channel 3 trigger event x1xxb - TE2 = 1 - Channel 2 trigger event xx1xb - TE1 = 1 - Channel 1 trigger event xxx1b - TE0 = 1 - Channel 0 trigger event
3-0 STATE	STATE These bits reflect the transmit state machine status. They can be polled for determination of state machine status. 0000b - IDLE 0001b - HEADER_AND_ADDRESS_FIELD 0010b - HEADER_AND_DATA_FIELD 0011b - HEADER_AND_CRC_FIELD 0100b - ADDRESS_AND_CRC_FIELD 0101b - ADDRESS_AND_DATA_FIELD 0110b - DATA_AND_CRC_FIELD 0111b - DATA_FIELD

82.7.32 SIPI Max Count Register (MAXCR)

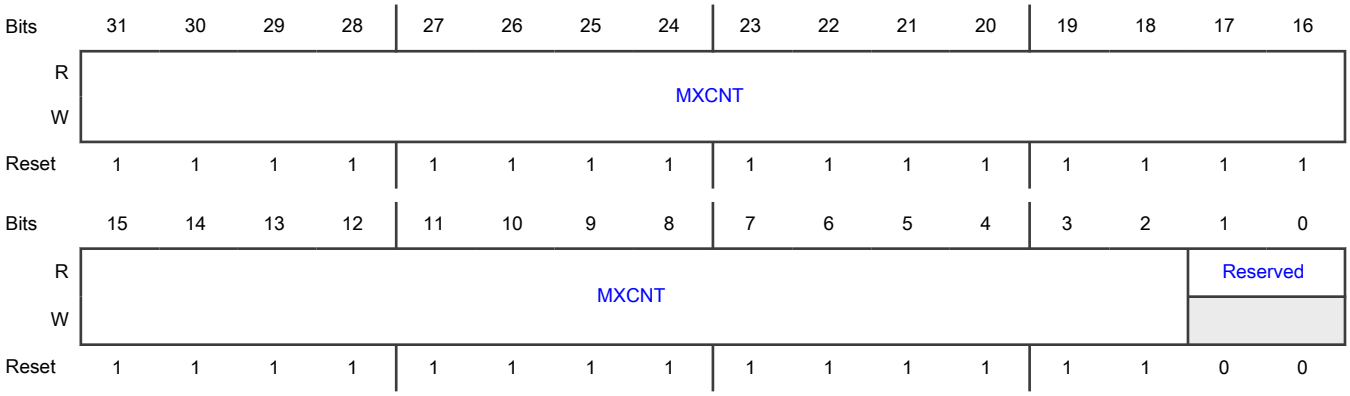
Offset

Register	Offset
MAXCR	A4h

Function

SIPI_MAXCR contains the maximum address count value at target node. It is programmed via direct write request through the initiator. This register can be read or written by software anytime.

Diagram



Fields

Field	Function
31-2 MXCNT	MXCNT This field contains the maximum address count value at the target node. It should be programmed via direct write request through the initiator.
1-0 —	Reserved

82.7.33 SIPI Address Reload Register (ARR)

Offset

Register	Offset
ARR	A8h

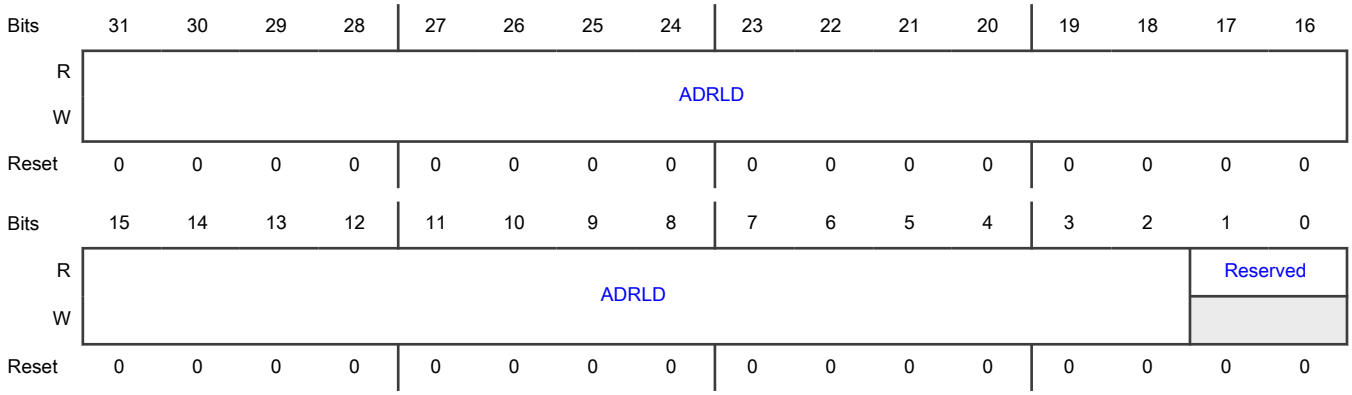
Function

The SIPI_ARR contains the reload value for the address counter at the target node. It should be configured by direct write request from the initiator.

NOTE

This register is writeable only when SIPI_MCR[INIT] = 1.

Diagram



Fields

Field	Function
31-2 ADRLD	ADRLD ADRLD contains the reload value for the address counter at the target node. It should be configured by direct write request from the initiator.
1-0 —	Reserved

82.7.34 SIPI Address Count Register (ACR)

Offset

Register	Offset
ACR	ACh

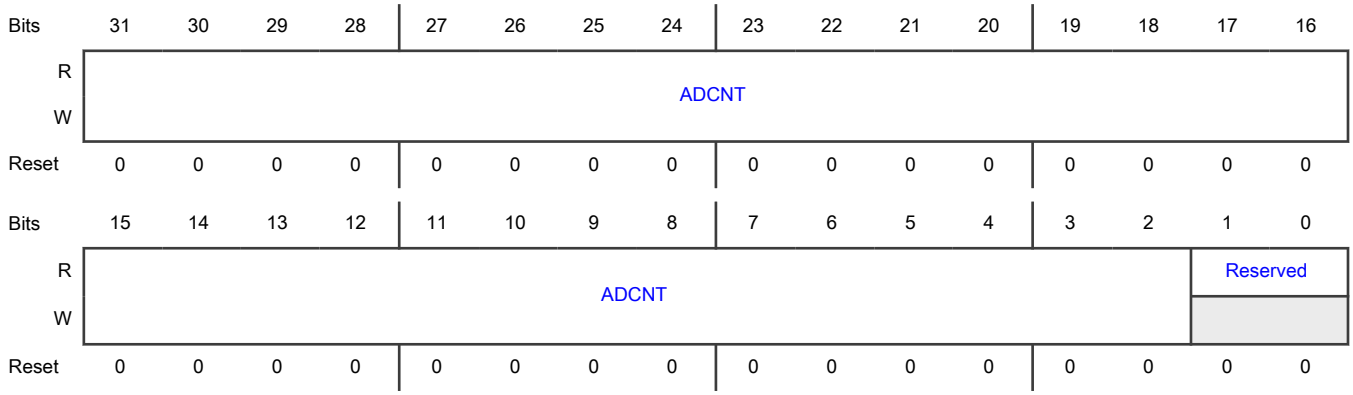
Function

This register reflects the count value of address counter at target node. It should be configured by direct write request from initiator. This register can be read/written by software anytime.

NOTE

- SIPI_ARR, SIPI_ACR and SIPI_MAXCR will be configured by direct write operation through the initiator.
- When a streaming write command is received, the target will start the write operation from the address present in SIPI_ACR (address count register).
- After each 32-bit write has completed, SIPI_ACR[ADCNT] is compared against SIPI_MAXCR[MXCNT]. If they are equal, SIPI_ACR[ADCNT] is loaded with the value stored in SIPI_ARR[ADRLD]. If they are not equal, the SIPI_ACR[ADCNT] will increment by 4, decrement by 4 or remain the same (depending on configuration). In both cases, the SIPI_ACR[ADCNT] will contain the address at which the next streaming write will occur.
- SIPI will not update ACR with ARR value in case the last beat in stream transaction reaches MAXCR address.

Diagram



Fields

Field	Function
31-2 ADCNT	Feflects the count value of address counter at target node. It should be configured by direct write request from the initiator. This register can be read/written by software anytime. At the end of the streaming operation, SIPI_ACR will point to the next address to be written.
1-0 —	Reserved

82.7.35 SIPI Error Register (ERR)

Offset

Register	Offset
ERR	B0h

Function

This register contains the error bits for the last transaction(s) for all the channels. Communication errors are generated only for out of range address accesses, areas that are read only and where accesses do not lead to generation of transfer errors. Also, writing to read only registers will not generate errors.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0					TOE3	TIDE3	ACKE3	0					TOE2	TIDE2	ACKE2
W						W1C	W1C	W1C						W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0					TOE1	TIDE1	ACKE1	0					TOE0	TIDE0	ACKE0
W						W1C	W1C	W1C						W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-27 —	Reserved
26 TOE3	TOE3 Timeout Error for Channel 3. 0b - Timeout error didn't occur 1b - Timeout error occurred
25 TIDE3	TIDE3 Transaction ID Error for Channel 3. 0b - Received transaction ID matched with the stored ID 1b - Received transaction ID didn't match with the stored ID
24 ACKE3	ACKE3 Acknowledge Error for Channel 3. 0b - Acknowledge received is correct. 1b - Acknowledge received is not correct.
23-19 —	Reserved
18 TOE2	TOE2 Timeout Error for Channel 2. 0b - Timeout error didn't occur 1b - Timeout error occurred
17	TIDE2

Table continues on the next page...

Table continued from the previous page...

Field	Function
TIDE2	Transaction ID Error for Channel 2. 0b - Received transaction ID matched with the stored ID 1b - Received transaction ID didn't match with the stored ID
16 ACKE2	ACKE2 Acknowledge Error for Channel 2. 0b - Acknowledge received is correct 1b - Acknowledge received is not correct
15-11 —	Reserved
10 TOE1	TOE1 Timeout Error for Channel 1. 0b - Timeout error didn't occur 1b - Timeout error occurred
9 TIDE1	TIDE1 Transaction ID Error for Channel 1. 0b - Received transaction ID matched with the stored ID 1b - Received transaction ID didn't match with the stored ID
8 ACKE1	ACKE1 Acknowledge Error for Channel 1. 0b - Acknowledge received is correct 1b - Acknowledge received is not correct
7-3 —	Reserved
2 TOE0	TOE0 Timeout Error for Channel 0. 0b - Timeout error didn't occur 1b - Timeout error occurred
1 TIDE0	TIDE0 Transaction ID Error for Channel 0. 0b - Received transaction ID matched with the stored ID 1b - Received transaction ID didn't match with the stored ID

Table continues on the next page...

Table continued from the previous page...

Field	Function
0 ACKE0	ACKE0 Acknowledge Error for Channel 0. 0b - Acknowledge received is correct. 1b - Acknowledge received is not correct.

82.7.36 SIPI Debug Register (DEBUG)

Offset

Register	Offset
DEBUG	B4h

Function

This register contains the debug information

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0												OUTSTANDING			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	STATE															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Fields

Field	Function
31-20 —	Reserved
19-16 OUTSTANDING	OUTSTANDING FRAMES Number of outstanding requests
15-0 STATE	STATE Receive FSM State information

82.7.37 SIPI Performance Monitor register (PMR)

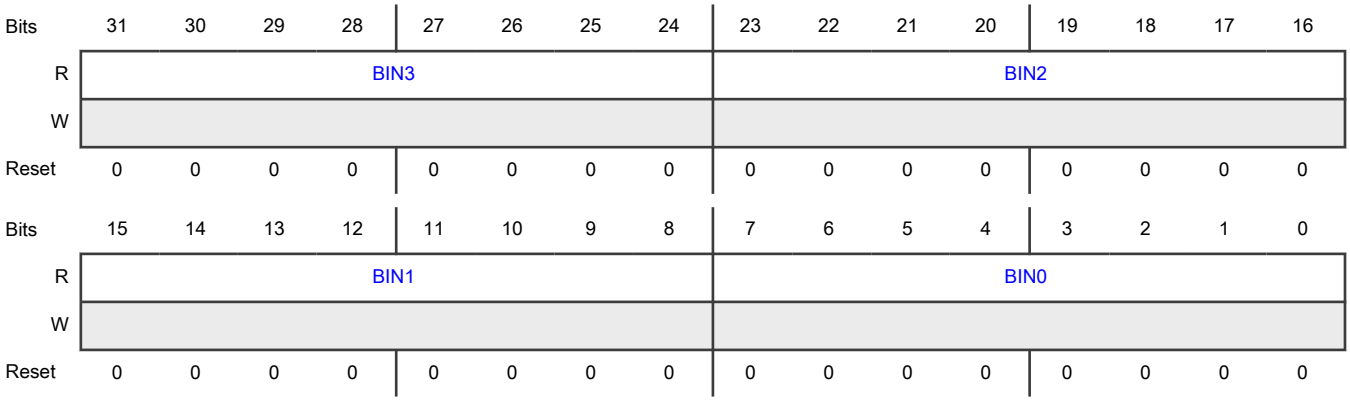
Offset

Register	Offset
PMR	B8h

Function

This register captures the number of frames whose turn around time falls within particular bin interval

Diagram



Fields

Field	Function
31-24 BIN3	BIN3 Stores the number of frames whose turn around time is between 2^11 to 2^12 cycles
23-16 BIN2	BIN2 Stores the number of frames whose turn around time is between 2^10 to 2^11 cycles
15-8 BIN1	BIN1 Stores the number of frames whose turn around time is between 2^9 to 2^10 cycles
7-0 BIN0	BIN0 Stores the number of frames whose turn around time is between 2^8 to 2^9 cycles

82.8 Transfer types

This section describes the available transfer types for the SIPI module. The SIPI frame is inserted inside the payload of the LFAST frame as shown in the following figures.

82.8.1 Read transfer

A read transfer can be of two types:

- Read Request Transfer (at the Initiator node)

- Read Response Transfer (at the Target node)

82.8.1.1 Register read request transfer

In case of a read request transfer, the Initiator node sends Header, Address, and CRC bits as shown in the following figure.

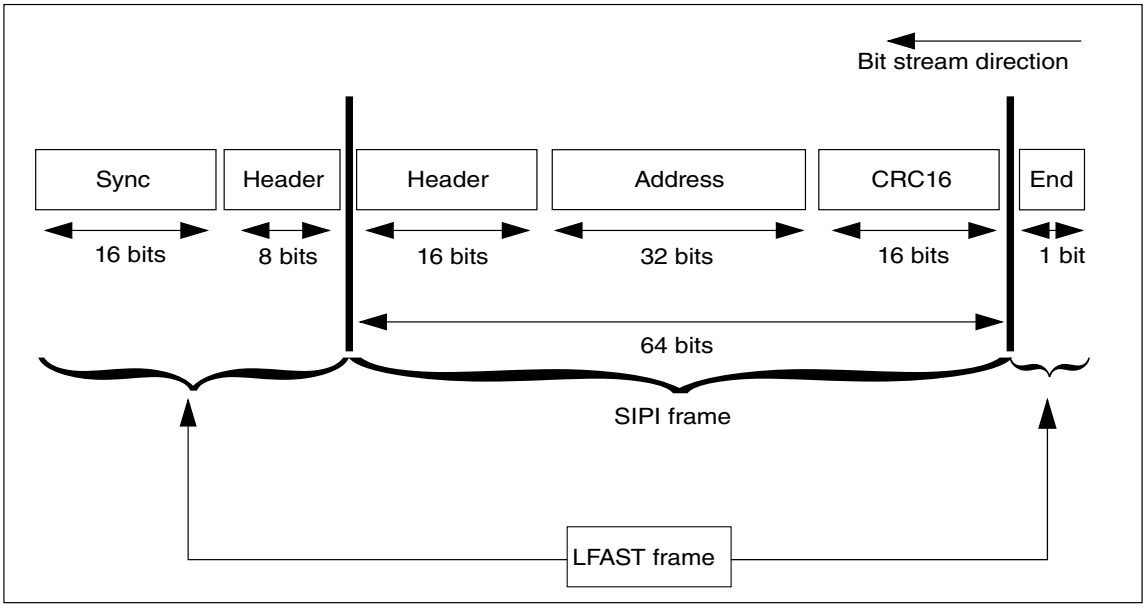


Figure 629. Read request transfer

82.8.2 Register read answer transfer

In response to a read request by the Initiator node, the Target node sends header, payload and CRC16. Data transfer could be in 8-bit, 16-bit, or 32-bit modes (see Figure 630). In case of 8-bit or 16-bit modes, copies of the SIPI data are sent in the payload (see Figure 631).

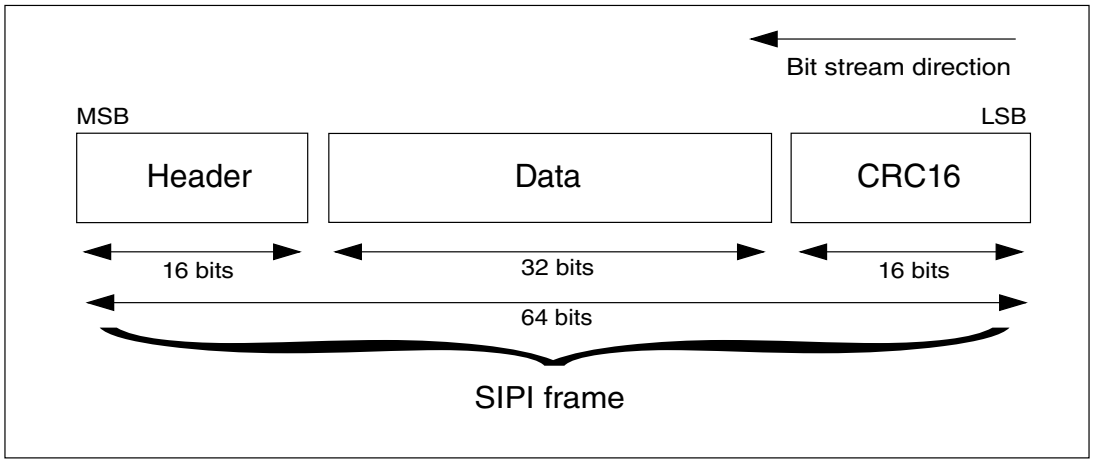


Figure 630. Read answer transfer

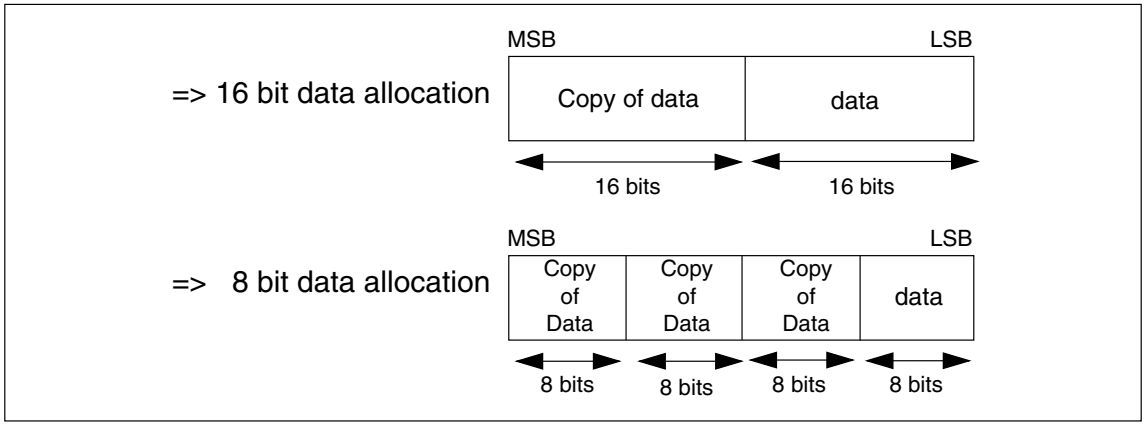


Figure 631. Data allocation

NOTE

- For an 8-bit transfer, SIPI uses address bits [31:2] as address and bits [1:0] as byte enables.
  - Bits[1:0]:
    - 00 - byte 3 enabled (MSB)
    - 01 - byte 2 enabled
    - 10 - byte 1 enabled
    - 11 - byte 0 enabled (LSB)
- For a 16-bit transfer, SIPI uses address bits [31:1] as address and bit [0] as halfword enable.
  - Bit[0]:
    - 0 - halfword 1 enabled (MSB)
    - 1 - halfword 0 enabled (LSB)

82.8.3 Register write transfer

Register write transfers can be of two types:

- Normal write transfer—applies to channels 0, 1, 2, and 3
- Streaming data transfer—applies to channel 2 only

A register write transfer can be performed through a normal write transfer for channels 0, 1, 2, and 3 (see Normal write transfer as shown in Figure 632.

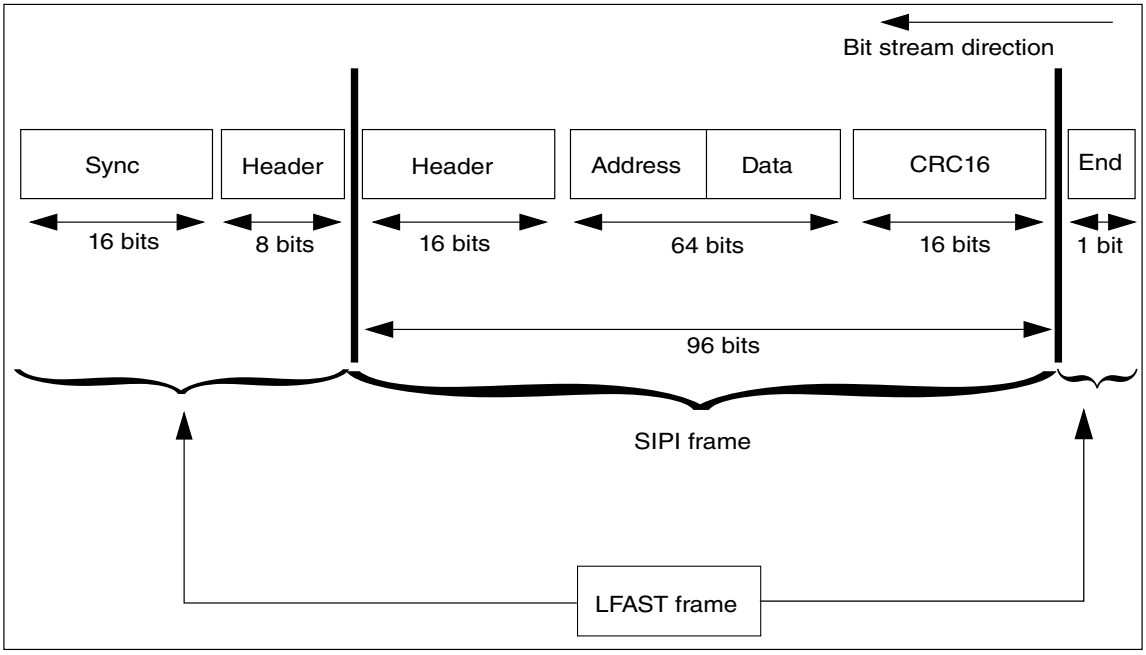


Figure 632. Register write transfer (showing LFAST frame encapsulation)

82.8.3.1 Normal write transfer

A normal write transfer contains header, address, data (32-bit), and CRC as shown in the following figure.

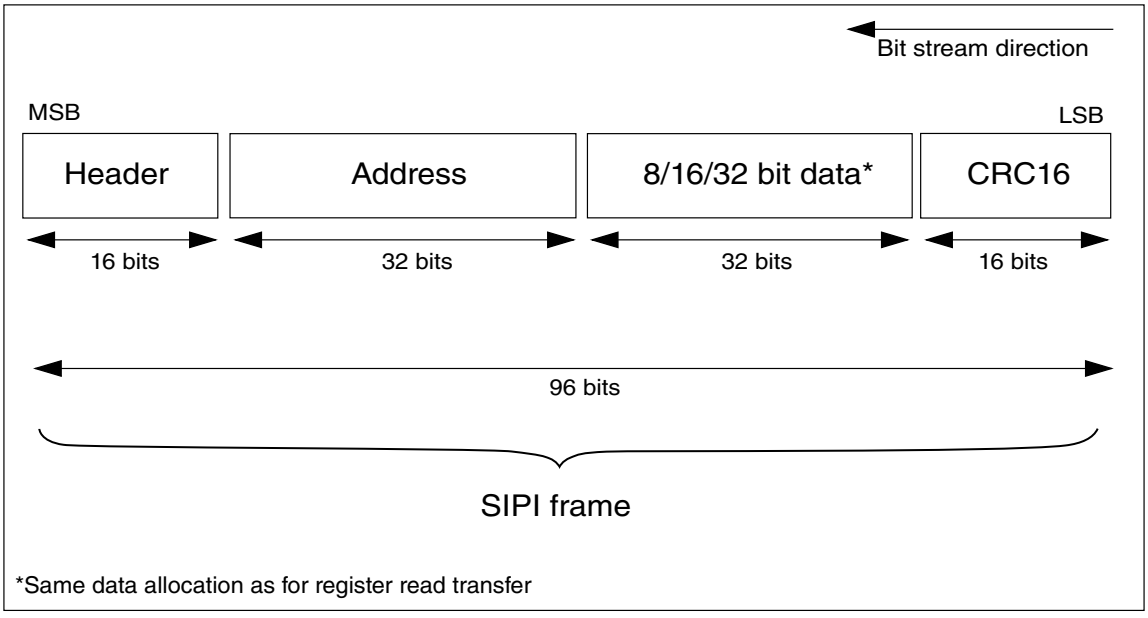


Figure 633. Write transfer (LFAST frame encapsulation is not shown)

NOTE

- For an 8-bit transfer, SIPI uses address bits [31:2] as address and bits [1:0] as byte enables.
  - Bits[1:0]:

- 00 - byte 3 enabled (MSB)
- 01 - byte 2 enabled
- 10 - byte 1 enabled
- 11 - byte 0 enabled (LSB)

- For a 16-bit transfer, SIPI uses address bits [31:1] as address and bit [0] as half-word enable.
  - Bit[0]:
    - 0 - half-word 1 enabled (MSB)
    - 1 - half-word 0 enabled (LSB)

82.8.3.2 Streaming write transfer

Streaming write transfer has 256 bits of payload.

82.8.3.2.1 Streaming write transfer with address

SIPI performs address setting using a direct write transfer. The MAXCR and ARR are written before ACR. This is to stop SIPI from accessing non-shared memory and is only true for the first streaming command; subsequent streaming command(s) may not need to write to MAXRC and ARR.

82.8.3.2.2 Streaming transfer with data

The following figure shows the packet structure of the streaming transfer containing data.

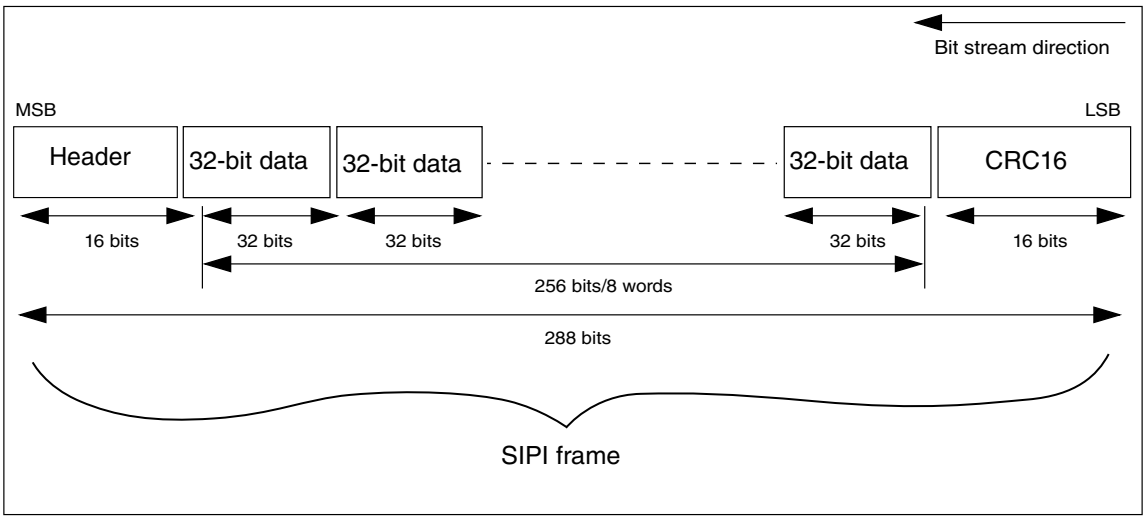


Figure 634. Streaming transfer with data

82.8.4 Write acknowledge transfer

A write acknowledge transfer contains only header and CRC bits (see the following figure). These bits are calculated on the Header field.

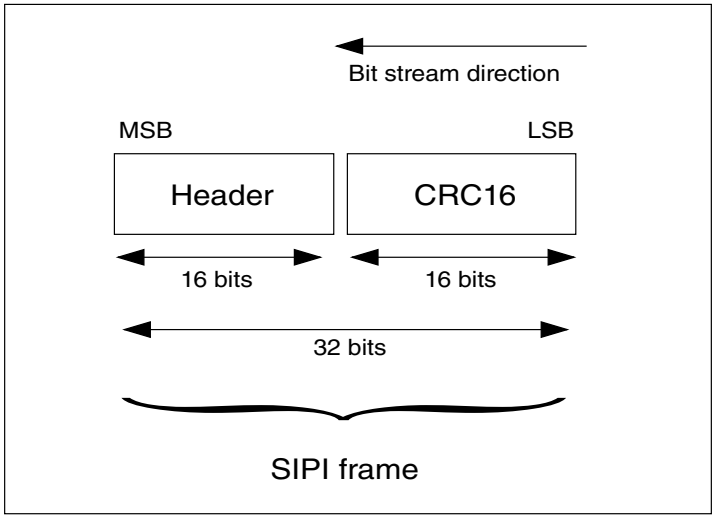


Figure 635. Write acknowledge transfer (LFAST encapsulation is not shown)

82.8.5 ID request response

82.8.5.1 ID request transfer

The Initiator node transmits an ID request, as shown in the following figure.

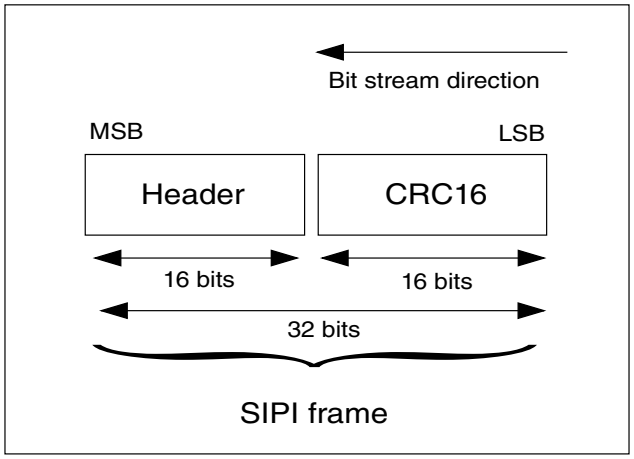


Figure 636. ID request transfer (LFAST encapsulation is not shown)

82.8.5.2 ID request response transfer

The Target node transmits an ID request response, as shown in the following figure.

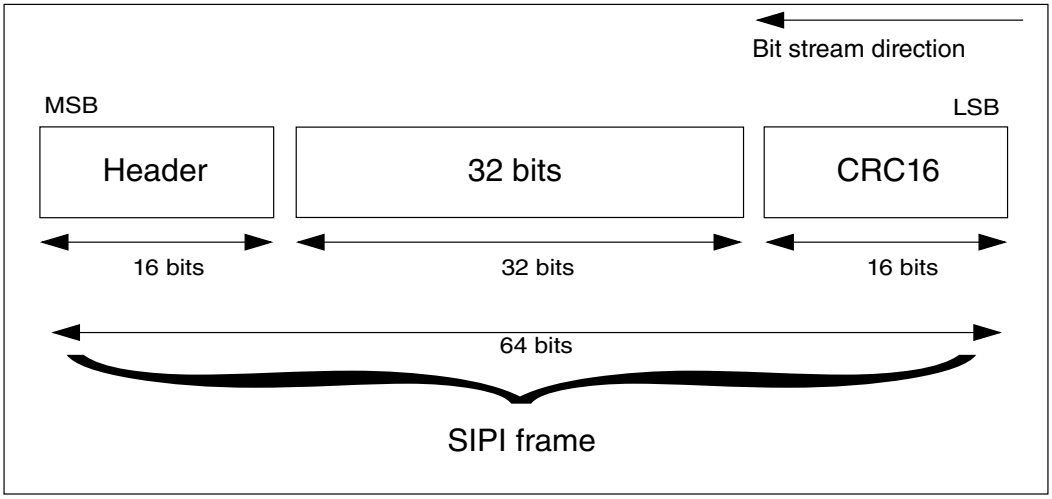


Figure 637. ID request response transfer

NOTE

The ID request response contains the value of the CHIP ID instead of the data.

82.9 Transfer API and flow charts

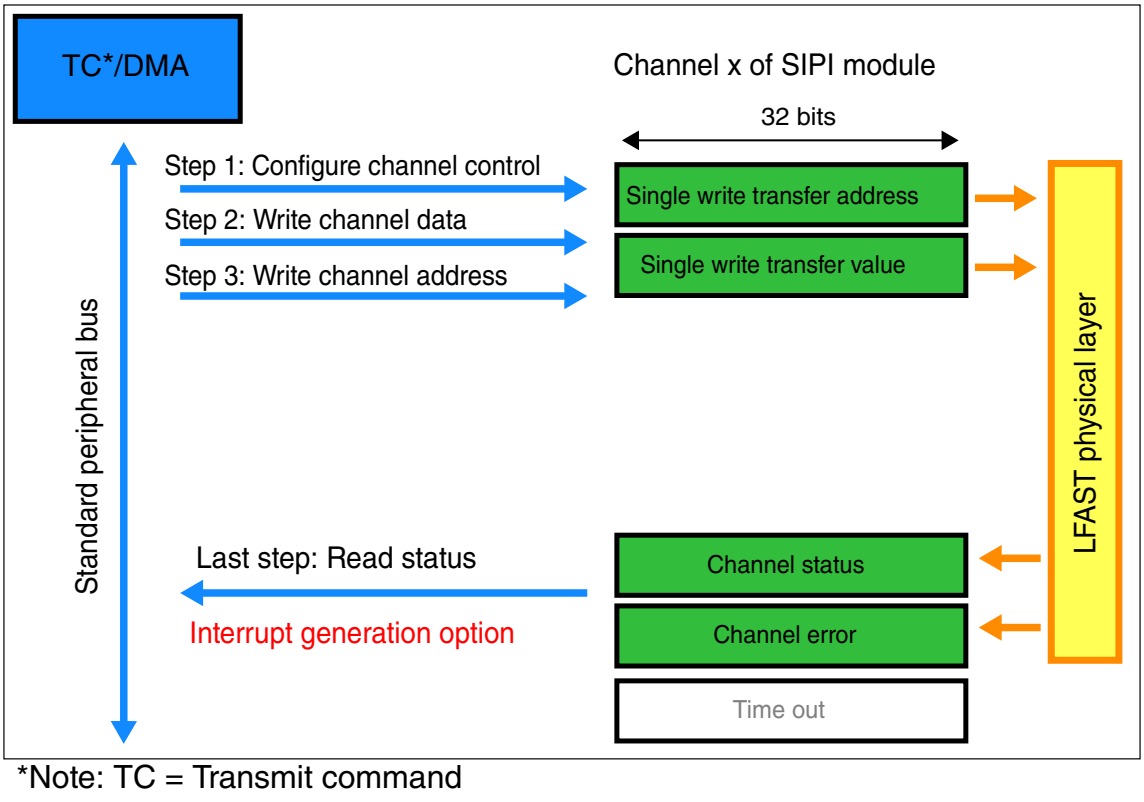


Figure 638. SIPI single register write API

If LEGACY_MODE_BIT bit is set to 1, then perform the following steps to generate a single write transfer request Steps to generate a single write transfer (see Figure 638):

1. Configure data and CCR*n* at the Initiator node.
2. Configure CAR*n* at the Initiator node.

   As soon as the Channel address register (CAR*n*) is written and if CCR*n*[CHEN] = 1, the initiator SIPI calculates the CRC on Header, Address, and Data fields and starts transmitting data to LFAST.

If LEGACY_MODE_BIT bit is set to 0, then perform the following steps to generate a single write transfer request:

1. Configure CCR*n* at the Initiator node.
2. Configure CAR*n* at the Initiator node.
3. Configure CDR*n* at the Initiator node.
4. As soon as the Channel data register (CDR*n*) is written and if CCR*n*[CHEN] = 1, the initiator SIPI calculates the CRC on Header, Address, and Data fields and starts transmitting data to LFAST.

The software polls the status register bits (CSR*n*) to determine when the request completes, CSR*n*[ACKR] = 1, and generates an interrupt if the corresponding CIR*n*[ACKIE] = 1.

On a single write transfer request reception (see Figure 639):

1. The Target node places the address, data, and control information on its AHB master interface.
2. When the process completes, the Target node generates an acknowledge frame and sends it back to LFAST.

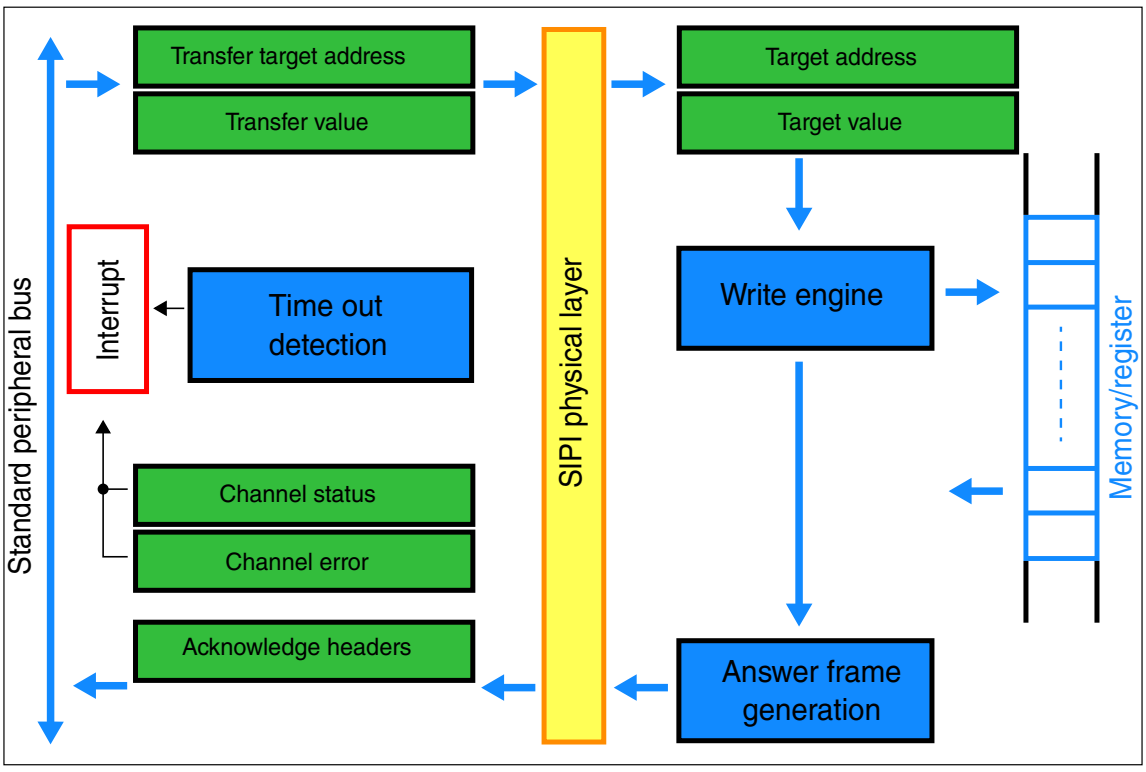


Figure 639. SIPI single register write API - flow chart

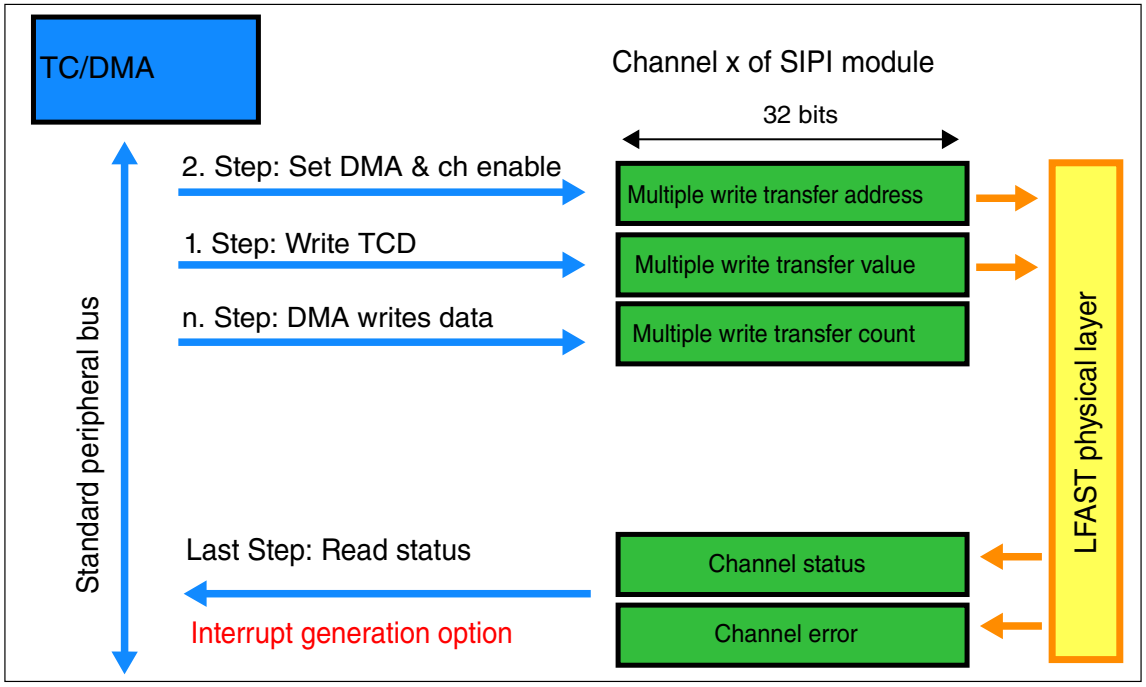


Figure 640. SIPI multiple register write API

For multiple write transfer request generation (see Figure 640):

1. The software configures Transfer Control Descriptor (TCD) of DMA.
2. The software writes CCR*n*[CHEN] = 1 and CCR*n*[DEN] = 1.
3. SIPI starts copying data to the CDR*n* through its DMA interface, depending on the transfer count and the size of data registers. CDR2_0 must be written with MSB.
4. After the data is copied, initiator SIPI calculates CRC on the Header, Address, and Data fields, and starts transmitting data to LFAST.
5. The software must poll the CSR*n* Status Register bits to determine if the request is complete. If CSR*n*[ACKR] = 1, it generates an interrupt (if the corresponding CIR*n*[ACKIE] = 1).
6. If CCR*n*[DEN] = 1, the SIPI request transfers to the DMA controller. If not, the state machine will go idle.
7. The software repeats steps 4-7.

On multiple write transfer request reception (see Figure 640):

1. The Target node places the address, data, and control information on its AHB master interface.
2. After the process is complete, the Target node generates an acknowledge frame and sends it to LFAST.

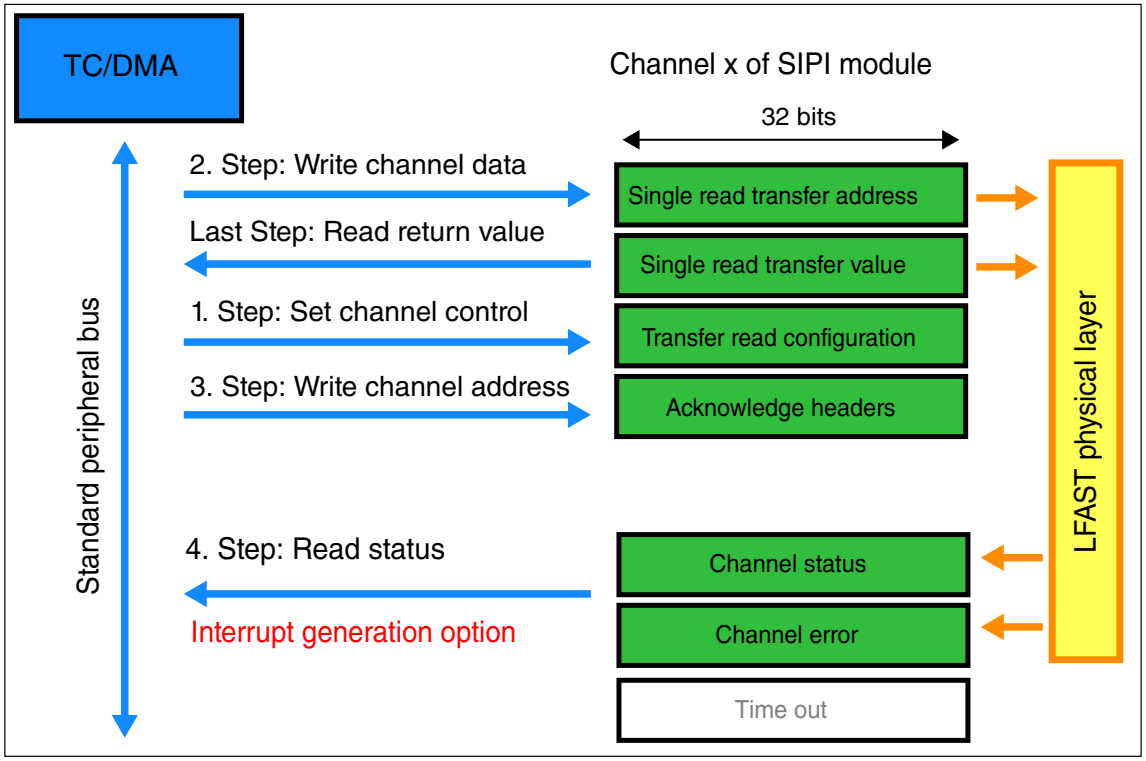


Figure 641. SIPI single register read API

For single read transfer request generation (see Figure 641):

1. The software/DMA configures CCR*n* and CDR*n*; writing CAR*n* as the last step.
2. As soon as the software writes to the CAR, initiator SIPI calculates CRC of the Header and Address fields and starts transmitting data to LFAST.
3. The software should poll CSR*n* to determine if the request is complete. If CSR*n*[RAR] = 1 and CIR*n*[RAIE] = 1, an interrupt generates. If CSR*n*[RAR] is not set, then ERR[TOE*n*] = 1 indicates that a timeout has occured.
4. If CSR*n*[RAR] = 1, then the software can read the data register, or can perform another necessary action if CSR*n*[RAR] = 0.

On single read transfer request reception (see Figure 641):

1. The Target node places the address and control information on its AHB master interface.
2. When the process in complete, the Target node sends the read response back to LFAST.

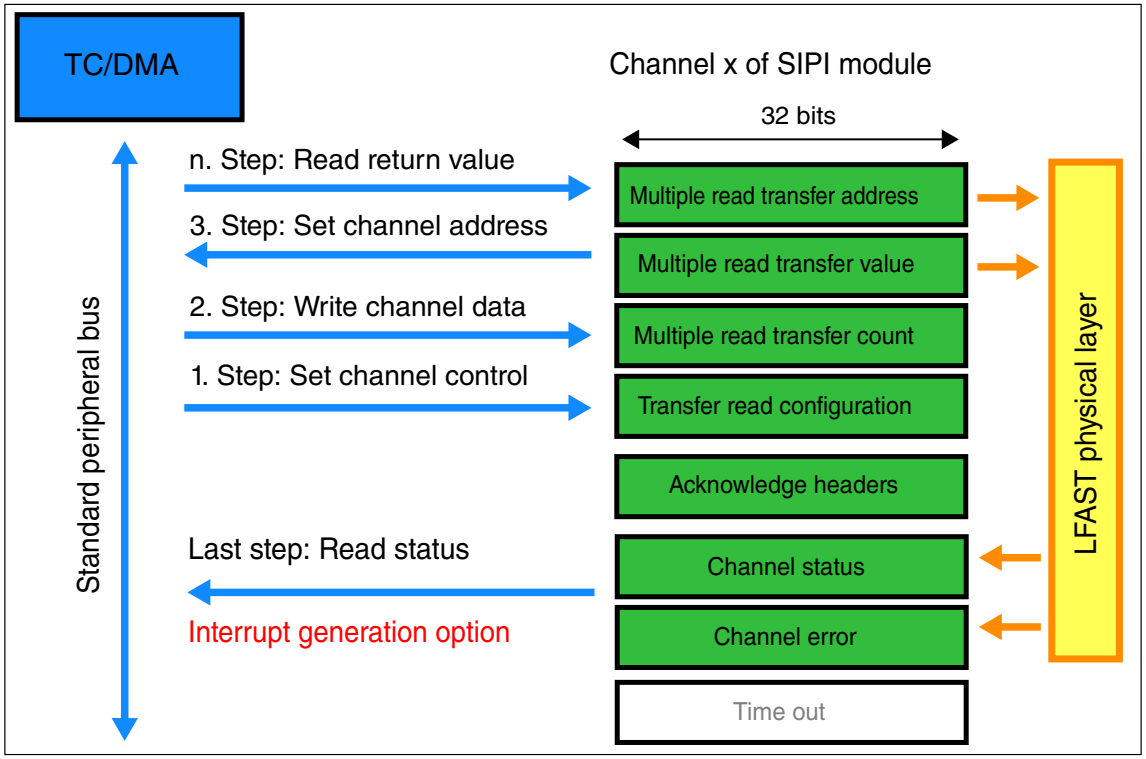


Figure 642. SIPI multiple register read API

For multiple read transfer request generation (see Figure 642):

1. The software/DMA configures CCR*n* and CDR*n*; writing CAR*n* as the last step.
2. As soon as the CAR is written, initiator SIPI calculates CRC on the Header and Address fields, and then starts transmitting data to LFAST.
3. The software should poll CSR*n* to determine if the request is complete. If CSR*n*[RAR] = 1 and CIR*n*[RAIE] = 1, an interrupt generates. If CSR*n*[RAR] is not set, then ERR[TOE*n*] = 1 indicates that a timeout has occured.
4. The software repeats steps 2-3 for multiple requests.

On multiple read transfer request reception (see Figure 642):

1. The Target node starts reading data through its AHB interface.
2. After the transfer is complete or all the data registers are full, it calculates CRC and sends the response frame back to LFAST.

NOTE

The hardware also clears the read answer interrupt pins in DMA transfers. This can lead the software in trouble if it tracks the requests by counting the number of times the interrupt was received and cleared.

See Figure 643, Figure 644, Figure 645, and Figure 646 that show the SIPI data streaming of data.

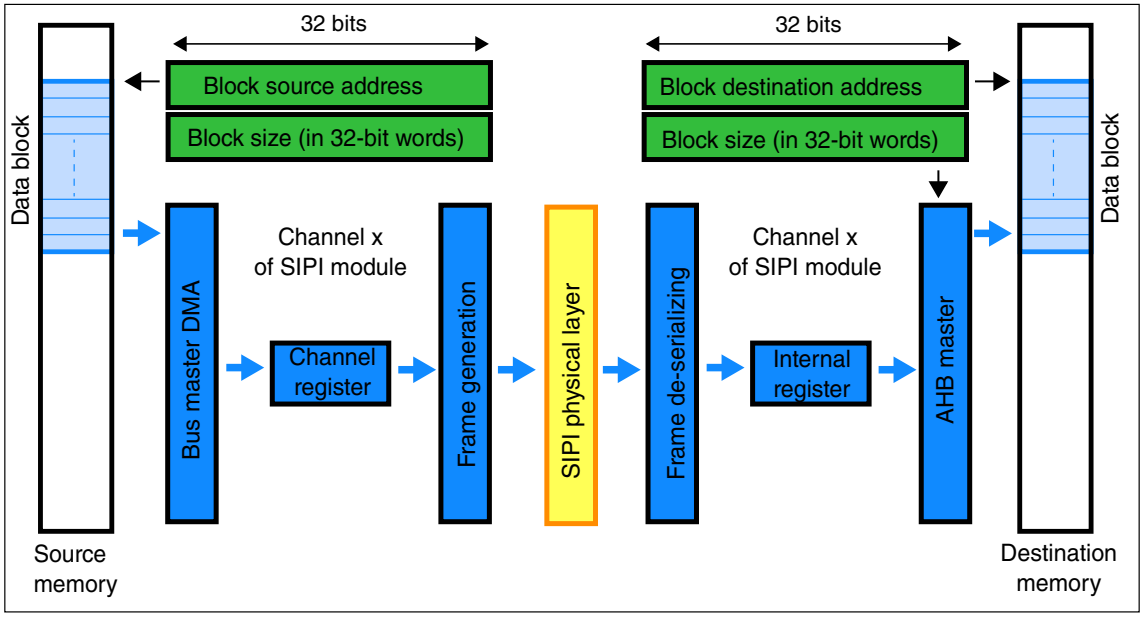


Figure 643. SIPI data stream model

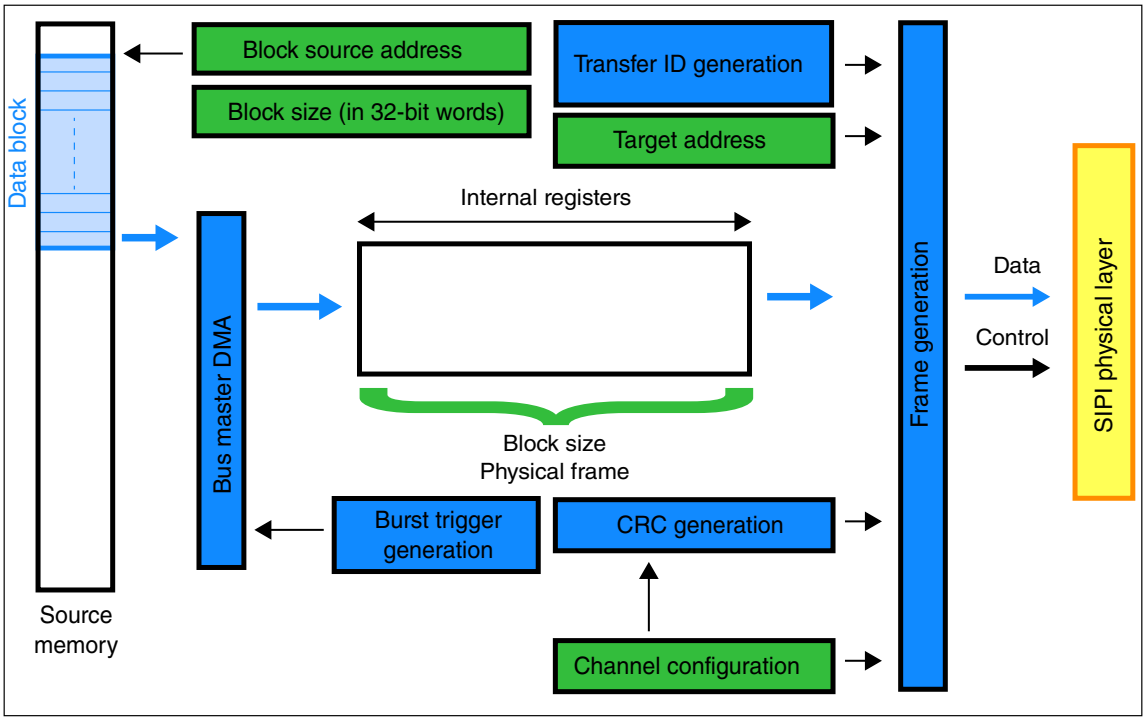


Figure 644. SIPI data stream model - Initiator

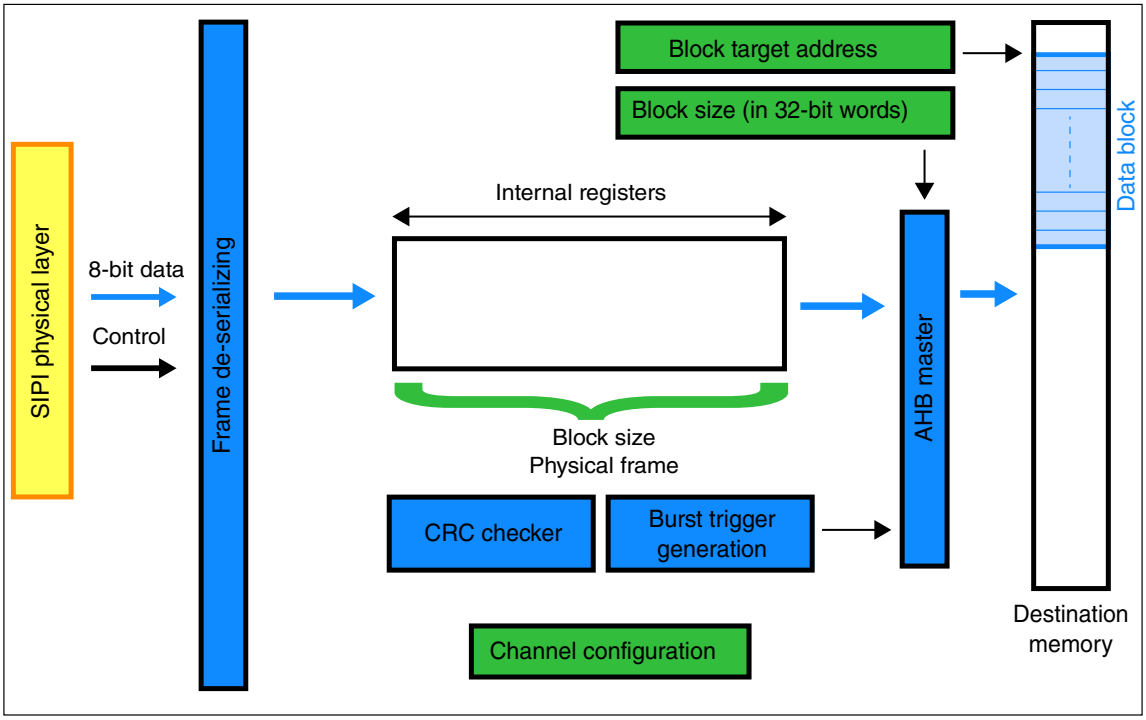


Figure 645. SIPI data stream model - Target

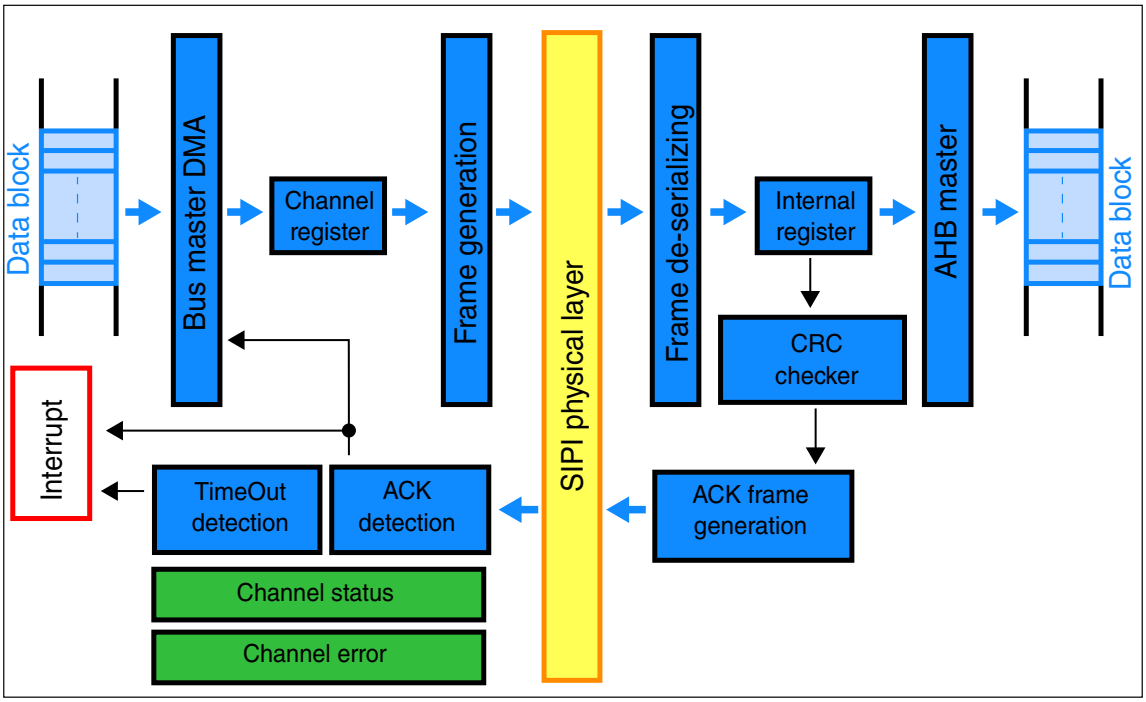


Figure 646. SIPI data stream with acknowledge trigger

82.10 DMA programming sequence

The DMA programming sequence is as follows:

1. Check whether the channel is ready for by reading CCRx[DEN]=0.

2. Check no error on the channel by reading ERR[TOEx]=0,ERR[TIDEx]=0 and ERR[ACKEx]=0.
3. Enable the channel by writing CCRn[CHEN]=1.
4. Select the operation by writing to the CCRx[RRT]=1 or CCRx[WRT]=1 or CCR2[ST]=1.
5. Program the transaction size by writing to the CCRx[WL].
6. Incase of write program the data register CDRx[CDR]. The whole frame data should be programmed altogether, in one minor loop.
7. Program the target node address, by writing on register CARx[CAR].

   If MCR[LEGACY_MODE_BIT]=0, the programming of CARz[CAR] is not needed for stream write
8. Incase of multiple minor loops go back to step 6. Once SIPI has transmitted the frame it will accept new commands from the DMA.
9. Incase of completion of major loop go back to step 1. Once SIPI completes the transaction it will set CCRx[DEN]=0.
10. If an error occurs:
    - SIPI generates an interrupt.
    - Software takes control of SIPI.

82.11 Modes of operation

SIPI supports three modes of operation:

- Initialization
- Normal
- Module Disable

After hardware reset, SIPI is in the Module Disable mode, which helps reduce power consumption.

82.11.1 Initialization mode

To enter the Initialization mode, software writes MCR[INIT]=1, and MCR[MOEN] must be set before attempting to write to MCR[INIT]. To exit the Initialization mode, the software writes MCR[INIT]=0.

NOTE

It is recommended that the software checks the state of MCR[MOEN] before setting the MCR[INIT] field.

82.11.2 Normal mode

After the software completes SIPI initialization (MCR[INIT] = 1), it can enter the Normal mode by writing MCR[INIT]=0. SIPI needs to be in the Normal mode for all data transfers.

NOTE

SIPI must be enabled before attempting to write MCR[MOEN]=1.

82.11.3 Module Disable (MD) mode

The MD mode in SIPI reduces power consumption. By default, SIPI is in the Disable mode, MCR[MOEN]=0, and exits by writing MCR[MOEN]=1. Future SIPI Tx transfers are disabled in this mode. To disable the Rx functionality, the Target Enable (TEN) field needs to be deasserted, and then the internal Rx state machine resets to the initial state.

82.12 Errors

This section describes the potential errors that can occur during a SIPI operation.

82.12.1 Timeout error

The module generates a timeout error at the Initiator node when the acknowledge/response is not received within the time configured in the corresponding CTOR*n*[TOR] field setting. It indicates a timeout error when ERR[TOE*n*] = 1.

NOTE

SIPI should not drop the response even after a timeout occurs. The software polls both the error and status flags after the transfer to see if there was a timeout error. In case of an error, the response received may be discarded.

82.12.2 CRC error

The module generates a CRC error at the Target nodes when the CRC received with the frame does not match the calculated CRC, and the SR[GCRCE] field is set. An interrupt is asserted if MCR[CRCIE]=1.

NOTE

The Target node does not send an acknowledge to the Initiator node when a CRC error is generated. An interrupt is generated on the target side if the corresponding interrupt enable bit is set. The Initiator node detects a timeout and takes the necessary action.

82.12.3 Maximum count reached error

The module generates the maximum count reached error at the Target node when the value of ACR is equal to that of MAXCR register. When ACR is equal to MAXCR, then SR[MCR]=1. SIPI triggers an interrupt if the interrupt is enabled, MCR[MCRIE]=1.

82.12.4 Transaction ID error

The module generates the Transaction ID (TID) error at the Initiator node only, when header bits 15-13 do not match CSR*n*[TID].

CSR*n*[TIDE]=1 when a TID error is detected, and an interrupt is generated if CIR*n*[TIDIE]=1.

82.12.5 Acknowledge error

When the acknowledge sent by an initiator is incorrect, ERR[ACKR*n*] is set. An interrupt is generated if CIR*n*[WAIE]=1.

82.13 CRC calculation

If header is AABBh, address is 1122_3344h, and data is CCDD_EEFFh, the module performs CRC calculation as follows :

1) The CRC seed is initialized by FFFF_FFFFh.

2) All the data is mirrored before sending to the CRC engine (for example, MSB is sent as LSB).

3) The header is sent as DD55_0000h.

4) The address is sent as 22CC_4488h.

5) The data is sent as FF77_BB33h.

82.14 Interrupt logic

A description of the interrupt logic is provided in the following figure.

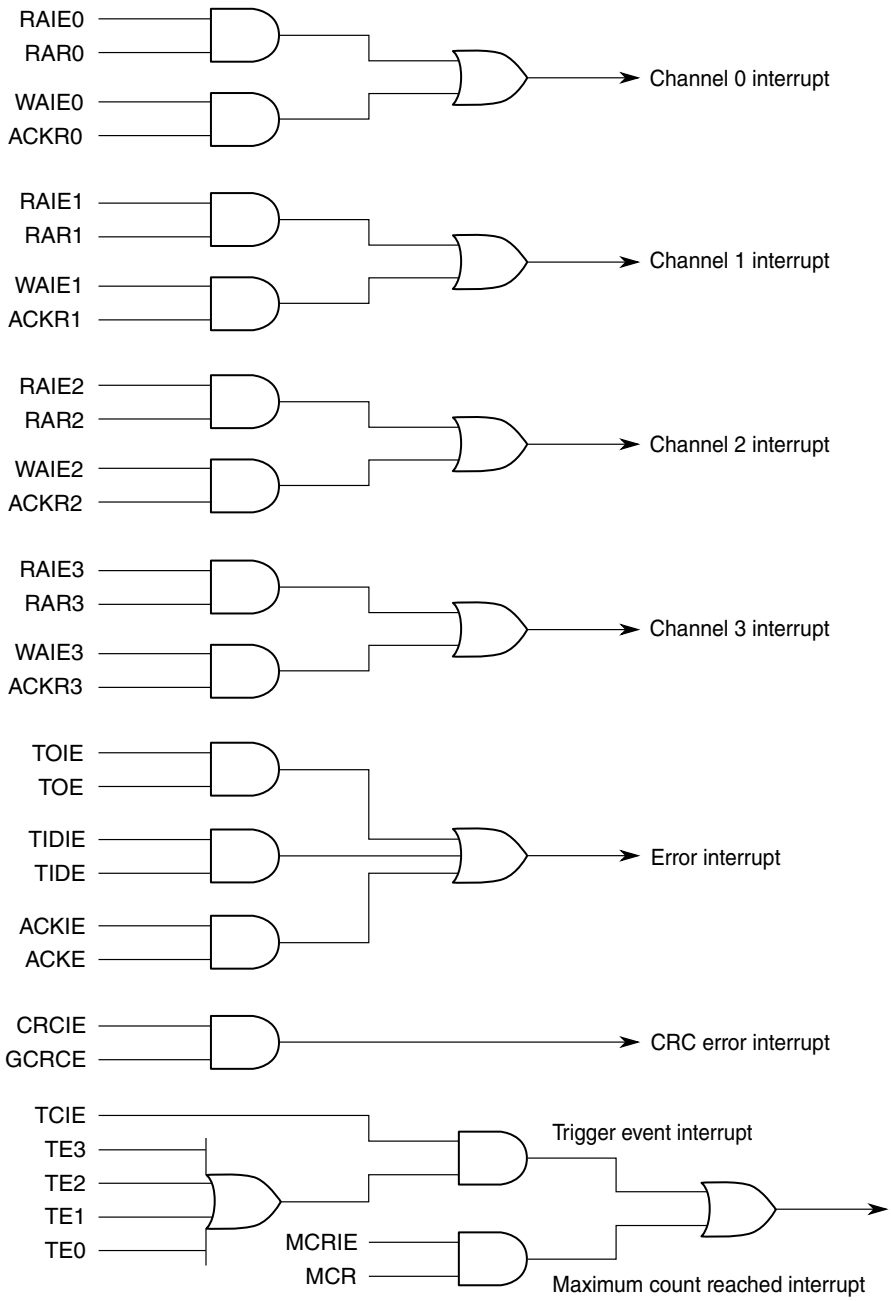


Figure 647. Interrupt description

82.15 SIPI control and status overview

The following figure shows the relationship between transfers and the SIPI control and status registers.

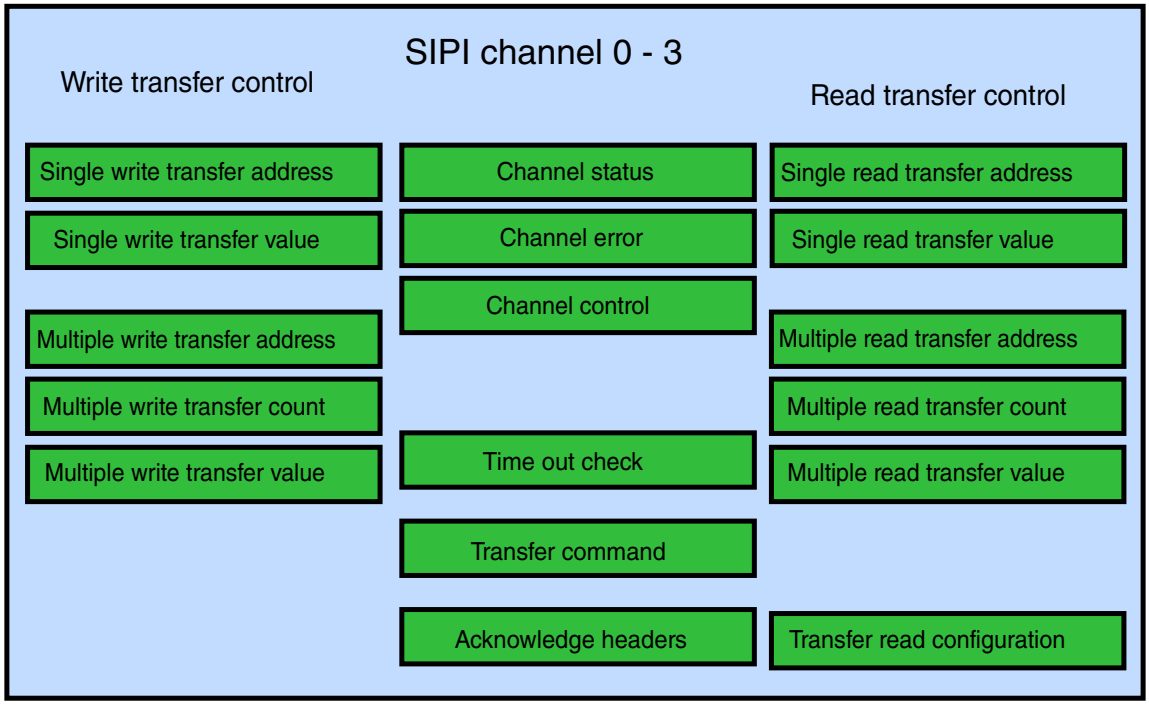


Figure 648. SIPI control and status overview - register transfer

Chapter 83
LVDS Fast Asynchronous Serial Transmission (LFAST)

83.1 Chip-specific LFAST information

83.1.1 LFAST instances and configuration

One instance of LFAST is instantiated.

Table 736. LFAST configuration

Configuration	S32K396
Transmit data FIFO width	32
Receive data FIFO width	32
Transmit data FIFO depth	38
Receive data FIFO depth	38
Transmit/Receive header FIFO width	6
Transmit/Receive header FIFO depth	6

83.2 Overview

This chapter describes the specifications of the LFAST module, which implements the LVDS Fast Asynchronous Serial Transmission (LFAST) module. LFAST is used in dual mode (software configurable master/slave operation) for interprocessor communications.

83.2.1 Block diagram

Figure 649 depicts LFAST interaction with other modules on the device.

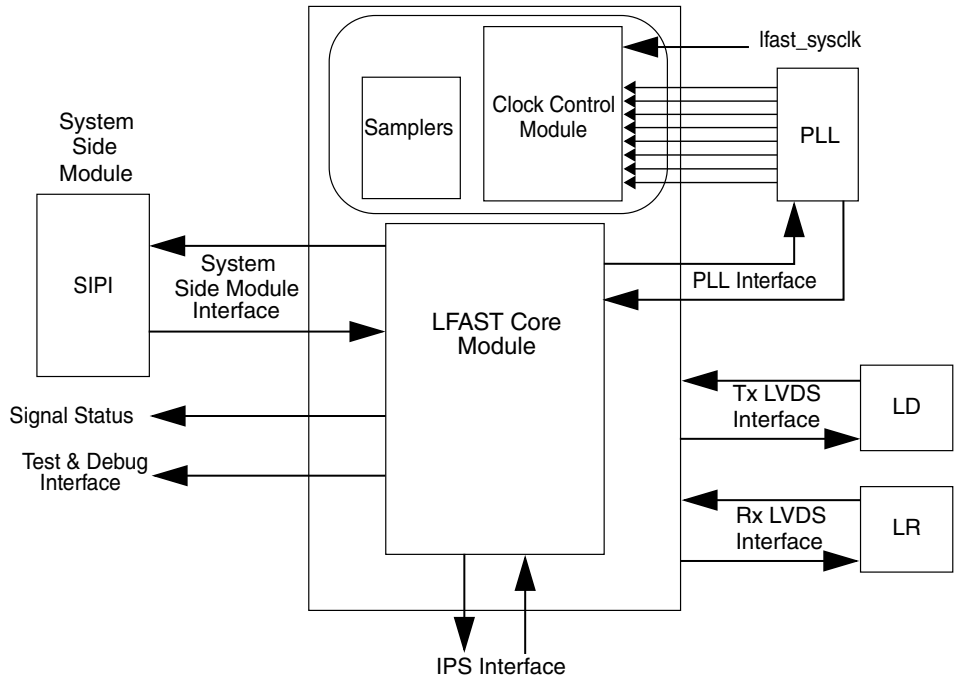


Figure 649. LFAST block diagram

83.2.2 Features

- Supports dual mode operation (register-configurable Master/Slave functionality).
- Supports asynchronous data transfer up to the maximum data rate shown in the product data sheet.
- Transmits and receives data, CTS, ICLC, and unsolicited frames.
- Provision of five interrupts for Tx and Rx channels.
- Supports processor - controlled transfer of ICLC frame with 8-bit payload size to implement the data rate changes and test modes.
- Supports LFAST - defined CTS - controlled data transfer. There is no dependency between data transmission and reception unless CTS mode is enabled.
- Supports flow control using sliding window protocol.
- Provides configurable frame length for data frame with variable payload sizes of 32, 64, 96, 128, 256, or 288 bits.
- Provides transmission of data frame length with 96 bits of payload size and reception of data frame with 128 bits of payload size.
- Provides configurable frame length for unsolicited frame with variable payload sizes of 8, 32, 64, 96, 128, 256, or 288 bits.
- Supports PLL configuration (for example, feedback loop divider, and so on.) through registers.
- Supports LVDS configuration through registers.
- Supports multiple loopback modes for checking the physical interface.
- Supports automatic ping response generation in slave mode.
- Supports for detection of unsupported channel number and unsupported payload size.

83.3 Functional description

This section provides a functional description of the LFAST.

83.3.1 Line receiver

This section describes the line receiver.

83.3.1.1 Introduction

The LR detects the voltage swing on the differential pair and converts it to a CMOS logic level that feeds the adaptive auto correlation block. The received data is sampled using the best of the eight (default) or four (alternative setting) possible sampling edges from the high speed clock or four phases using the low speed clock. The sampling edge is chosen by checking which of the 8/4 correlators provide the maximum correlation. If more than one sampling edge provides the maximum then the state machine will choose the sampling edge based on a defined selection algorithm.

After the correct sampling edge is chosen, the remaining unused sampling edges are turned off. Once the header is received the length of the frame (payload size) and logical channel definition can be obtained. The logical channel definition will determine the data type of the payload and therefore will determine the destination for the payload. Decoding of the ICLC commands from the payload is required in order to extract the interface control, rate mode,and PLL commands.

Figure 650 shows the block diagram of Uplink Controller.

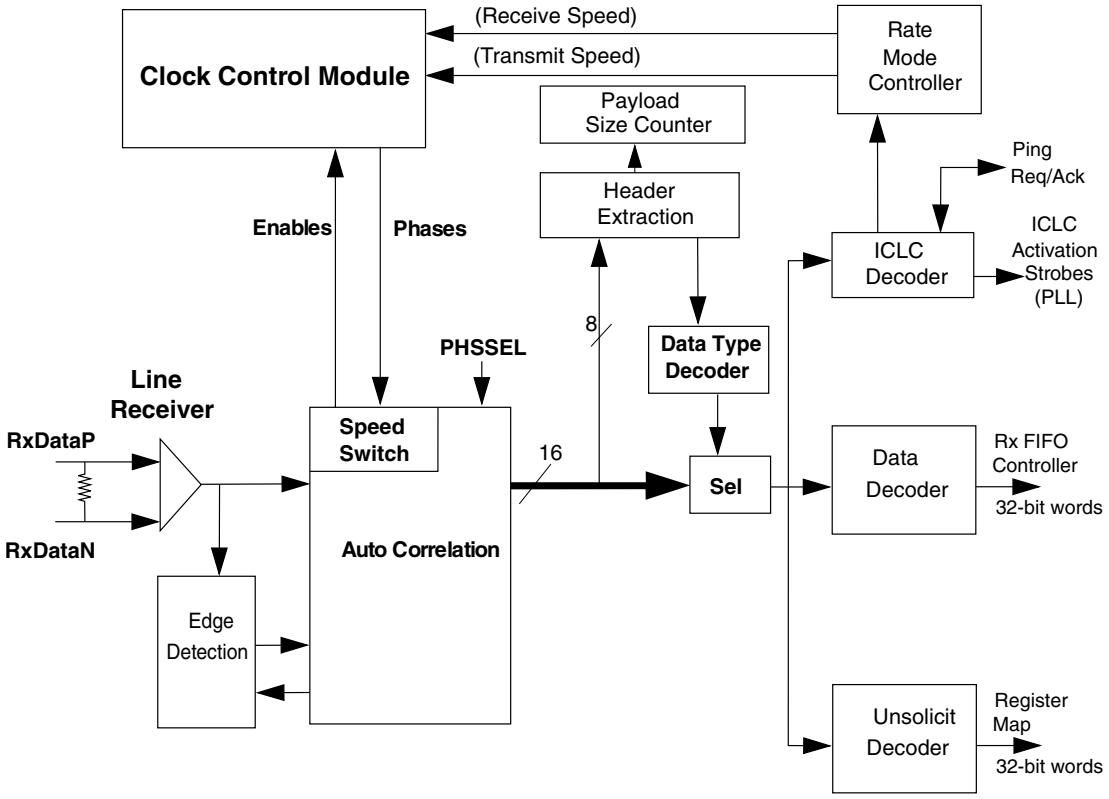


Figure 650. Top level receive controller

83.3.1.2 Edge detection and auto-correlation

The edge detection and auto correlation are described together, as the mode setting of the auto-correlation block impacts largely on whether the edge detection circuitry is used or not. The edge detection will be performed first if required before auto-correlation.

83.3.1.2.1 Auto-correlation modes

This section describes the auto-correlation modes.

83.3.1.2.1.1 Hunt correlation mode

On reset the Receive Controller will always come up in hunt correlation mode. In this mode all the correlators are enabled and the Receive Controller is always hunting for the synchronization pattern. The phase enables (either 8 or 4) to the external clock control module are always high. There is no edge detection for the first bit of the synchronization pattern. Hunt correlation mode is considered the safest mode as the Receive Controller is always checking for the synchronization pattern, but it is the mode that consumes the most power. In hunt correlation mode the correlation is performed over all 16 bits of the synchronization pattern.

Figure 651 shows the block diagram of Hunt correlation mode.

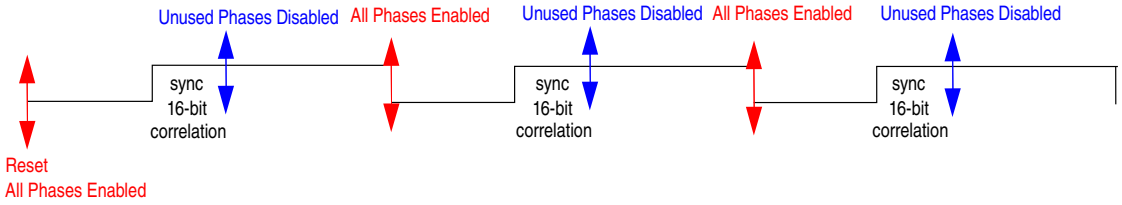


Figure 651. Hunt correlation mode

83.3.1.2.2 Edge detection

The edge detector is disabled in hunt correlation mode.

83.3.1.2.3 Auto correlation

The data transmission between the 2 devices LD and LR is asynchronous in nature. Hence the Receive Controller does not have the knowledge about the correct clock phase to be used for extracting the data. The task of the auto correlation (or synchronization) scheme is to estimate the best clock phase (8 or 4) for extraction of data as shown in the following figure.

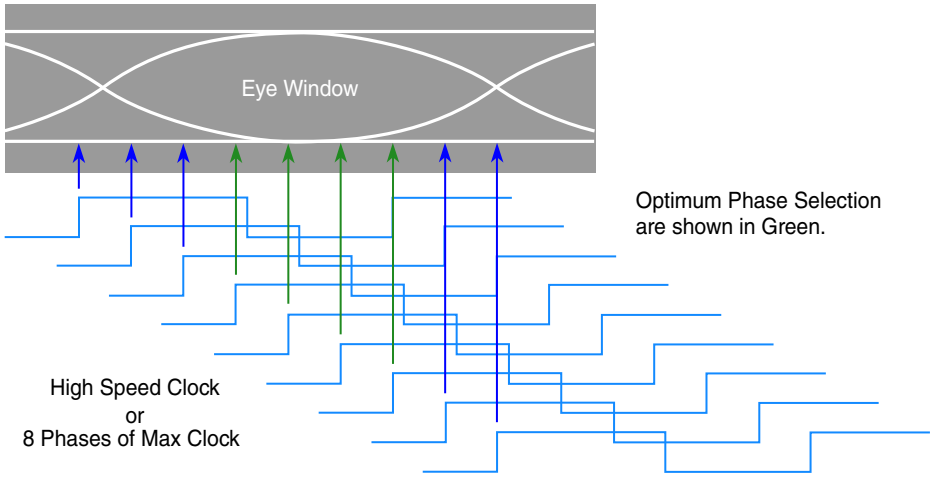


Figure 652. High speed 8 phase selection

The objective of the auto correlation is to select the clock phase that occurs closest to the center of the eye diagram window. For 8 Phase clock alignment the worst case selection is when the clock edge is just after the LR output transition. The 8 clock phases will sample the correct value but the middle clock phases are the ideal selection. If one of the middle phases are selected then the minimum distance to the LR transition is 3 clock phases as shown in the following figure.

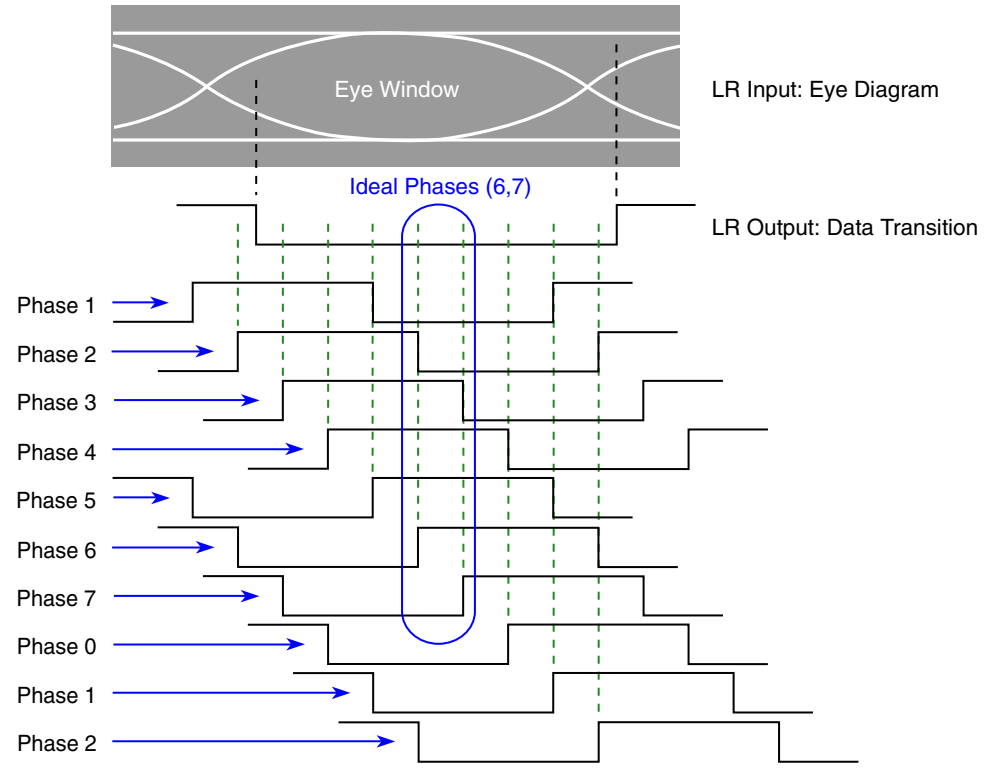


Figure 653. High speed 8 phase clock alignment example

Each of the 8 high speed phases are 45 degrees separated. For 4 phases, whether high or low speed, the phases are 90 degrees separated but can have different phases enabled as shown in Figure 654 and Figure 655.

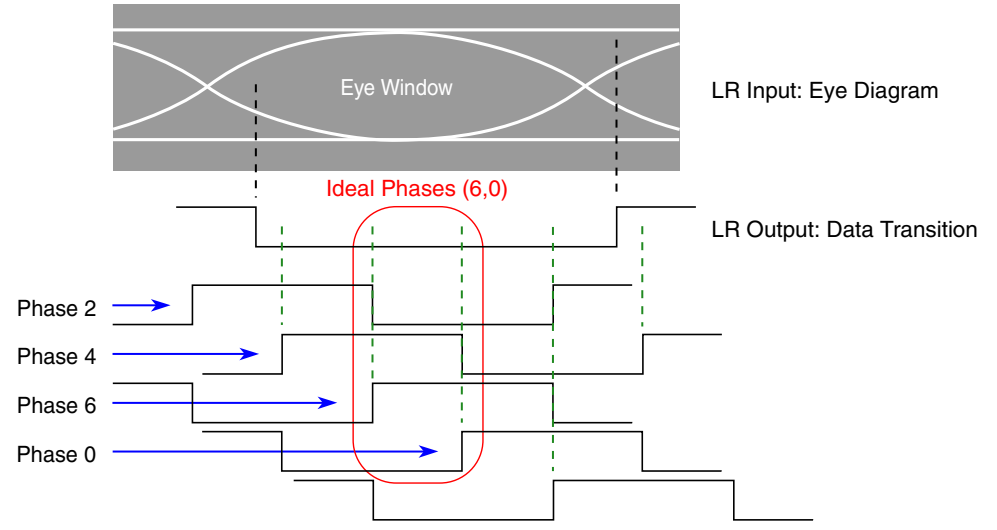


Figure 654. High speed 4 phase clock alignment example

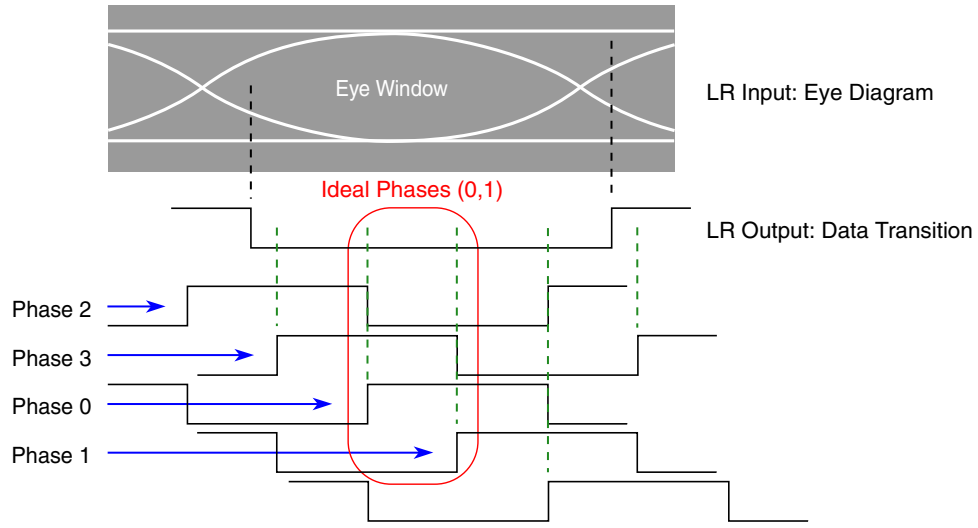


Figure 655. Low speed 4 phase clock alignment example

The auto correlation and selection of the correct clock phase starts after the edge detection finds a 0 to 1 transition. The high speed 8 or 4 phases from the PLL and the low speed 4 phases (generated inside the clocking module) are muxed inside the clocking module. The LFAST interface block will determine which phases are to be enabled and disabled. The only time the interface does not choose the phases is when the clocking module overrides the phase enables using COCR[SMPSEL].

The input data path can be sampled by different samplers depending on the configuration:

- High speed 8-phases: Samplers 0,1,2,3,4,5,6,7
- High speed 4-phases: Samplers 0,2,4,6
- Low speed 4-phases: Samplers 0,1,2,3

Each sampler block samples the data path with a different clock phase from the clocking module, and resamples it to a intermediate phase as shown in Table 737, Table 738, and Table 739 before resampling it to Phase 0. The intermediate phase is used to make static timing between the initial phase and the final phase 0. The final phase, Phase 0 is chosen so all the clock trees after the sampler are clocked by the same clock.

Table 737. High speed 8 phase selection - sampling procedure

Samplers	Initial sample	Intermediate sample	Final Sample
0	Phase 0	Phase 0	Phase 0
1	Phase 1	Phase 0	Phase 0
2	Phase 2	Phase 0	Phase 0
3	Phase 3	Phase 0	Phase 0
4	Phase 4	Phase 2	Phase 0
5	Phase 5	Phase 2	Phase 0
6	Phase 6	Phase 4	Phase 0
7	Phase 7	Phase 4	Phase 0

Table 738. High speed 4 phase selection - sampling procedure

Samplers	Initial sample phase	Intermediate sample phase	Final sample phase
0	Phase 0	Phase 0	Phase 0
1	Disabled	Disabled	Disabled
2	Phase 2	Phase 0	Phase 0
3	Disabled	Disabled	Disabled
4	Phase 4	Phase 2	Phase 0
5	Disabled	Disabled	Disabled
6	Phase 6	Phase 4	Phase 0
7	Disabled	Disabled	Disabled

For High speed 4 Phase selection, See Table 738, Samplers 1, 3, 5, 7 are disabled. In the Phase Select algorithm Phase 1 is mapped to Phase0, Phase 3 is mapped to Phase 2, Phase 5 is mapped to Phase 4, Phase 7 is mapped to Phase 6 so it simplifies the algorithm and allows the algorithm to be the same independent of 4 or 8 Phases in high speed.

Table 739. Low speed 4 phase selection - sampling procedure

Samplers	Initial sample phase	Intermediate sample phase	Final sample phase
0	Phase 0	Phase 0	Phase 0
1	Phase 1	Phase 0	Phase 0
2	Phase 2	Phase 0	Phase 0
3	Phase 3	Phase 0	Phase 0
4	Disabled	Disabled	Disabled
5	Disabled	Disabled	Disabled
6	Disabled	Disabled	Disabled
7	Disabled	Disabled	Disabled

For low speed 4 phase selection, See Table 739, Samplers 4, 5, 6, 7 are disabled. The first four samplers (0,1,2,3) of the low 4 phase speed selection algorithm are the same as the four samplers required for the high 8 phase speed. Therefore the same architecture can be used for both high speed and low speed with the other four data paths disabled for low speed.

83.3.1.2.4 Sampler block and phase enable and disable

There are 8 data sampler paths in total inside the auto correlation block, each data sampler has 3 sampling registers with the possibility of each register being clocked by a different phase (in example, Sampler 5 for high speed can have Phases 5, 2 and 0). Therefore, after the correct data sampler has been selected for either high or low speed, the block can turn off all the sampler paths except for one, therefore 3 out of 24 registers will remain enabled while the others are disabled, as shown in the following figure.

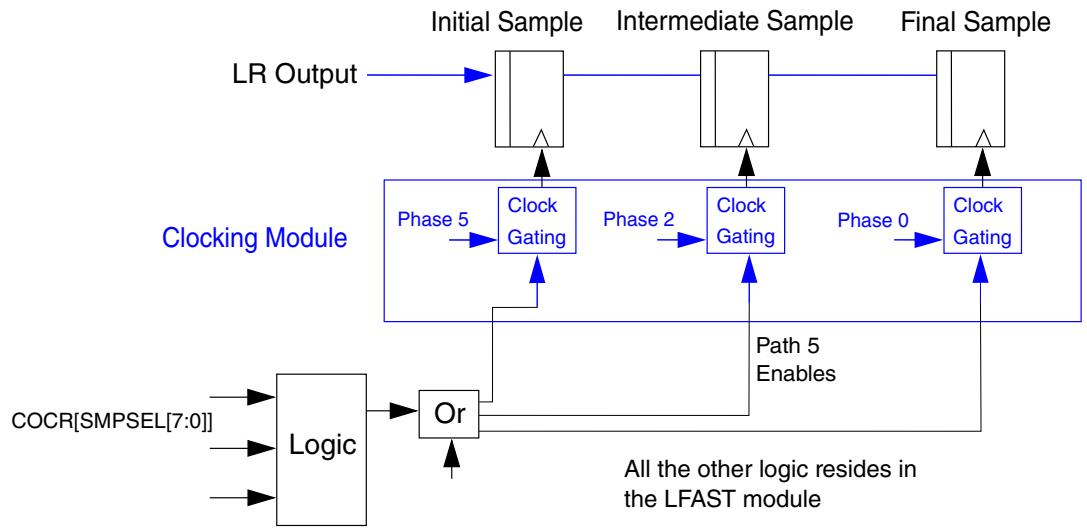


Figure 656. Sampler 5 logic

After correlation and the correct data sampler has been selected all the other data samplers whose initial phase does not match the select phase are disabled. The selected sampler will then keep the required phases needed enabled, this can be max 3 phases (for example, Sampler 5 has Phases 5, 2, 0) or min 1 phase (in example below, Sampler 0 has all Phase 0 content).

The end result is that the Rx Controller can disable the required number of unused sampler registers and disable any unnecessary phases from the clocking module by deasserting the respective phase enables.

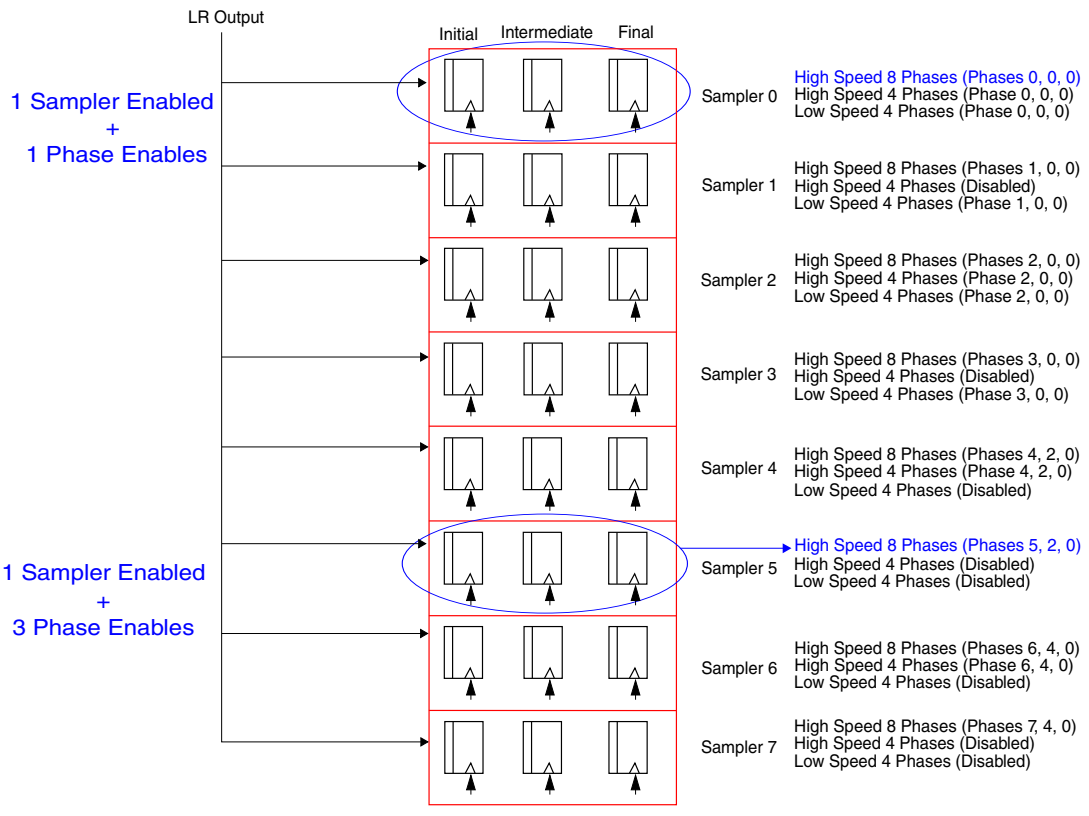


Figure 657. 8 Samplers, each sampler has 3 registers

In order to achieve the sampler and phase enable requirements each Sampler block will require the logic as shown in the following figure.

The Clock gating element resides inside the clocking module block. The interface will provide the enables to the clocking module and the clocking module will in return provide the individual clocks to the sampling registers.

83.3.1.3 Header and payload extraction

Once the Phases/Samplers are chosen after synchronization and correlation the next part of the flow is the header extraction. The Receive Controller will output a 16 bit word, bit shifted every Phase 0 clock as shown in the Figure 658.

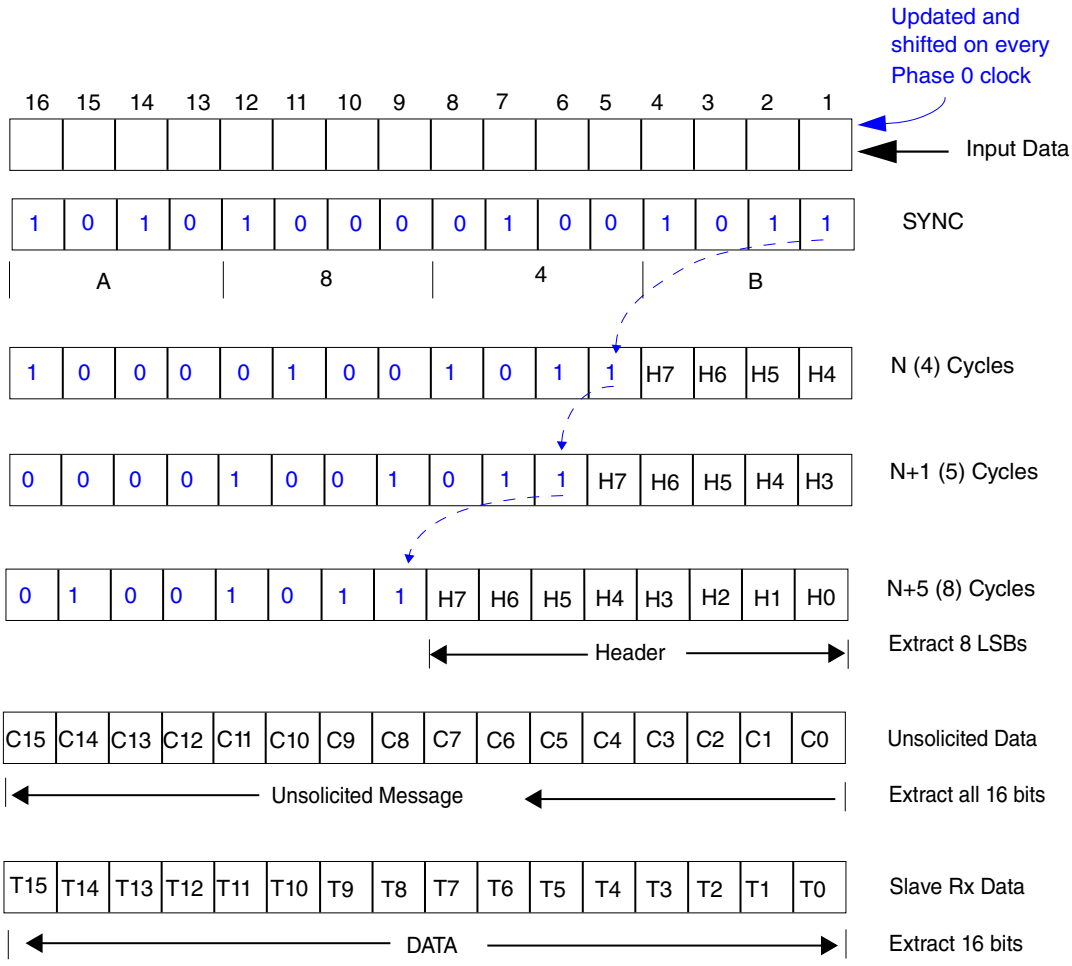


Figure 658. Extracting header and payload from the 16-bit output from auto correlation.

83.3.2 Transmit controller

This section describes the transmit controller.

83.3.2.1 Introduction

The transmit controller uses Rx information, status information and error control data and codes them into the appropriate frame structure for transmission to the LD. This includes the synchronization and header, in preparation for the LD, which transmits the frame to peer LFAST IC at either low or high speed. The transmit controller creates a frame structure that is converted to a serial format for the LD.

An arbitration block will determine which message has higher priority data, unsolicited, ICLC, CTS, ping, and so on. The data frames are extracted from the FIFO controller, the unsolicited message from the register block, the CTS messages from the receive controller and the ping response from the register block.

The Tx interface has two speed modes:

- Low speed
- Fast speed

The transmit controller consists of the following blocks as shown in the following figure.

- Arbitrator
- Framer
- Request Clock Control

The arbitrator will grant access to the framer from the request that has the highest priority. The framer block will extract the payload data from the granted request source and build the frame (adding synchronization or header if required). The frame is fed into a Parallel In Serial Out (PISO) and eventually sent to the LD.

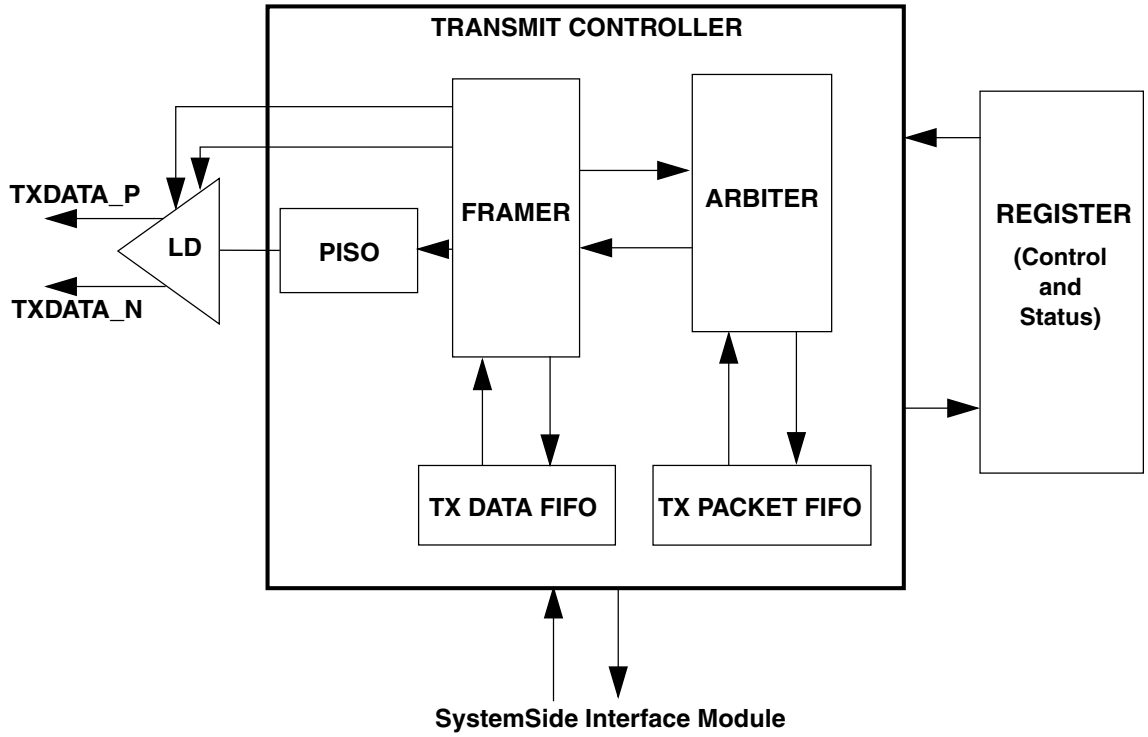


Figure 659. Transmit controller connections

83.3.2.2 Arbitration

The arbitration block prioritizes between requests from multiple sources like

- S/W programmable registers
- System side interface FIFO
- Rx interface controller

The level of priority for each request is shown in Table 740

Table 740. Priority levels for the transmit controller

Request	LFAST master priority	LFAST slave priority	Triggering conditions *(at least one of the listed)*
LFAST interface enable	1	1	• LFAST interface enable is asserted • LFAST interface enable is negated
Tx Interface disabled	2	2	• MCR[DRFEN] = 0 • MCR[TXEN] = 0 • MCR[DRFRST] = 1 • MCR[TXARBD] = 1 • LFAST Slave: ICLC frame with payload for "Disable Rx interface" received
Tx Interface speedmode change	3	3	• SCR[TDR] is modified • LFAST Slave: ICLC frame with payload for changing Rx interface speed received
Loopback frame in Loopback mode	4	4	• TMCR[LPON] = 1Dig • RF Slave: ICLC frame with payload for loopback mode enable received **NOTE** Valid only for following TMCR[LPMOD] settings: LPMOD[2:0] = 011b LPMOD[2:0] = 100b
ICLC frame request	5	-	• LFAST Master: ICR[SNDICLC] = 1 • LFAST Master: ICR[ICLCSEQ] = 1
Ping response request	-	5	• LFAST Slave: ICLC frame with payload for ping request received and PICR[PNGAUTO] = 1 • LFAST Slave: PICR[PNGREQ] = 1
Unsolicited frame request	6	6	• Last Frame with CTS = 1 received from the peer LFAST device • UNSTCR[USNDRQ] = 1
Data frame from Tx FIFO	7	7	• Tx FIFO contains one or more frames • Last Frame with CTS = 1 received from the peer LFAST device • MCR[DATAEN] = 1
CTSFrame	8	8	• MCR[CTSEN] = 1

Table continues on the next page...

Table 740. Priority levels for the transmit controller (continued)

Request	LFAST master priority	LFAST slave priority	Triggering conditions *(at least one of the listed)*
			• Rx FIFO reaches High/Low threshold, defined by TISR and no frame pending
Clock mode test	9	9	• TMCR[CLKTST] = 0 • LFAST Slave: ICLC frame with payload for clock test mode enable received

Once the arbitrator has granted access to a request, the framer will commence building the frame. Any new requests for frame or data rate change will not be granted access until the framer has finished transmitting the current frame. If a data rate change request for the Tx interface is received while the transmit controller is in the middle of sending a frame then the rate change request to the clocking module will be delayed. This allows for the frame to be completed before the change in speed mode. This prevents any speed mode change during the transmission of a frame. Once the speed mode request is sent to the clocking module by the Tx interface controller, it will then not allow any new requests to be processed for a specific time period defined by the bit field RCDCR[DRCNT].

83.3.2.3 Line Driver digital connections

83.3.2.3.1 Line driver states

The LD has the following states:

- Shutdown

  The LD enters the shutdown state when the LD powerdown signal and the output buffer enable is high. In this state, the LD regulator is not supplying power and the LD outputs are connected to ground. Once LD powerdown signal is negated, a settling time is required before the LD may be used for communication.

- Sleep

  The LD enters in sleep state when the signal is asserted. In this state, the LD is enabled, but held in a power-saving state. Sleep mode may be used during inter-frame gaps that are long compared to the frame durations but not long enough to allow the interface(s) or high-speed clock generators to be powered down completely. In the sleep state the LD outputs are connected to Vcm (common mode voltage). To exit from sleep mode the LD sleep signal is negated. The LD is required to transmit a logic 0 level on the interface for a pre-defined minimum time. The minimum time is the summation of settling time of LD after negation of LD sleep signaland the wakeup time of the LR on the other side.

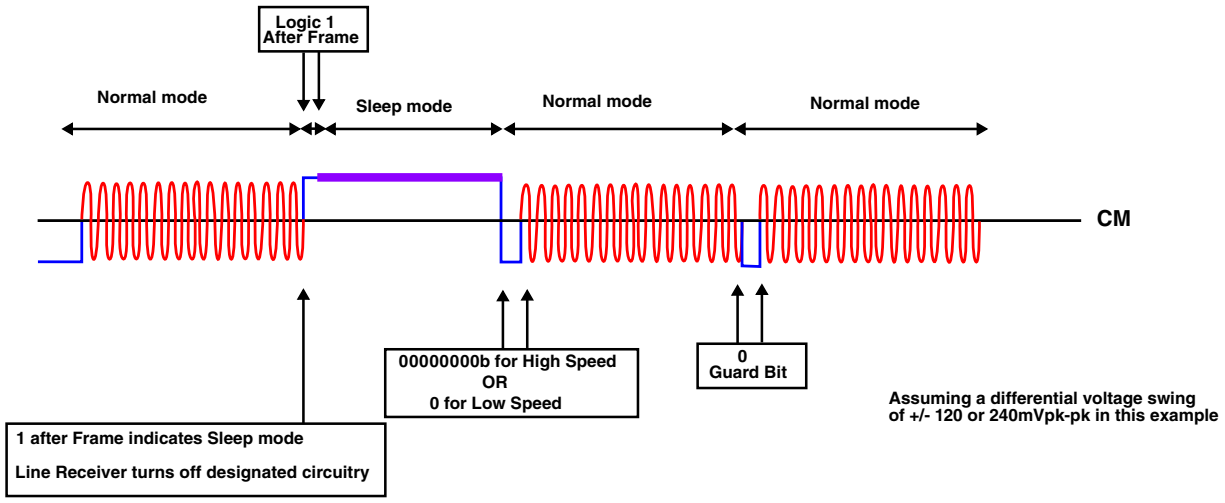


Figure 660. Example of sleep mode

As shown in Figure 660 before every normal mode burst on the txdatap line there is one guard bit period (minimum inter-frame gap) where a logic 0 will be transmitted.

- Normal

  In the normal state the LD is primed for transmission. The LD shall drive the interface as dictated by the input data bit that is supplied by a shift register under the control of a finite state machine. If the LD is not enabled, and the framer is activated, and has a frame to transmit, an interrupt (TISR[TXIEF]) will be generated. The LD moves back to the shutdown state when the LFAST master sends an ICLC Rx data off command.

Table 741. Line driver states

LD state	LFAST master triggers	LFAST slave triggers
Shutdown	• Programing LCR[SWOFFLD] and LCR[SWONLD] • Programing MCR[TXEN] and MCR[DRFEN]	• LFAST interface enable negation/assertion • Programing LCR[SWOFFLD] and LCR[SWONLD] • ICLC command from LFAST master • Programing MCR[TXEN] and MCR[DRFEN]
Sleep	• Programing LCR[SWSLPLD] and LCR[SWWKLD]	• No pending frame for transmission • Programing LCR[SWSLPLD] and LCR[SWWKLD]
Normal	Absence of above mentioned conditions	Absence of above mentioned conditions

83.3.3 CTS mode support

LFAST module supports flow control methods. The CTS is a protocol defined method to ensure no loss of frame, due to Rx FIFO unavailability. The optimal use of bandwidth of LFAST, without losing frames, is ensured by proper programing of the Rx FIFO Lower threshold (RFCR[CTSMN]) and higher threshold (RFCR[CTSMX]). The CTS is supported by both the LFAST Master and Slave.

CTS transmission:

The LFAST device sends CTS information with each frame to the peer LFAST device.

If the CTS mode is enabled by write MCR[CTSEN] = 1 then:

- Sends CTS bit as 0 in LFAST frame (bit[0] of header field) whenever the Rx FIFO reaches the higher threshold defined by the bitfield TISR[CTSMX]. This indicates that the LFAST device doesn't want the peer device to send data. The CTS bit of all frame are sent 0 until the Rx FIFO pointer reaches the lower threshold, as described below.
- Sends CTS bit as 1 in LFAST frame (bit[0] of header field) whenever the Rx FIFO reaches the lower threshold defined by the bitfield TISR[CTSMN]. This indicates that the LFAST device is ready to receive data from the peer device. The CTS bit of all frame are sent 1 until the Rx FIFO pointer reaches the higher threshold, as described above.
- The CTS bit can be sent through any type of frame (data, unsolicited, or ICLC). When there are no frames available in LFAST to send to the peer device, a CTS frame is sent. In this frame, bit[4-1] of header field are sent as 0011b and 8-bit payload of 0.

If the CTS mode is not enabled (for example, bit MCR[CTSEN] = 0) then:

- All the frame sent will have CTS bit as 1 in LFAST frame (bit[0] of Header field).

CTS reception:

The reception of a LFAST frame with CTS bit 0 indicates that the peer device is not ready to receive data frames. The transmission of all pending data and unsolicited frames are postponed until a frame with CTS bit 1 is received.

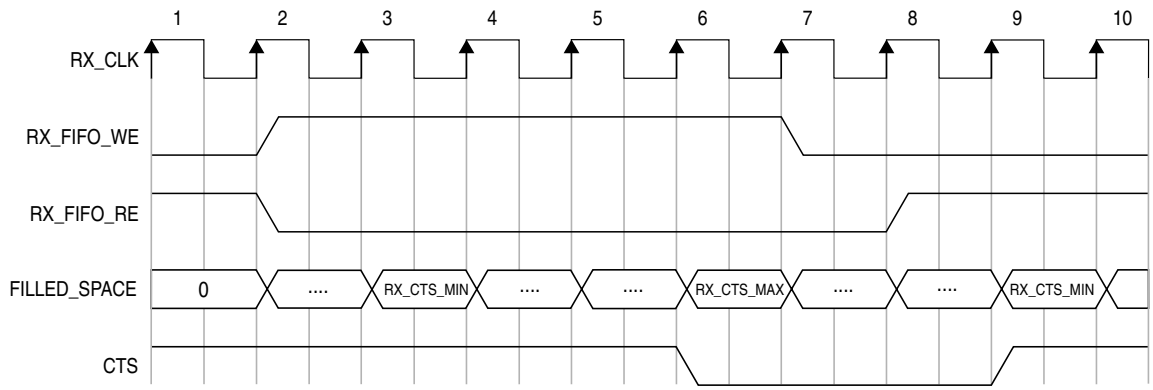


Figure 661. CTS generation

83.3.4 LFAST frame structure

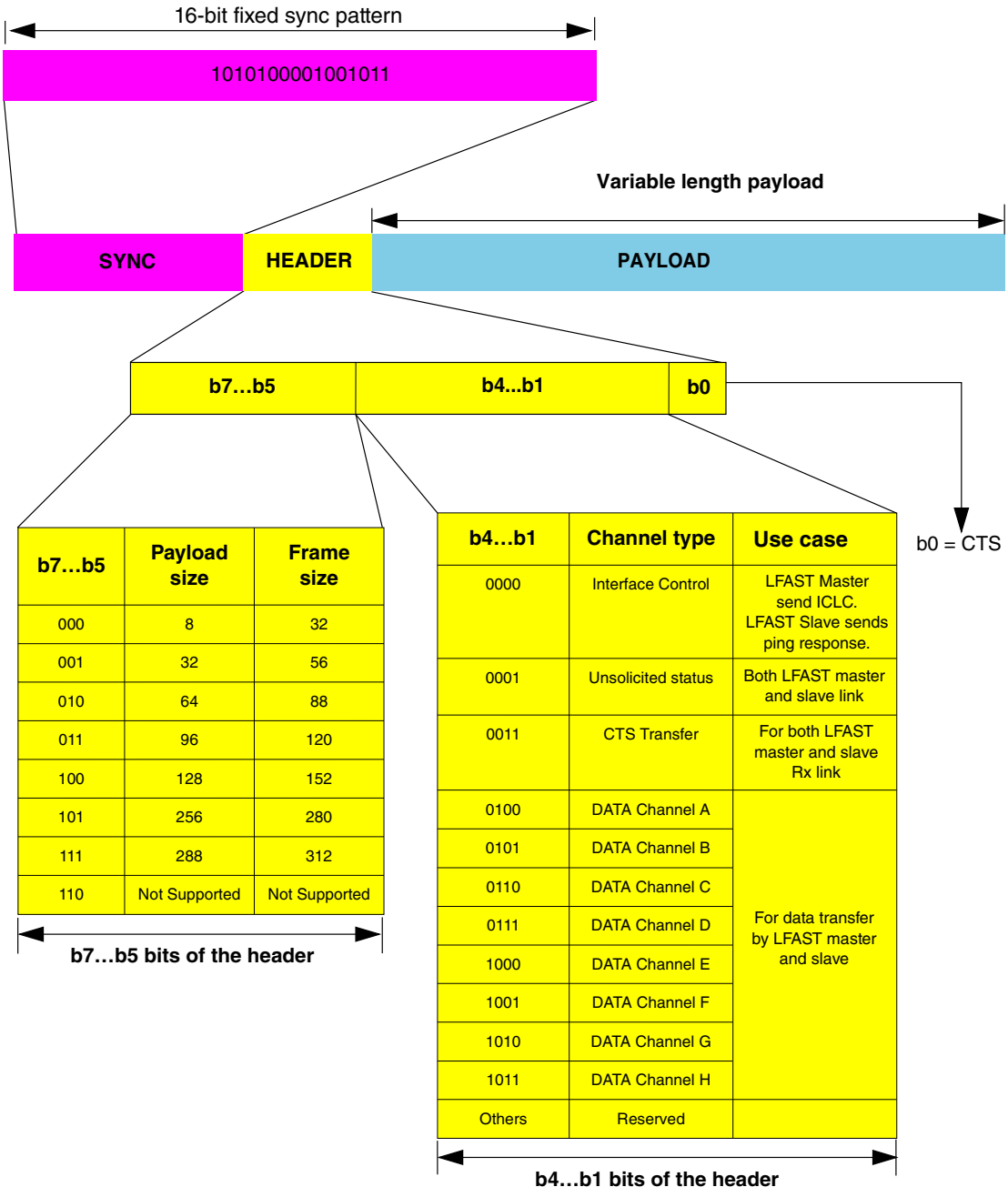
An LFAST frame is made up of three fields:

- Sync pattern
- Header
- Payload

Sync pattern and header fields are of fixed length.

Sync pattern is used to synchronize an incoming data stream in LFAST module.

The header field of the frame distinguishes various types of data and control transferred and also contains information about the length of the payload. The payload field is the actual data that is transferred across the channel. See Figure 662 for details of the LFAST frame.



b7…b5	Payload size	Frame size
000	8	32
001	32	56
010	64	88
011	96	120
100	128	152
101	256	280
111	288	312
110	Not Supported	Not Supported

b4…b1	Channel type	Use case
0000	Interface Control	LFAST Master send ICLC. LFAST Slave sends ping response.
0001	Unsolicited status	Both LFAST master and slave link
0011	CTS Transfer	For both LFAST master and slave Rx link
0100	DATA Channel A	For data transfer by LFAST master and slave
0101	DATA Channel B	
0110	DATA Channel C	
0111	DATA Channel D	
1000	DATA Channel E	
1001	DATA Channel F	
1010	DATA Channel G	
1011	DATA Channel H	
Others	Reserved	

Figure 662. LFAST frame structure

The same protocol is used on both transmit and receive interfaces for communicating data, control, and status information. A synchronization pattern (16 bits) and header (8 bits) are present in every frame.

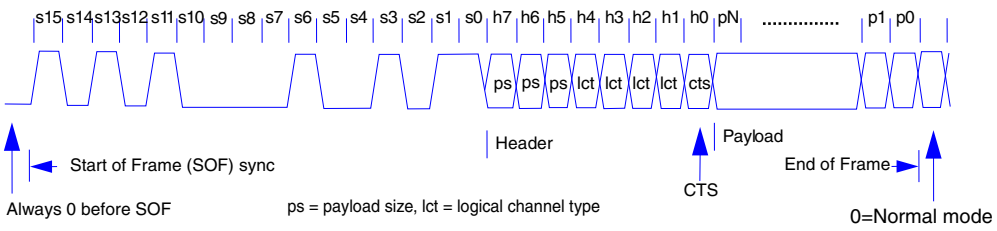


Figure 663. Serial frame structure

The frame structure is shown in Figure 663 and consists of the following:

- **16-bit synchronization pattern:** Used for clock synchronization and pattern recognition. The frame synchronization code at the start of every frame is a unique reserved word that is used to identify whether the data received is the start of the frame and for synchronization (clock phase extraction) with the stream data. A synchronous sequence is used to give a high quality auto correlation. The LFAST 16-bit synchronization sequence = 1010_1000_0100_1011b = A84Bh.
- **Header - 3 MSB (b7 - b5):** Defines the payload size as shown in Table 742:

Table 742. Header payload sizes

b7-b5(bin)	Payload size	Frame size
000	8	32
001	32	56
010	64	88
011	96	120
100	128	152
101	256	280
110	—	—
111	288	312

- **Header - (b4 - b1):** Defines the logical channel types, which indicate the type of payload that the frame carries. How the payload field of a frame is used for any other logical channel type is system side module specific except in the case of the interface control logical channel type and Clear To Send (CTS) frame.
- **Header - (b0):** CTS on the both LFAST master and slave devices.
- **Payload:** Content dependent upon frame type.
- **Bit after frame:** This bit determines entry into Sleep mode (1 = Sleep mode, 0 = normal mode)

83.3.5 Frames supported

Table 743 provides the frames supported and their permissible payload sizes

Table 743. Frames supported by LFAST interfaces

Frame type	LCT code	Supported by 1. LFAST master Tx2. LFAST slave Rx	Supported by1. LFAST slave Tx2. LFAST master Rx	Payload size (bits)
Data Frame	0100b – 1011b	YES	YES	32, 64, 96, 128, 256, 288
Unsolicited Frame	0001b	YES	YES	8, 32, 64, 96, 128, 256 and 288
ICLC Frame	0000b	YES	NO[1]	8
CTS Frame	0011b	YES	YES	8
Reserved	All others	—	—	—

1. Except the ICLC PING response frame.

If logical channel type (LCT) code other than the above mentioned are received then the interrupt flag RISR[RXLCEF] = 1. If the payload size received does not match any value in Table 743 then the flag RISR[RXSZF] = 1. In both these error conditions the received frame is ignored. The S/W may have to take the necessary steps to recover from such an error.

83.3.6 Frame flow

Following sections describe data frame flow, ICLC flow and Rx unsolicited data flow.

83.3.6.1 Data flow

LFAST supports the transfer of data between master and slave LFAST devices.

83.3.6.1.1 Data transmit

System side module is the initiator of all the Tx data frame to LFAST peer device. Data frame transmit is triggered whenever the Tx Data FIFO has at least one valid frame. The MCR[DATAEN], MCR[DRFEN] and MCR[TXEN] bits, should be set to enable the transfer of Tx data.

If MCR[DATAEN] = 0, then the valid frames in the in Tx data FIFO will be ignored for transmission. The payload size and channel type of each frame is specified by the system side module interface during transfer of the frame to the LFAST interface. The frame header is stored in the Tx packet FIFO and the payload in the Tx data FIFO.Whenever the Tx FIFO has at least one frame then a data transmit request is made to the Tx arbiter of the LFAST. Tx block arbitrates the data transmit request and schedules it depending on the priority of all the pending transmit requests. When data request is scheduled by Tx block, the required data is fetched from Tx data FIFO. The number of frames present in the Tx FIFO for transmission is indicated by the bitfield DFSR[TXFCNT].

83.3.6.1.1.1 Programing model for Tx data transmit

1. Program MCR[DATAEN] = 1, MCR[TXEN] = 1 and MCR[DRFEN] = 1 to enable the Tx path of LFAST device
2. Select the desired clock rate at which data should be transmitted, using ICLC transfers and appropriate programing of SCR[TDR] bits.
3. Frame present in TX FIFO (Data and Packet FIFO) are sent.
4. TISR[TXDTF] = 1 after each frame transfer
5. CTS is set depending on the push/pull mode setting defined by MCR[CTSEN].

83.3.6.1.2 Data receive

LFAST master and slave supports reception of data frame. The received frame is determined to be of data frame type by decoding channel type field of the header present in the received frame. The MCR[DATAEN], MCR[RXEN] and MCR[DRFEN] bits should be set to enable the data frame reception. When MCR[DATAEN] = 0 the received data frames will be ignored and will not be placed in the Rx data FIFO.

The Rx data frames received by Rx block are stored in the Rx FIFO. Whenever the frame is received in the Rx FIFO the system side module is indicated by assertion of LFAST Rx FIFO ready signal. The frame size and the channel type is passed to the LFAST. The frame boundaries are indicated by start of frame and end of frame signals. The number of unread frames in the Rx Data FIFO are indicated by DFSR[RXFCNT]. When Rx DATA FIFO is full and cannot accommodate current frame completely, then the remaining data of the Rx frame is discarded. In this case, UNSRSR[RXOF] = 1 and an interrupt is generated if the RIER[RXOFIE] = 1.

83.3.6.2 Unsolicited flow

83.3.6.2.1 Unsolicited frame transmit flow

The S/W is the initiator for unsolicited frames to the LFAST peer device. The unsolicited frame header and payload is programed into the unsolicited data and control registers. Once the payload is programed UNSTCR[USNDRQ] is set, generating a request for unsolicited frame transfer to the Tx arbiter.

83.3.6.2.1.1 Programing model for unsolicited frame transmit

1. Program MCR[TXEN] = 1 and MCR[DRFEN] = 1 in the Mode Configuration Register (MCR) to enable the Tx path
2. Select the desired clock rate at which data should be transmitted, using ICLC transfers and appropriate programing of SCR[TDR].
3. Read the UNSTCR[USNDRQ].
   - If UNSTCR[USNDRQ] = 1 then wait for either of the following:
     - UNSTCR[USNDRQ] = 0
     - TISR[TXUNSF] = 1
   - If UNSTCR[USNDRQ] = 0 then:
     - Program the unsolicited payload in UNSTDR0–UNSTDR8, and can be written up to a payload of frame of a maximum of 288 bits.
     - Program the unsolicited frame header in UNSTCR[UNSHDR].
     - Program UNSTCR[USNDRQ] = 1.
4. UNSTCR[USNDRQ] is cleared by the Tx block after the frame transfer.
5. TISR[TXUNSF] = 1 when the frame is transmitted.
6. CTS is set depending on the Push-Pull mode setting defined by MCR[CTSEN].

83.3.6.2.2 Unsolicited frame receive flow

Whenever an Unsolicited frame is received from the peer device, the following steps are performed:

If UNSRSR[URXDV] = 0 then:

1. The payload size field of the header is first saved into the UNSRSR[URPCNT].
2. The payload is stored in the UNSTDR0–UNSTDR8.
3. UNSRSR[URXDV] = 1 and the RISR[RXUNSF] = 1 indicating the successful reception of the frame.

If UNSRSR[URXDV] = 1 then:

1. The current unsolicited frame is ignored.
2. RISR[RXUOF] = 1.

Typical steps by the processor after RISR[RXUNSF] = 1 is as follows:

1. The processor reads UNSRSR to get the payload size of the frame.
2. It then reads the complete frame by reading UNSRDR8–UNSRDR0 for the payload size as received in the frame.
3. Then it clears the interrupt (write RISR[RXUNSF] = 1) and also the UNSRSR[URXDV] bit.

83.3.6.3 ICLC flow

The Interface Control Logical Channel (ICLC) is a separate logical channel type, which is mainly meant for implementing the data rate change in the LFAST interface and initiating the test modes.

83.3.6.3.1 ICLC data transmit flow

Whenever the processor intends to transfer an ICLC frame to the LFAST slave then the following steps are to be followed.

1. Write the ICLC frame payload in the ICR[ICLCPLD] (see Table 744 for payloads as defined by the standard).
2. Program ICR[SNDICLC] = 1 to initiate the ICLC frame transfer. This bit clears itself when the ICLC frame has been transmitted. The processor needs to poll this bit to make sure it is cleared before setting this bit again (even when ICR[ICLCSEQ] = 1).
3. TISR[TXICLCF] = 1 after the transfer of the ICLC frame.
4. CTS is set depending on the Push-Pull mode setting defined by MCR[CTSEN].

To determine whether the ICLC frame has been sent or not, either the ICR[SNDICLC] bit can be polled, or wait for TISR[TXICLCF] = 1.

Table 744. Supported ICLC payloads

ICLC code(hex)	ICLC function
00	Ping Request from LFAST Master to LFAST Slave
01	Reserved
02	Start PLLIn preparation for High Speed mode
04	Stop PLL Fallback to low speed mode
08	Select RxData Slow (LFAST Slave Rx Interface)
10	Select RxData Fast (LFAST Slave Rx Interface)
20	Select TxData Slow (LFAST Slave Tx Interface)
40	Not Supported
80	Select TxData Fast (LFAST Slave Tx Interface)
31	Enable TxData Interface (LFAST Slave Tx Interface)
32	Disable TxData Interface (LFAST Slave Tx Interface)

Table continues on the next page...

Table 744. Supported ICLC payloads (continued)

ICLC code(hex)	ICLC function
34	Clock Test mode Send 101010… continuously using the currently configured clock rate (slow, fast);
FF	Turn payload loopback on
38	Turn Test mode (Loopback and Clock Test) off

Programing model for ICLC frame transmit:

1. Set the ICR[ICLCSEQ] bit (optional).
2. Write the ICLC frame payload in the ICR[ICLCPLD], corresponding to the desired Tx/Rx data rate change, as described in the Table 744.
3. Write ICR[SNDICLC] = 1 to initiate the ICLC frame transfer.
4. LFAST master will schedule the ICLC transfer. Data present in ICR[ICLCPLD] is transmitted to the LFAST slave at the old Tx data rate. LFAST slave will configure its Tx/Rx interface data rate accordingly.
5. Reset the ICR[ICLCSEQ] to allow the scheduling of other types of frames, which will be sent at the new data rate.

When ICR[ICLCSEQ] = 0, though the ICLC frame transfer still has highest arbitration priority, other frames may be scheduled if no valid ICLC frame request exist.

NOTE

ICLC frame transmit will not trigger the internal data rate change of LFAST master Tx/Rx interface. LFAST master Tx/Rx interface data rate will only be changed, when corresponding SCR[TDR] and SCR[RDR] bits are appropriately configured.

Processor requires to take care that no data frames are to be transmitted while data rate change is happening or ICLC is transmitting frames by setting ICR[ICLCSEQ] bit in Table 744.

83.3.6.3.2 ICLC data receive flow

When the bits 4 to 1 of a receive frame are 0000b it indicates that the payload is an ICLC. ICLC payloads are always 8 bits.

The reception of an ICLC frame is indicated by an interrupt to the system. The ICLC status register RISR indicates the type of the ICLC frame received. The Rx block will decode and generate the appropriate signals. An invalid ICLC code besides the ones listed in Table 744 will cause RISR[RXICF] = 1.

83.3.6.3.2.1 Ping request ICLC

The LFAST slaves ICLC decoder will decode the ping request and set RIISR[ICPRF]. The S/W can also write to PICR[PNGREQ] to indicate to the Tx block that a ping response frame needs to be transmitted. The PICR[PNGAUTO] indicates whether Tx block can respond automatically to the request by the LFAST master ICLC ping request frame. The Tx block will arbitrate the ping response frame request and send a ping frame with ping data defined by bitfield PICR[PNGPLYD]. Once the ping response frame has been sent the Tx block will set TISR[TXPNGF] and clear PICR[PNGREQ], if set.

83.3.6.3.2.2 LFAST slaves RxData interface slow/fast ICLC

The LFAST slaves Rx Interface has two speed modes supported: slow (low speed) and fast (high speed). The ICLC command will write RIISR[ICRSF] = 1 (low speed) or RIISR[ICRFF] = 1 (high speed).

83.3.6.3.2.3 LFAST slaves TxData interface slow/fast ICLC

The LFAST slaves Tx interface controller has two speed modes: slow (low speed), and fast (high speed). The ICLC command will write RIISR[ICTSF] = 1 (low speed) or RIISR[ICTFF] = 1 (high speed).

83.3.6.3.2.4 Enable/disable LFAST slaves TxData interface ICLC

The ICLC commands, enable RxData interface and disable RxData interface are decoded and the appropriate enable/disable signal sent to the Tx block Controller. These ICLC command writes RIISR[ICTEF] = 1 and RIISR[ICTDF] = 1. The ICLC Tx enable command will write MCR[TXEN] = 1.

No frames can be sent on the LFAST slave Tx interface until the either LFAST master has enabled it via an ICLC frame or S/W programs MCR[TXEN] = 1.

83.3.6.3.2.5 Clock test mode ICLC

This ICLC command is decoded, and then is used to write TMCR[CLKTST] = 1. This indicates to the Tx interface to output an alternating pattern of 1 and 0 at the currently configured clock rate. The Rx interface generates RIISR[ICCTF] = 1 on reception of this ICLC command.

The exit from this mode happens on reception of test mode off ICLC command.

83.3.6.3.2.6 Loopback payload on ICLC

This ICLC command is decoded and TMCR[LPON] = 1 to indicate to the Tx Block that the received payload is to be sent back. The exit from this mode happens on reception of Test mode off ICLC command. The Rx interface causes RIISR[ICLPF] = 1 on reception of this ICLC command.

83.3.6.3.2.7 Test mode off ICLC

This ICLC command is decoded and TMCR[LPON] and TMCR[CLKTST] are cleared to indicate to the Tx block to exit from loopback mode or clock test mode.

Another option is for the payload loopback option to remain enabled until negated on the toggling of LFAST interface enable.

83.3.6.3.2.8 Ping response ICLC

The LFAST master considers any ICLC frame payload as ping response data. The LFAST masters Rx block will store the received ping data in PISR[RXPNGD] and match it with PICR[PNGPYLD]. RIISR[ICPSF] = 1 if the ping received matches with the one stored in PICR[PNGPYLD], or RIISR[ICPFF] = 1.

83.3.6.4 CTS flow

83.3.6.4.1 CTS Tx flow

The CTS frame, if enabled by the S/W, indicates the status of the receive data FIFO. CTS frame is triggered whenever Rx Data FIFO reaches either the high/low threshold and no data, ICLC or unsolicited frame is ready for transmission.

Programing model for CTS frame transmit:

- Program RFCR[CTSMX] and RFCR[CTSMN].
- Enable the CTS frame transmission by programming MCR[CTSEN] = 1.
- Program MCR[TXEN] = 1 and MCR[DRFEN] = 1 to enable the Tx path.
- The CTS bit sent with a valid frame (for example, data, ICLC, and unsolicited) is 1 until the Rx data FIFO reaches high threshold.
- When the Rx Data FIFO reaches higher threshold and no valid frame (data, ICLC, and unsolicited) is pending for transmission, then the CTS frame is triggered, with CTS bit of header = 0 and the status bit RISR[RXMXF] = 1.

- When the Rx data FIFO reaches low threshold, due to system side reads and no valid frame (data, ICLC, and unsolicited) is pending for transmission, then the CTS frame is triggered, with CTS bit of header = 1, and status bit RISR[RXMNF] = 1.

83.3.6.4.2 CTS Rx flow

Whenever a CTS frame header or any other frame with valid header is received with CTS bit = 0, then RISR[RXCTSF] = 1. The Tx Interface arbitration for unsolicited frame and data frame transmit request is turned off on reception of frame with CTS bit 0. The arbitration for unsolicited frame and data frame is enabled on reception of frame with CTS bit 1. Frame with LCT type CTS are not stored in the LFAST.

83.3.7 Test and debug support

The test and debug interface helps to debug the LFAST module. These signals can be brought out for ease of validation.

83.3.7.1 Loopback test mode

The loopback function allows to verify the correct operation of the physical interface and the basic checks for the LFAST module without a peer device.

There are certain prerequisites before entering the Loopback mode:

- LD and LR should be turned on.
- Tx and Rx mode should be enabled.
- Interrupts needed for S/W should be enabled.
- Both Tx and Rx interface should be in same speed mode.
- For automatic test mode TMCR[LPFRMTH] should be programed.

The LFAST module supports four loopback modes, defined by TMCR[LPMOD].

Table 745. Loopback modes

LPMOD[2:0]	Mode selected
000	Rx Loopback (default)
001	Rx LVDS Loopback
010	Tx Loopback without Automatic frame generation
011	Tx Loopback with Automatic frame generation
100	Tx LVDS Loopback (external) with Automatic frame generation

The TMCR[LPON] bit controls the state of the loopback function, and the default setting is 0 (off). This can be written by S/W, or in the case of the LFAST slave, the TMCR[LPON] bit can be modified by the Rx interface controller on decoding of a valid ICLC loopback on or test mode off commands. The LPMOD should not be changed when the LPON bit is set.

In all loopback modes, except Tx loopback without automatic frame generation, the decoding of frame and error flags is stopped. Only decoding of following is done:

- ICLC turn test mode off frame.
- CTS bit of all frames.
- Automatic loopback frame decoding (only in automatic frame generation mode).

83.3.7.1.1 Rx loopback mode

For Rx loopback mode the output of the LR is passed to the LD with manipulation via the Rx and Tx interface controllers. CTS bit (Bit 0) of the header is guaranteed to be asserted when the incoming data from the other device is looped back. In Rx Loopback mode the Rx interface controller operates in normal mode, decoding the frames (header, payloads). This allows the LFAST master to control the loopback mode on and off by sending ICLC commands.

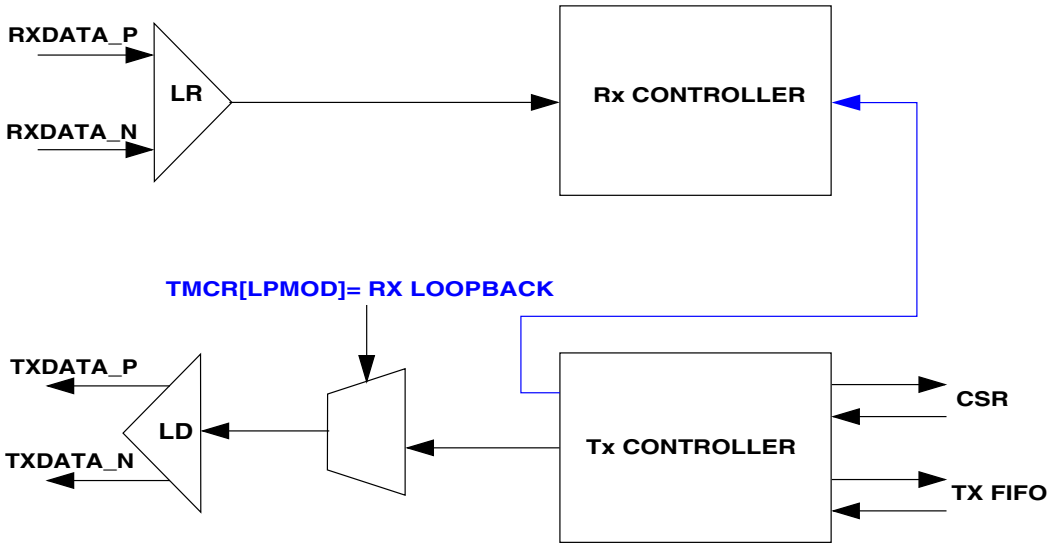


Figure 664. Rx loopback mode

Entry to Rx loopback mode:

1. S/W programs TMCR[LPMOD] = 000b.
2. Loopback can be turned on by either of the following methods:
   - S/W programs TMCR[LPON] = 1.
   - For slave only: - Reception of ICLC Frame with payload FFh (loopback mode on), from LFAST master.

Exit from Rx loopback mode can be done by any of the following methods:

- S/W programs TMCR[LPON] = 0.
- For LFAST Slave: - Transmission of ICLC Frame with payload 38h (test mode off), from LFAST master.

The peer LFAST device is required to maintain at least 2-bit IFG between two loopback frames in this mode.

83.3.7.1.2 Rx LVDS loopback mode

This loopback mode is provided to verify and characterize the LVDS pads. In this loopback mode the data received by LFAST on Rx LVDS input is loopback to Tx LVDS output, bypassing LFAST. For LVDS loopback the output of the LR is passed to the LD via "Rx LVDS LoopBack Mux". Bit 0 of the header cannot be guaranteed to be asserted when the incoming data from the other device is looped back. In this loopback, the Rx interface controller operates in normal mode, decoding the frames (header, payloads) but the Tx Interface Controller is ignored.

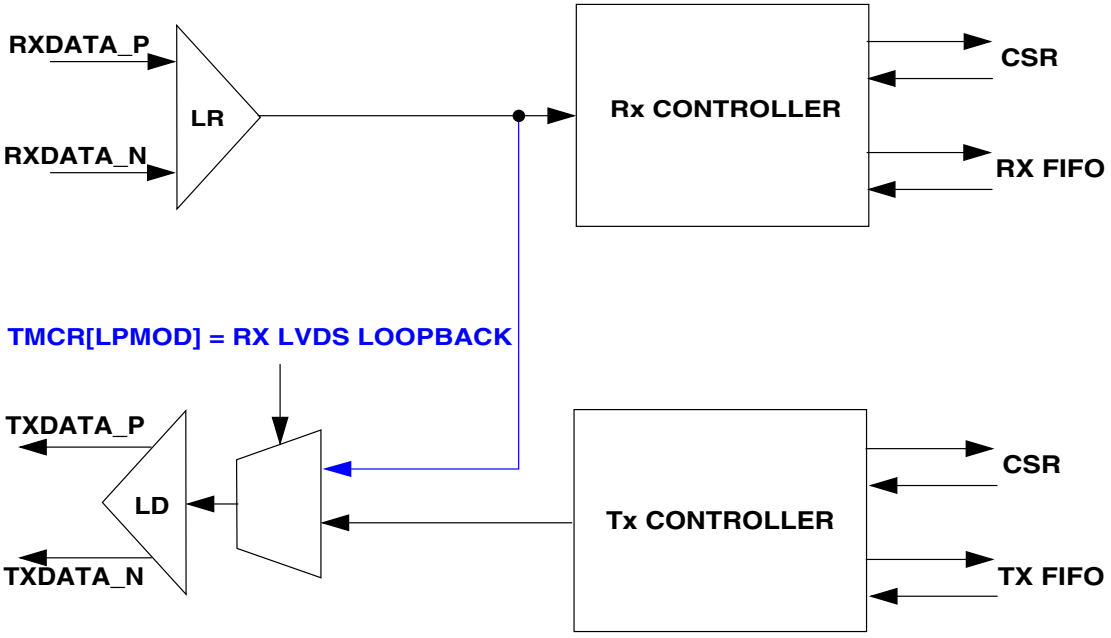


Figure 665. Rx LVDS loopBack mode

Entry to Rx LVDS loopback mode:

1. S/W programs TMCR[LPMOD] = 001b.
2. Loopback can be turned ON by either of the following methods:
   - S/W writes TMCR[LPON] = 1.
   - For slave Only: - Reception of ICLC Frame with payload = FFh (loopback mode ON), from LFAST master.

Exit from Rx LVDS loopback mode can be done by any of the following methods:

- S/W programs TMCR[LPON] = 0.
- For LFAST slave:
  - Transmission of ICLC frame with payload 38h (test mode off), from LFAST master.

83.3.7.1.3 Tx loopback mode without automatic frame generation

This loopback mode is provided to verify the LFAST functionality, if LVDS pads are not functional. In this loopback mode the data transmitted by LFAST on Tx LVDS output is loopbacked internally on Rx LVDS input, bypassing LVDS pads.

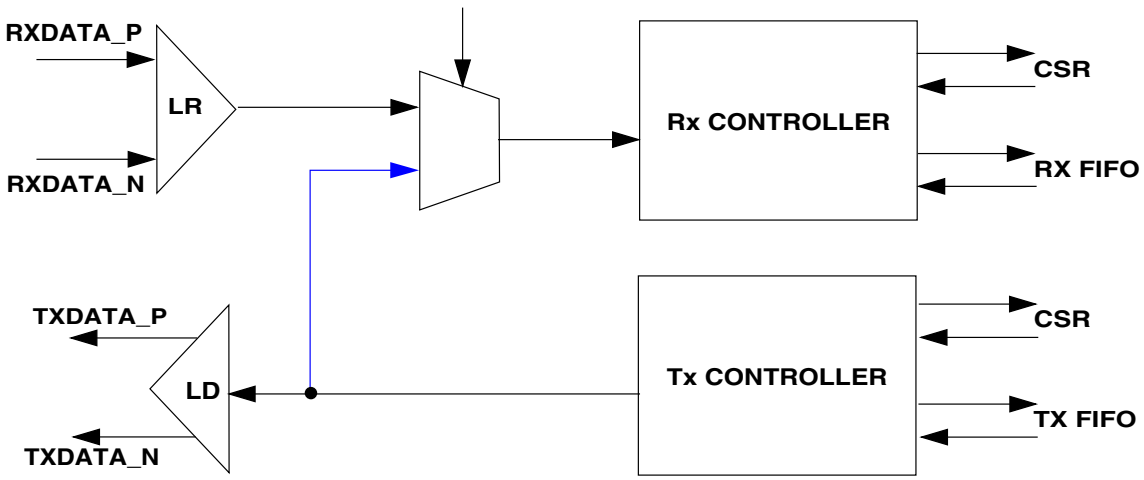


Figure 666. Tx loopBack mode without automatic frame generation

Entry to Tx loopback without automatic frame generation mode:

1. S/W programs TMCR[LPMOD] = 010b.
2. Loopback can be turned on by either of the following methods:
   - S/W programs TMCR[LPON] = 1.
   - For slave only: Reception of ICLC frame with payload FFh (loopback mode on), from LFAST master

Exit from Tx loopback without automatic frame generation mode can be done by any of the following methods:

- S/W programs TMCR[LPON] = 0.
- For LFAST slave: Reception of ICLC frame with payload 38h (test mode off), from Tx interface (using unsolicited frame).

All frames and error flags are decoded in this mode.

83.3.7.1.4 Automatic frame generation

The LFAST module supports two loopback modes where pre-defined frames are generated automatically by the Tx interface and Rx interface indicates its successful reception by dedicated signals and status registers. These modes are defined for BIST like check for the LFAST, with minimal S/W intervention.

The Control register used for these modes are:

- ALCR[LPCNTEN] defines whether fixed number of auto loopback frames to be transmitted.
- ALCR[LPFMCNT] defines the number of loopback frames to be transmitted if ALCR[LPCNTEN] = 1.

The Status signals and register used for these modes are:

- GSR[LPCSDV]: Valid synchronization received.
- GSR[LPCHDV]: Frame with header of 13h received.
- GSR[LPCPDV]: Frame with payload of CBh received.
- GSR[LPTXDN]: Number of Auto loopback frame transmitted with valid synchronization, header (13h) and payload (CBh) is equal to ALCR[LPFMCNT].

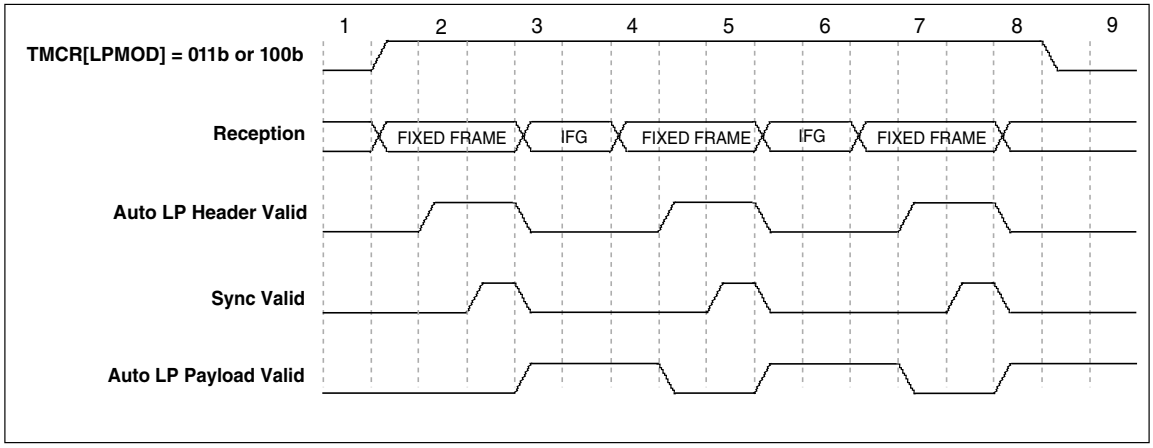


Figure 667. Automatic loopback test status signal timings

The two loopback with automatic frame generation modes are:

1. Tx loopback with automatic frame generation
2. Tx LVDS (external) with automatic frame generation

83.3.7.1.4.1 Tx loopback mode with automatic frame generation

When TMCR[LPMOD] = 011b (Tx loopback mode with automatic frame generation) the frames are generated by the Tx Interface. This mode helps to validate the Tx and Rx Path with minimal intervention from the S/W. The frames generated have fixed header of 13h and payload of CBh. The successful reception of this frame is indicated by the status signals and registers.

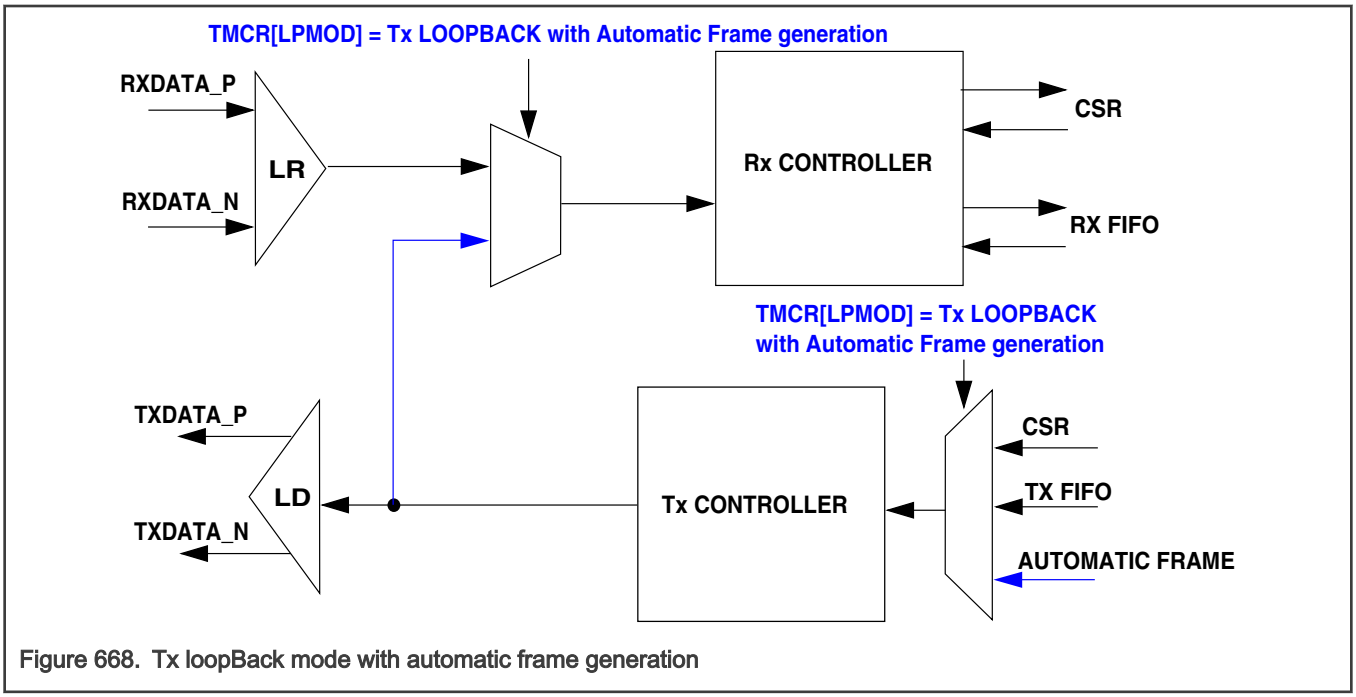


Figure 668. Tx loopBack mode with automatic frame generation

Entry to Tx loopback with automatic frame generation mode:

1. S/W programs TMCR[LPMOD] = 011b.
2. Loopback can be turned on by either of the following methods:
   - S/W programs TMCR[LPON] = 1.

- For slave only: Reception of ICLC frame with payload FFh (loopback mode on), from LFAST master.

Exit from Tx Loopback with automatic frame generation mode can be done by any of the following methods:

- S/W programs TMCR[LPON] = 0.

83.3.7.1.4.2 Tx LVDS loopback (external) mode with automatic frame generation

In this mode the LD/Tx controller is used to test the LR/Rx controller. The idea is to use a test frame (predefined) from the Tx controller out through the LD, loopback completed on the DUT-board (LD connected to LR via a transmission line), back into the LR, synchronized, and correlated in the Rx controller and compared to what was sent in the downlink controller.

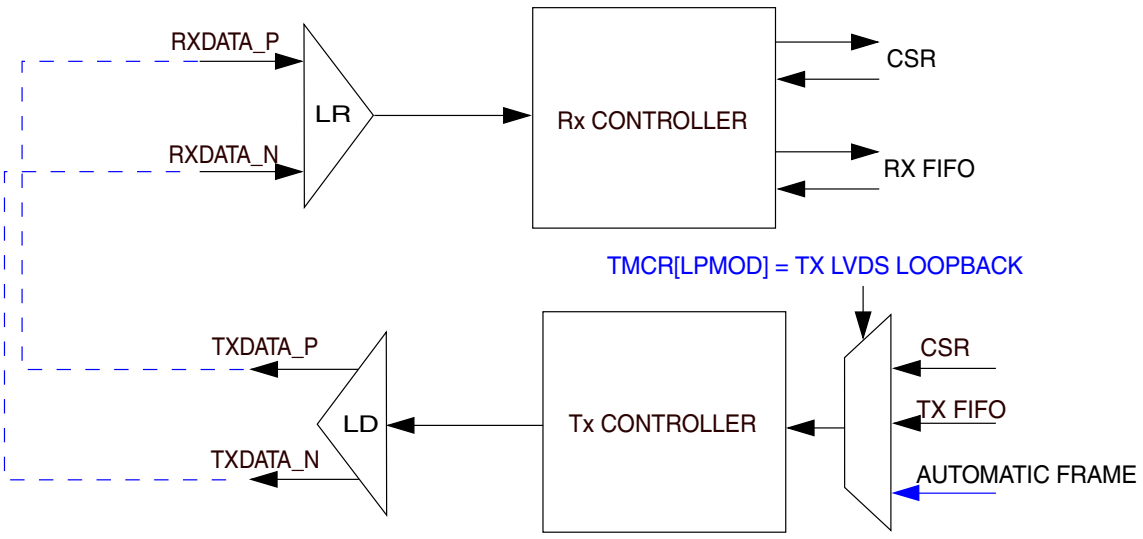


Figure 669. Tx LVDS loopback (external) mode with automatic frame generation

Entry to Tx LVDS loopback with automatic frame generation mode:

1. S/W programs TMCR[LPMOD] = 100b.
2. Loopback can be turned on by either of the following methods:
   - S/W programs TMCR[LPON] = 1.
   - For slave only: Reception of ICLC frame with payload FFh (loopback mode on), from LFAST master

Exit from Tx LVDS loopback with automatic frame generation mode can be done by the following method:

- S/W programs TMCR[LPON] = 0.

83.3.7.2 Clock test mode

The bit TMCR[CLKTST] enables or disables the clock test mode of the LFAST module. In this mode the LFAST sends fixed pattern out on the LD at the current configured RxData clock rate. It is a RWM bitfield and the default setting is 0 (off). This bit can be set under one of the following conditions:

- S/W programs TMCR[CLKTST].

The Tx Controller will send out a pattern of alternating 1 and 0 (pattern 101010...). This provides a divide by 2 test clock of the current Tx clock.

The clock test mode can be canceled by either of the following methods:

- S/W programs TMCR[CLKTST] = 0.
- For LFAST slave: Reception of ICLC frame with payload 38h (Test mode off) from LFAST master.

In clock test mode the Tx controller does not output any synchronization pattern or header, just a pattern of alternating 1's and 0's.

This mode doesn't affect the functionality of the Rx interface.

83.3.8 Clocks

The LFAST mainly works on three clocks:

- System bus clock used to program the registers.
- Protocol clock, which is either high speed PLL clock or low speed clock depending on the speed mode, used for LFAST protocol operation.
- System side module clock, which is synchronous to the system bus clock.

83.3.8.1 Clocking strategy

The following figure shows the clock domain in which each module functions. The PLL provides eight phases of the high speed clock to the Clock muxing portion of the CCM. The Clock Module will then generate four phases of slow speed clock using both the edges of lfast_sysclk, muxes high speed and low speed clocks and provides a muxed clock to the Sampler Module.

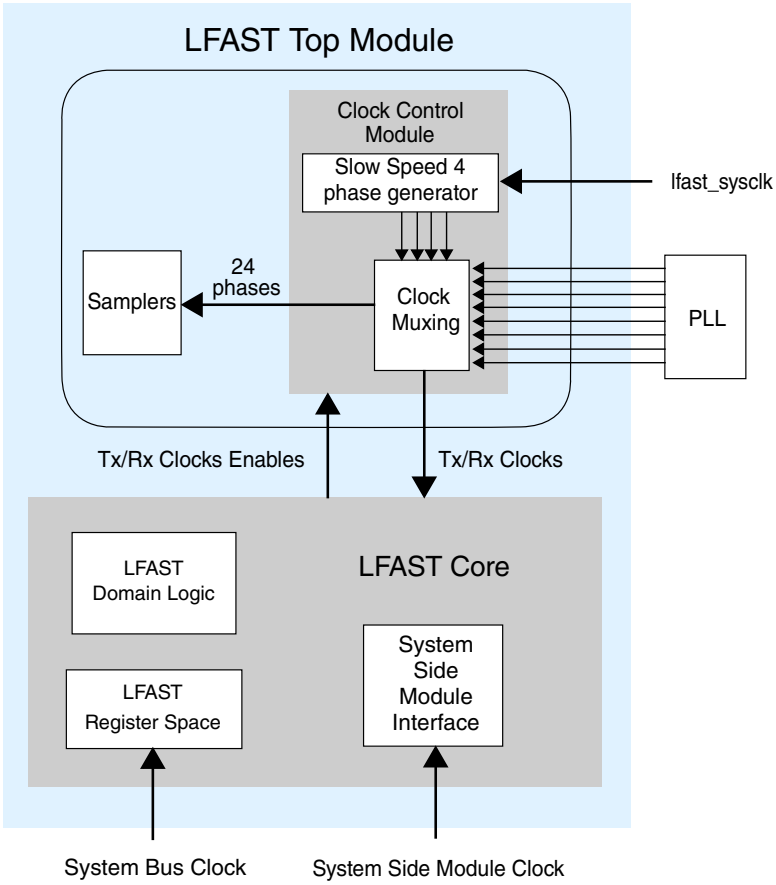


Figure 670. LFAST module clock domains

83.3.8.2 Slow speed clock

83.3.8.2.1 External muxing

The CCM will receive lfast_sysclk from the clocking subsystem as shown in Figure 671, Figure 672 and Figure 673.

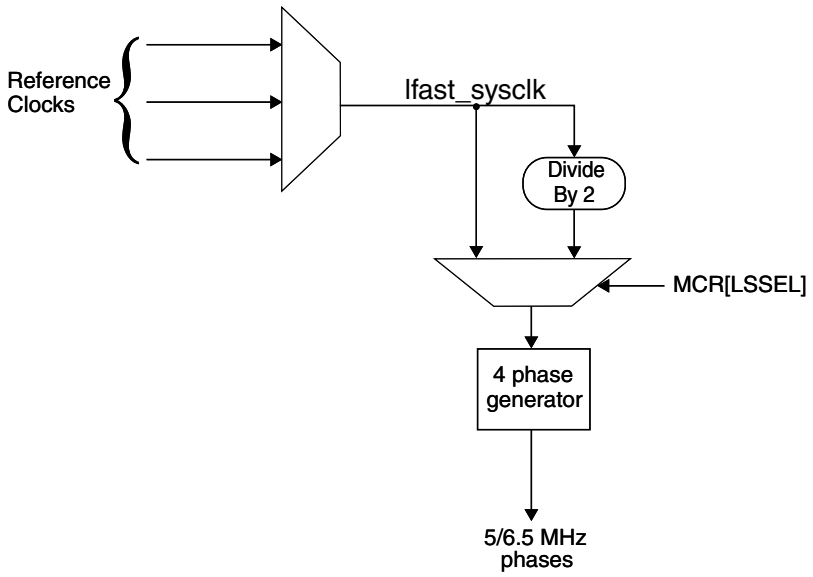


Figure 671. External clock muxing of lfast_sysclk

All the reference clocks will be muxed first to provide lfast_sysclk to the module and then either div/2 or direct muxed clock will be used to generate 4 slow speed phases in the CCM of LFAST as shown in Figure 671.

The lfast_sysclk could be either 20/26 MHz or 10/13 MHz. When lfast_sysclk is 20/26 MHz frequency, the clock control module will generate 4 phases of slow speed clock of frequency lfast_sysclk/4 when MCR[LSSEL] = 1. If lfast_sysclk is 20/26 MHz it needs to be first divided by 2 before using it for 4 phase generation in LFAST Clock Module, which generates 4 phases of half of the input frequency as shown in Figure 672 (selected clock path shown in green).

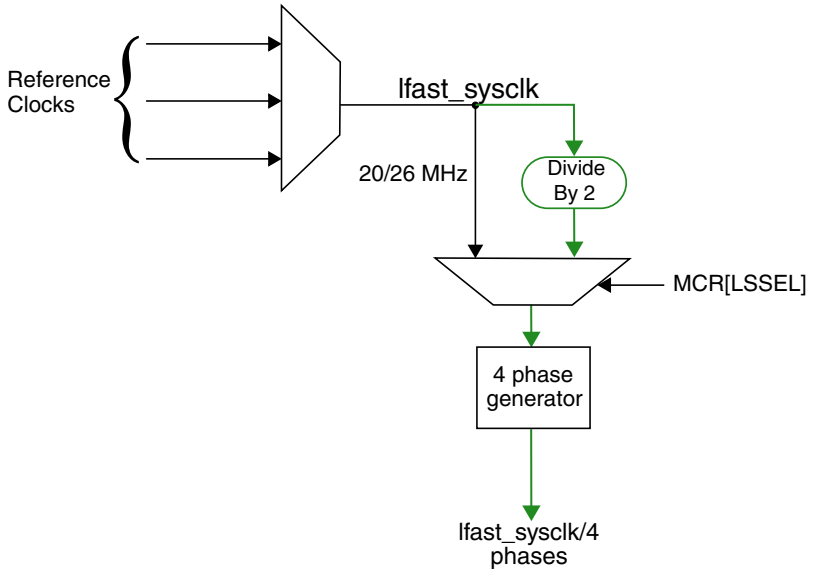


Figure 672. External clock muxing of lfast_sysclk of 20/26 MHz

In this case, lfast_sysclk is 10/13 MHz frequency, the clock control module will generate 4 phases of slow speed clock of frequency lfast_sysclk/2 when MCR[LSSEL] = 0. If lfast_sysclk is 10/13 MHz then it does not need to be first divided by 2 before using it for 4 phase generation in LFAST Clock Module, which generates 4 phases of half of the input frequency as shown in Figure 673 (selected clock path selected shown in magenta).

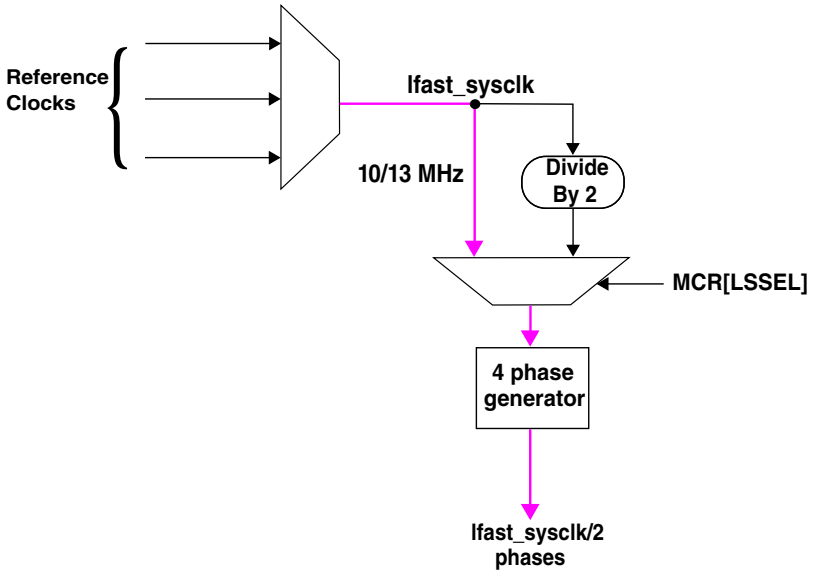


Figure 673. External clock muxing of lfast_sysclk of 10 MHz

83.3.8.2.2 Slow speed 4 phase generator

CCM will generate 4 phases of slow speed clock of frequency of 10/13 MHz. For instance, if lfast_sysclk is 10 MHz then 4 phases of 5 MHz will be generated. The following figure shows 4 phases getting generated using lfast_sysclk.

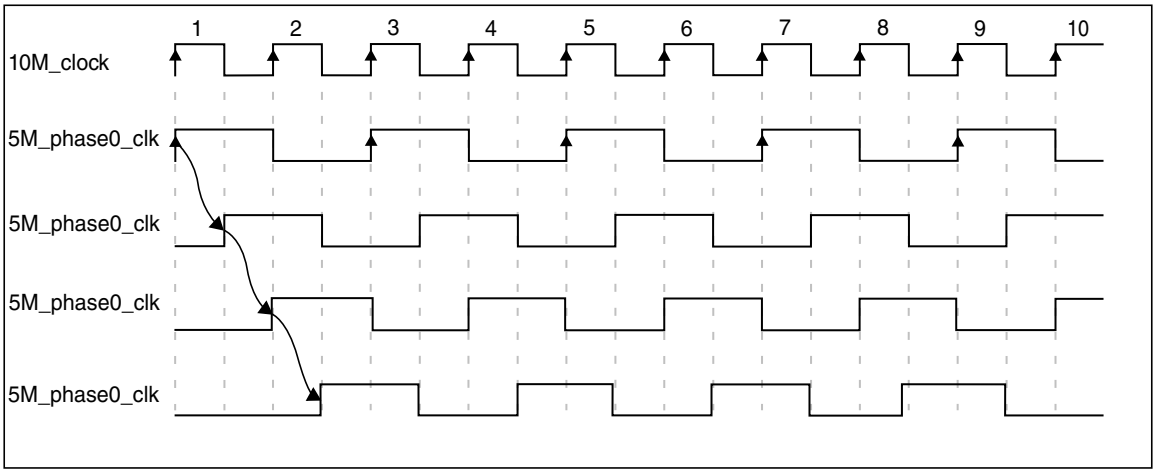


Figure 674. Slow speed 4 phases generation

83.3.8.3 Clocking module requirements for high speed phases

The high speed phases are obtained from the PLL via the Clocking Module as shown in the following figure.

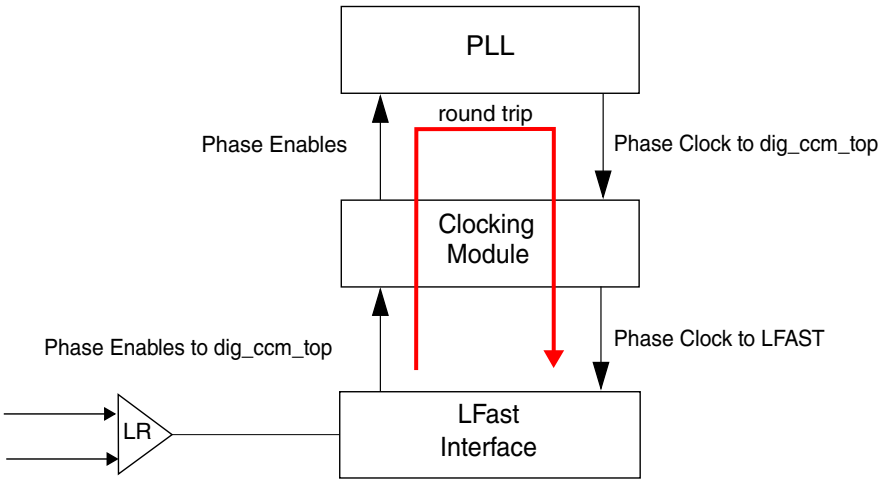


Figure 675. Clock enables and clock paths

The LFAST block will know which of the phases will be required for the different modes of operations. Therefore the LFAST block will provide enables and speed mode switches to the clocking module. The clocking module will use these signals to control the enables to the clock phases to reduce the power consumption.

The 8 phases of clocks signal are fed to the clocking module and muxed with the low speed phases. Depending on enables and data rate speed modes, the selected clocks are passed to the Sampler block and interface block.

COCR[PHSSEL] is connected to the clocking module, which selects whether 8 or 4 phases are selected for high speed mode. It is only valid for high speed.

The routing of the 8 high speed phases to the interface is critical. Each clock phase will need to have the same routing track length from the PLL to the interface of clocking module. Each of the 8 high speed phases are separated by 45 degrees. This separation needs to be maintained from the phase generator to the interface.

83.3.8.4 Clock module requirements for low speed phases

83.3.8.4.1 Low speed

The low speed clock phases are generated in clocking module. These four phases are required to sample the data correctly at low speed mode. The LFAST block will provide the enable for the phases. The clock source for the low speed phases is SYSCLK. The clocking module block will need to generate the 4 phases of low speed clock 90 degrees apart.

Using the low speed mode on the interface allows the polyphase generation logic to be turned off and the requirement of high-speed-freq × 8 MHz clock from the PLL is not needed.

Table 746. Rx clocks summary

Rx speed mode	Source
Low Speed	lfast_sysclk
High Speed	PLL

83.3.8.5 Tx controller clocks

83.3.8.5.1 Clocking module requirements for speed phases

The low speed phase 0 clock is sourced from the lfast_sysclk and the high speed phase 0 clock is sourced from the PLL. See the following table.

Table 747. Tx clocks summary

Tx speed mode	Source
Low Speed	lfast_sysclk
High Speed	PLL

83.3.8.5.2 Transmit clock muxing

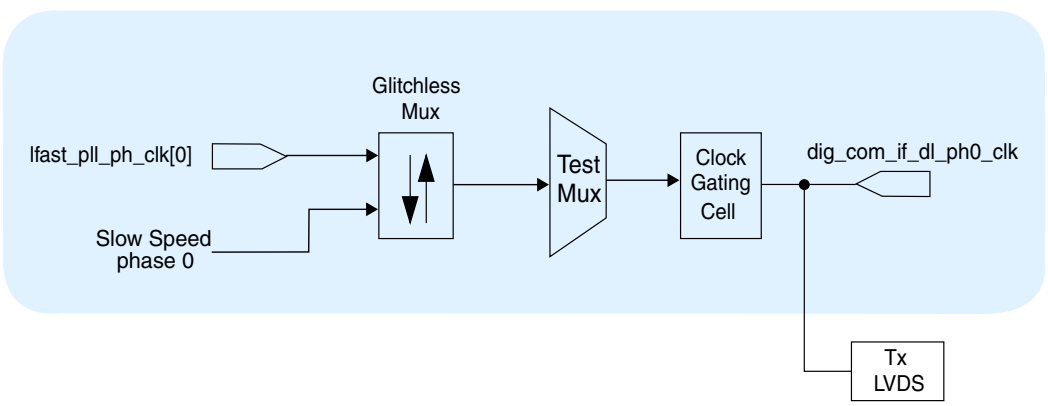


Figure 676. Transmit Clocks Muxing

83.3.8.5.3 Tx request clock control

The Tx phase 0 clock is enabled when all the resets are negated.

83.3.9 Resets

The various blocks in LFAST are reset as described in the table below.

Table 748. Recommended receive exception handling mechanism

Reset	Blocks reset
Asynchronous hardware reset	Polarity: active low • Clock Control Module (CCM) • LFAST domain logic (Rx and Tx block) • System side module interface FIFOs • LFAST register space
DRFRST bit of Mode Configuration Register (MCR)	Polarity: Active High • Clock control module (CCM) • LFAST domain logic (Rx and Tx block) • System side module interface FIFOs • LFAST register space

Table continues on the next page...

Table 748. Recommended receive exception handling mechanism (continued)

Reset	Blocks reset
DRFEN bit of Mode Configuration Register (MCR)	Polarity: active low • Clock control module (CCM) • LFAST domain logic (Rx and Tx block) • System side module interface FIFOs • LFAST Status Registers • SCR[RDR] and SCR[TDR] • TMCR[CLKTST] and TMCR[LPON] • ICR[ICLCSEQ] and ICR[SNDICLC] • PICR[PNGREQ] • UNSTCR[USNDRQ]

83.3.10 Interrupts

The LFAST module generates five interrupts to the processor:

- Transmit complete interrupt
- Transmit exception interrupt
- Receive complete interrupt
- Receive exception interrupt
- ICLC receive interrupt

Each interrupt is asserted when any one of their status conditions is met.

83.3.10.1 Transmit complete interrupt

This interrupt indicates a transfer completion of a frame. This interrupt is asserted whenever any of the following bits are set in the TISR and also the corresponding mask bits are set in the TIER.

- TXDTF
- TXICLCF
- TXUNSF
- TXPNGF

Each of these bits can be individually maskable. So, those bits that are not required to generate an interrupt to the processor can be masked. Once the interrupt is asserted, it can be negated by clearing the corresponding flag bit in the TISR.

83.3.10.2 Transmit exception interrupt

This interrupt indicates occurrence of an exception condition in the Tx block. This interrupt is asserted whenever any of the following bits are set in the TISR along with the corresponding mask bits in the TIER.

- TXOVF
- TXIEF

Each of these bits can be individually masked. So, those bits that are not required to generate an interrupt to the processor can be masked. Once the interrupt is asserted, it can be negated by clearing the corresponding flag bit in the TISR.

Table 749. Recommended transmit exception handling

Exception	Recommendation
TXOVF	• MCR[TXEN] = 0 • The system level interfaces transmit is reset and enabled again • For Slave: After reception of ICLC Ping Response Request the MCR[TXEN] may be set • For Master: The MCR[TXEN] should be set and an ICLC frame Ping Response Request should be sent
TXIEF	• The MCR[TXEN] should be set

83.3.10.3 Receive complete interrupt

This interrupt indicates a reception of a frame. This interrupt is asserted whenever any of the following bits is set in the RISR along with the corresponding interrupt enable bit is also set in the RIER.

- RXCTSF
- RXDF
- RXUNSF

Each of these bits are individually maskable. So, the bits that are not required to generate an interrupt to the processor can be masked by clearing its bit in the RIER. Once the interrupt is asserted, it can be negated by clearing the corresponding flag bit in the RISR.

83.3.10.4 Receive exception interrupt

This interrupt indicates occurrence of an exception condition in Rx block. This interrupt is asserted whenever any of the following bits is set in the RISR and corresponding enable mask bit is also set in the RIER.

- RXLCEF
- RXICF
- RXSZF
- RXUOF
- RXUFF
- RXMXF
- RXMNF
- RXOFF

Each of these bits are individually maskable. So, those bits that are not required to generate an interrupt to the processor can be masked by clearing the appropriate bit in the RIER. For details on the cause of assertion of each bit refer to the RISR description. Once the interrupt is asserted, it can be negated by clearing the corresponding flag bit in the RISR.

Table 750. Recommended receive exception handling mechanism

Exception	Recommendation
RXLCEF	The MCR[RXEN] may be set and cleared, as this exception can result in loss of subsequent packet

Table continues on the next page...

Table 750. Recommended receive exception handling mechanism (continued)

Exception	Recommendation
RXICF	No action required
RXSZF	The MCR[RXEN] may be set and cleared, as this exception can result in loss of subsequent packet
RXOFF	• The MCR[RXEN] may be cleared • The system level interfaces receive may be reset and enabled, as current transfer may be corrupted
RXUFF	No action required
RXMXF	The system level interfaces receive should be enabled, if not enabled
RXMNF	No action required
RXUNSF	No action required

83.3.10.5 ICLC receive interrupt

This interrupt indicates reception of a valid ICLC frame. This interrupt is asserted whenever any of the following bits is set in the RIISR along with the corresponding enable bit mask bit is set in the RIIER.

- ICPONF
- ICPOFF
- ICTSF
- ICTFF
- ICRSF
- ICRFF
- ICTEF
- ICTDF
- ICCTF
- ICLPF
- ICTOF
- ICPRF
- ICPSF
- ICPFF

Each of these bits are individually maskable. So those bits that are not required to generate an interrupt to the processor can be masked. For details on the cause of assertion of each bit, refer RIISR. Once the interrupt is asserted, it can be negated by clearing the corresponding flag bit in RIISR.

83.3.11 Packet memory

The LFAST stores packet frames for transmission, and reads packet frames after reception. The transmitter has its own dedicated buffer and the receiver has it own dedicated buffer, and they are not shared between each other.

Table 751. Frames supported by LFAST interfaces

Frame type	Tx buffer(in bits)	Rx buffer(in bits)	Memory type
Data frame	38 × 32 max 6 packets	38 × 32 max 6 packets	FIFO
Unsolicited frame	9 × 32 max 1 packet	9 × 32 max 1 packet	Registers UNSTD[8-0], UNSRDR[8-0]
ICLC frame	1 × 7 max 1 packet[1]	1 × 8 max 1 packet[2]	Registers ICR, PISR
CTS frame	N/A	N/A	N/A

1. Only for MCR[MSEN] = 1
2. Only for ping response data when MCR[MSEN] = 1

83.4 External signals

LFAST is a five-pin interface with the following signals :

- lfast_sysclk
  - Reference clock of the LFAST master and slave.
- txdatap/txdatan
  - Differential transmit (Tx) interface pair.
- rxdatap/rxdatan
  - Differential receive (Rx) interface pair.

LFAST interface is an asynchronous high speed LVDS interface.

83.4.1 LFAST operating data rates

The change of data rate is controlled by the LFAST master by issuing appropriate Interface Control Logical Channel (ICLC) packets to the LFAST slave. In this document, the data rate 6.5Mbps /5Mbps (lfast_sysclk ÷ 4 or lfast_sysclk ÷ 2) is referred to as the low data rate. The high data rate is in the data sheet.

83.5 Initialization

The LFAST requires a sequence of operations before it can be used for communication. The procedure to enable LFAST for proper operation is listed in the following figure.

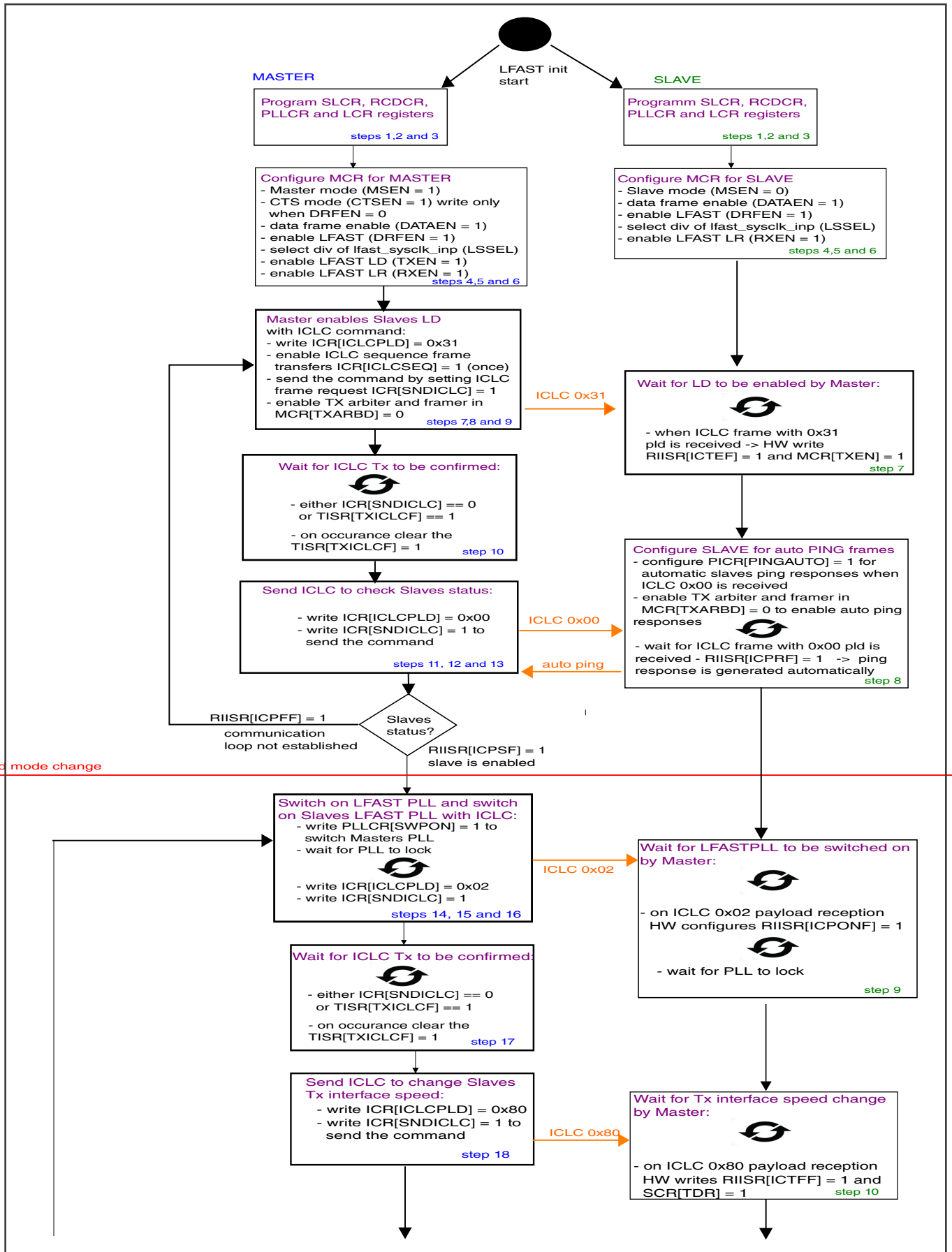


Figure 677. Startup procedure (sheet 1 of 2)

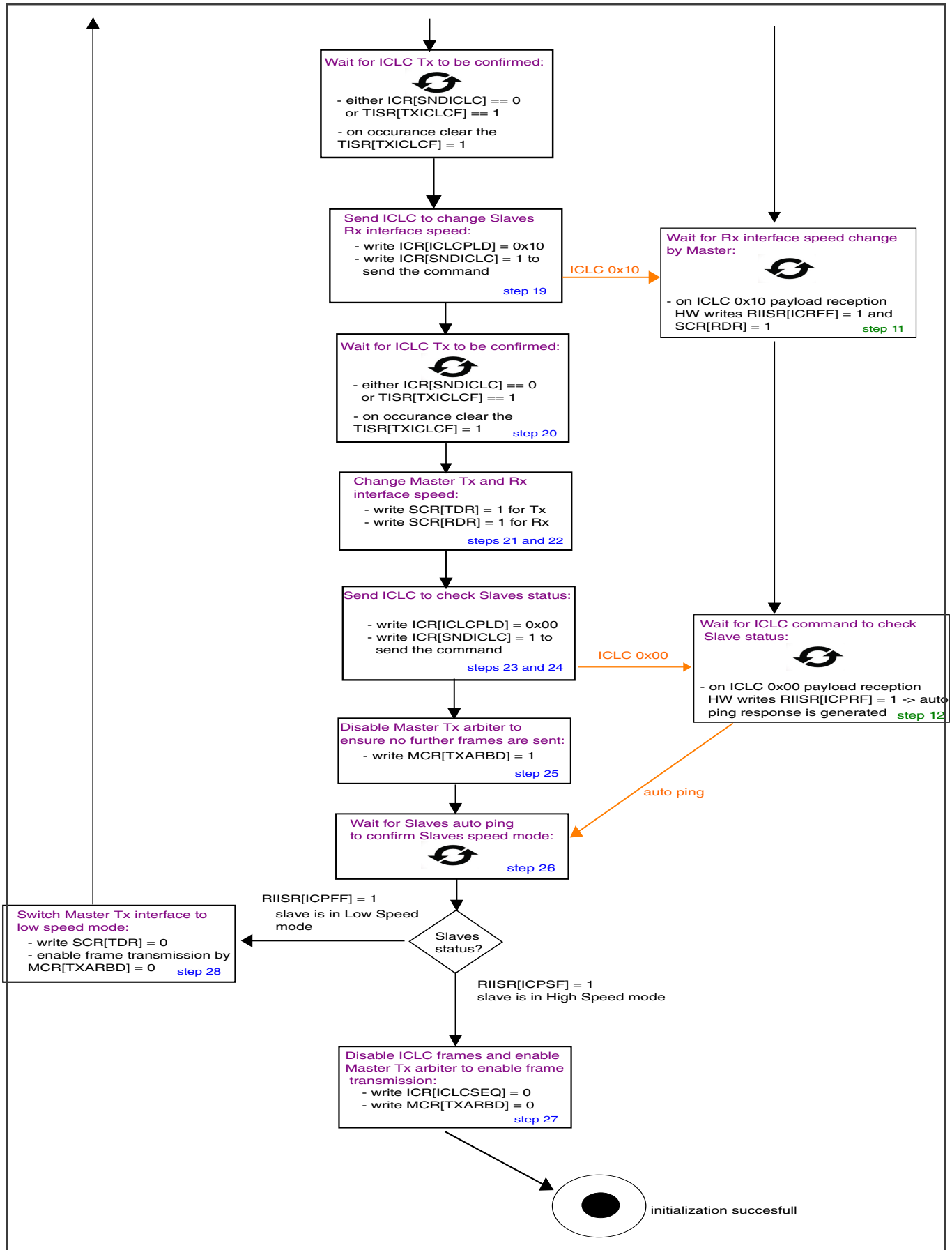


Figure 678. Startup procedure (sheet 2 of 2)

83.6 PLL configuration example

Assume that the frequency of the high speed clock is 320 MHz, with a reference clock having a frequency of 20 MHz. Follow these steps to configure the LFAST high-speed clock:

1. Write 20h to PLLCR[FBDIV] and 0b to PLLCR[FDIVEN] for the feedback division factor.
2. Write 01b to PLLCR[PREDIV] for the division factor to divide the PLL reference clock input by 2.
3. Write 1b to PLLCR[SWPON] for switching on the PLL.

You must wait for:

1. PLLLSR[PLLDIS] to become 0, indicating that the PLL is enabled.
2. PLLLSR[PLDCR] to become 1, indicating that the PLL is locked and ready for use.

The formula for calculating the PLL output frequency, with fraction divider on, is as follows:

$$\text{PLL Clock} = \left(\frac{\text{clk_in}}{\text{PLLCR[PREDIV]}}\right) \times (\text{PLLCR[FBDIV]} + 0.5) \qquad \text{where PLLCR[FDIVEN]=1}$$

The formula for calculating the PLL output frequency, with fraction divider off, is as follows:

$$\text{PLL Clock} = \left(\frac{\text{clk_in}}{\text{PLLCR[PREDIV]}}\right) \times (\text{PLLCR[FBDIV]}) \qquad \text{where PLLCR[FDIVEN]=0}$$

83.7 LFAST register descriptions

All registers are 32 bits wide.

NOTE

- Read/Write accesses to all unimplemented registers and write accesses to Read only register will return a Transfer Error.

83.7.1 LFAST memory map

digrf_top base address: 404F_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	LFAST Mode Configuration (MCR)	32	RW	0000_0010h
4h	LFAST Speed Control (SCR)	32	RW	0001_0000h
8h	LFAST Correlator Control (COCR)	32	RW	0000_000Eh
Ch	LFAST Test Mode Control (TMCR)	32	RW	0000_0000h
10h	LFAST Auto Loopback Control (ALCR)	32	RW	0000_0000h
14h	LFAST Rate Change Delay Control (RCDCR)	32	RW	000F_0000h
1Ch	LFAST ICLC Control (ICR)	32	RW	0000_0000h
20h	LFAST Ping Control (PICR)	32	RW	0000_80CAh
2Ch	LFAST Rx FIFO CTS Control (RFCR)	32	RW	000F_0009h

Table continues on the next page...

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Offset	Register	Width (In bits)	Access	Reset value
30h	LFAST Tx Interrupt Enable (TIER)	32	RW	0000_0000h
34h	LFAST Rx Interrupt Enable (RIER)	32	RW	0000_0000h
38h	LFAST Rx ICLC Interrupt Enable (RIIER)	32	RW	0000_0000h
3Ch	LFAST PLL Control (PLLCR)	32	RW	See section
40h	LFAST LVDS Control (LCR)	32	RW	0000_5004h
44h	LFAST Unsolicited Tx Control (UNSTCR)	32	RW	0000_0000h
48h - 68h	LFAST Unsolicited Tx Data Registers (UNSTDR0 - UNSTDR8)	32	RW	0000_0000h
80h	LFAST Global Status (GSR)	32	R	8000_0000h
84h	LFAST Ping Status (PISR)	32	R	0000_0000h
94h	LFAST Data Frame Status (DFSR)	32	R	0000_0000h
98h	LFAST Tx Interrupt Status (TISR)	32	RW	0000_0000h
9Ch	LFAST Rx Interrupt Status (RISR)	32	RW	0000_0000h
A0h	LFAST Rx ICLC Interrupt Status (RIISR)	32	RW	0000_0000h
A4h	LFAST PLL and LVDS Status (PLLLSR)	32	R	0002_0003h
A8h	LFAST Unsolicited Rx Status (UNSRSR)	32	RW	0000_0000h
ACh - CCh	LFAST Unsolicited Rx Data (UNSRDR0 - UNSRDR8)	32	R	0000_0000h
D4h	General Purpose registers (GPR0)	32	RW	See section

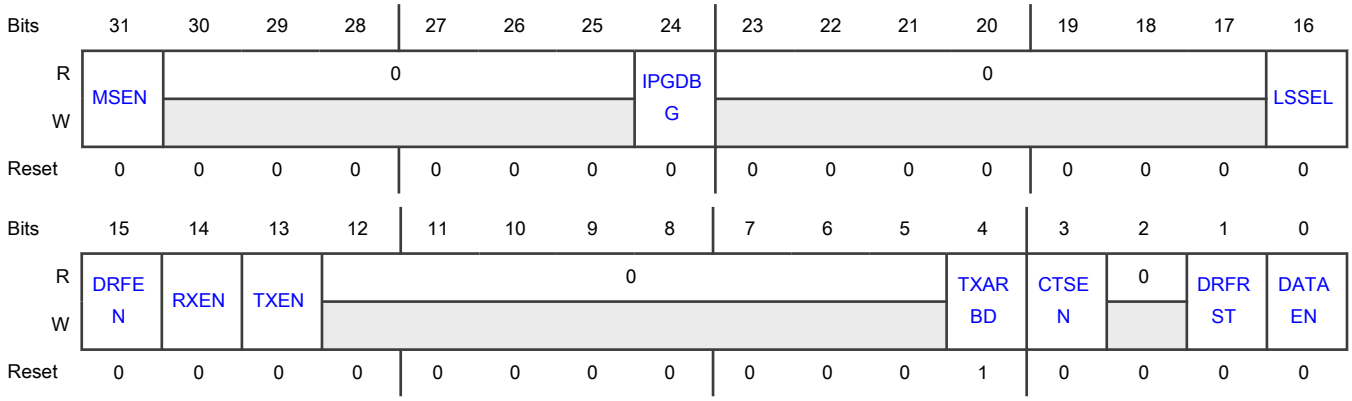
83.7.2 LFAST Mode Configuration (MCR)

Offset

Register	Offset
MCR	0h

Function
Controls the functionality of LFAST including mode configurations and soft reset.

Diagram



Fields

Field	Function
31 MSEN	LFAST Master or Slave mode Enable This bit selects either the LFAST master or slave functionality. **NOTE** Writable only once after the asynchronous reset. 0b - Enable the modules LFAST Slave functionality only. 1b - Enable the modules LFAST Master functionality only.
30-25 —	Reserved
24 IPGDBG	IPG Debug mode Control bit to enable support for IPG Debug mode. This mode is indicated by assertion of IPG debug mode signal. 0b - IPG debug mode enable signal will be ignored. 1b - IPG debug mode enable signal will not be ignored.
23-17 —	Reserved
16 LSSEL	Low Speed Select Mode Selects the fraction of sysclk in Low speed select mode (see Slow speed clock for details). 0b - Low speed mode in which the lfast_sysclk input is used to generate 4 phases of lfast_sysclk/2. 1b - Low speed mode in which the lfast_sysclk input is used to generate 4 phases of lfast_sysclk/4.
15	LFAST Enable

Table continues on the next page...

Table continued from the previous page...

Field	Function
DRFEN	This bit enables/disables the reception and transfer of LFAST device. 0b - LFAST is immediately disabled. All current/pending requests are terminated and the Tx and Rx data FIFOs are flushed. If this bit is cleared in the middle of a transmit/receive operation, then that operation is terminated immediately and nothing is transmitted/received further. All the programmable registers retain their values and status registers are cleared to their reset values. Registers read/write operations can be performed through the IPS Bus. 1b - LFAST is Enabled.
14 RXEN	LFAST Receiver Enable This bit controls the reception of the frames and decoding on the LFAST device. This bit also disables the Rx LVDS Line Receiver (LR). 0b - Receiver Interface is disabled. If this bit is cleared during a data transfer, the current frame is received and then the Rx block is disabled. After the Rx block is disabled, all new frames from LFAST peer device are ignored. System Side Module Rx interface isn't disabled by this bit. 1b - Receiver Interface is Enabled.
13 TXEN	LFAST Transmitter Enable This bit controls the transmission of frames from the LFAST device and disables the Tx LVDS LD. This bit can also be modified by LFAST slave H/W on reception of an ICLC command frame. This field can only be written in dual mode (LFAST_GSR[DUALMD] = 1). 0b - LFAST transmitter interface is disabled. No new request is accepted but ongoing request is served. 1b - LFAST transmitter interface is enabled. New requests are accepted.
12-5 —	Reserved
4 TXARBD	Tx Arbiter Disable This bit enables/disables the Tx block arbiter. Current frame transfer is completed, but new frame requests are ignored. 0b - Enable Tx arbiter and framer. When enabled it takes all the frame request and services based on priority. 1b - Disable Tx arbiter and framer. All frame requests are ignored.
3 CTSEN	CTS Enable This bit defines the Push-Pull mode of the LFAST devices receiver. This bit is used to enable/disable CTS mode of the Tx block. This bit is only writable when MCR[DRFEN] = 0. **NOTE** Only writable when MCR[DRFEN] = 0. 0b - CTS mode is disabled. Indicates that the device is in Push mode. The CTS bit of frames transmitted is 1. The CTS bit doesn't represent the status of Rx FIFO.

Table continues on the next page...

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Field	Function
	1b - CTS mode is enabled. The CTS bit of all transmit frames is set when the Rx FIFO empty space is on or above higher threshold, and cleared when the Rx FIFO empty space is on or below lower threshold.
2 —	Reserved
1 DRFRST	LFAST Soft Reset This bit is automatically cleared after reset. **NOTE** Set by user software and then cleared by system hardware. 0b - No soft reset 1b - Soft reset to LFAST is asserted. When set it causes a reset of the LFAST module; all the registers will be reset to their default values and all the FIFOs will be flushed.
0 DATAEN	DATA Frame Enable This bit enables/disables the transmission and reception of data frames between the LFAST master and slave devices. 0b - Data frame transmission and reception is disabled. Tx data frame requests are ignored by the transmitter. Frame with LCT of data frame is ignored by the receiver. 1b - Data frame transmission and reception is enabled. Tx data frame requests are serviced by the transmitter. Frame with LCT of data frame is received and placed into the Rx data FIFO.

83.7.3 LFAST Speed Control (SCR)

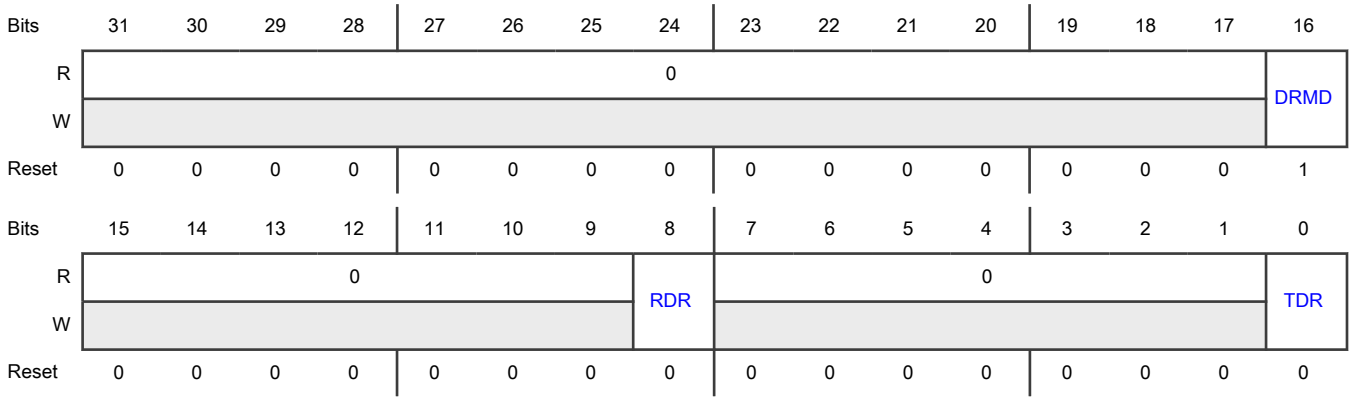
Offset

Register	Offset
SCR	4h

Function

Configure the Rx and Tx data rate of the LFAST.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 DRMD	Data Rate Controller mode Defines the mode setting for LFAST slave device by S/W or LFAST master. 0b - S/W controls the data rate controller mode. In LFAST Slave the ICLC frames for rate change have no affect on the data rate. 1b - In LFAST Slave the reception of ICLC frame for rate change sets appropriate speed mode. In LFAST master the SCR[DRMD] should be 0.
15-9 —	Reserved
8 RDR	Receiver Data Rate This bit defines the receiver data rate. For LFAST master: • S/W should program this bit only after transmission of an ICLC frame changing the speed mode of the slaves Tx interface. For LFAST slave: • When SCR[DRMD] = 1, the H/W programs this bit on reception of ICLC frame for changing speed mode of Slaves Rx interface. • The S/W can program this bit when SCR[DRMD] = 0. • This bit is cleared on MCR[DRFEN] negation. 0b - Data rate of Rx block is low speed. 1b - Data rate of Rx block is high speed.
7-1	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
0 TDR	Transmit Data Rate This bit defines the transmitter data rate. For LFAST master: • S/W should program this bit only after transmission of an ICLC frame changing the speed mode of the slaves Rx interface. For LFAST slave: • When SCR[DRMD] = 1, the H/W programs this bit on reception of ICLC frame for changing speed mode of Slaves Tx interface. • The S/W can program this bit when SCR[DRMD] = 0. • This bit is cleared on MCR[DRFEN] negation. 0b - Data rate of Tx block is low speed. 1b - Data rate of Tx block is high speed.

83.7.4 LFAST Correlator Control (COCR)

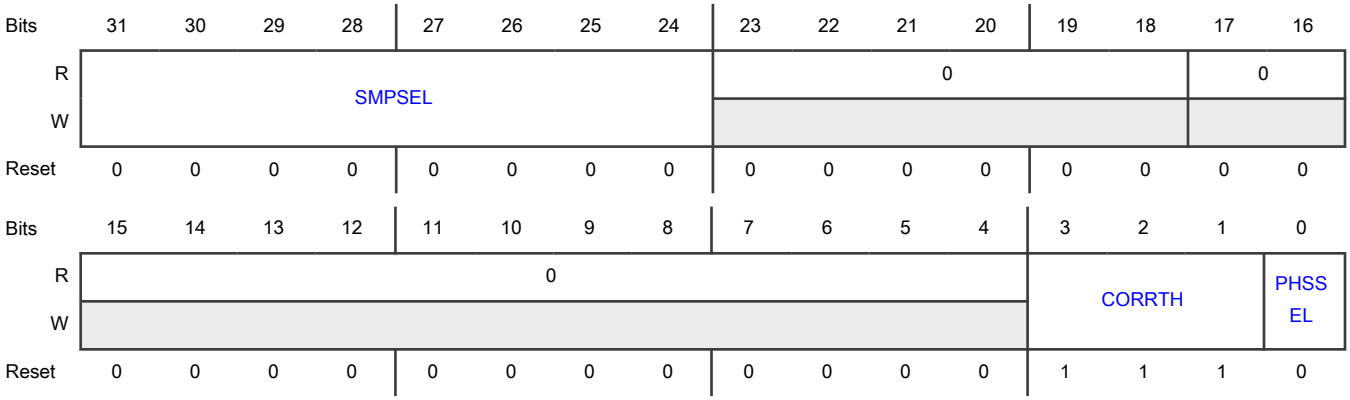
Offset

Register	Offset
COCR	8h

Function

Selects the sampler data path and the number of bits of correlation to be used.

Diagram



Fields

Field	Function
31-24 SMPSEL	Sampler Data Path Selector (overrides the correlator selection) Defines the sampler data path to be activated at all the times. All the bits should be 0 (00h) for Sampler Data Path to be selected by the correlator. In Low Speed mode only Sampler Data Paths 0-3 are valid. This field can only be written when MCR[RXEN] = 0. 00h Sampler Data Path selected by correlator 01h Sampler Data Path 0 selected 02h Sampler Data Path 1 selected 04h Sampler Data Path 2 selected 08h Sampler Data Path 3 selected 10h Sampler Data Path 4 selected 20h Sampler Data Path 5 selected 40h Sampler Data Path 6 selected others Sampler Data Path 7 selected
23-18 —	Reserved
17-16 —	Reserved
15-4 —	Reserved
3-1 CORRTH	Correlator Threshold Level Defines the correlation threshold level. This field can only be written when MCR[RXEN] = 0. 000 9 Bits of correlation 001 10 Bits of correlation ... 110 15 Bits of correlation 111 16 Bits of correlation
0 PHSSEL	Polyphase 8 or 4 phase selection. Defines the number of phases for the polyphase generator used. This bit is ignored in low speed mode since only 4 Phases are used in low speed mode. In High Speed mode phase 0, 2, 4 and 6 are used when 4 phase mode is selected. This field can only be written when MCR[RXEN] = 0 0b - 8 phases 1b - 4 phases

83.7.5 LFAST Test Mode Control (TMCR)

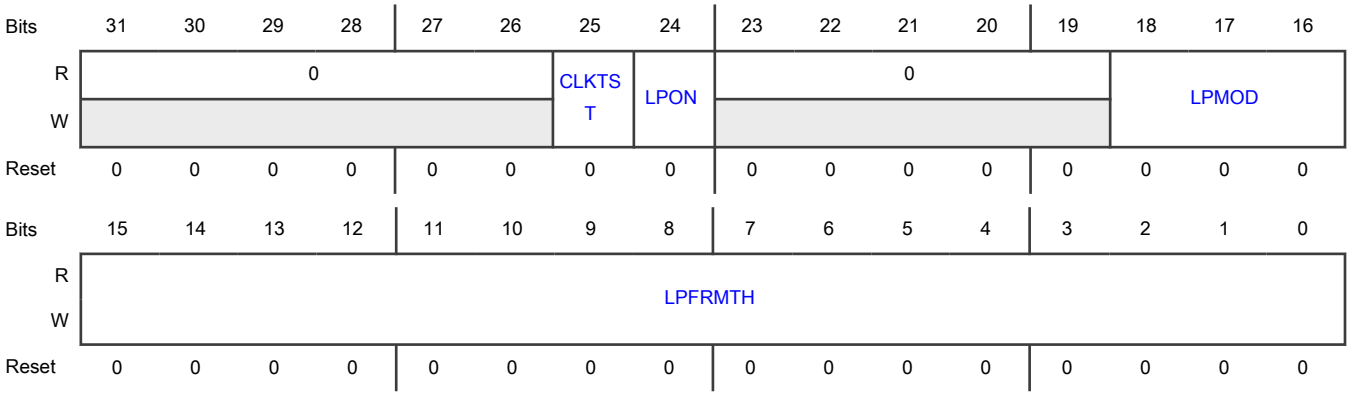
Offset

Register	Offset
TMCR	Ch

Function

Enables and configures the LFAST clock test and loopback modes.

Diagram



Fields

Field	Function
31-26 —	Reserved
25 CLKTST	Clock Test Mode S/W can define when the clock test mode is enabled. This bit can also be set and cleared by LFAST slave H/W on reception of an ICLC command. 0b - Clock test mode disabled 1b - Clock test mode enabled
24 LPON	Loopback Mode Logic Enable S/W can define when the loopback logic is enabled. This bit can also be written by LFAST slave H/W on reception of an ICLC command. 0b - Loopback mode is disabled 1b - Loopback mode is enabled
23-19 —	Reserved

Table continues on the next page...

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Field	Function
18-16 LPMOD	Loopback Mode Defines the type of loopback mode enabled. This field can only be written when TMCR[LPON] = 0. 000b - Rx loopback 001b - Rx LVDS loopback 010b - Tx loopback without automatic frame generation 011b - Tx loopback with automatic frame generation 100b - Tx LVDS loopback (external) with automatic frame generation 101b - Reserved 110b - Reserved 111b - Reserved
15-0 LPFRMTH	Loopback check mode valid pass frames threshold value. Defines the number of frames to verify before setting GCR[LPFPDV] when running in automatic loopback frame mode. The loopback frame is considered pass when the payload is CBh, header is 13h and sync is valid. This mode is valid only when TMCR[LPMOD] = 011b or TMCR[LPMOD] = 100b. This field can only be written when TMCR[LPON] = 0. 0000h Reserved 0001h Check 1 frame have correct sync, header and payload. ... FFFEh Check 65534 frames have correct sync, header and payload. FFFFh Check 65535 frames have correct sync, header and payload.

83.7.6 LFAST Auto Loopback Control (ALCR)

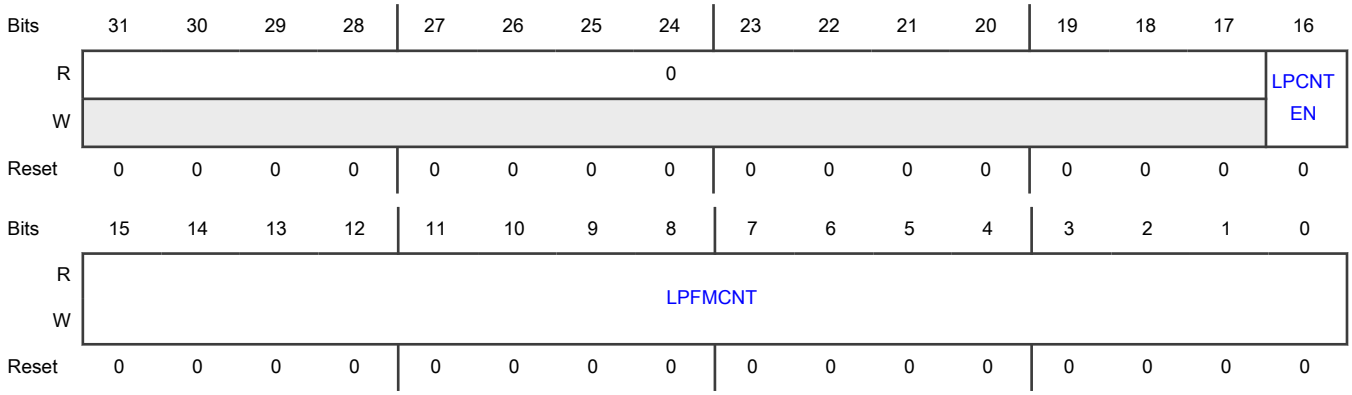
Offset

Register	Offset
ALCR	10h

Function

Enables and configures the loopback frame transmission count.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 LPCNTEN	Auto Loopback Frame Transmission Count Enable Enables fixed number of auto pre-defined loopback frame transmission. This field can only be written when TMCR[LPON] = 0. 0b - Infinite pre-defined loopback frame transmission enabled 1b - Fixed count of pre-defined loopback frame transmission enabled
15-0 LPFMCNT	Auto Loopback Frame Transmission Count Defines the number of pre-defined auto loopback frames to be sent. The pre-defined loopback frame has payload CBh, header 13h and valid sync. This mode is valid if TMCR[LPMOD] = 011b or TMCR[LPMOD] = 100b. This field can only be written when TMCR[LPON] = 0. 0000h Reserved. 0001h Send 1 frame with correct sync, header and payload ... FFFEh Send 65534 frames with correct sync, header and payload FFFFh Send 65535 frames with correct sync, header and payload.

83.7.7 LFAST Rate Change Delay Control (RCDCR)

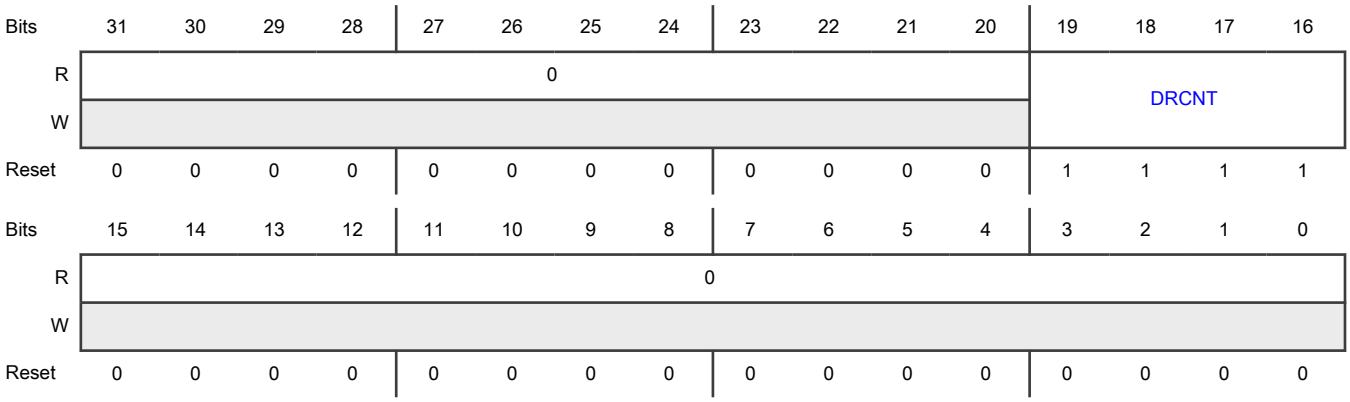
Offset

Register	Offset
RCDCR	14h

Function

Configure the number of cycles of Phase 0 clock needed by the Tx interface data rate change controller to switch from one speed mode to another.

Diagram



Fields

Field	Function
31-20 —	Reserved
19-16 DRCNT	Data Rate Controller Counter Value Defines the number of cycles of Phase 0 clock needed by the Tx interface Data rate change controller to switch from one speed mode to another. The arbitrator ignores all requests during this period. This field can only be written when MCR[DRFEN] = 1. Number of cycles = DRCNT value.
15-0 —	Reserved

83.7.8 LFAST ICLC Control (ICR)

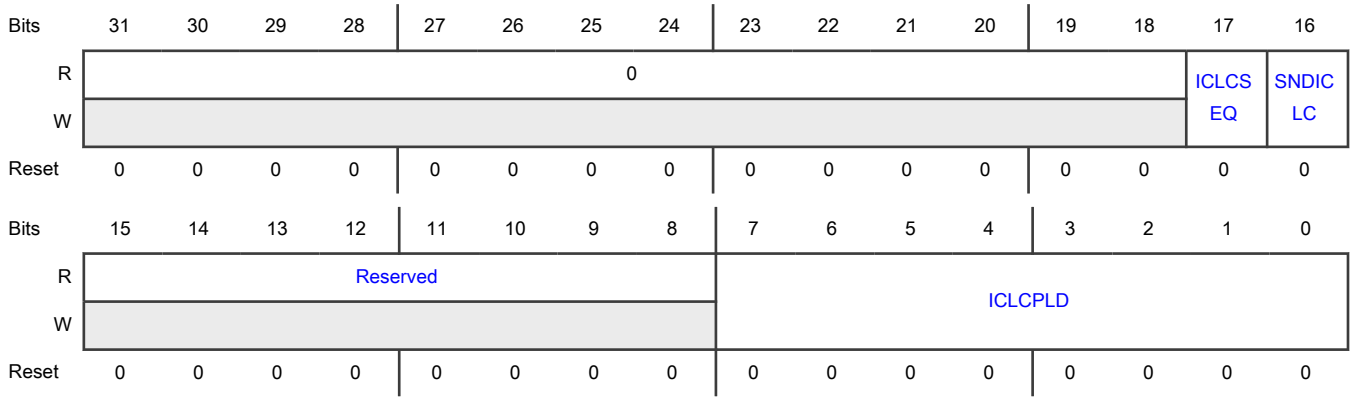
Offset

Register	Offset
ICR	1Ch

Function

Configures the interface control logical channel (ICLC) frame transfer.

Diagram



Fields

Field	Function
31-18 —	Reserved
17 ICLCSEQ	ICLC Enabled This bit should be set whenever the S/W is performing a series of ICLC frame transfers. This bit ensures only ICLC frame transmission request is serviced, other pending frames request are ignored. 0b - Single ICLC frame transfer. 1b - S/W is performing ICLC frame transfers. Only the ICLC frames will be scheduled during this period. All the other frames will be scheduled only after ICR[ICLCSEQ] = 0.
16 SNDICLC	ICLC Frame Request This bit is set to initiate the transfer of ICLC frame by LFAST master. This bit should be set (ICR[SNDICLC] = 1) after writing the required ICLC payload to be transmitted in the ICLCPLD field of the register. This bit is self clearing, which will be cleared when ICLC frame transfer is complete. Set by user software and cleared by system hardware. 0b - No Valid ICLC frame for transfer. 1b - Valid ICLC frame for transfer.
15-8 —	Reserved
7-0 ICLCPLD	ICLC Payload This field is used to program the payload of the ICLC frame to be transmitted. New ICLC payload should be set when ICR[SNDICLC] = 0. This field can only be written when ICR[SNDICLC] = 0 (see Table 744 for supported ICLC payloads).

83.7.9 LFAST Ping Control (PICR)

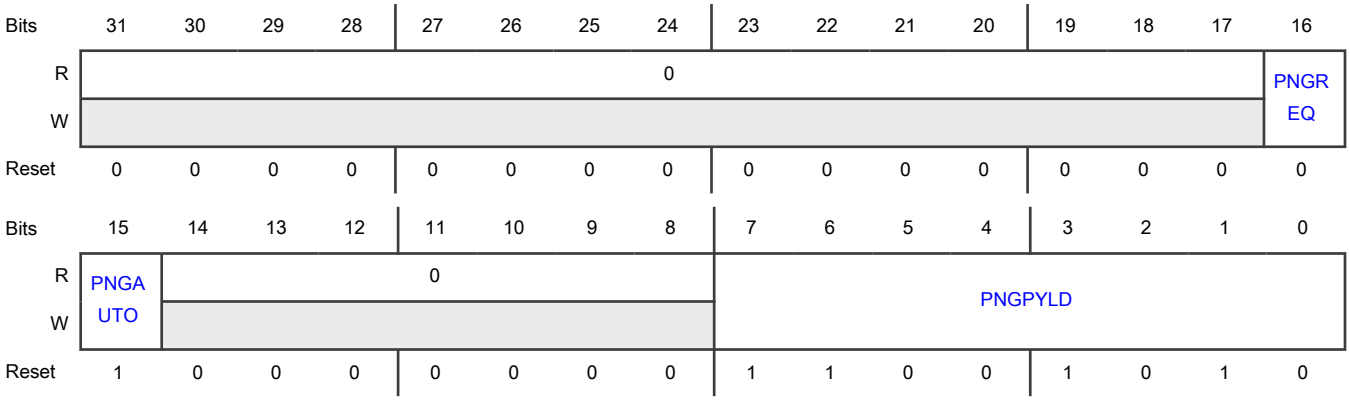
Offset

Register	Offset
PICR	20h

Function

Configures the ping response frame transfer.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 PNGREQ	Ping Response Frame Request This bit is set to initiate the transfer of Ping response frame. Cleared after transmission of Ping response frame. Set by user software and cleared by system hardware. 0b - No pending Ping response frame transmission request 1b - Ping response frame transmission request is queued
15 PNGAUTO	Ping Response Enable Defines when ping response should be automatically sent on reception of Ping ICLC frame from LFAST master. This field can only be written when MCR[DRFEN] = 0. 0b - Ping response should not be automatically sent. 1b - Ping response should be automatically sent.
14-8 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
7-0 PNGPYLD	LFAST Slave: Defines the LFAST slaves ping reply frame payload content. This field can only be written when MCR[DRFEN] = 0. LFAST Master: Defines the expected payload of ping response frame. Used for comparison with ping frame received.

83.7.10 LFAST Rx FIFO CTS Control (RFCR)

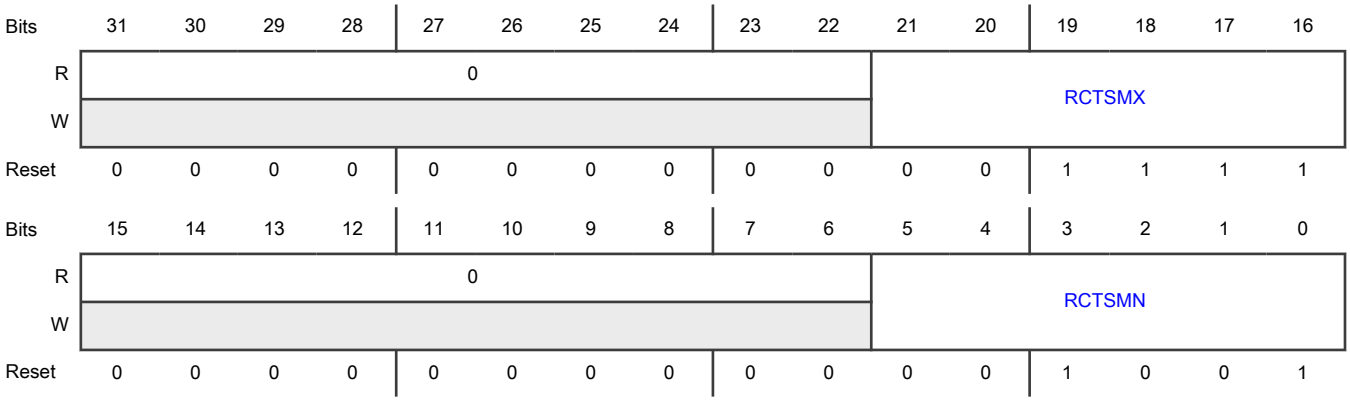
Offset

Register	Offset
RFCR	2Ch

Function

Configures the Rx FIFO lower and higher threshold values which are used to define the condition for CTS bit of the frame.

Diagram



Fields

Field	Function
31-22 —	Reserved
21-16 RCTSMX	Rx FIFO Maximum Threshold Defines the condition for CTS bit of frames to be negated. This field can only be written when LFAST_MCR[DRFEN] = 0.
15-6 —	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
5-0 RCTSMN	Rx FIFO Minimum Threshold Defines the condition for CTS bit of frames to be set. This field can only be written when LFAST_MCR[DRFEN] = 0.

83.7.11 LFAST Tx Interrupt Enable (TIER)

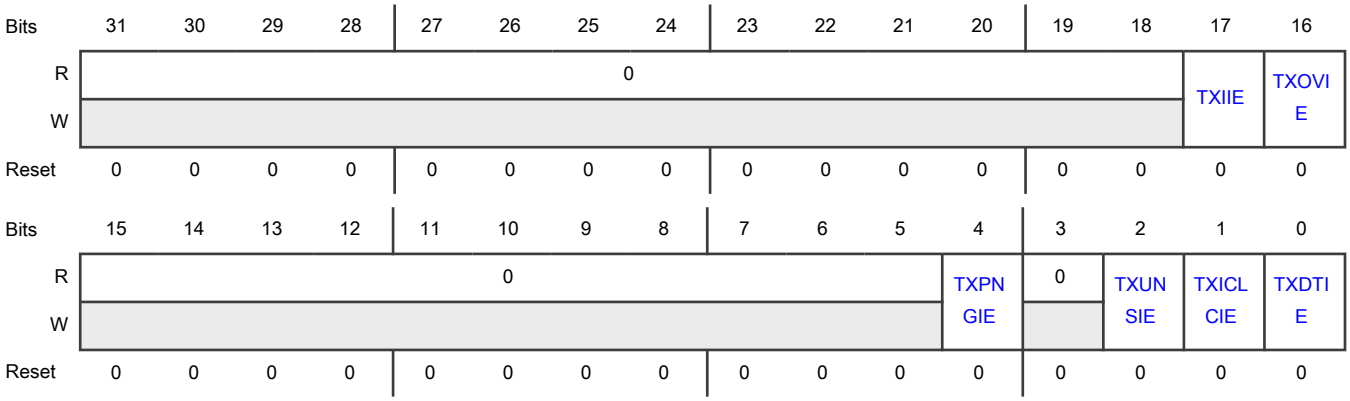
Offset

Register	Offset
TIER	30h

Function

Configures the frame transmit interrupt enables.

Diagram



Fields

Field	Function
31-18 —	Reserved
17 TXIIE	Tx Data Interface Not Enabled - (Mask) Enables or disables the interrupt. Tx Data Interface not enabled and a frame is ready to be transmitted 0b - Interrupt is disabled 1b - Interrupt is enabled
16 TXOVIE	Transmit Data FIFO Overflow Interrupt Enable.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Interrupt is disabled 1b - Interrupt is enabled
15-5 —	Reserved
4 TXPNGIE	Ping Response Frame Transmitted Interrupt Enable. 0b - Interrupt is disabled 1b - Interrupt is enabled
3 —	Reserved
2 TXUNSIE	Unsolicited Frame transmitted Interrupt Enable 0b - Interrupt is disabled 1b - Interrupt is enabled
1 TXICLCIE	This field is 0 when MCR[MSEN] is 0. ICLC Frame Transmitted Interrupt Enable 0b - Interrupt is disabled 1b - Interrupt is enabled
0 TXDTIE	Data Frame Transmitted Interrupt Enable 0b - Interrupt is disabled 1b - Interrupt is enabled

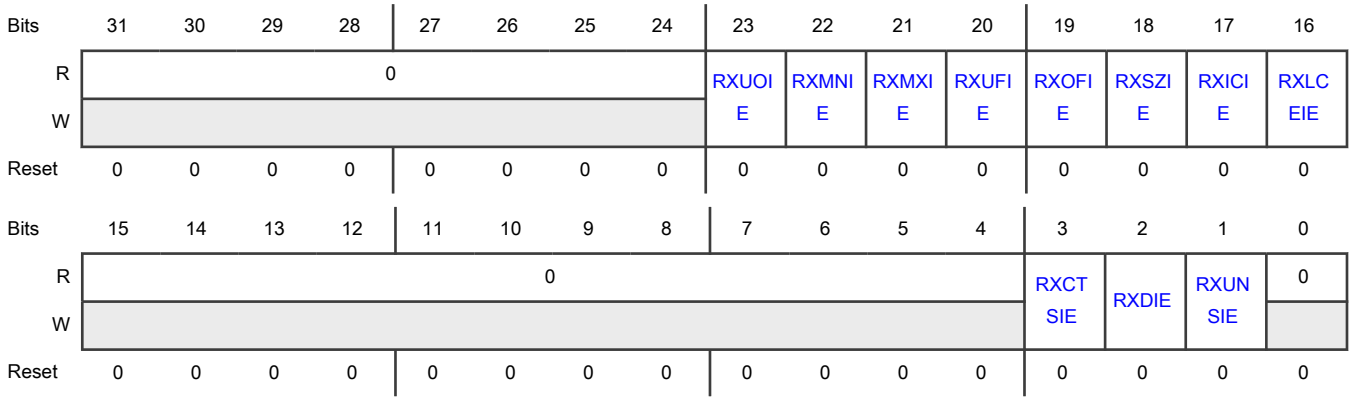
83.7.12 LFAST Rx Interrupt Enable (RIER)

Offset

Register	Offset
RIER	34h

Function
Configures the frame receive interrupt enables.

Diagram



Fields

Field	Function
31-24 —	Reserved
23 RXUOIE	Unsolicited frame register overflow. Indicates existing unsolicited frame hasn't been read and a new unsolicited frame has arrived. 0b - Interrupt is disabled 1b - Interrupt is enabled
22 RXMNIE	Rx Data FIFO Min Threshold reached 0b - Interrupt is disabled 1b - Interrupt is enabled
21 RXMXIE	Rx Data FIFO Max Threshold reached 0b - Interrupt is disabled 1b - Interrupt is enabled
20 RXUFIE	Rx Data FIFO Underflow 0b - Interrupt is disabled 1b - Interrupt is enabled
19 RXOFIE	Rx Data FIFO Overflow 0b - Interrupt is disabled 1b - Interrupt is enabled
18 RXSZIE	Frame with unsupported frame size received. Valid frame sizes are defined in Table 751 0b - Interrupt is disabled 1b - Interrupt is enabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
17 RXICIE	Invalid ICLC code Received 0b - Interrupt is disabled 1b - Interrupt is enabled
16 RXLCEIE	Invalid Logical Channel Type 0b - Interrupt is disabled 1b - Interrupt is enabled
15-4 —	Reserved
3 RXCTSIE	Frame with CTS bit Low Received 0b - Interrupt is disabled 1b - Interrupt is enabled
2 RXDIE	Data frame received 0b - Interrupt is disabled 1b - Interrupt is enabled
1 RXUNSIE	Unsolicited Frame received 0b - Interrupt is disabled 1b - Interrupt is enabled
0 —	Reserved

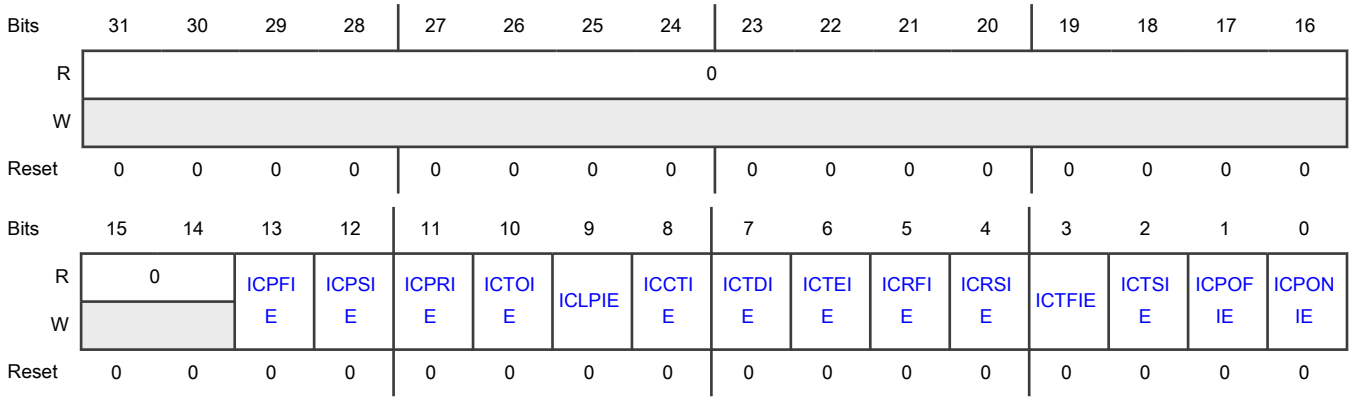
83.7.13 LFAST Rx ICLC Interrupt Enable (RIIER)

Offset

Register	Offset
RIIER	38h

Function
Configures the ICIL frame receive interrupt enables.

Diagram



Fields

Field	Function
31-14 —	Reserved
13 ICPFIE	This field is 0 when MCR[MSEN] is 0. Ping Frame Response failed 0b - Interrupt is disabled 1b - Interrupt is enabled
12 ICPSIE	This field is 0 when MCR[MSEN] is 0. Ping Frame Response successful 0b - Interrupt is disabled 1b - Interrupt is enabled
11 ICPRIE	ICLC frame for Ping Frame Request received 0b - Interrupt is disabled 1b - Interrupt is enabled
10 ICTOIE	ICLC frame for Test mode off received 0b - Interrupt is disabled 1b - Interrupt is enabled
9 ICLPIE	ICLC frame for Loopback On received 0b - Interrupt is disabled 1b - Interrupt is enabled
8 ICCTIE	ICLC frame for Clk Test mode on received 0b - Interrupt is disabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
	1b - Interrupt is enabled
7 ICTDIE	ICLC frame for LFAST Slaves Tx Interface Disable received 0b - Interrupt is disabled 1b - Interrupt is enabled
6 ICTEIE	ICLC frame for LFAST Slaves Tx Interface Enable received 0b - Interrupt is disabled 1b - Interrupt is enabled
5 ICRFIE	ICLC frame for LFAST Slaves Rx Interface fast mode switch received 0b - Interrupt is disabled 1b - Interrupt is enabled
4 ICRSIE	ICLC frame for LFAST Slaves Rx Interface slow mode switch received 0b - Interrupt is disabled 1b - Interrupt is enabled
3 ICTFIE	ICLC frame for LFAST Slaves Tx Interface fast mode switch received 0b - Interrupt is disabled 1b - Interrupt is enabled
2 ICTSIE	ICLC frame for LFAST Slaves Tx Interface slow mode switch received 0b - Interrupt is disabled 1b - Interrupt is enabled
1 ICPOFIE	ICLC frame for PLL OFF received 0b - Interrupt is disabled 1b - Interrupt is enabled
0 ICPONIE	ICLC frame for PLL ON received 0b - Interrupt is disabled 1b - Interrupt is enabled

83.7.14 LFAST PLL Control (PLLCR)

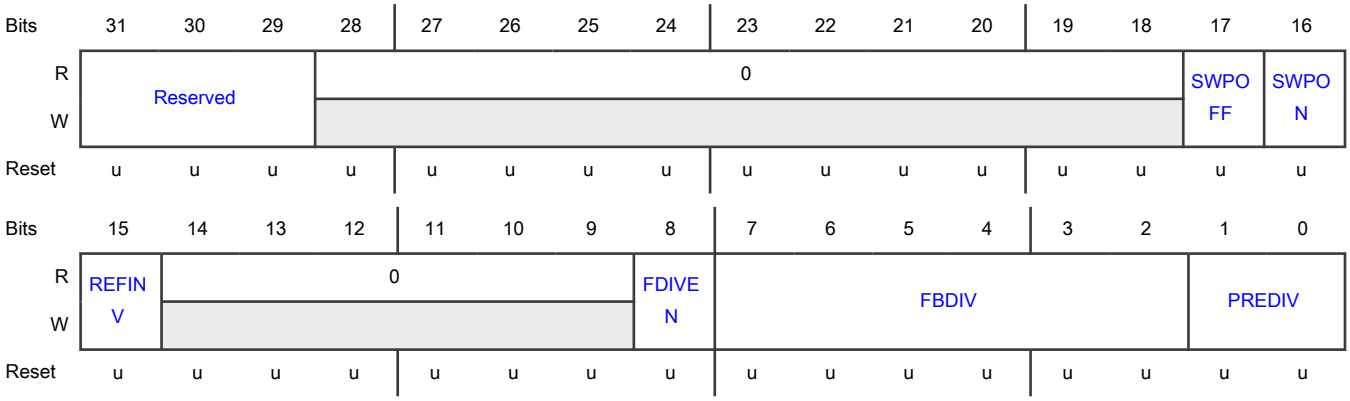
Offset

Register	Offset
PLLCR	3Ch

Function

Defines the PLL configuration.

Diagram



Fields

Field	Function
31-29 —	Reserved
28-18 —	Reserved
17 SWPOFF	SW signal to turn OFF the PLL. Set by user software and cleared by system hardware. 0b - No effect 1b - PLL will be turned OFF.
16 SWPON	SW signal to turn ON the PLL. Set by user software and cleared by system hardware. 0b - No effect 1b - PLL will be turned ON
15 REFINV	Inverts reference clock edge to PFD. If System PLL PFD using same reference clock, enabling this feature will minimize noise injection crosstalk via the substrate. 0b - Do not inverted 1b - Invert
14-9 —	Reserved
8 FDIVEN	Enable fraction division mode in feedback divider. Enables the division of vco clock output by a factor of (FBDIV + 0.5). 0b - Fraction division mode not enabled 1b - Fraction division mode enabled

Table continues on the next page...

Table continued from the previous page...

Field	Function
7-2 FBDIV	Feedback Division factor for VCO output clock. This field can only be written when LFAST_MCR[DRFEN] = 0. 00h No clock output 01h – 0Ah Reserved 0Bh Divide by 11 12 (11.5, if FDIVEN = 1) ... ... 1Fh Divide by 31 32 (31.5, if FDIVEN = 1) 20h – 3Fh Reserved
1-0 PREDIV	Division factor for PLL Reference Clock input. This field can only be written when LFAST_MCR[DRFEN] = 0. 00b - Direct clock passed 01b - Divide by 2 10b - Divide by 3 11b - Divide by 4

83.7.15 LFAST LVDS Control (LCR)

Offset

Register	Offset
LCR	40h

Function

Defines the LVDS interface configuration for LD and LR.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								SWWKLD	SWSLPLD	SWWKLR	SWSLPLR	SWOFFLD	SWONLD	SWOFFLR	SWONLR
W																
Reset	0	0	0	0	0	0	0	0	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	LVRXOFF	LVTXOE	TXCMUX	LVRFEN	LVLPEN	0					LVRXOP_...	Reserved	LVRXOP_...	Reserved	Reserved	Reserved
W																
Reset	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0

1. Set by user software and cleared by system hardware.

Fields

Field	Function
31-24 —	Reserved
23 SWWKLD	SW signal to take LVDS LD out of Sleep mode. This field can only be written when LFAST_MCR[DRFEN] = 1. **NOTE** Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LD will be taken out of sleep (provided no other source is trying to put it in sleep)
22 SWSLPLD	SW signal to put LVDS LD into Sleep mode. This field can only be written when LFAST_MCR[DRFEN] = 1. **NOTE** Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LD will be put in sleep
21 SWWKLR	SW signal to take LVDS LR out of Sleep mode. This field can only be written when LFAST_MCR[DRFEN] = 1. **NOTE** Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LR will be taken out of sleep (provided no other source is trying to put it in sleep)
20 SWSLPLR	SW signal to put LVDS LR into Sleep mode. This field can only be written when LFAST_MCR[DRFEN] = 1. **NOTE** Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LR will be put in sleep (provided no other source is trying to wake it up)
19 SWOFFLD	SW signal to turn OFF the LVDS LD. This field can only be written when LFAST_MCR[DRFEN] = 1. **NOTE** Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LD will be turned OFF(provided no other source is trying to turn the LD ON)
18 SWONLD	SW signal to turn ON the LVDS LD. This field can only be written when LFAST_MCR[DRFEN] = 1.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LD will be turned ON
17 SWOFFLR	SW signal to turn OFF the LVDS LR. This field can only be written when LFAST_MCR[DRFEN] = 1. **NOTE** Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LR will be turned OFF (provided no other source is trying to turn the LR ON)
16 SWONLR	SW signal to turn ON the LVDS LR. This field can only be written when LFAST_MCR[DRFEN] = 1. **NOTE** Writes are not reflected in the read of this field. 0b - No effect 1b - LVDS LR will be turned ON
15 LVRXOFF	Indicates the value driven onto LVDS LR output when in shutdown mode
14 LVTXOE	LVDS LD output buffer enable. 0 LVDS LD output buffer enable is disabled. 1 LVDS LD output buffer enabled
13 TXCMUX	Tx and Clock Mux The bit can be used to bring out PLL Phase 0 clock on Tx LVDS pad. 0 No effect 1 PLL Phase 0 clock will be brought out to Tx LVDS pad
12 LVRFEN	LVDS pad reference enable 0 LVDS reference pad disabled 1 LVDS reference pad enabled
11 LVLPEN	Tx LVDS internal loopback enable The bit is reflected by output signal ipp_digrf_lvds_lpbk_en.The internal loopback is not intended for board level functionality, so this feature should not be implemented. 0b - Tx LVDS normal mode enabled 1b - Tx LVDS internal loopback mode enabled

Table continues on the next page...

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Field	Function
10-6 —	Reserved
5 LVRXOP_TR	Used to enable or disable the on-chip receiver termination resistor in LFAST mode (applies to LVDS pad use for LFAST only): 0 Disable on-chip LFAST receiver termination 1 Enable on-chip LFAST receiver termination
4 —	Reserved
3 LVRXOP_BR	Used to set the bias current for the receiver in LFAST mode. It is recommended to always write 1 to this bit when using the LFAST interface. Writing 0 will allow for a small power savings during lower baud rates (applies to LVDS pad use for LFAST only): 0 Use for LFAST receiver baud rates less than the maximum baud rate. 1 Required for LFAST receiver maximum baud rate.
2 —	Reserved
1 —	Reserved
0 —	Reserved

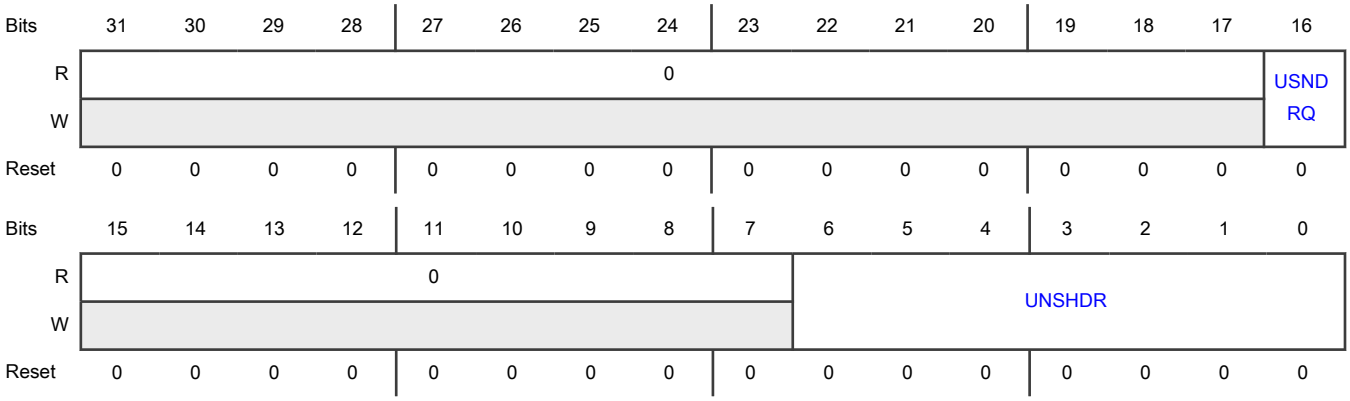
83.7.16 LFAST Unsolicited Tx Control (UNSTCR)

Offset

Register	Offset
UNSTCR	44h

Function
Defines the unsolicited transmit frame configuration.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 USNDRQ	Tx Unsolicited send request Set by user software and cleared by system hardware. 0b - No valid Unsolicited frame exists 1b - Valid Unsolicited frame exists for transmission
15-7 —	Reserved
6-0 UNSHDR	Tx Unsolicited Message Header This field can only be written when LFAST_UNSTCR[USNDRQ] = 0

83.7.17 LFAST Unsolicited Tx Data Registers (UNSTDR0 - UNSTDR8)

Offset

For a = 0 to 8:

Register	Offset
UNSTDRa	48h + (a × 4h)

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	UNTXD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	UNTXD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 UNTXD	Unsolicited Transmit Data 8-0. This represents 9 registers for Unsolicited transmit data. The first bit to transmitted as part of the payload will be from UNTXD8[31], second bit from UNTXD8[30], and so on. So the last bit transmitted will be from UNTXD0[0] in case of 288 bit payload.

83.7.18 LFAST Global Status (GSR)

Offset

Register	Offset
GSR	80h

Function

Provides status information of modes of LFAST modules.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	DUALMD	0												LRMD	LDSM	DRSM
W																
Reset	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0											LPTXDN	LPFPDV	LPCPDV	LPCHDV	LPCSDV
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 DUALMD	Indicates the LFAST module is in Dual mode 0b - LFAST Module in Slave only mode 1b - LFAST Module in Dual mode
30-19 —	Reserved
18 LRMD	Indicates if the Rx Controller is idle/active and that the Rx clocks are enabled. In functional mode this will always be active. 0b - Rx Controller is in Idle state 1b - Rx Controller is active
17 LDSM	Transmit Interface Data Rate Status Indicates the current speed rate of the Tx controller 0b - Data rate of LOW speed mode 1b - Data rate of HIGH speed mode
16 DRSM	Receive Interface Data Rate Status Indicates the current speed rate of the Rx controller 0b - Data rate of LOW speed mode 1b - Data rate of HIGH speed mode
15-5 —	Reserved
4 LPTXDN	Auto loopback frame transmission count reached. The Count of frame is defined by LFAST_ALCR[LPFMCNT]. 0b - Auto loopback frame transmission count not reached. 1b - Auto loopback frame transmission count reached.
3 LPFPDV	Loopback frame pass threshold reached. 0b - Pass frame threshold not reached. 1b - Pass frame threshold achieved
2 LPCPDV	Valid payload received during loopback check mode. Indicates whether the Loop back frame received payload is CBh. 0b - Payload received is not CBh 1b - Payload received is CBh

Table continues on the next page...

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Field	Function
1 LPCHDV	Valid header received during loopback check mode. Indicates whether the Loop back frame received header is 13h. 0b - Header received is not 13h 1b - Header received is 13h
0 LPCSDV	Valid synchronization received. 0b - Valid Synchronization pattern not detected 1b - Valid Synchronization pattern detected

83.7.19 LFAST Ping Status (PISR)

Offset

Register	Offset
PISR	84h

Function

Provides status information of ping frame.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0								RXPNGD							
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-8 —	Reserved
7-0 RXPNGD	Ping Data Register In LFAST Master mode the Ping response ICLC frame received is stored into this register.

83.7.20 LFAST Data Frame Status (DFSR)

Offset

Register	Offset
DFSR	94h

Function

Provides status information of data frame.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0		RXDCNT						0				RXFCNT			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		TXDCNT						0				TXFCNT			
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-30 —	Reserved
29-24 RXDCNT	Unread Rx Frame Data Count Indicates the number of unread data stored in the Rx Data FIFO.
23-19 —	Reserved
18-16 RXFCNT	Unread Rx Frame Count Indicates the number of unread data frames stored in the Rx Data FIFO.
15-14 —	Reserved
13-8 TXDCNT	Unread Tx Frame Data Count Indicates the number of unread data stored in the Tx Data FIFO.
7-3	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
2-0 TXFCNT	Unread Tx Frame Count Count of pending Data Frames programed by System Side Module.

83.7.21 LFAST Tx Interrupt Status (TISR)

Offset

Register	Offset
TISR	98h

Function

Provides status information of frame transmit interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0														TXIEF	TXOVF
W															W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0											TXPNGF	0	TXUNSF	TXICLCF	TXDTF
W												W1C		W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-18 —	Reserved
17 TXIEF	TxData Interface not enabled. Tx Data Interface not enabled and a frame is ready to be transmitted 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
16	Transmit Data FIFO Overflow Interrupt

Table continues on the next page...

Table continued from the previous page...

Field	Function
TXOVF	0b - Interrupt event has not occurred 1b - Interrupt event has occurred
15-5 —	Reserved
4 TXPNGF	Ping response frame transmitted interrupt 0 Interrupt event has not occurred 1 Interrupt event has occurred
3 —	Reserved
2 TXUNSF	TXUNSF Unsolicited Frame Transmitted Interrupt 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
1 TXICLCF	ICLC Frame Transmitted Interrupt 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
0 TXDTF	Data Frame Transmitted Interrupt 0b - Interrupt event has not occurred 1b - Interrupt event has occurred

83.7.22 LFAST Rx Interrupt Status (RISR)

Offset

Register	Offset
RISR	9Ch

Function
Provides status information of frame receive interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0								RXUOF	RXMNF	RXMXF	RXUFF	RXOFF	RXSZF	RXICF	RXLCEF
W									W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												RXCTSF	RXDF	RXUNSF	0
W													W1C	W1C	W1C	
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-24 —	Reserved
23 RXUOF	Unsolicited frame register overflow. Indicates existing unsolicited frame hasn't been read and a new unsolicited frame has arrived. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
22 RXMNF	Rx Data FIFO Min Threshold reached. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
21 RXMXF	Rx Data FIFO Max Threshold reached. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
20 RXUFF	Rx Data FIFO Underflow. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
19 RXOFF	Rx Data FIFO Overflow. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
18 RXSZF	Frame with unsupported frame size received. See "Frames Supported by LFAST interfaces" table for details. 0b - Interrupt event has not occurred

Table continues on the next page...

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Field	Function
	1b - Interrupt event has occurred - On reception of frame with payload size for a frame other than mentioned in the "Frames Supported by LFAST interfaces" table.
17 RXICF	Invalid ICLC code Received. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
16 RXLCEF	Invalid Logical Channel Type. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
15-4 —	Reserved
3 RXCTSF	Frame with CTS bit Low Received. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
2 RXDF	Data frame received. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
1 RXUNSF	Unsolicited Frame received. 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
0 —	Reserved

83.7.23 LFAST Rx ICLC Interrupt Status (RIISR)

Offset

Register	Offset
RIISR	A0h

Function

Provides status information of ICIL frame receive interrupts.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0		ICPFF	ICPSF	ICPRF	ICTOF	ICLPF	ICCTF	ICTDF	ICTEF	ICRFF	ICRSF	ICTFF	ICTSF	ICPOFF	ICPONF
W			W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C	W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-14 —	Reserved
13 ICPFF	Ping Frame Response Failed 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
12 ICPSF	Ping Frame Response Successful 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
11 ICPRF	ICLC Ping Frame Request received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
10 ICTOF	ICLC frame for Test mode off received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
9 ICLPF	ICLC frame for Loopback On received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
8 ICCTF	ICLC frame for Clk Test mode received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
7	ICLC frame for LFAST Slaves Tx Interface Disable received

Table continues on the next page...

Table continued from the previous page...

Field	Function
ICTDF	0b - Interrupt event has not occurred 1b - Interrupt event has occurred
6 ICTEF	ICLC frame for LFAST Slaves Tx Interface Enable received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
5 ICRFF	ICLC frame for LFAST Slaves Rx Interface fast mode switch received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
4 ICRSF	ICLC frame for LFAST Slaves Rx Interface slow mode switch received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
3 ICTFF	ICLC frame for LFAST Slaves Tx Interface fast mode switch received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
2 ICTSF	ICLC frame for LFAST Slaves Tx Interface slow mode switch received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
1 ICPOFF	ICLC frame for PLL OFF received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred
0 ICPONF	ICLC frame for PLL ON received 0b - Interrupt event has not occurred 1b - Interrupt event has occurred

83.7.24 LFAST PLL and LVDS Status (PLLLSR)

Offset

Register	Offset
PLLLSR	A4h

Function
Provides status information of PLL and LVDS configuration.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved														PLLDIS	PLDCR
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0												LRSLPS	LDSLPS	LDPDS	LRPDS
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Fields

Field	Function
31-18 —	Reserved
17 PLLDIS	PLL Disable Status When asserted, PLL is put in the power down state. 0b - PLL disable signal is negated. 1b - PLL disable signal is asserted.
16 PLDCR	PLL Lock Delay Counter Ready When asserted this bit indicates that the PLL is locked after N number of reference/PLLCR[PREDIV] cycles 0b - PLL Lock delay counter is not decremented to 0 1b - PLL Lock delay counter is decremented to 0
15-4 —	Reserved
3 LRSLPS	This bit indicates the real time status of LR sleep signal 0b - LR power sleep signal is negated. 1b - LR power sleep signal is asserted.
2 LDSLPS	This bit indicates the real time status of LD sleep signal 0b - LD sleep signal is negated. 1b - LD sleep signal is asserted.
1 LDPDS	This bit indicates the real time status of LD power down signal When asserted, LD is put in the power down state.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - LD power down signal is negated. 1b - LD power down signal is asserted.
0 LRPDS	This bit indicates the real time status of LR power down signal When asserted, LR is put in the power down state. 0b - LR power down signal is negated. 1b - LR power down signal is asserted.

83.7.25 LFAST Unsolicited Rx Status (UNSRSR)

Offset

Register	Offset
UNSRSR	A8h

Function

Provides the information of a valid frame exists in the unsolicited received data registers.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0							URXDV	0				URPCNT			
W								0								
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-9 —	Reserved
8 URXDV	Unsolicited Data Valid Indicates a valid frame exists in the Unsolicited Data registers.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	NOTE Writing 0 will clear this bit
7-3 —	Reserved
2-0 URPCNT	Rx Unsolicited Payload Indicates the number of bytes of valid Rx unsolicited Data payload present in the LFAST_UNSRDR[8:0].

83.7.26 LFAST Unsolicited Rx Data (UNSRDR0 - UNSRDR8)

Offset

For a = 0 to 8:

Register	Offset
UNSRDRa	ACh + (a × 4h)

Function

Contains the information of unsolicited received frame data.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	UNRXD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	UNRXD															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 UNRXD	Unsolicited Receive Data This represents 9 registers for Unsolicited received data.It is read only register. The first bit received as part of the payload will be stored at UNRXD8[31], second bit at UNRXD8[30], and so on. So the last bit will be stored at UNRXD0[0] in case of 288 bit payload.

83.7.27 General Purpose registers (GPR0)

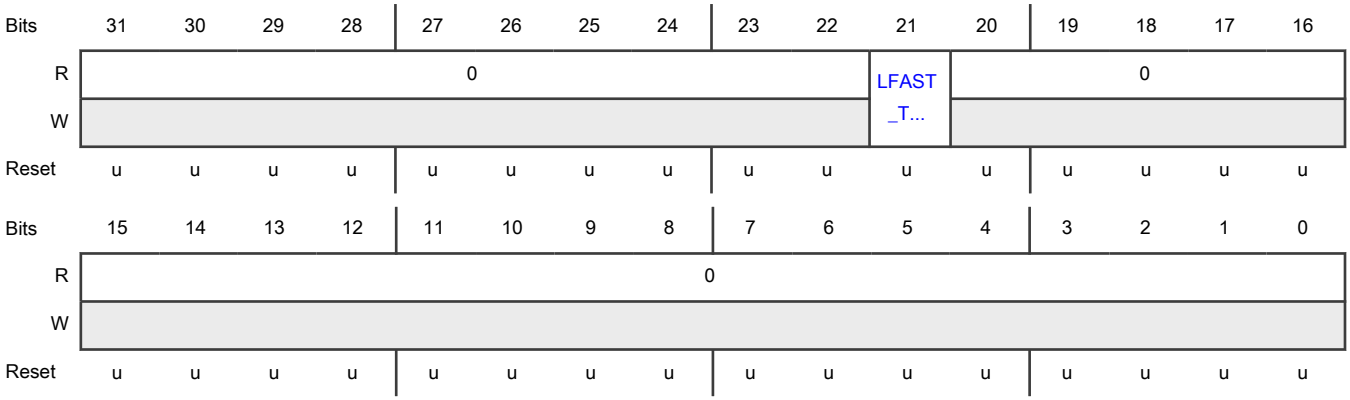
Offset

Register	Offset
GPR0	D4h

Function

General purpose registers, used for implementing PLL sideband signals.

Diagram



Fields

Field	Function
31-22 —	Reserved
21 LFAST_TX_OBE_EN	LFAST TX Output Buffer Enable gating 0b - Output buffer disabled 1b - Output buffer enabled
20-0 —	Reserved

Chapter 84
Debug Subsystem

84.1 Introduction

This chapter discusses the debug and trace architecture of the chip that is based on the specifications provided in the *Arm® CoreSight™ SoC-400 Technical Reference Manual*. See References for a link to this document and to other related documentation available on the Arm website.

The chip architecture includes debug and trace modules. See Features for details on the debug and trace features that Cortex-M7 core clusters support.

The debug components that the Cortex-M7 core supports are accessible via the Arm DAP controller-based architecture. The DAP controller works in parallel with the system JTAGC. Both these controllers share the JTAG port and JTAG instruction set.

The system components are similar for different chips in the same family and include the primary core debug interfaces, the chip-level debug interfaces, and chip-level trace interfaces. The accelerator components include debug and trace circuits. These circuits are necessary for any application-specific accelerators required for the different application spaces that a chip supports. They vary from one chip to another and could include only trace components.

84.2 Interfaces supported in S32K396

The following interfaces are supported in S32K396:

- Cortex-M7_0 (CTI, DWT, BPU, ETM, ITM)
- Cortex-M7_1 (CTI, DWT, BPU, ETM, ITM)
- Cortex-M7_2 (CTI, DWT, BPU, ETM, ITM)
- Cortex-M0+
- HTM (CTI +DMA/EMAC TRACE)
- SWO
- TPIU
- ETF (5)
- FUNNELs (4)
- CTI (6)
- CTM (2)
- Timestamp
- MDM_AP
- SDA_AP
- HSE (MTB)

84.3 Block diagram

This figure illustrates the DAP architecture of the S32K396.

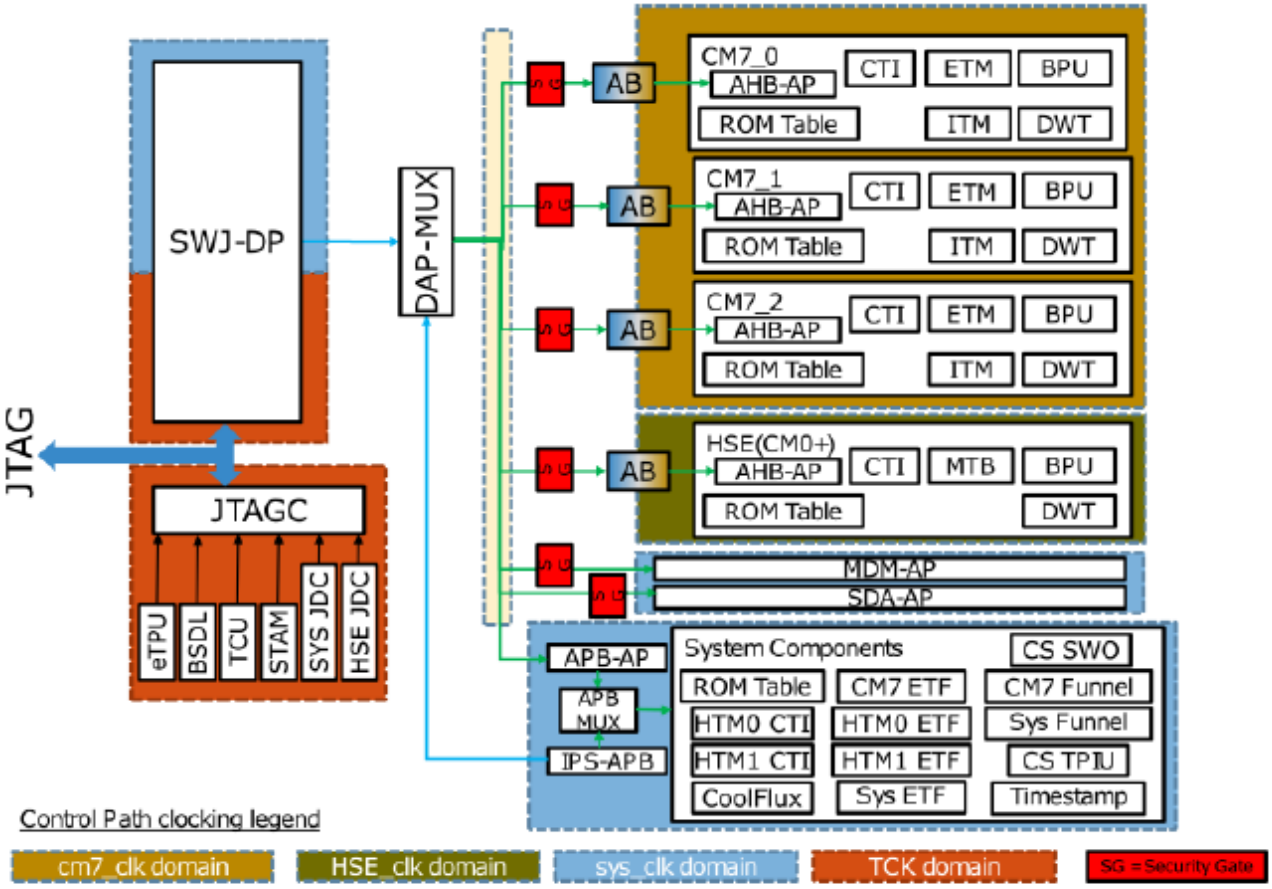


Figure 679. Detailed DAP architecture

NOTE

Debug components other than the Cortex-M0+ core are accessible through software path (CORE > AXBS > AIPS > DAPMUX > APs), that is, by directly specifying the memory mapped addresses without doing challenge response.

84.4 Features

This chip includes these features that support the functions listed under each feature type:

- Debug control
  - Is implemented via IEEE 1149.1-compliant JTAG
- Test control
  - Is implemented via IEEE 1149.1-compliant JTAG
  - Uses IEEE 1149.6 extension to IEEE 1149.1
- Trace interface
  - Includes four high-speed data pads and one clock pad @120 MHz (240 Mbit/s throughput per pad)
  - Includes 16 low-speed data pads and one clock pad @25 MHz (50 Mbit/s throughput per pad)
- Debug security

  - Includes a DAP/TAP interface that controls all debug features and is gated by Cortex M0+ JDC module
  - Includes security modes as described in the "Security" chapter
- Debugging and run control
  - Is implemented through stopping points, starting points, breakpoints, and watchpoints
  - Each Cortex-M7 core supports eight instruction comparators and a watchpoint unit having four watchpoints
- Trace source
  - Includes Cortex-M7:
    - ETM that provides instruction and data trace
    - ITM that provides DWT, time-stamping, and diagnostic information
- Cross-triggering support
  - Controls run-control options of cores based on other cores
  - Provides a matrix having connections to:
    - HTM via system CTI
    - All Cortex-M7 CPUs
- Ability to view and modify all memory-mapped areas that are not otherwise blocked—includes a system bus debug access port
- Performance monitoring of cores—implements a performance monitoring unit (PMU) on each Cortex core
- Safety
  - Supports monitoring of debug signals to avoid common mode faults
  - Allows checking of erroneous activation of debugging, especially if intrusive (for example, a CPU entering Debug state)
- Timestamps
  - Generates a timestamp bus for distribution to the trace sources
  - Includes a 48-bit binary timestamp bus
  - Clocks timestamp generator by a frequency of 160 MHz
- CoolFlux have APB connection to DAP and CTI interface.
- JTAGC interface for eTPU run control and debug register access (breakpoints, watchpoints).

84.5 Debug

84.5.1 TAP connectivity

This figure shows a detailed view of TAP connectivity. JTAG select, SWJ-DP, and JTAG-DP are parts of DAP.

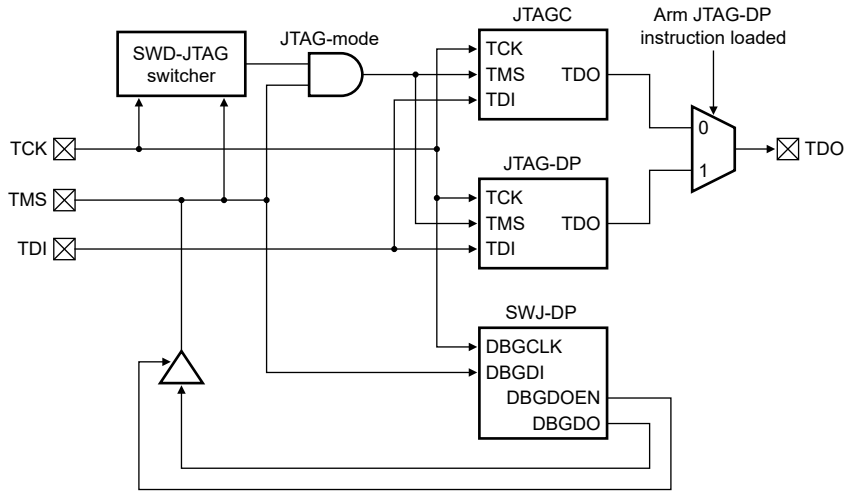


Figure 680. TAP connectivity

The debug port comes out of reset in a standard JTAG mode. It switches to another mode by using the change sequences. After the mode changes, unused debug pins can be reassigned to any of their alternative muxed functions.

JTAG-DP and JTAGC are connected in an overlay scheme and both have an Instruction Register (IR) length of 8 bits.

84.5.2 DAP TAP

DAP is an Arm component that provides multiple-master driving ports. A single external interface port accesses and controls these ports to provide system-wide debug.

The DAP Instruction Register (DAP IR) overlays with the system JTAG Instruction Register (JTAGC IR). Table 752 presents DAP instructions. In addition to the four codes listed in the table, DAP uses BYPASS, which is identical to JTAGC BYPASS and is therefore not shown in the table.

Table 752. DAP IR codes

Code	DAP IR
1111_1000b	ABORT
1111_1010b	DPACC
1111_1011b	APACC
1111_1110b	IDCODE

DAP offers an AHB master interface to access system buses. It also exports the internal DAP bus to extend the access ports. For more information on DAP TAP, see the *Arm Debug Interface Architecture Specification* document available in References.

In this chip:

- The AHB slave ports of all Cortex-M*x* cores provide debugger access to all memory units and registers in the system.
- The new pass-through approach allows the debugger to see a cache coherent view of the memory map for that core.
- The debugger must access the corresponding AHB_AP port to access the AHB-S port of that subsystem.
- XRDC controls system access.
- A core can access the debug components of another core through a DAPMUX to the bus interconnect.
- The exported DAP bus hosts AHB_AP and MDM_AP.

— MDM_AP hosts system-level JTAG status and control registers (see MDM_AP register descriptions). These registers can be used for cross triggering, synchronized debug, and other miscellaneous control and status functions.

— APB_AP uses an APSEL value of 1h to access any APB-mapped debug modules.

Table 756 describes the access addresses of APB-mapped debug modules. The value of the DAP select signal in the APSEL field of SWJ-DP's Select register selects the access ports in the DAP. Table 753 shows APSEL decoding.

Table 753. DAP master address mapping

DAP master #	DAP component	DAPBUS base address (access from debugger) [1]	System memory map address (access from cores)	
			Page number	Base address
0h	Reserved	0000_0000h	0	4025_0000h
1h	APB_AP to all APB-mapped debug modules (for example, ETFs, HTM, trace funnels, etc)	0100_0000h	0	4025_0100h
2h	Reserved	0200_0000h	0	4025_0200h
3h	AHB_AP to Cortex-M7_2 debug modules and chip system memory map	0300_0000h	0	4025_0300h
4h	AHB_AP to Cortex-M7_0 debug modules and chip system memory map	0400_0000h	0	4025_0400h
5h	AHB_AP to Cortex-M7_1 debug modules and chip system memory map	0500_0000h	0	4025_0500h
6h	MDM_AP	0600_0000h	0	4025_0600h
7h	SDA_AP	0700_0000h	0	4025_4700h
8h—FFh	Reserved (default AP response)	—	—	—

1. For example, 4000_XXYYh address is provided when accessing access ports (APs) via the debugger. Here, XX shows the AP select number and YY shows the address to be accessed. If you access SDA_AP via the debugger on 80h, you must provide the address 4000_0780h.

NOTE

Accessing SDA_AP simultaneously from the core and the debugger is prohibited. If you try to do so, you may receive unpredictable responses to core-initiated transactions (for example, incorrect data read, a failed attempt to write to the register, or a transfer error). Debugger-initiated transactions proceed correctly.

84.5.3 System JTAGC

JTAGC connects in parallel with the TAP controller (JTAG-DP of DAP), which has an IR length of 8 bits. The JTAGC IR codes overlay the ones of the DAP controller. DAP uses four instructions and JTAGC uses the remaining ones. The TAP outputs (TPOs) are multiplexed based on the selected IR code. This chip is fully JTAG-compliant and appears as a single TAP to the JTAG chain.

This table shows the JTAGC IR codes. The instructions that are used by Arm DAP TAP are shown in Table 752.

Table 754. JTAG instructions for JTAGC

Code	JTAGC IR
0000_0000b	IDCODE
0000_0001b	CENSOR_CTRL
0000_0010b	SAMPLE/PRELOAD
0000_0011b	SAMPLE
0000_0100b	EXTEST
0000_0101b	HI-Z
0000_0110b	Reserved
0000_0111b	Reserved
0000_1010b—0000_1011b	Reserved JTAG
0000_1100b	CLAMP
0000_1101b	ENABLE_SOC_DATA1
0000_1110b	Reserved
0000_1111b	Reserved
0001_0000b - 0111_1111b	Reserved
1000_0000b	Reserved
1000_0001b	Reserved
1000_0010b	Reserved
1000_0011b	Reserved
1000_0100b—1000_1110b	Reserved
1000_1111b	Reserved
1001_0000b	Security JDC
1001_0001b	System JDC
1001_0010b—1011_1111b	Reserved
1100_0000b—1110_1111b	Reserved

Table continues on the next page...

Table 754. JTAG instructions for JTAGC (continued)

Code	JTAGC IR
1100_0000b—1100_0011b	Reserved
1100_0100b	eTPU
1100_0101b—1100_1111b	Reserved
1101_0000b—1101_1111b	Reserved
1100_0010b—1110_1111b	Reserved
1111_0000b—1111_0111b	Reserved
1111_1000b	ABORT (Arm)
1111_1010b	DPACC (Arm)
1111_1011b	APACC (Arm)
1111_1100b	Reserved
1111_1101b	Reserved
1111_1110b	IDCODE (Arm)
1111_1111b	BYPASS

84.5.3.1 Chip JTAG/Target ID

S32K396 includes a unique JTAG ID, which must be changed when instantiated with a different die in an SiP. The table shows the JTAGC ID for this chip.

Table 755. JTAG/Target ID

Chip	PRN	DC	PIN	MIC	IDCODE ID	JTAG ID	Target ID
S32K396	1	26h (38d)	156h (342d)	Eh (14d)	1	1995_601Dh	1995_601Dh

84.5.3.2 JDC

JDC allows you to access two 32-bit data registers by using the JTAG interface and by software running on one of the CPUs in the chip. These registers exchange data between an internal CPU and an external debug tool.

84.5.4 Peripheral IPG debug implementation

S32K396 is a multi-core chip. Any core can control a peripheral instance individually. You define the core's control over a peripheral during application development.

For peripheral halt, all individual cores have the same capability and are gated by a dedicated MDM_AP core halt register field. For more information, see the configurations defined in MDM_AP register descriptions.

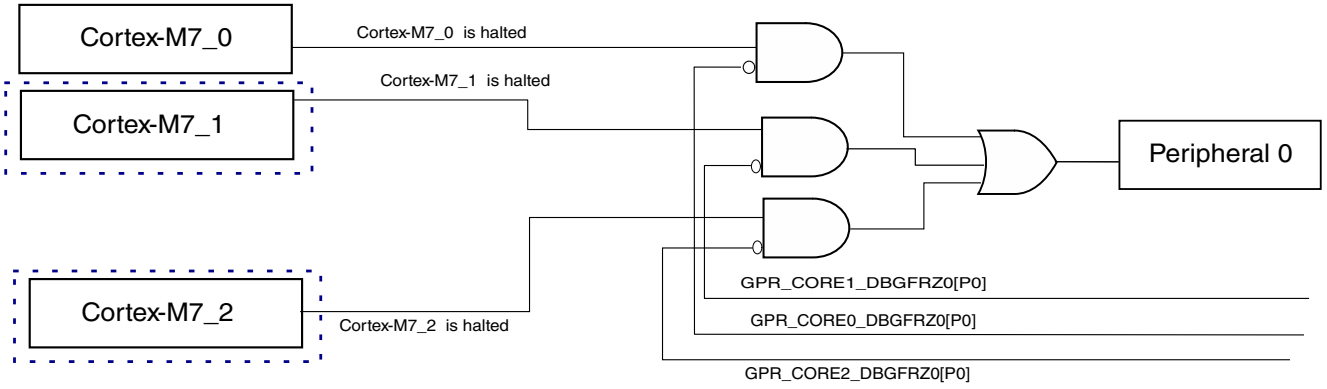


Figure 681. Peripheral IPG debug implementation

84.5.5 Application debugging

This section covers the following two cases:

- Case 1: Debugger connected—application debugging from the first instruction
- Case 2: Debugger not connected

84.5.5.1 Application debugging from first instruction

This chip supports debugging from the first instruction on system power-up, destructive reset, functional reset, and standby exit. However, by default, debugging from the first instruction is disabled.

The next figure shows the timing diagram of application debug implementation from first instruction on system power-up or destructive reset.

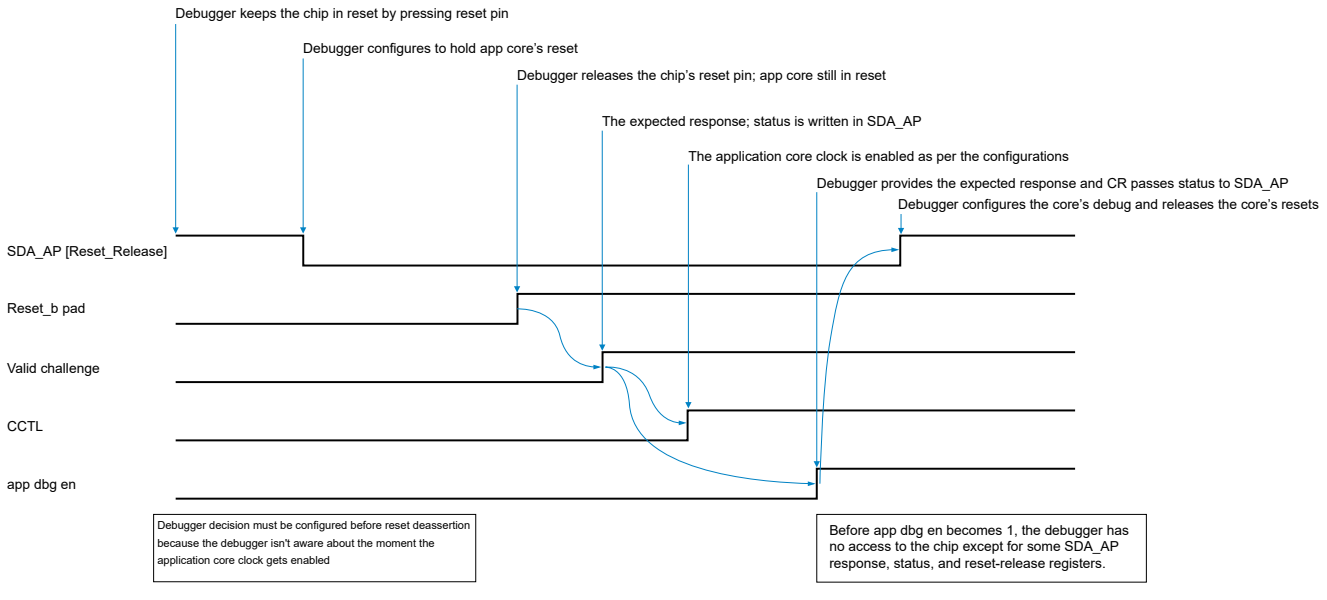


Figure 682. Application debug implementation from first instruction

These are the steps involved in enabling application debug from the first instruction on system power-up or destructive reset:

1. After the reset is applied, the debugger provides an option to debug from the first instruction. To do this:

a. Write 1 to SDAAPRSTCTRL[RSTRELTLCM70] and SDAAPRSTCTRL[RSTRELTLCM7].

b. Set the reset value of Reset Control (SDAAPRSTCTRL).

2. Cortex M0+ starts after the reset pin is released.
3. Debugger challenge-response (CR) starts.
4. Cortex-M7_0 and Cortex-M7_1 remain in reset until MC_ME's PRTN0_CORE0_PCONF[CCE] field becomes 1 for Cortex-M7_0 and PRTN0_CORE1_PCONF[CCE] field becomes 1 for Cortex-M7_1.
5. When BAF or FW writes 1 to MC_ME's PRTN0_CORE0_PCONF[CCE] field for Cortex-M7_0 and to PRTN0_CORE1_PCONF[CCE] field for Cortex-M7_1, and the debugger CR has passed:
   - If the value of SDAAPRSTCTRL[RSTRELTLCM71] and SDAAPRSTCTRL[RSTRELTLCM70] is 1 for their respective cores, the debugger configures the core debug registers and then enables these fields that start the code execution.

To debug from the first instruction during the low-power debug protocol, the debugger:

1. Writes 0 to SDAAPRSTCTRL[RSTRELTLCM71] and SDAAPRSTCTRL[RSTRELTLCM70] for their respective cores.
2. Writes 1 to MDMAPWIRREL[WTRSTRGM].

84.5.5.2 Debugger not connected

If the debugger is not connected, the value of the DBGPWRUP_ACK signal is 0 as there is no DBGPWRUP_REQ. This results in the following scenario:

1. The booting core writes 1 to MC_ME's PRTN0_CORE0_PCONF[CCE] field for Cortex-M7_0 and to PRTN0_CORE1_PCONF[CCE][42] field for Cortex-M7_1.
2. The application core starts running. In case of Lock-step mode, the checker core executes the same code after a delay of two cycles.

84.5.6 Debugger considerations while flash program/erase

The flash programming can be done by application cores as well as debugger. The debugger can program/erase flash using either of the following two options:

1. Loading the program/erase code to SRAM from the debugger and then executing the program/erase sequence by application code from SRAM.
   - Debugger is connected and authenticated.
   - The debugger loads the code in the form of application binary image into the on-chip SRAM.
   - The debugger then initiates the application core to execute the binary from SRAM.
2. Debugger executing the program/erase sequence.
   - Debugger is connected and authenticated.
   - The debugger then initiates the flash programming by reading/writing the registers involved and following the program/erase sequence.

First option is the recommended because of less execution time. In second option, the debugger is the master and since the debug interface is serial, the execution takes more time.

In some cases, you might experience flash program/erase failure due to flash watchdog timeout when debugger executes the flash program/erase sequence due to the serial interface. Therefore, it is recommended to use the first option. In case second option is required, it should be performed in reduced clocking options (Option E and E2 only. For details, refer to the **Clocking details** section in the **Clocking** chapter).

[42] PRTN0_CORE1_PCONF[CCE] is reserved for S32K36x as Cortex-M7_1 is not available.

84.5.7 SWJ-DP sequence for debug authentication

To perform the SWJ-DP sequence for debug authentication, the debugger:

1. Polls the AUTHSTTS[CHALRDY] field until it indicates the challenge status.
2. Reads Key Challenge (KEYCHAL0 - KEYCHAL7) if the challenge is valid and creates an authenticated 256-bit response key.
3. Writes a 256-bit response key to Key Response (KEYRESP0 - KEYRESP7).
4. Indicates that the response is ready by configuring AUTHCTL[HSEAUTHREQ].
5. Checks the status of Authentication Status (AUTHSTTS) to evaluate if the operation is successful.

   If the authentication process is successful and the debugger has write access to Debug Enable Control (DBGENCTRL), the challenge or response is considered successful too.

NOTE

SDA_AP supports challenge and response based on both JTAG and SWJ-DP modes. See SDAAPGENCTRL0[JTAG_CR_EN] for details.

84.6 APB memory map

You can access the debug registers via the APB_AP bus. The next table shows all the addresses for the CoreSight APB components and the addressing used for accessing the DAP components via the memory interface. You can also access all APB registers from the processing cores.

Table 756. APB components mapping

Debug APB component	APBIC base address (access from debugger)	System memory map address (access from cores)		Memory allocation (KB)	APB-AP0 slot number
		Page number	Base address		
APB_AP ROM table	F8h	0	4024_00F8h	4	APBIC base
Funnel 0	1000h	0	4024_1000h	4	0
Funnel 1	2000h	0	4024_2000h	4	1
Funnel 2	3000h	0	4024_3000h	4	2
CM7_cluster_ETF_ETMI	4000h	0	4024_4000h	4	3
CM7_cluster_ETF_ETMD	5000h	0	4024_5000h	4	4
HTM ETF	6000h	0	4024_6000h	4	5
Shared_system_ETF	7000h	0	4024_7000h	4	6
HTM 0	8000h	0	4024_8000h	4	7
HTM 0 CTI	9000h	0	4024_9000h	4	8
TPIU	A000h	0	4024_A000h	4	9

Table continues on the next page...

Table 756. APB components mapping (continued)

Debug APB component	APBIC base address (access from debugger)	System memory map address (access from cores)		Memory allocation (KB)	APB-AP0 slot number
		Page number	Base address		
System SWO	B000h	0	4024_B000h	4	10
Timestamp CTL	C000h	0	4024_C000h	4	11
HTM 1	D000h	0	4024_D000h	4	12
HTM 1 CTI	E000h	0	4024_E000h	4	13
Funnel 3	F000h	0	4024_F000h	4	14
Coolflux	10000h	1	4024_0000h	4	15
eTPU ETF4	11000h	1	4024_1000h	4	16
Reserved	12000h	1	4024_2000h	4	17
Reserved	13000h	1	4024_3000h	4	18

84.7 Trace

84.7.1 Trace modules and connectivity

The Trace subsystem:

- Combines trace data from all internal clients that generate trace information
- Includes a 32-bit TPIU
- Includes these components:
  - ATB
  - ATBR
  - CSTF
  - Debug APB
  - ETF
  - TPIU

Multiple options for trace output allow parallel tracing. Trace information can be read from the trace interface or the DAP interface, and traces can be alternatively read out from ETF at a slow speed via APB_AP. Table 757 shows EFT sizes.

Table 757. ETF sizes

FIFO	Memory interface data width (in bits)	Size (KB)
Cortex-M7 ETM/ITM cluster ETF	32	2
Cortex-M7 ETMD cluster ETF	64	2
HTM ETF	32	1
Shared system ETF	32	4
ETPU ETF	32	1

NOTE

- The DMA-HTM trace supports four words at 80 MHz. For HTM trace, both DBGENCTRL[GSPNIDEN] and DBGENCTRL[GSPIDEN] must be 1.
- Enabling any one of data trace causes overflow inside ETM and trace packets get dropped. Enabling instruction trace of both the core simultaneously does not cause any overflow.

Control (MDMAPCTL) provides fields to override the speed control (see Table 758 for details) from some of the trace sinks (and TPIU). The complete trace pipeline bandwidth is limited by the slowest sink component. The default settings of these fields allow maximum bandwidth for the TPIU to trace. When tracing to memory (if supported), the fields may need to be changed.

Table 758. Trace output overrides

Trace destination	SWO_override	TPIU_override
TPIU	1	0

The trace sources of the chip are the cores and their related modules. Trace funnels exist for all possible trace clients. For more information on the various components in the trace bus connectivity, see the *CoreSight Components Technical Reference Manual* (available in References). See Table 759 for details on funnel assignments.

The ATBR is integrated to send a shared funnel output across TPIU. This figure illustrates the chip's detailed trace architecture.

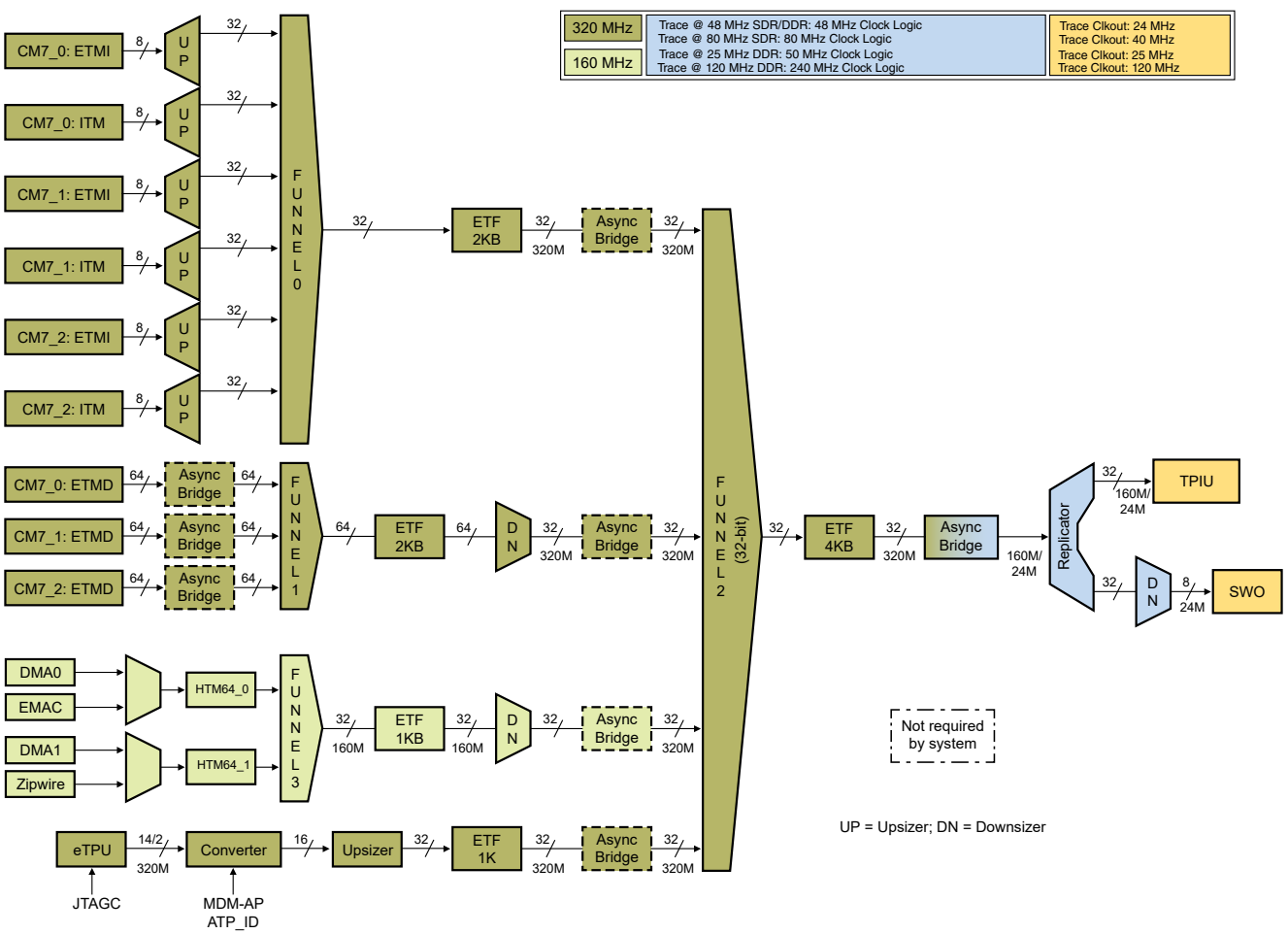


Figure 683. S32K396 detailed trace architecture

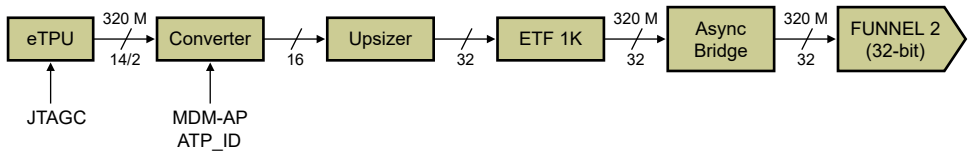


Figure 684. eTPU Trace

Table 759. Funnel assignments

Funnel	Port	Input	Frequency
0	0	CM7_0 ETMI	320 MHz
0	1	CM7_0 ITM	320 MHz
0	2	CM7_1 ETMI	320 MHz
0	3	CM7_1 ITM	320 MHz
0	4	CM7_2 ETMI	320 MHz
0	5	CM7_2 ITM	320 MHz
1	0	CM7_0 ETMD	320 MHz
1	1	CM7_1 ETMD	320 MHz
1	2	CM7_2 ETMD	320 MHz
2	0	CM7 Instruction ETF through an Async Bridge	320 MHz
2	1	CM7 Data ETF through an Async Bridge	320 MHz
2	2	HTM ETF through an Async Bridge	160 MHz
2	3	eTPU through asyncbridge	320 MHz
3	0	HTM_0	160 MHz
3	1	HTM_1	160 MHz

84.7.1.1 Chip's bus trace client

This chip include a bus trace client.

HTM provides the address and data trace information about AXBS buses. The information from an HTM can be used with the debugger to enable easy, accurate debugging on AXBS-based embedded systems. The chip implements an HTM64 configuration to trace 64-bit AXBS masters in the system. To simplify the implementation, instead of tracing the individual ports of various AXBS masters and slaves, which may be running at different frequencies, HTM64 snoops the AXBS crossbar master ports that are all synchronous with a 160 MHz system clock. This table provides details related to the HTM input connectivity.

Table 760. HTM connections

HTM64 port	AHB crossbar port
HTM_0_BUSSELECT0	M0 AXBS_Lite XBIC (DMA)
HTM_0_BUSSELECT1	M0 AXBS_Lite XBIC (Ethernet)

Table continues on the next page...

Table 760. HTM connections (continued)

HTM64 port	AHB crossbar port
HTM_1_BUSSELECT0	M1 AXBS_Lite XBIC (DMA)
HTM_1_BUSSELECT1	M1 AXBS (Zipwire)

84.7.1.2 TPIU interface

A standard 16-bit parallel TPIU is integrated into the debug subsystem. This chip generate the trace via the trace port.

To prevent instruction trace from being dropped in a multi-core environment, a TPIU throughput of 55.2 MB/s or higher must be maintained. You could use these pin and frequency combinations:

- Four high-speed data + one clock pads @120 MHz (240 Mbit/s throughput per pad equivalent to 30 MB/s) resulting in total 120 MB/s
- 16 low-speed data + one clock pads @25 MHz (50 Mbit/s throughput per pad equivalent to 6.25 MB/s) resulting in total 100 MB/s

This chip can support at least 56 MB/s of trace throughput on the TPIU interface.

Table 761. Throughput

Core	Throughput value
Cortex-M7_0	27.6 MB/s
Cortex-M7_1	27.6 MB/s
Cortex-M7_2	27.6 MB/s
Total	82.8 MB/s

84.7.1.3 TPIU flush

To allow the chip to enter Standby mode, software executes an WFI instruction indicating Standby entry. When the chip enters this mode, MC_RGM asserts a trace flush request to the TPIU and waits for a trace flush done signal from the TPIU before requesting MC_PCU to proceed. The TPIU and debug infrastructure clocks can be gated after this. Because the TPIU is sourced from system clock, the clock must not be gated until this point.

84.7.1.4 Trace through reset

All debug and trace components (HTM, ETM, ETF, and so on) are on destructive reset. When tracing through reset, the clock switches from PLL to FIRC. It is recommended to preserve the following pad configurations across reset, which are performed through MDMAPCTL[DBGRSTFASTPAD] and MDMAPCTL[DBGRSTSLOWPAD]:

- Four high-speed data + one clock pads @120 MHz (240 Mbits/s throughput per pad) totaling 120 MB/s
- 16 low-speed data + one clock pads @25 MHz (50 Mbits/s throughput per pad) totaling 100 MB/s

The implementation involves writing 1 to MDMAPCTL[DBGRSTFASTPAD] or MDMAPCTL[DBGRSTSLOWPAD], depending on which set of trace pads you need to enable. These fields also control:

- The trace pad mux.
- The "obe" of the trace pads, which, if configured, is retained over functional reset because the reset is controlled using the above-mentioned corresponding fields.

84.7.2 Trace assignments

ETF combines trace information from multiple clients into a single stream of trace data. This table shows the CoreSight funnel input assignments.

Table 762. CoreSight funnel assignments

Instance name	Port assignment
Funnel 0 (CSTF0)	Cortex-M7_0 ETMI
	Cortex-M7_0 ITM
	Cortex-M7_1 ETMI
	Cortex-M7_1 ITM
	Cortex-M7_2 ITM
	Cortex-M7_2 ETMI
Funnel 1 (CSTF1)	Cortex-M7_0 ETMD
	Cortex-M7_1 ETMD
	Cortex-M7_2 ETMD
Funnel 2 (CSTF2)	Funnel 0
	Funnel 1
	Funnel 3
	eTPU through asyncbridge
Funnel 3 (CSTF3)	HTM64 (DMA0)
	HTM64 (DMA1)

84.8 Embedded cross trigger (ECT)

ECT allows multi-core run control and trace cross-triggering, such as synchronous stop-start for all cores or trigger trace on a trigger event from another core or module. See the *CoreSight Components Technical Reference Manual* (available in References) for detailed information on ECT.

ECT architecture involves CTMs and CTIs. The CTIs provide a cross-triggering interface between the cores and other debug and trace modules. The channels of these CTIs are interconnected using CTMs, as shown in this figure.

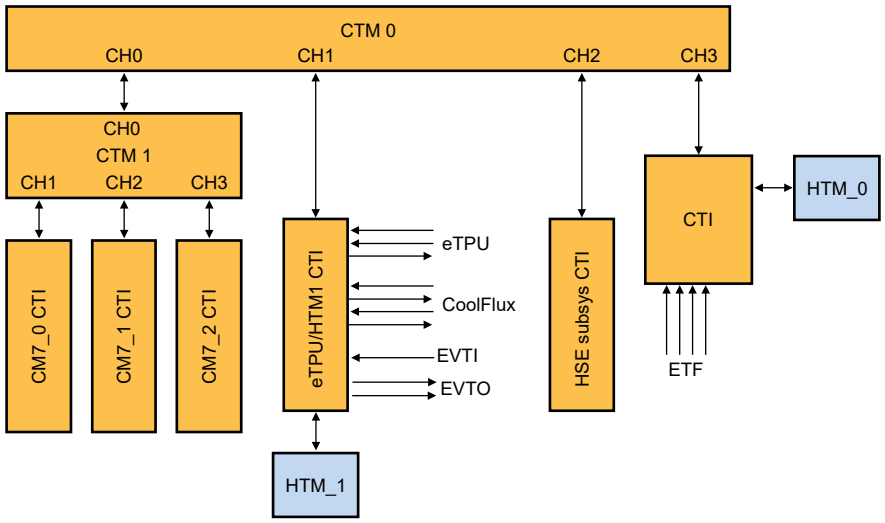


Figure 685. ECT

84.8.1 CTI assignments

6 CTIs are used for cross triggering the following components in multicore deivces: CM7_0,CM7_1,CM7_2, HSE subsystem and HTM x2

Table 763. CTI assignments

CTI instance	Trigger number	Trigger in	Trigger out
CTI1_COOLFLUX_ETPU_HTM1	7	EVTI	EVTO_1[1]
	6	Break_out (ETPU)	EVTO_0[1]
	5	Event_Out (ETPU)	Event_In (ETPU)
	4	Break_in (COOLFLUX)	Break_Out (COOLFLUX)
	3	Restart_in (COOLFLUX)	Restart_out (COOLFLUX)
	2	HTM1 External Trigger input 1	HTM1 External Output Event 1
	1	HTM1 External Trigger input 0	HTM1 External Output Event 0
	0	Reserved	HTM Trigger
CTI0_HTM_ETF	7	Reserved (grounded)	Reserved (no connection)
	6	ETF3 full trigger indication	ETF3 Trigger input
	5	ETF2 full trigger indication	ETF2 Trigger input
	4	ETF1 full trigger indication	ETF1 Trigger input
	3	ETF0 full trigger indication	ETF0 Trigger input
	2	HTM trigger output 2	HTM trigger input 2
	1	HTM trigger output 1	HTM trigger input 1
	0	Reserved	HTM Trigger input 0
CTI_Cortex-M7_0	7	ETM event output 3	Processor restart
	6	ETM event output 2	ETM event input 3
	5	ETM event output 1	ETM event input 2
	4	ETM event output 0	ETM event input 1
	3	DWT comparator output 2	ETM event input 0
	2	DWT comparator output 1	Interrupt request 1
	1	DWT comparator output 0	Interrupt request 0
	0	Processor halted	Processor debug request
CTI_Cortex-M7_1	7	ETM event output 3	Processor restart
	6	ETM event output 2	ETM event input 3
	5	ETM event output 1	ETM event input 2
	4	ETM event output 0	ETM event input 1

Table continues on the next page...

Table 763. CTI assignments (continued)

CTI instance	Trigger number	Trigger in	Trigger out
	3	DWT comparator output 2	ETM event input 0
	2	DWT comparator output 1	Interrupt request 1
	1	DWT comparator output 0	Interrupt request 0
	0	Processor halted	Processor debug request
CTI_Cortex-M7_2	7	ETM event output 3	Processor restart
	6	ETM event output 2	ETM event input 3
	5	ETM event output 1	ETM event input 2
	4	ETM event output 0	ETM event input 1
	3	DWT comparator output 2	ETM event input 0
	2	DWT comparator output 1	Interrupt request 1
	1	DWT comparator output 0	Interrupt request 0
	0	Processor halted	Processor debug request

1. eTPU triggers need glue logic for CTI compatibility. The Nexus Event in/out signals are pulse signals. CTI needs to be configured for pulse.

NOTE

Additional configuration is required for CoolFlux.

84.9 Low-power debug handshake protocol

The debugger must perform this sequence to enter or exit Standby mode, if the debugger handshake is enabled:

1. Power on DAP.

   The debugger connection is established.

2. Configure the Debug subsystem for the relevant operations.
3. Write 1 to MDMAPWIREN[LWPWREN] to gate entry into Standby mode with the debugger handshake. If TPIU is disabled, write 1 to MDMAPWIREN[LWPRSTPRVT] too.
4. Disable POR_WDG for monitoring the entry to or exit from Standby mode by writing 1 to DCM's DCMRWP1[8] field. This is required for low-power debug handshake because debugger configurations can be more time consuming than the POR_WDG threshold levels and can raise a false POR_WDG event.
5. Write 1 to DCMRWF1[STANDBY_IO_CONFIG] in the Device Configuration Module (DCM). This causes padkeeping to be disabled on standby entry itself without any software dependency. This is needed in case of low-power debug since otherwise the padkeeping on TDO would result in no debugger communication. In other cases, DCMRWF1[STANDBY_IO_CONFIG] should be configured as 0 before standby entry.
6. Initiate entry into Standby mode. See the "Power Management" chapter for the Standby mode entry sequence and configurations.
7. Identify whether the low-power debug is enabled on the low-power entry.
   - If low-power debug is enabled and TPIU is enabled too, trace flush starts, and the debugger acknowledges the following:
     - Low-power debug traces
     - DAP-related configuration reception and context saving

After this, the chip enters Standby mode.

- If TPIU is disabled:
  - The debugger acknowledges DAP-related configuration reception and context saving by writing 1 to MDMAPWIRREL[PRVNTRSTRGM].

    After this, the chip enters Standby mode.
- If low-power debug is disabled, the chip enters Standby mode without waiting for debugger acknowledgment.

On any wakeup event, the chip starts the Standby mode exit sequence described in the "Power Management" chapter. After the chip exits Standby mode, the debugger connection is restored. By this time, the debugger is already aware that it has enabled the low-power debug handshake. In this case, the debugger must poll MDMAPSTTS[DESTRST] to check whether:

- The debug infrastructure is out of reset.
- The DAP connection can be established.

After DAP is powered on (the debugger connection is established), the debugger:

a. Reconfigures the debug and trace attributes using the fields in DBGENCTRL

b. Writes 1 to MDMAPWIRREL[WTRSTRGM] after the debugger trace context is restored

   The chip exits Standby mode.

   If low-power debug is not configured, the chip exits Standby mode without waiting for the debugger to write to MDMAPWIRREL[WTRSTRGM].

8. Reconfigure the debug and trace configuration in SDA_AP register descriptions after the chip exits Standby mode.

NOTE

If the chip wakes up from Standby mode through pad reset, the debugger must perform a CR again.

84.10 Development Trigger Semaphore (DTS)

The MDM-AP shall implement the DTS option with 128 triggers, 4 start-up register and 1 information register.The MDM-AP will include similar functionality to the Development Trigger Semaphore (DTS).

DTS Register access

A summary of accesses to all 32-bit DTS registers. Only proper 32-bit accesses are valid. The effects of write accesses that are not 32 bits are not defined. External/Internal determine by memory space used to access the register.

- SIUL Pin configuration for MSCR19
- DTS enable from External access
- Write on DTS Semaphore register through Internal access
- EVTO trigger will be written via DTS Semaphore register with DTS enable from external access.

NOTE

Internal Access: Access by Software and External Access: Access by Debugger.

Table 764. DTS Register access

Register	32-bit read		32-bit write	
	External Access	Internal Access	External Access	Internal Access
DTS_ENABLE	Data	Data	Data	No effect
DTS_STARTUP	Data	Data	Data	No effect

Table continues on the next page...

Table 764. DTS Register access (continued)

Register	32-bit read		32-bit write	
	External Access	Internal Access	External Access	Internal Access
DTS_STARTUP_B	Data	Data	Data	No effect
DTS_STARTUP_C	Data	Data	Data	No effect
DTS_STARTUP_D	Data	Data	Data	No effect
DTS_SEMAPHORE	Data and Clear	Data	No effect	Bit OR
DTS_SEMAPHORE_B	Data and Clear	Data	No effect	Bit OR
DTS_SEMAPHORE_C	Data and Clear	Data	No effect	Bit OR
DTS_SEMAPHORE_D	Data and Clear	Data	No effect	Bit OR

NOTE

A read of the Semaphore registers by the external access is destructive and clears all bits in the registers.

The DTS / CTI implements two external inputs (EVTI) to enable triggering of debug events (e.g. breakpoints and watchpoints.

The DTS / CTI implements two external outputs (EVTO) to enable external signaling of debug events (e.g. breakpoints and watchpoints).

DTS/CTI external triggering implementation is shown in the diagram below:

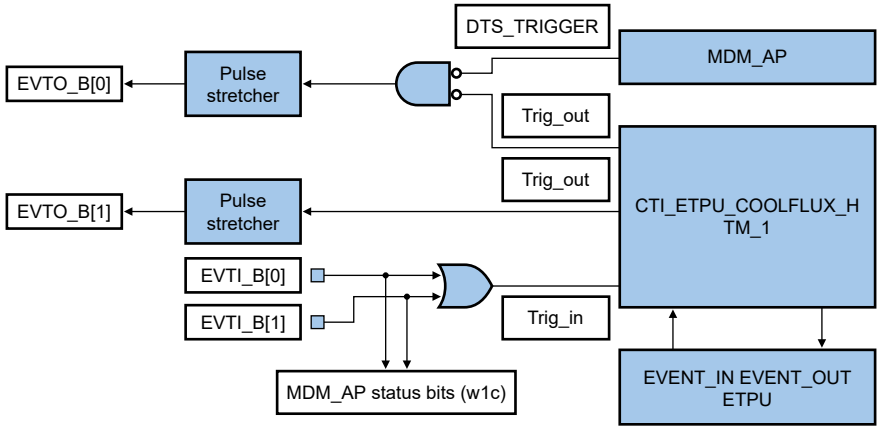


Figure 686. DTS - CTI Implementation

84.11 Debug resets

The debug subsystem follows this sequence on the source of reset:

1. POR resets the complete debug logic.
2. The destructive reset resets all types of debug logic except JTAGC.

Conversely, the debug subsystem can generate a system reset using these mechanisms:

- System destructive reset defined in Control (MDMAPCTL) that allows the debugger to provide the destructive reset to the system. The debugger loses connection to the system with this reset.
- System functional reset defined in Control (MDMAPCTL) that allows the debugger to hold the system in functional reset.

To program various debug registers, the functional clocks must be enabled. All debug and trace components must be on destructive reset.

84.12 Pin interface

This table presents a summary of functional and power pins that are used for debugging purposes.

Table 765. Pin interface

Pin type	Pins	Number of pins (balls)[1]	Nominal voltage
Functional JTAG	JCOMP, TCK, TMS, TDI, TDO	Five (only TDI and TDO can be multiplexed with GPIO or other functions)	3.3 V, 5 V
Functional trace pins (parallel trace)	TRACE_CLK	One	3.3 V, 5 V
	TRACE_D[15:0]	16	3.3 V, 5 V
Ground	VSS	See the IOMUX file attached to this document for information on the number of VSS pins in various packages.	0 V

1. The terms pins and balls are used interchangeably. Some chip packages include pins and others include balls.

84.12.1 Debug port and pin descriptions

The pads to which the debug signals are mapped operate using the JTAG functionality out of reset but can later be reassigned to their alternate functionalities. TDI and TDO can operate as alternate GPIO functions. See this table for pin assignments in different modes.

Table 766. Debug port pins

Pin name	JTAG debug port		Internal pullup or pulldown logic
	Type	Description	
TMS	I/O	JTAG test mode selection (TMS)	Pullup
TCK/SWCLK	I	JTAG test clock (TCK)	Pulldown
TDI	I	JTAG test data input (TDI)	Pullup
TDO/TRACESWO	O	JTAG test data output (TDO)	Not connected

84.12.2 Trace port pin descriptions

This chip generates trace via TPIU that transmits the trace data out of the chip over a parallel trace port. The trace port consists of an ETM trace clock and 16 parallel trace data outputs. The Arm optional trace port control (TRACECTRL), debug request (DBGRQ), and debug acknowledge (DBGACK) signals are not implemented.

Table 767. Trace output port pins

Pin name	Description
TRACE_DATA00	ETM parallel trace data output 01
TRACE_DATA01	ETM parallel trace data output 01
TRACE_DATA02	ETM parallel trace data output 02
TRACE_DATA03	ETM parallel trace data output 03
TRACE_DATA04	ETM parallel trace data output 04
TRACE_DATA05	ETM parallel trace data output 05
TRACE_DATA06	ETM parallel trace data output 06
TRACE_DATA07	ETM parallel trace data output 07
TRACE_DATA08	ETM parallel trace data output 08
TRACE_DATA09	ETM parallel trace data output 09
TRACE_DATA10	ETM parallel trace data output 10
TRACE_DATA11	ETM parallel trace data output 11
TRACE_DATA12	ETM parallel trace data output 12
TRACE_DATA13	ETM parallel trace data output 13
TRACE_DATA14	ETM parallel trace data output 14
TRACE_DATA15	ETM parallel trace data output 15
TRACE_CLK	ETM parallel trace clock output

NOTE

By default, Rx pins float and are not pulled inside. An internal active pulldown logic exists only when you enable Rx via software (IBE).

84.13 Timestamp distribution network

The timestamp distribution network uses CoreSight timestamp components to generate a 48-bit timestamp value for the trace sources, as shown in the next figure. The CoreSight timestamp generator generates a 64-bit counter value, but only the least significant 48 bits are distributed to the trace sources. A 7-bit narrow timestamp is derived from the 48-bit timestamp and distributed to the trace client, where a decoder regenerates the 48-bit timestamp. The generator must be programmed, and you could find the related programming information in the *CoreSight Components Technical Reference Manual* (available in References).

This chip supports 48-bit timestamping. The generator operates at a frequency of 160 MHz and gives a 64-bit timestamp value. The Cortex-M7_0 and Cortex-M7_1 cores operate at a frequency of 160 MHz.

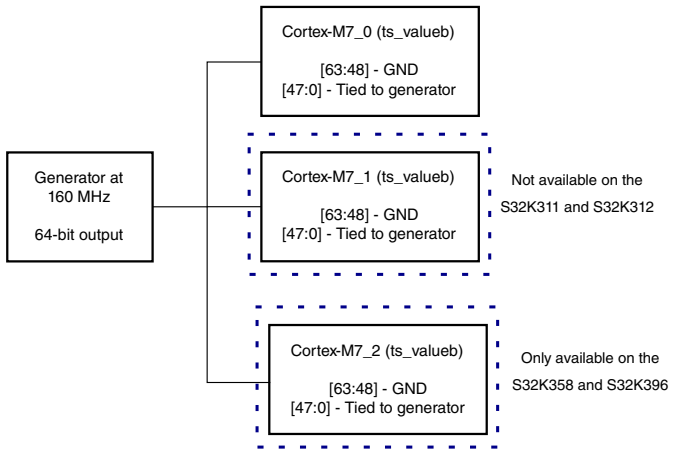


Figure 687. Timestamp distribution network

84.14 Peripheral debug freeze register descriptions

Implement the logic provided in this section for each peripheral instance supporting the debug operation.

NOTE

Debug freeze is enabled for all the peripherals so that as soon as the core halts, peripherals can be frozen to support debugging from the first instruction.

For register details, refer to the following registers in the Device Configuration Module (DCM):

- Read Write GPR On Destructive Reset Register (DCMRWD6)
- Read Write GPR On Destructive Reset Register (DCMRWD7)
- Read Write GPR On Destructive Reset Register (DCMRWD8)
- Read Write GPR On Destructive Reset Register (DCMRWD9)

84.15 MDM_AP register descriptions

The debugger has access to the status and control elements implemented as registers in MDM_AP, which is selected by APSEL (6h) on the DAP bus. These registers provide additional control and status information for typical debug, cross-triggering, and run-control scenarios. Also, the register fields provide a way for the debugger to get the updated status of the core without initiating a bus transaction across the crossbar switch, thus remaining less intrusive during a debug session.

MDM_AP is accessible as DAP (see DAP TAP for details).

NOTE

eTPU is supported for S32K396 only.

84.15.1 MDM_AP memory map

MDM_AP base address: 4025_0600h

Offset	Register	Width (In bits)	Access	Reset value
0h	Status (MDMAPSTTS)	32	R	F000_0000h

Table continues on the next page...

Table continued from the previous page...

Offset	Register	Width (In bits)	Access	Reset value
4h	Control (MDMAPCTL)	32	RW	0640_0000h
8h	DTS Enable (MDMAPDTSEN)	32	RW	0000_0000h
Ch	DTS Startup (MDMAPDTSSTARTUP)	32	RW	0000_0000h
10h	DTS Startup B (MDMAPDTSSTARTUPB)	32	RW	0000_0000h
14h	DTS Startup C (MDMAPDTSSTARTUPC)	32	RW	0000_0000h
18h	DTS Startup D (MDMAPDTSSTARTUPD)	32	RW	0000_0000h
1Ch	DTS Semaphore (MDMAPDTSSEMAPHORE)	32	RW	0000_0000h
20h	DTS Semaphore B (MDMAPDTSSEMAPHOREB)	32	RW	0000_0000h
24h	DTS Semaphore C (MDMAPDTSSEMAPHOREC)	32	RW	0000_0000h
28h	DTS Semaphore D (MDMAPDTSSEMAPHORED)	32	RW	0000_0000h
30h	WIR Enable (MDMAPWIREN)	32	RW	0000_0000h
34h	WIR Status (MDMAPWIRSTTS)	32	R	0000_0000h
38h	WIR Release (MDMAPWIRREL)	32	RW	0000_0000h
44h	ETPU_CONTROL_ENABLE (MDMAPETPUCTRLEN)	32	RW	0000_0300h
48h	ETPU_STATUS_ENABLE (MDMAPETPUSTTSEN)	32	R	0000_000Ch
FCh	Identity (ID)	32	R	001C_0030h

84.15.2 Status (MDMAPSTTS)

Offset

Register	Offset
MDMAPSTTS	0h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	CM72 DBG...	Reserved	CM71 DBG...	CM70 DBG...	Reserved				Reserved	CM72 SLP...	CM71 SLP...	CM70 SLP...	Reserved	CM72 DPS...	CM71 DPS...	CM70 DPS...
W																
Reset	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved	CM72 HLT	CM71 HLT	CM70 HLT	Reserved									FUNC RST	DEST RST	Reserved
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 CM72DBGRSTRD	Cortex-M7_2 Debug Restarted Indicates if Cortex-M7_2 has returned to Normal mode from Debug mode. 0b - In Debug mode 1b - In Normal mode
30 —	Reserved
29 CM71DBGRSTRD	Cortex-M7_1 Debug Restarted Indicates if Cortex-M7_1 has returned to Normal mode from Debug mode. 0b - In Debug mode 1b - In Normal mode
28 CM70DBGRSTRD	Cortex-M7_0 Debug Restarted Indicates if Cortex-M7_0 has returned to Normal mode from Debug mode. 0b - In Debug mode 1b - In Normal mode
27-24 —	Reserved
23 —	Reserved
22 CM72SLPNG	CM7_2 Sleeping Indicates if Cortex-M7_2 is in Sleep mode.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not in Sleep mode 1b - In Sleep mode
21 CM71SLPNG	CM7_1 Sleeping Indicates if Cortex-M7_1 is in Sleep mode. 0b - Not in Sleep mode 1b - In Sleep mode
20 CM70SLPNG	Cortex-M7_0 Sleeping Indicates if Cortex-M7_0 is in Sleep mode. 0b - Not in Sleep mode 1b - In Sleep mode
19 —	Reserved
18 CM72DPSLP	Cortex-M7_2 Deep Sleep Indicates if Cortex-M7_2 is in Deep Sleep mode. 0b - Not in Deep Sleep mode 1b - In Deep Sleep mode
17 CM71DPSLP	Cortex-M7_1 Deep Sleep Indicates if Cortex-M7_1 is in Deep Sleep mode. 0b - Not in Deep Sleep mode 1b - In Deep Sleep mode
16 CM70DPSLP	Cortex-M7_0 Deep Sleep Indicates if Cortex-M7_0 is in Deep Sleep mode. 0b - Not in Deep Sleep mode 1b - In Deep Sleep mode
15 —	Reserved
14 CM72HLT	CM7_2 Debug Halted Indicates if Cortex-M7_2 is halted because of entry into Debug mode. 0b - Core is not halted 1b - Core is halted
13	CM7_1 Debug Halted

Table continues on the next page...

Table continued from the previous page...

Field	Function
CM71HLT	Indicates if Cortex-M7_1 is halted because of entry into Debug mode. 0b - Core is not halted 1b - Core is halted
12 CM70HLT	Cortex-M7_0 Halted Indicates if Cortex-M7_0 is halted because of entry into Debug mode. 0b - Core is not halted 1b - Core is halted
11-3 —	Reserved
2 FUNCRST	Functional Reset Indicates the system reset state. 0b - Not in functional reset 1b - In functional reset
1 DESTRST	Destructive Reset Indicates the system reset state. 0b - Not in destructive reset 1b - In destructive reset
0 —	Reserved

84.15.3 Control (MDMAPCTL)

Offset

Register	Offset
MDMAPCTL	4h

Function

Allows the debugger:

- To give the destructive reset to the system. A system destructive reset enables this. The debugger also loses connection to the system with this reset.
- To hold the system in functional reset. A system functional reset enables this.

NOTE

The trace functionality on trace pins is selected with this register and is retained across the functional reset.

NOTE

For lockstep cores, both bits for the core and its checker core need to be set together. Bits 18 and 19 should be written in conjunction always. Bits 16 and 17 should be written in conjunction if lockstep is enabled for cores 0 and 1.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	CM72 DBG...	Reserved	CM71 DBG...	CM70 DBG...	Reserved					SWOO VRD	Reserved	TRIUO VRD	CM7_2 _C...	CM7_2 _C...	CM7_1 _C...	CM7_0 _C...
Reset	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	POR_ WDG...	Reserved	DBGR STF...	DBGR STS...	Reserved	CM72 DBG...	CM71 DBG...	CM70 DBG...	Reserved		SYSF UNC...	SYSR ESE...	Reserved			
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31 CM72DBGRSRT	Cortex-M7_2 Debug Restart Indicates if a request to Cortex-M7_2 to leave the debug halt state is asserted. 0b - Normal operation 1b - Request asserted
30 —	Reserved
29 CM71DBGRSRT	Cortex-M7_1 Debug Restart Indicates if a request to Cortex-M7_1 to leave the debug halt state is asserted. 0b - Normal operation 1b - Request asserted
28 CM70DBGRSRT	Cortex-M7_0 Debug Restart Indicates if a request to Cortex-M7_0 to leave the debug halt state is asserted. 0b - Normal operation 1b - Request asserted
27-23 —	Reserved
22 SWOOVRD	SWO Override Indicates if the SWO trace response is overriden. When TPIU is not the selected trace sink target, you must override the trace response.

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - Not overridden, and SWO generates the trace response 1b - Is overridden
21 —	Reserved
20 TRIUOVRD	TPIU Override Indicates if TPIU trace response is overridden. When TPIU is not the selected trace sink target, you must override the trace response. 0b - Not overridden, and TPIU generates the trace response 1b - Is overridden and asserted
19 CM7_2_CHK_CORE_ACCESS	Debugger Access To Application Cortex-M7_2 checker core Indicates if debugger access to Cortex-M7_2 checker core across the functional reset phase is supported. After programming the Cortex-M7_2 core debug logic, the debugger can write 1 to this field. Because of this, the clock gating control for CLK and FCLK of Cortex-M7_2 checker core shifts to CCTL. 0b - Supported 1b - Not supported
18 CM7_2_CORE_ACCESS	Debugger Access To Application Cortex-M7_2 Indicates if debugger access to Cortex-M7_2 across the functional reset phase is supported. After programming the Cortex-M7_2 core debug logic, the debugger can write 1 to this field. Because of this, the clock gating control for CLK and FCLK of Cortex-M7_2 shifts to CCTL. 0b - Supported 1b - Not supported
17 CM7_1_CORE_ACCESS	Debugger Access To Application Cortex-M7_1 Indicates if debugger access to Cortex-M7_1 across the functional reset phase is supported. After programming the Cortex-M7_1 core debug logic, the debugger can write 1 to this field. Because of this, the clock gating control for CLK and FCLK of Cortex-M7_1 shifts to CCTL. 0b - Supported 1b - Not supported
16 CM7_0_CORE_ACCESS	Debugger Access To Application Cortex-M7_0 Indicates if debugger access to Cortex-M7_0 across the functional reset phase is supported. After programming the Cortex-M7_0 core debug logic, the debugger can write 1 to this field. Because of this scenario, the clock gating control for CLK and FCLK of Cortex-M7_0 shifts to CCTL. 0b - Supported 1b - Not supported

Table continues on the next page...

Table continued from the previous page...

Field	Function
15 POR_WDG_DIS	Power Watchdog Status When a 0 is written to this field, the power watchdog is disabled in case of MDM FUNC reset or JTAG reset. When a 1 is written to this field, the power watchdog is enabled in case of MDM FUNC reset or JTAG reset. 0b - Power watchdog is disabled 1b - Power watchdog is enabled
14 —	Reserved
13 DBGRSTFASTPAD	Debug Over Reset Via Fast Pads Enables or disables trace via fast pads. If enabled, the trace pads have trace over functional reset feature enabled. This field does not take care of the clock configuration. **NOTE** Pad configuration must be DSE = 1b and SRE = 0b. 0b - Disabled 1b - Enabled
12 DBGRSTSLOWPAD	Debug Over Reset Via Slow Pads Enables or diasables trace via slow pads. If enabled, the trace pads have trace over functional reset feature enabled. This field does not take care of the clock configuration. 0b - Disabled 1b - Enabled
11 —	Reserved
10 CM72DBGREQ	Cortex-M7_2 Debug Request Drives the EDBGREQ input for Cortex-M7_2 and indicates if the debug request is generated. When the core goes into debug state, the field acknowledges that with a halted output signal (see MDMAPSTTS[CM72HLT]). If the core is in Stop mode, this field is used to wake up the core and transition it to the debug halt state. 0b - Debug request is not generated 1b - Debug request is generated
9 CM71DBGREQ	Cortex-M7_1 Debug Request Drives the EDBGREQ input for Cortex-M7_1 and indicates if the debug request is generated. When the core goes into debug state, the field acknowledges that with a halted output signal (see MDMAPSTTS[CM71HLT]). If the core is in Stop mode, this field is used to wake up the core and transition it to the debug halt state.

Table continues on the next page...

Table continued from the previous page...

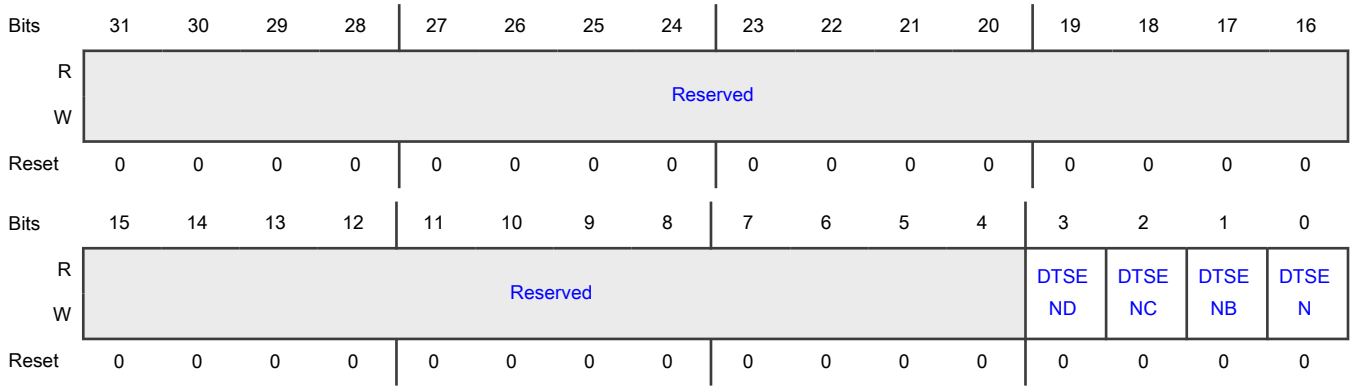
Field	Function
	0b - Debug request is not generated 1b - Debug request is generated
8 CM70DBGREQ	Cortex-M7_0 Debug Request Drives the EDBGREQ input for Cortex-M7_0 and indicates if the debug request is generated. When the core goes into debug state, the field acknowledges that with a halted output signal (see MDMAPSTTS[CM70HLT]). If the core is in Stop mode, this field is used to wake up the core and transition it to the debug halt state. 0b - Debug request is not generated 1b - Debug request is generated
7-6 —	Reserved
5 SYSFUNCRST	System Functional Reset Asserts or deasserts functional reset to the chip. The debugger maintains connection with the chip. 0b - Deasserted 1b - Asserted
4 SYSRESETREQ	System Destructive Reset Asserts or deasserts destructive reset to the chip. The debugger also loses connection with this reset. When this field is reset, the entire system comes out of reset. 0b - Deasserted 1b - Asserted
3-0 —	Reserved

84.15.4 DTS Enable (MDMAPDTSEN)

Offset

Register	Offset
MDMAPDTSEN	8h

Diagram



Fields

Field	Function
31-4 —	Reserved
3 DTSEND	Enable the Trigger Functionality using DTS Semaphore D Register 0b - Disable Triggers 1b - Enable Triggers
2 DTSENC	Enable the Trigger Functionality using DTS Semaphore C Register 0b - Disable Triggers 1b - Enable Triggers
1 DTSENB	Enable the Trigger Functionality using DTS Semaphore B Register 0b - Disable Triggers 1b - Enable Triggers
0 DTSEN	Enable the Trigger Functionality using DTS Semaphore Register 0b - Disable Triggers 1b - Enable Triggers

84.15.5 DTS Startup (MDMAPDTSSTARTUP)

Offset

Register	Offset
MDMAPDTSSTARTUP	Ch

Function

Used for tool detection and startup information exchange between external data acquisition tool and the embedded controller. All 32-bits are implemented.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	AD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	AD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 AD	Application Dependent register bits. Application Dependent register bits. The bits have no defined meaning to the microcontroller. They are used by an external tool to pass information (for example, application options and status) to the application software running on the target microcontroller at startup time. Internal address writes to this register are ignored

84.15.6 DTS Startup B (MDMAPDTSSTARTUPB)

Offset

Register	Offset
MDMAPDTSSTARTUPB	10h

Function

Used for tool detection and startup information exchange between external data acquisition tool and the embedded controller. All 32-bits are implemented.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	AD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	AD															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 AD	Application Dependent register bits. Application Dependent register bits. The bits have no defined meaning to the microcontroller. They are used by an external tool to pass information (for example, application options and status) to the application software running on the target microcontroller at startup time. Internal address writes to this register are ignored

84.15.7 DTS Startup C (MDMAPDTSSTARTUPC)

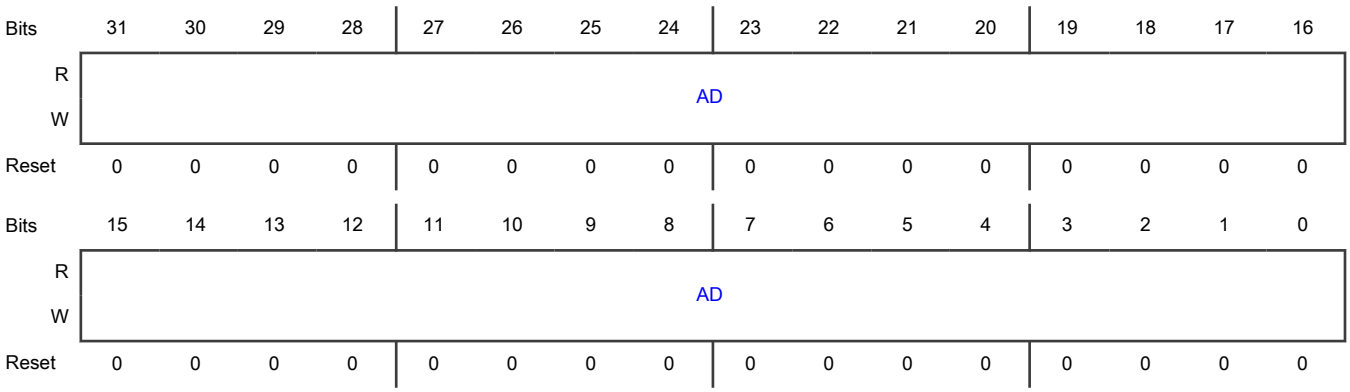
Offset

Register	Offset
MDMAPDTSSTARTUPC	14h

Function

Used for tool detection and startup information exchange between external data acquisition tool and the embedded controller. All 32-bits are implemented.

Diagram



Fields

Field	Function
31-0 AD	Application Dependent register bits. Application Dependent register bits. The bits have no defined meaning to the microcontroller. They are used by an external tool to pass information (for example, application options and status) to the application software running on the target microcontroller at startup time. Internal address writes to this register are ignored

84.15.8 DTS Startup D (MDMAPDTSSTARTUPD)

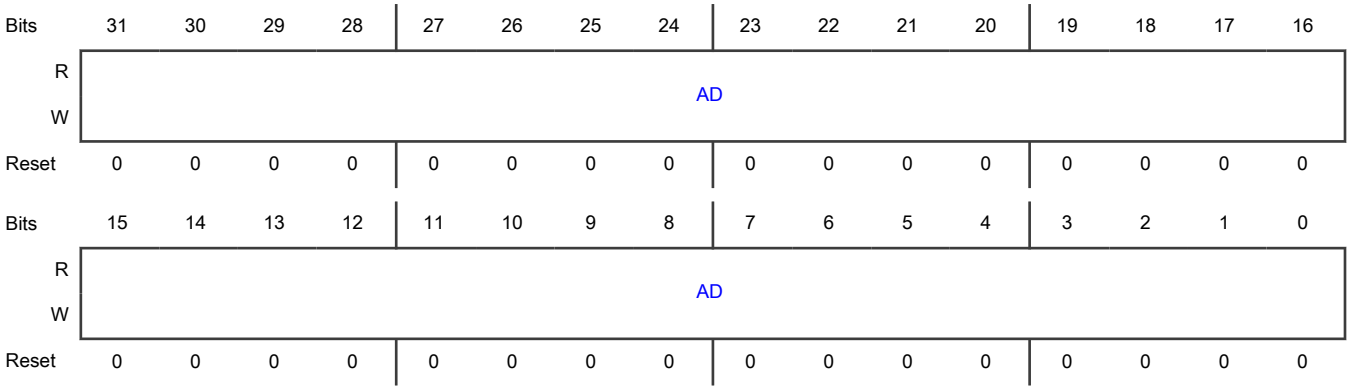
Offset

Register	Offset
MDMAPDTSSTARTUPD	18h

Function

Used for tool detection and startup information exchange between external data acquisition tool and the embedded controller. All 32-bits are implemented.

Diagram



Fields

Field	Function
31-0 AD	Application Dependent register bits. Application Dependent register bits. The bits have no defined meaning to the microcontroller. They are used by an external tool to pass information (for example, application options and status) to the application software running on the target microcontroller at startup time. Internal address writes to this register are ignored.

84.15.9 DTS Semaphore (MDMAPDTSSEMAPHORE)

Offset

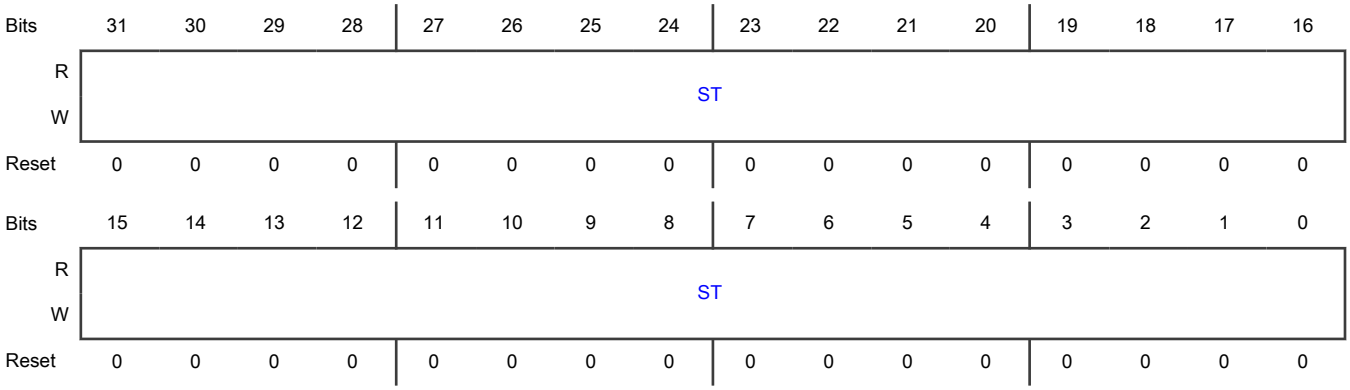
Register	Offset
MDMAPDTSSEMAPHORE	1Ch

Function

Used by software to assert triggers into the CoreSight cross-trigger matrix, which can be configured as to an external debug pin on the device. The intended use of this register is to notify tools that data is available. Individual bits identify the specific data. This register stores calibration variable triggers. When any of the trigger bits are set and the DTS_ENABLE is set, the module asserts an indicator to the EVTO pin. All 32 bits are implemented.

The dts_trigger out is NOT connected directly to the CTM network. You can achieve this functionality externally by looping back the output trigger onto the EVTI trigger input.

Diagram



Fields

Field	Function
31-0 ST	Semaphore Trigger When a core or eDMA writes a logical '1' to a bit, the bit is set. A write of '0' by the core or DMA does not change the state of the bit. - All register bits are set to '1' by a device reset. - The register can be accessed, with restrictions, by any core or DMA. - For the core or DMA, only 32-bit write or read accesses are valid. - A core or DMA valid read access returns the current value of the register and leaves the register unchanged. Only 32-bit accesses are valid. A core or DMA valid read access returns the current value of the register and leaves the register unchanged. When a core or DMA writes a logical '1' to a bit, the bit is set. When a core or DMA writes a logical '0' to a bit, it does not change the state of any bit. A read access from external Debugger address space returns the current value and automatically clears all set bits in the register. A write access from external debugger address space has no effect. Access by other masters also has no effect. 0 No flag 1 Flag is set

84.15.10 DTS Semaphore B (MDMAPDTSSEMAPHOREB)

Offset

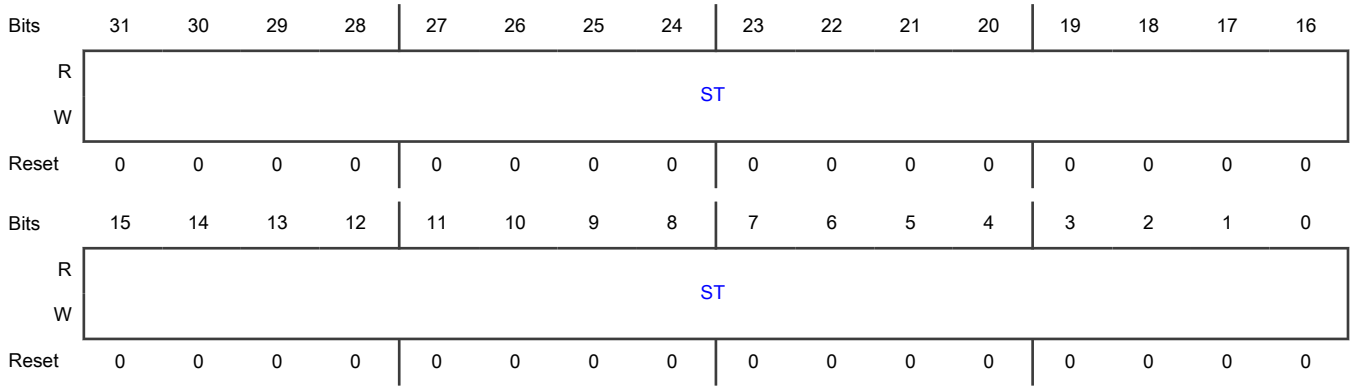
Register	Offset
MDMAPDTSSEMAPHOREB	20h

Function

Used by software to assert triggers into the CoreSight cross-trigger matrix, which can be configured as to an external debug pin on the device. The intended use of this register is to notify tools that data is available. Individual bits identify the specific data. This register stores calibration variable triggers. When any of the trigger bits are set and the DTS_ENABLE is set, the module asserts an indicator to the EVTO pin. All 32 bits are implemented.

The dts_trigger out is NOT connected directly to the CTM network. You can achieve this functionality externally by looping back the output trigger onto the EVTI trigger input.

Diagram



Fields

Field	Function
31-0 ST	Semaphore Trigger Extension When a core or eDMA writes a logical '1' to a bit, the bit is set. A write of '0' by the core or DMA does not change the state of the bit. - All register bits are set to '1' by a device reset. - The register can be accessed, with restrictions, by any core or DMA. - For the core or DMA, only 32-bit write or read accesses are valid. - A core or DMA valid read access returns the current value of the register and leaves the register unchanged. Only 32-bit accesses are valid. A core or DMA valid read access returns the current value of the register and leaves the register unchanged. When a core or DMA writes a logical '1' to a bit, the bit is set. When a core or DMA writes a logical '0' to a bit, it does not change the state of any bit. A read access from external Debugger address space returns the current value and automatically clears all set bits in the register. A write access from external debugger address space has no effect. Access by other masters also has no effect. 0 No flag 1 Flag is set

84.15.11 DTS Semaphore C (MDMAPDTSSEMAPHOREC)

Offset

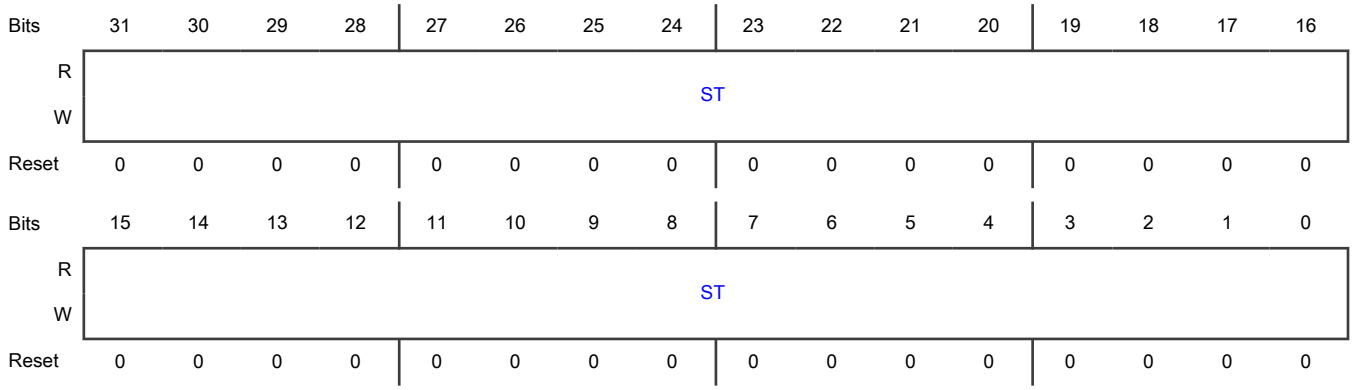
Register	Offset
MDMAPDTSSEMAPHOREC	24h

Function

Used by software to assert triggers into the CoreSight cross-trigger matrix, which can be configured as to an external debug pin on the device. The intended use of this register is to notify tools that data is available. Individual bits identify the specific data. This register stores calibration variable triggers. When any of the trigger bits are set and the DTS_ENABLE is set, the module asserts an indicator to the EVTO pin. All 32 bits are implemented.

The dts_trigger out is NOT connected directly to the CTM network. You can achieve this functionality externally by looping back the output trigger onto the EVTI trigger input.

Diagram



Fields

Field	Function
31-0 ST	Semaphore Trigger Extension When a core or eDMA writes a logical '1' to a bit, the bit is set. A write of '0' by the core or DMA does not change the state of the bit. - All register bits are set to '1' by a device reset. - The register can be accessed, with restrictions, by any core or DMA. - For the core or DMA, only 32-bit write or read accesses are valid. - A core or DMA valid read access returns the current value of the register and leaves the register unchanged. Only 32-bit accesses are valid. A core or DMA valid read access returns the current value of the register and leaves the register unchanged. When a core or DMA writes a logical '1' to a bit, the bit is set. When a core or DMA writes a logical '0' to a bit, it does not change the state of any bit. A read access from external Debugger address space returns the current value and automatically clears all set bits in the register. A write access from external debugger address space has no effect. Access by other masters also has no effect. 0 No flag 1 Flag is set

84.15.12 DTS Semaphore D (MDMAPDTSSEMAPHORED)

Offset

Register	Offset
MDMAPDTSSEMAPHORED	28h

Function

Used by software to assert triggers into the CoreSight cross-trigger matrix, which can be configured as to an external debug pin on the device. The intended use of this register is to notify tools that data is available. Individual bits identify the specific data. This register stores calibration variable triggers. When any of the trigger bits are set and the DTS_ENABLE is set, the module asserts an indicator to the EVTO pin. All 32 bits are implemented

The dts_trigger out is NOT connected directly to the CTM network. You can achieve this functionality externally by looping back the output trigger onto the EVTI trigger input.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	ST															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	ST															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0 ST	Semaphore Trigger Extension When a core or eDMA writes a logical '1' to a bit, the bit is set. A write of '0' by the core or DMA does not change the state of the bit. - All register bits are set to '1' by a device reset. - The register can be accessed, with restrictions, by any core or DMA. - For the core or DMA, only 32-bit write or read accesses are valid. - A core or DMA valid read access returns the current value of the register and leaves the register unchanged. Only 32-bit accesses are valid. A core or DMA valid read access returns the current value of the register and leaves the register unchanged. When a core or DMA writes a logical '1' to a bit, the bit is set. When a core or DMA writes a logical '0' to a bit, it does not change the state of any bit. A read access from external Debugger address space returns the current value and automatically clears all set bits in the register. A write access from external debugger address space has no effect. Access by other masters also has no effect. 0 No flag 1 Flag is set

84.15.13 WIR Enable (MDMAPWIREN)

Offset

Register	Offset
MDMAPWIREN	30h

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R W	Reserved															
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R W	Reserved														LWPR STP...	LWPW REN
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

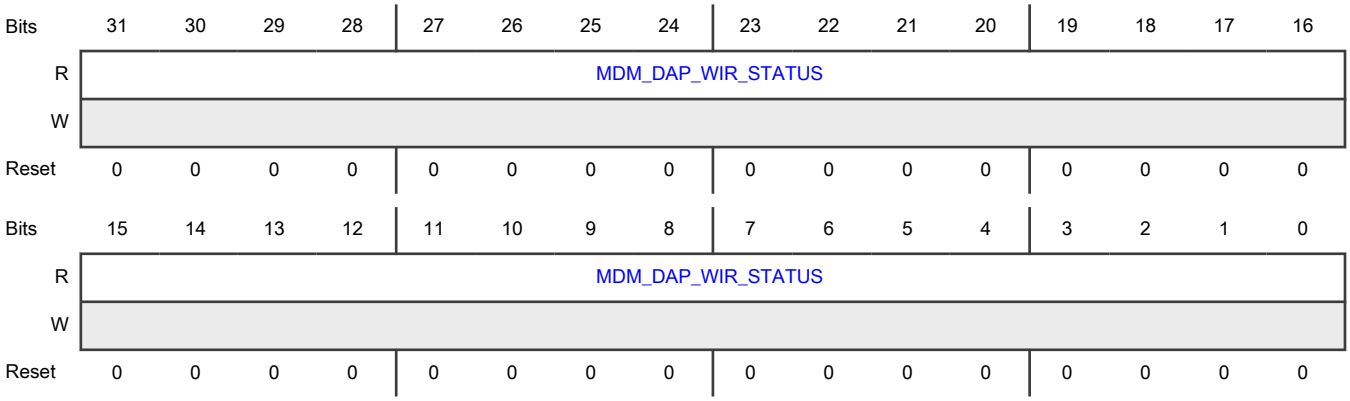
Field	Function
31-2 —	Reserved
1 LWPRSTPRVT	Low-Power Entry 0b - Prevents MC_RGM from generating the reset until the MC_RGM TPIU flush receives an acknowledgment from TPIU 1b - Prevents MC_RGM from generating the reset even if MC_RGM receives an acknowledgment from TPIU
0 LWPWREN	Low Power Debug Enable Enables or disables low-power debug. 0b - Disabled 1b - Enabled

84.15.14 WIR Status (MDMAPWIRSTTS)

Offset

Register	Offset
MDMAPWIRSTTS	34h

Diagram



Fields

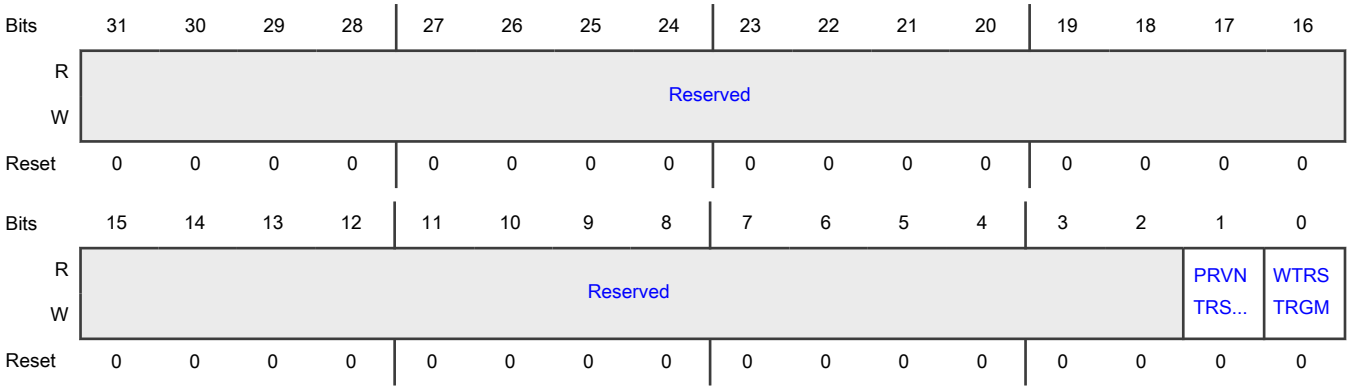
Field	Function
31-0 MDM_DAP_WIR_STATUS	MDM_AP WIR Status 0b - Indicates WIR status 1b - Does not indicate WIR status

84.15.15 WIR Release (MDMAPWIRREL)

Offset

Register	Offset
MDMAPWIRREL	38h

Diagram



Fields

Field	Function
31-2 —	Reserved
1 PRVNTRSTRGM	Prevent Reset Indicates if MC_RGM is prevented from generating reset. After TPIU flush, this field prevents MC_RGM from generating reset even if MC_RGM receives an acknowledge response from TPIU. This is valid for low-power entry. 0b - Normal operation 1b - MC_RGM prevented
0 WTRSTRGM	Wait In Reset B Indicates if waiting of MC_RGM from generating reset is supported. On exiting Standby mode, MC_RGM waits until the debugger writes to another field in the MDM_AP register to allow it to exit reset. 0b - Normal operation 1b - Wait supported

84.15.16 ETPU_CONTROL_ENABLE (MDMAPETPUCTRLEN)

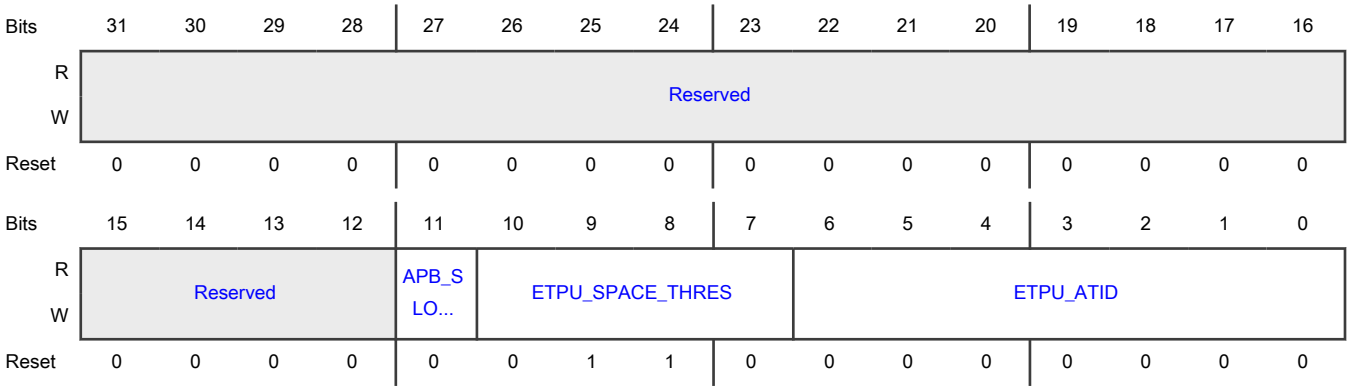
Offset

Register	Offset
MDMAPETPUCTRLEN	44h

Function

This register configures the trace ID and fifo space threshold for ETPU trace messages. It is also used to configure the page number for the APB slot address [refer to debug APB component table for page usage].

Diagram



Fields

Field	Function
31-12 —	Reserved
11 APB_SLOT_SEL	Prevent Reset Configures the page number for the APB slot address. 0b - Page 0 is selected 1b - Page 1 is selected
10-7 ETPU_SPACE_THRES	Configures the FIFO space threshold for ETPU.
6-0 ETPU_ATID	Configures the trace ID for ETPU.

84.15.17 ETPU_STATUS_ENABLE (MDMAPETPUSTTSEN)

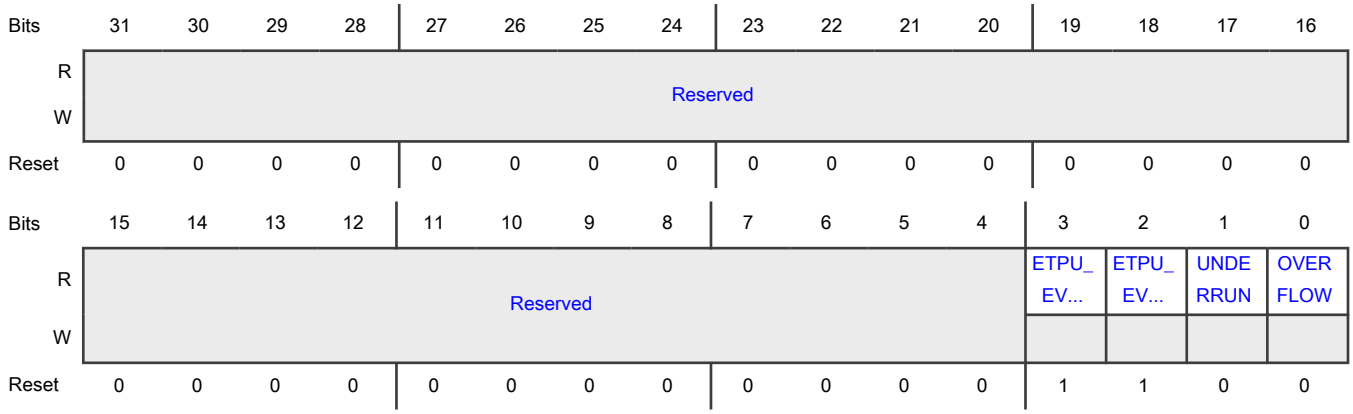
Offset

Register	Offset
MDMAPETPUSTTSEN	48h

Function

This register provide status about overflow, underrun and triggers for ETPU.

Diagram



Fields

Field	Function
31-4 —	Reserved
3 ETPU_EVTI_1	Latch EVTI[1]. This is W1C (Write 1 to CLEAR). 0b - Event is not generated at EVTI[1] pin 1b - Event is generated at EVTI[1] pin
2 ETPU_EVTI_0	Latch EVTI[0]. This is W1C (Write 1 to CLEAR). 0b - Event is not generated at EVTI[0] pin 1b - Event is generated at EVTI[0] pin
1 UNDERRUN	NEXUS TO ATB FIFO has underflow status. 0b - Underflow has not occurred. 1b - Underflow has occurred.

Table continues on the next page...

Table continued from the previous page...

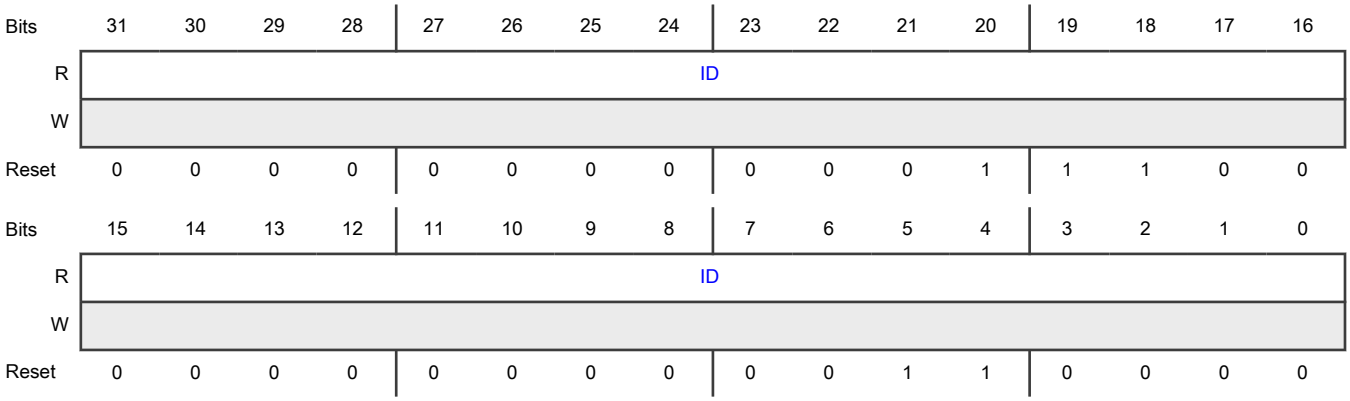
Field	Function
0 OVERFLOW	NEXUS TO ATB FIFO has overflow status. 0b - Overflow has not occurred 1b - Overflow has occurred

84.15.18 Identity (ID)

Offset

Register	Offset
ID	FCh

Diagram



Fields

Field	Function
31-0 ID	Identity

84.16 SDA_AP register descriptions

The debugger and system have access to secure authentication control and status, implemented as registers in SDA_AP on the DAP bus. These registers provide authentication control, authentication status, key exchange information, and debug enable controls.

NOTE

The access to SDA_AP is possible even with the MC_ME.PRTN1_COFB0_CLKEN[REQ21] set as 1'b0.

84.16.1 SDA_AP memory map

SDA_AP base address: 4025_4700h

Offset	Register	Width (In bits)	Access	Reset value
0h	Authentication Status (AUTHSTTS)	32	R	6000_0004h
4h	Authentication Control (AUTHCTL)	32	RW	0000_0000h
10h - 2Ch	Key Challenge (KEYCHAL0 - KEYCHAL7)	32	R	0000_0000h
40h - 5Ch	Key Response (KEYRESP0 - KEYRESP7)	32	RW	0000_0000h
70h	User Identification 0 (UID0)	32	R	0000_0000h
74h	User Identification 1 (UID1)	32	R	0000_0000h
80h	Debug Enable Control (DBGENCTRL)	32	RW	See section
90h	Reset Control (SDAAPRSTCTRL)	32	RW	0E00_0000h
A0h	SDA_AP Generic Status (SDAAPGENSTATUS0)	32	R	0000_0000h
A4h	Generic Control 0 (SDAAPGENCTRL0)	32	RW	0000_0000h
B0h	SDA_AP Generic Status (SDAAPGENSTATUS1)	32	R	0000_0000h
C0h	SDA_AP Generic Status (SDAAPGENSTATUS2)	32	R	0000_0000h
D0h	SDA_AP Generic Status (SDAAPGENSTATUS3)	32	R	0000_0000h
E0h	SDA_AP Generic Status (SDAAPGENSTATUS4)	32	R	0000_0000h
FCh	Identity (ID)	32	R	001C_0040h

84.16.2 Authentication Status (AUTHSTTS)

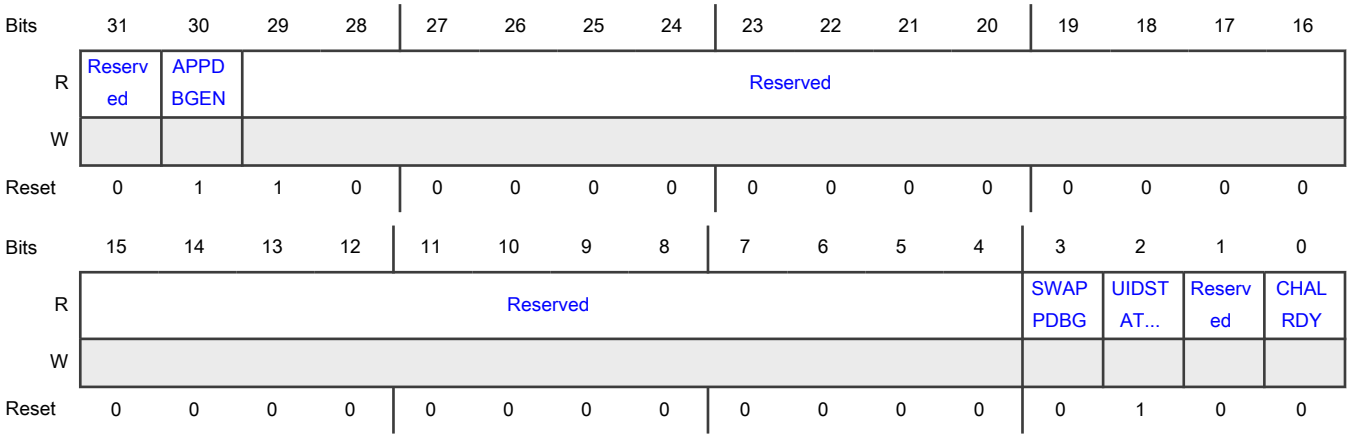
Offset

Register	Offset
AUTHSTTS	0h

Function

Indicates the status of the authentication process.

Diagram



Fields

Field	Function
31 —	Reserved
30 APPDBGEN	Application Debug Enabled or Disabled Indicates: • The status of application debug • Whether CR is satisfied • Whether access to other APs is allowed 0b - Application debug disabled 1b - Application debug enabled
29-4 —	Reserved
3 SWAPPDBG	Software Application Debug Indicates: • The status of software application debug • Whether access to debug controls is allowed 0b - Software application debug disabled 1b - Software application debug enabled
2 UIDSTATUS	User Identification Status Indicates: • The status of UID • Whether DCM has finished reading the flash memory user section

Table continues on the next page...

Table continued from the previous page...

Field	Function
	0b - UID is not ready and is invalid 1b - UID is ready and is valid
1 —	Reserved
0 CHALRDY	Challenge Ready Indicates: • The status of challenge ready when the value of export control is 0 • The status of the DCM_DONE signal if the value of export control is 1 0b - Challenge is not ready 1b - Challenge is ready

84.16.3 Authentication Control (AUTHCTL)

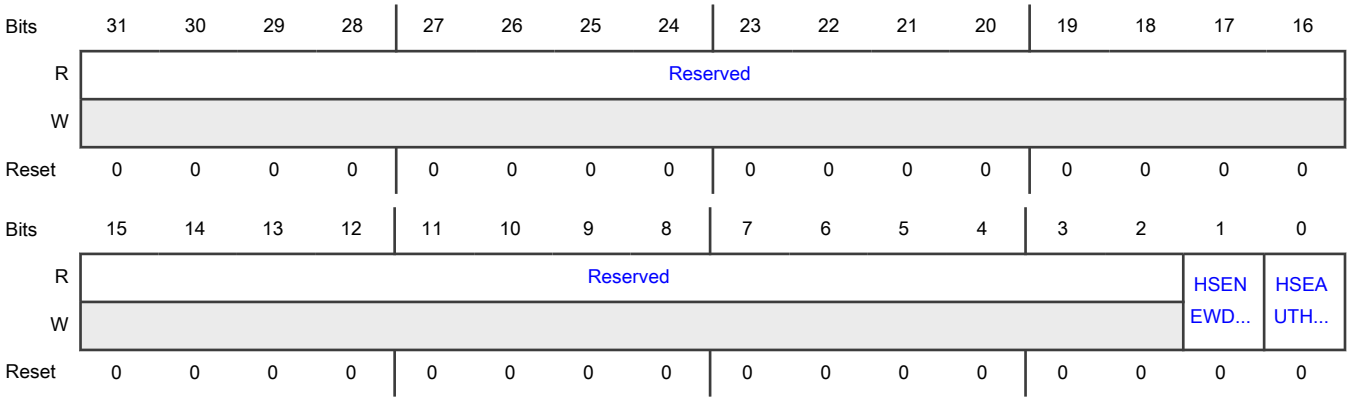
Offset

Register	Offset
AUTHCTL	4h

Function

Controls the authentication process.

Diagram



Fields

Field	Function
31-2 —	Reserved
1 HSENEWDATACTL	New Data Control Indicates that the debugger has consumed the data registers. It is alright for the core to provide new data. 0b - Does not indicate that the debugger has consumed the data registers 1b - Indicates that the debugger has consumed the data registers
0 HSEAUTHREQ	Debug Enablement Authentication Request Indicates that all key values are written and the chip can start the authentication request. 0b - Does not start the authentication request 1b - Starts the authentication request

84.16.4 Key Challenge (KEYCHAL0 - KEYCHAL7)

Offset

For a = 0 to 7:

Register	Offset
KEYCHALa	10h + (a × 4h)

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	KEYCHAL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	KEYCHAL															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-0	Debug Enablement Key Challenge

Table continues on the next page...

Field	Function
KEYCHAL	

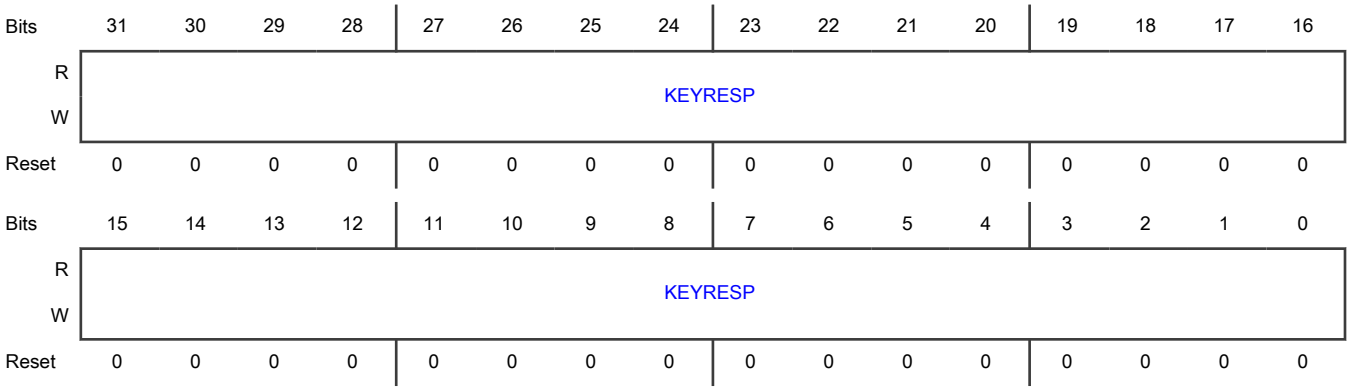
84.16.5 Key Response (KEYRESP0 - KEYRESP7)

Offset

For a = 0 to 7:

Register	Offset
KEYRESPa	40h + (a × 4h)

Diagram



Fields

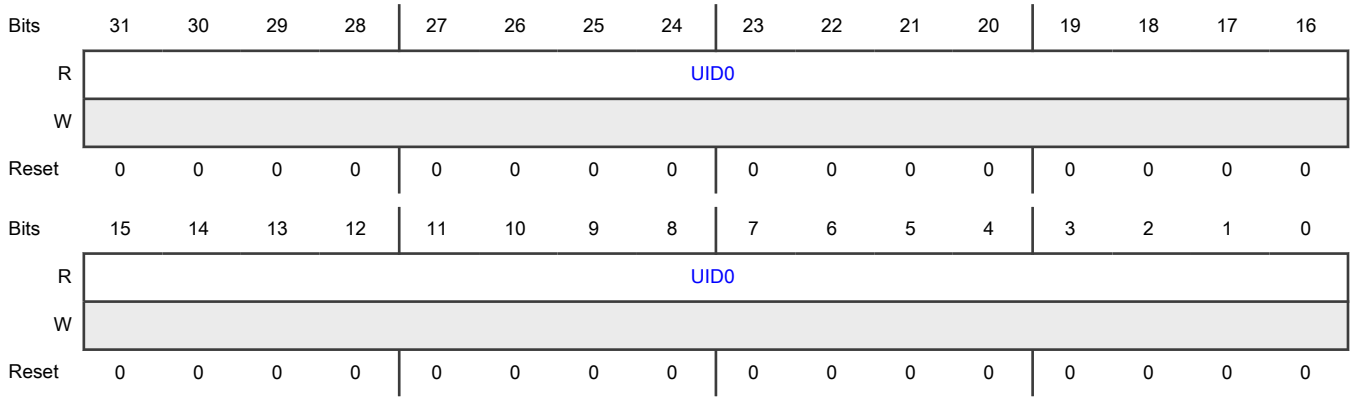
Field	Function
31-0 KEYRESP	Debug Enablement Key Response

84.16.6 User Identification 0 (UID0)

Offset

Register	Offset
UID0	70h

Diagram



Fields

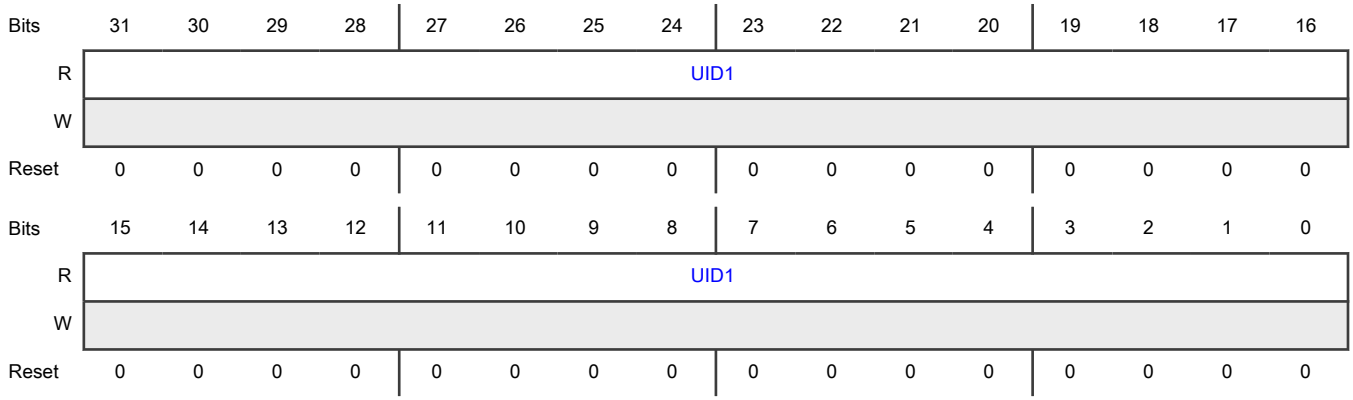
Field	Function
31-0 UID0	User ID 0 Indicates the JTAG user ID bits of the lower word.

84.16.7 User Identification 1 (UID1)

Offset

Register	Offset
UID1	74h

Diagram



Fields

Field	Function
31-0 UID1	User ID 1 Indicates the JTAG user ID bits of the upper word.

84.16.8 Debug Enable Control (DBGENCTRL)

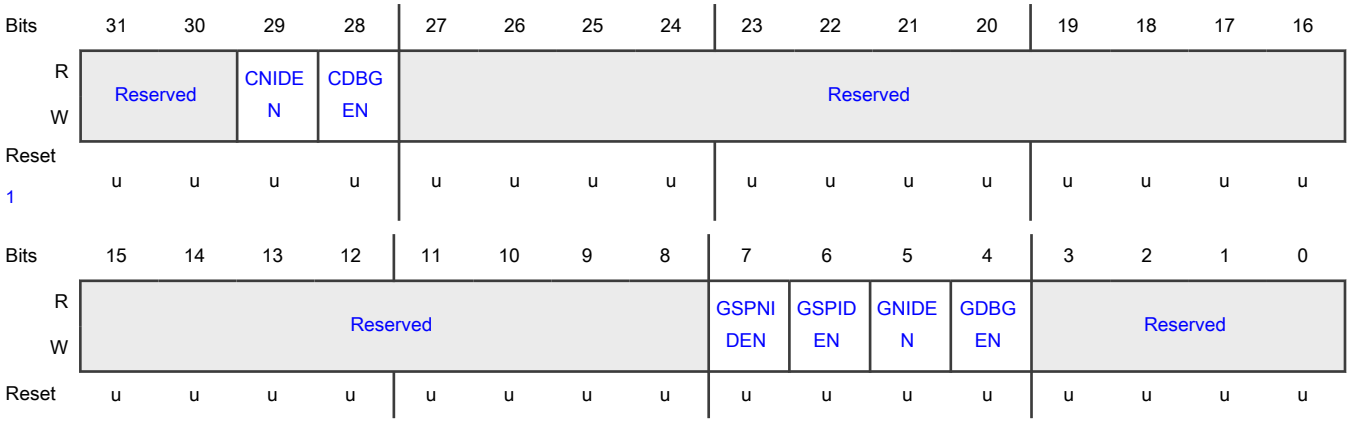
Offset

Register	Offset
DBGENCTRL	80h

Function

Includes a special protection that allows access from Cortex-M0+ only if bit 30 of Authentication Status (AUTHSTTS) is 1.

Diagram



1. The reset value is controlled by an export control enable input. If export control is enabled, the reset value of this register is FFFF_FFF0h. Otherwise, it is 0000_0000h.

Fields

Field	Function
31-30 —	Reserved
29 CNIDEN	Core Non-Invasive Debug Enable Controls CNIDEN of debug blocks coupled with the Cortex-M7 core. 0b - Disabled 1b - Enabled
28 CDBGEN	Core Debug Enable Controls CDBGEN of debug blocks coupled with the Cortex-M7 core. 0b - Disabled 1b - Enabled
27-8 —	Reserved

Table continues on the next page...

Table continued from the previous page...

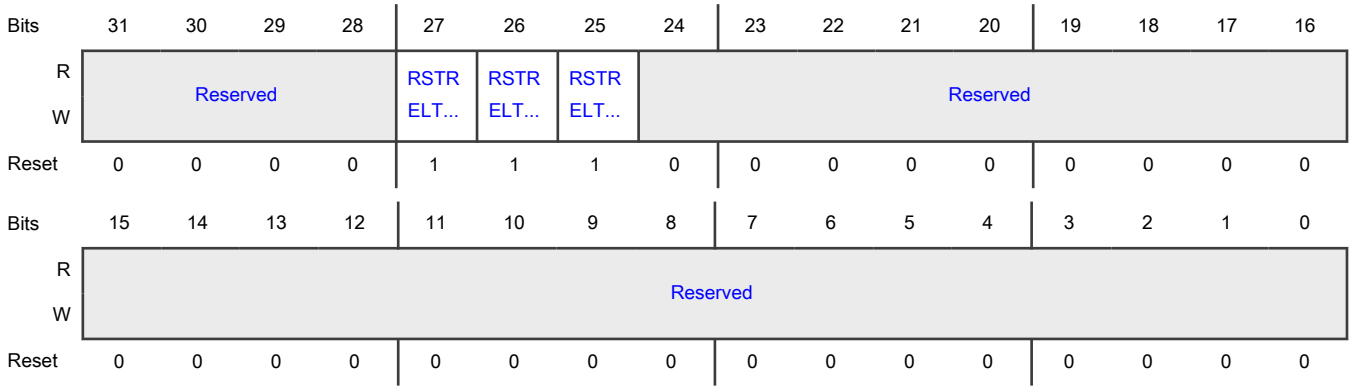
Field	Function
7 GSPNIDEN	Global Secure Privileged Non-Invasive Debug Enable Controls GSPNIDEN of debug blocks coupled with Cortex-M7's subsystems, ETM, ITM, and CTI. 0b - Disabled 1b - Enabled
6 GSPIDEN	Global Secure Privileged Debug Enable Controls GSPIDEN of debug blocks coupled with Cortex-M7's subsystems, ETM, ITM, and CTI. 0b - Disabled 1b - Enabled
5 GNIDEN	Global Non-Invasive Debug Enable Controls GNIDEN of debug blocks coupled with Cortex-M7's subsystems, ETM, ITM, and CTI. 0b - Disabled 1b - Enabled
4 GDBGEN	Global Debug Enable Controls GDBGEN of debug blocks coupled with Cortex-M7's subsystems, ETM, ITM, and CTI. 0b - Disabled 1b - Enabled
3-0 —	Reserved

84.16.9 Reset Control (SDAAPRSTCTRL)

Offset

Register	Offset
SDAAPRSTCTRL	90h

Diagram



Fields

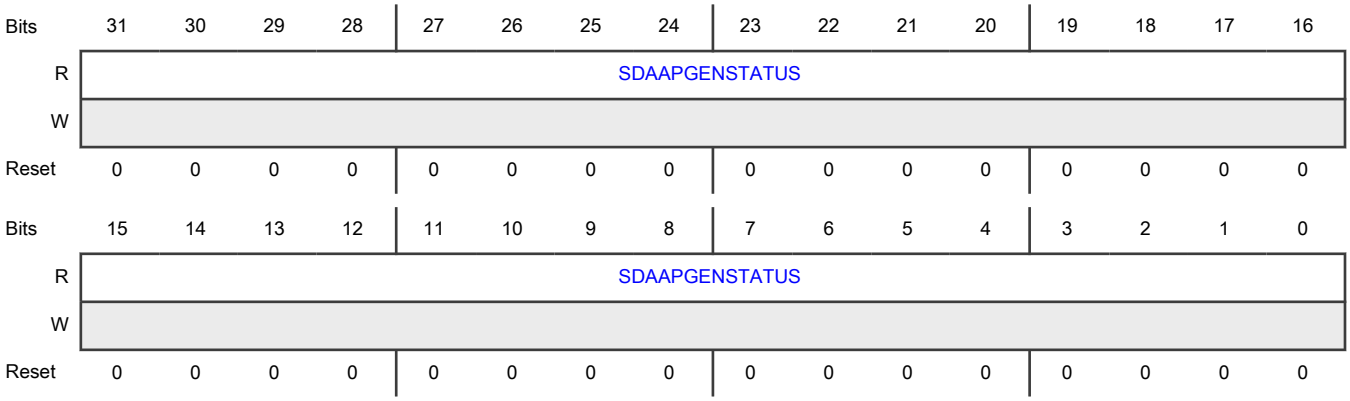
Field	Function
31-28 —	Reserved
27 RSTRELTLCM72	Reset Release Cortex-M7_2 Indicates if the control signal released the reset for Cortex-M7_2. The reset is released to debug the core from first instruction. The default value of this field is 1. 0b - Core is in reset 1b - Reset is released
26 RSTRELTLCM71	Reset Release Cortex-M7_1 Indicates if the control signal released the reset for Cortex-M7_1. The reset is released to debug the core from first instruction. The default value of this field is 1. 0b - Core is in reset 1b - Reset is released
25 RSTRELTLCM70	Reset Release Cortex-M7_0 Indicates if the control signal released the reset for Cortex-M7_0. The reset is released to debug the core from the first instruction. The default value of this field is 1. 0b - Core is in reset 1b - Reset is released
24-0 —	Reserved

84.16.10 SDA_AP Generic Status (SDAAPGENSTATUS0 - SDAAPGENSTATUS4)

Offset

Register	Offset
SDAAPGENSTATUS0	A0h
SDAAPGENSTATUS1	B0h
SDAAPGENSTATUS2	C0h
SDAAPGENSTATUS3	D0h
SDAAPGENSTATUS4	E0h

Diagram



Fields

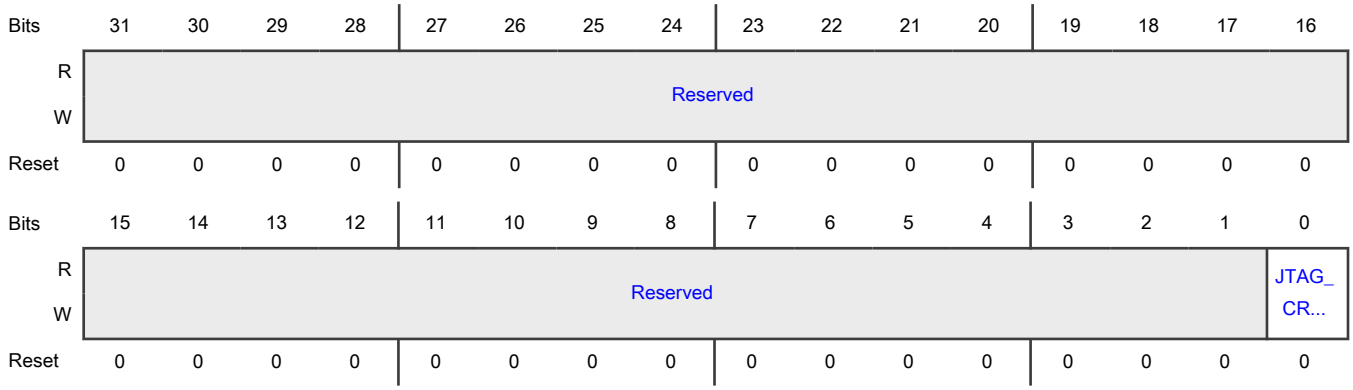
Field	Function
31-0 SDAAPGENSTATUS	DAP Generic Status Is a generic status field for future use. 0b - Does not show generic status 1b - Shows generic status

84.16.11 Generic Control 0 (SDAAPGENCTRL0)

Offset

Register	Offset
SDAAPGENCTRL0	A4h

Diagram



Fields

Field	Function
31-1 —	Reserved
0 JTAG_CR_EN	JTAG CR Enable Performs CR or password comparison based on SWJ-DP mode or JTAG mode. If you write 1 to this field, this function is performed using JTAG irrespective of SWJ-DP mode of the debugger. 0b - Function performed on the basis of SWJ-DP mode 1b - Function performed on the basis of JTAG mode

84.16.12 Identity (ID)

Offset

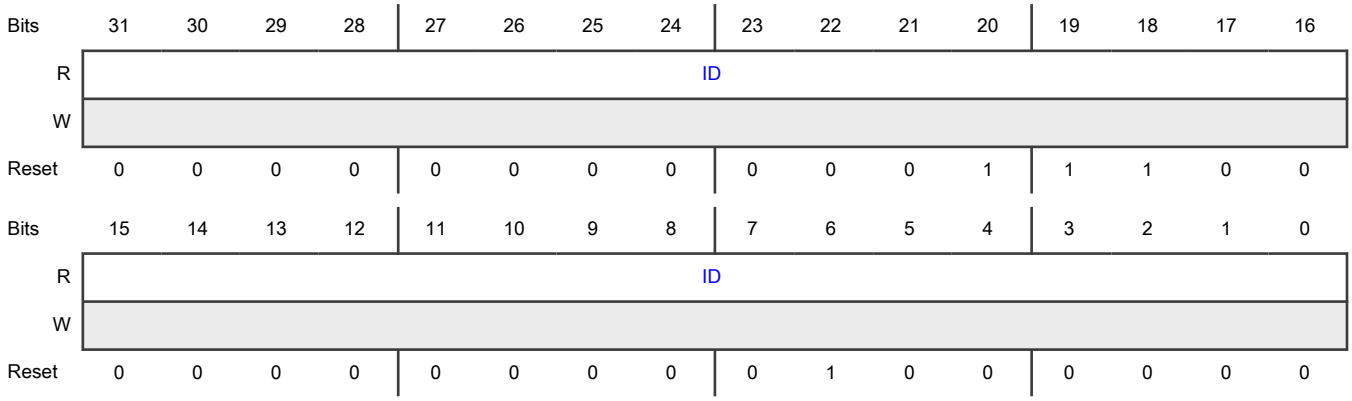
Register	Offset
ID	FCh

Function

NOTE

This register does not generate the bus error on performing the write operation.

Diagram



Fields

Field	Function
31-0 ID	Identity

84.17 eTPU Nexus configuration

- 14 MDO signals
- 2 MSEO signals
- Message Clock input
- Source ID for eTPU will be driven from MDM-AP module

ETPU supports the jtag debug only.

84.18 Glossary

AHB	Advanced high-performance bus
AHB_AP	Advanced high-performance bus access port
APB	Advanced peripheral bus
APB_AP	Advanced peripheral bus access port
ATB	Advanced trace bus
ATBR	ATB replicator
CSTF	CoreSight trace funnel
DAP	Debug access port
DC	Design center
ETF	Embedded CoreSight funnels
JTAG-DP	JTAG debug port
MDM_AP	Miscellaneous debug module access port
MIC	Manufacturer identity code

PIN	Part identification number
PRN	Part revision number
SDA_AP	Serial data access port
SiP	System-in-package
SWJ-DP	Serial wire/JTAG debug port
TAP	Test and debug access port
TPIU	Trace port interface unit

84.19 References

- Arm CoreSight SoC-400 Technical Reference Manual
  https://static.docs.arm.com/100536/0302/coresight_soc400_technical_reference_manual_100536_0302_01_en.pdf
- Arm CoreSight Architecture Specification
  http://infocenter.arm.com/help/topic/com.arm.doc.ihi0029d/IHI0029D_coresight_architecture_spec_v2_0.pdf
- CoreSight Components Technical Reference Manual
  http://infocenter.arm.com/help/topic/com.arm.doc.ddi0314h/DDI0314H_coresight_components_trm.pdf
- Arm Debug Interface Architecture Specification
  https://static.docs.arm.com/ihi0031/c/IHI0031C_debug_interface_as.pdf

Chapter 85
JTAG Controller (JTAGC)

85.1 Chip-specific JTAGC information

85.1.1 Chip-specific JTAGC information

The following figure shows the detailed TAP connectivity. SWD/JTAG SELECT, SWDP and JTAG-DP are part of ARM DAP

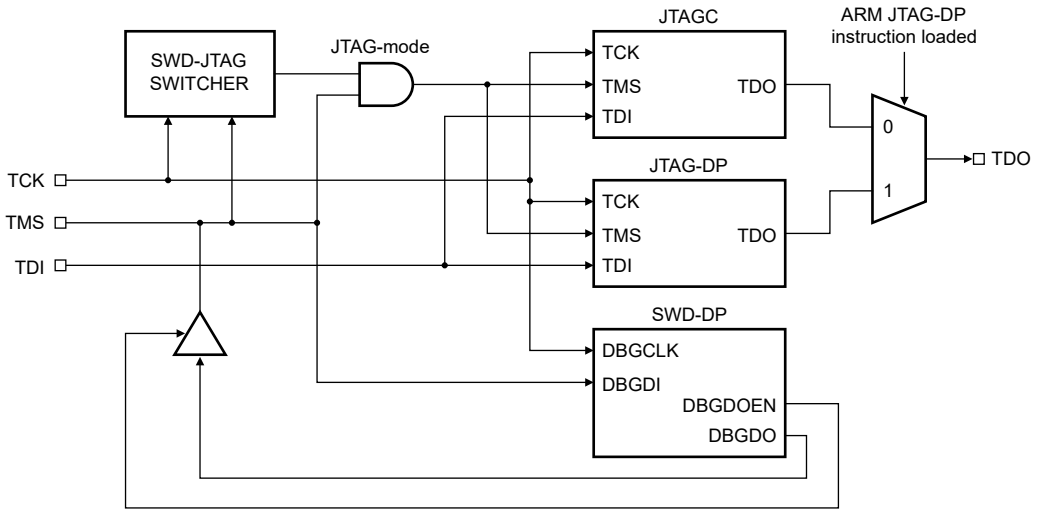


Figure 688. Test and Debug Access Port (TAP) connectivity

The debug port comes out of reset in a standard JTAG mode. It is switched to SWD mode by the change sequences described in JTAG to SWD change sequence . Once the mode has been changed, unused debug pins can be reassigned to any of their alternative muxed functions

JTAG-to-SWD change sequence:

1. Send more than 50 TCK cycles with TMS (SWDIO) =1
2. Send the 16-bit sequence on TMS (SWDIO) = 0111_1001_1110_0111 (MSB transmitted first)
3. Send more than 50 TCK cycles with TMS (SWDIO) =1

NOTE

In case of any reset event, JTAGC is moved to Test Logic Reset (TLR) state first and then JTAGC should be used.

NOTE

If JTAG pins are used for alternative functionality and reset event arrives then these pins need to be reconfigured to required functionality before using it, in order to avoid unintentional entry in JTAG mode.

85.1.1.1 Device identification register reset values

Table 768. Device identification register reset values

Register Bit	Reset values
PRN	0000
DC	1001_10

Table continues on the next page...

Table 768. Device identification register reset values (continued)

Register Bit	Reset values
PIN	0101_0101_10
MIC	0000_0001_110

85.2 Overview

JTAGC allows you to test chip functionality and connectivity while remaining transparent to system logic when not in test mode. Testing is performed via a boundary scan technique, as defined in the IEEE 1149.1-2001 standard. All data input to and output from JTAGC is communicated in serial format.

85.2.1 Block diagram

The following is a simplified block diagram of the JTAG Controller (JTAGC) block. See the chip-specific configuration information within this chapter as well as Register description for more information about the JTAGC registers.

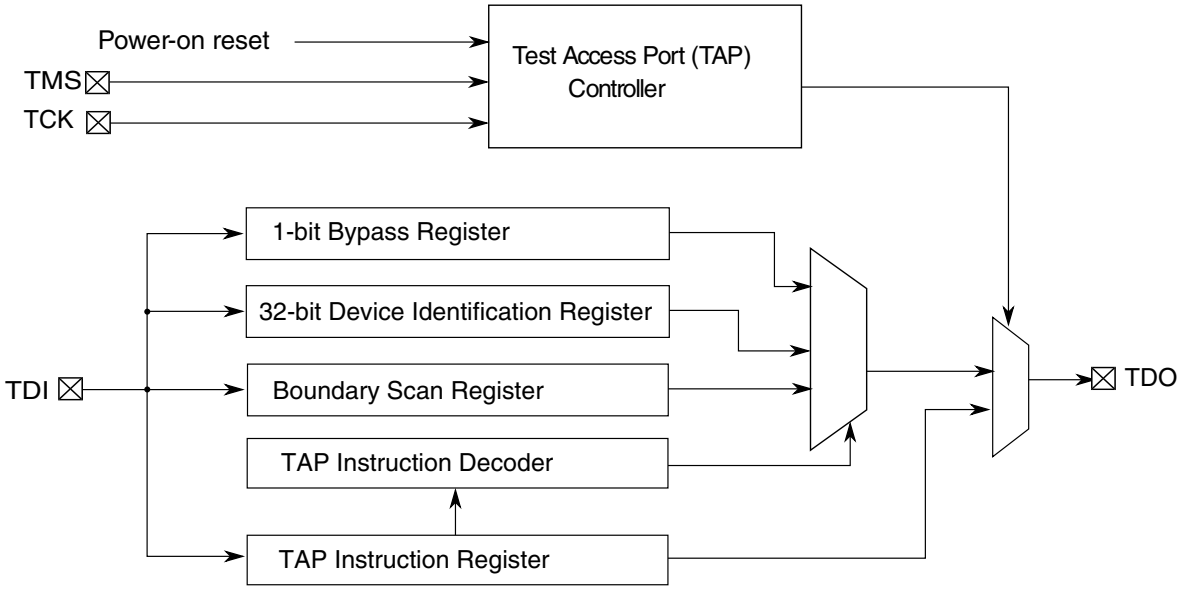


Figure 689. JTAG (IEEE 1149.1) block diagram

85.2.2 Features

The JTAGC block is compliant with the IEEE 1149.1-2001 standard, and supports the following features:

- IEEE 1149.1-2001 TAP interface
  - Four pins (TDI, TMS, TCK, and TDO)
- Instruction register that supports several IEEE 1149.1–2001 defined instructions as well as several public and private device-specific instructions (see JTAGC block instructions for a list of supported instructions).
- Sharing of the TAP with other TAP controllers via ACCESS_AUX_x instructions
- Bypass register, boundary scan register, and device identification register
- TAP controller state machine that controls the operation of the data registers, instruction register, and associated circuitry

85.3 Functional description

85.3.1 Modes of operation

The JTAGC block uses a power-on reset indication as its primary reset signals. Several IEEE 1149.1–2001 defined test modes are supported, as well as a bypass mode.

85.3.1.1 IEEE 1149.1–2001 defined test modes

The JTAGC block supports several IEEE 1149.1–2001 defined test modes. A test mode is selected by loading the appropriate instruction into the instruction register when the JTAGC is enabled. Supported test instructions include EXTEST, HIGHZ, CLAMP, PRELOAD.

Each instruction defines the set of data register(s) that may operate and interact with the on-chip system logic when the instruction is current. Only one test data register path is enabled to shift data between TDI and TDO for each instruction.

The boundary scan register is enabled for serial access between TDI and TDO when the EXTEST, PRELOAD instructions are active. The single-bit bypass register shift stage is enabled for serial access between TDI and TDO when the following instructions are active:

- BYPASS
- HIGHZ
- CLAMP

The functionality of each test mode is explained in more detail in JTAGC block instructions.

85.3.1.2 Bypass mode

When no test operation is required, the BYPASS instruction can be loaded to place the JTAGC block into bypass mode. When in bypass mode, the single-bit bypass shift register is used to provide a minimum-length serial path to shift data between TDI and TDO.

85.3.2 IEEE 1149.1-2001 (JTAG) TAP

The JTAGC block uses the IEEE 1149.1-2001 TAP for accessing registers. This port can be shared with other TAP controllers on the MCU. Ownership of the port is determined by the value of the currently loaded instruction. For more detail on TAP sharing via JTAGC instructions, see ACCESS_AUX_x instructions .

Data is shifted between TDI and TDO through the selected register starting with the least significant bit, as illustrated in the following figure. This applies for the instruction register, test data registers, and the bypass register.

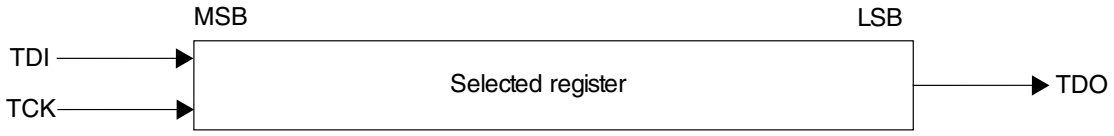
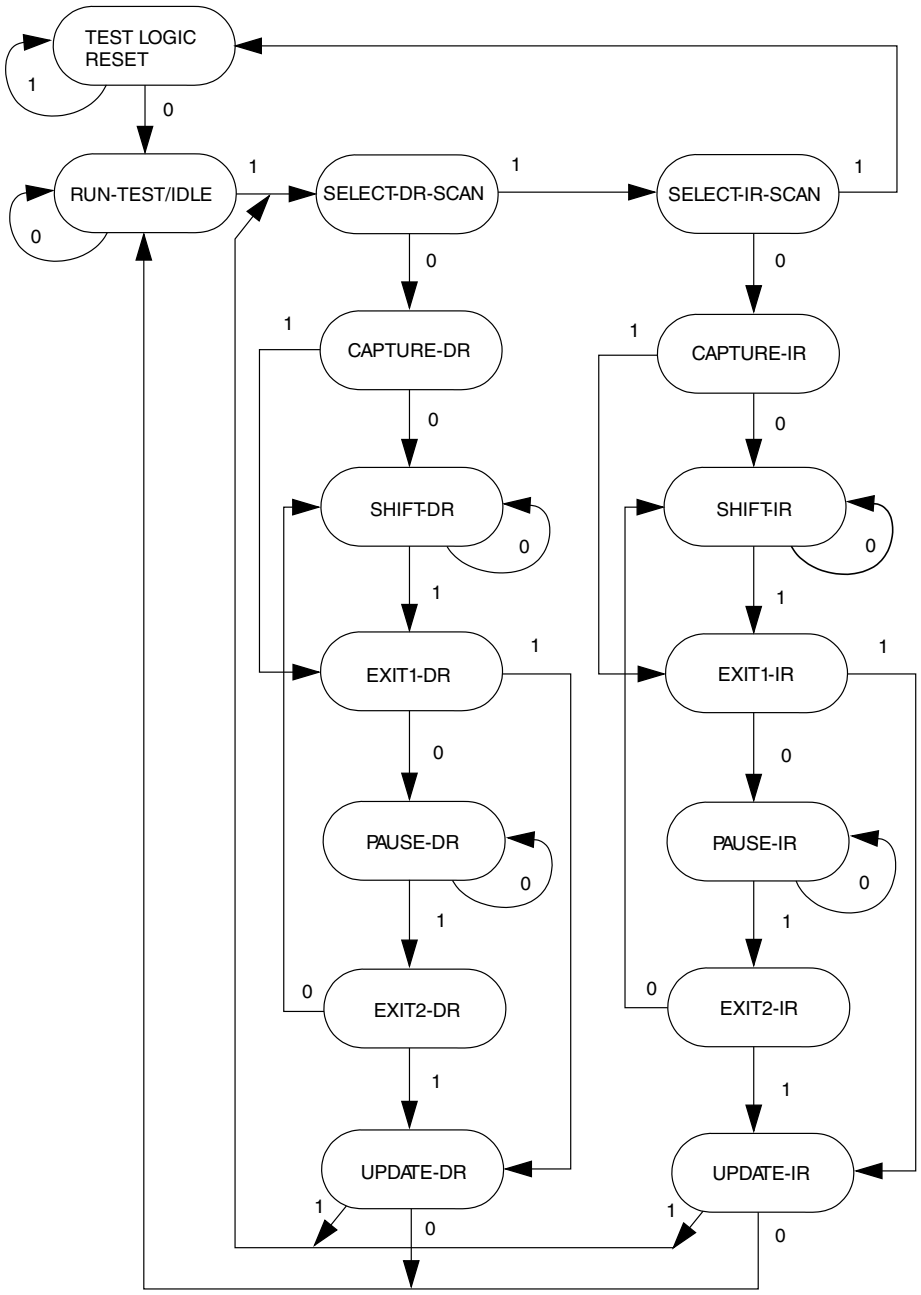


Figure 690. Shifting data through a register

85.3.3 TAP controller state machine

The TAP controller is a synchronous state machine that interprets the sequence of logical values on the TMS pin.

The following figure shows the machine's states. The value shown next to each state is the value of the TMS signal sampled on the rising edge of the TCK signal. As the figure shows, holding TMS at logic 1 when clocking TCK through a sufficient number of rising edges also causes the state machine to enter the Test-Logic-Reset state.



The value shown adjacent to each state transition in this figure represents the value of TMS at the time of a rising edge of TCK.

Figure 691. IEEE 1149.1-2001 TAP controller finite state machine

85.3.3.1 Enabling the TAP controller

The JTAGC TAP controller is enabled by setting the JTAGC enable to a logic 1 value.

85.3.3.2 Selecting an IEEE 1149.1-2001 register

Access to the JTAGC data registers is achieved by loading the instruction register with any of the JTAGC block instructions when the JTAGC is enabled. Instructions are shifted in via the Select-IR-Scan path and loaded in the Update-IR state. At this point, all data register access is performed via the Select-DR-Scan path.

The Select-DR-Scan path is used to read or write the register data by shifting in the data (LSB first) during the Shift-DR state. When reading a register, the register value is loaded into the IEEE 1149.1-2001 shifter during the Capture-DR state. When writing a register, the value is loaded from the IEEE 1149.1-2001 shifter to the register during the Update-DR state. When reading a register, there is no requirement to shift out the entire register contents. Shifting may be terminated after the required number of bits have been acquired.

85.3.4 JTAGC block instructions

The JTAGC implements instructions defined in IEEE 1149.1-2001. See the chip-specific JTAGC information for the JTAGC instructions implemented on this chip. See the IEEE 1149.1-2001 standard for additional information. All undefined opcodes are reserved.

85.3.4.1 IDCODE instruction

IDCODE selects the 32-bit device identification register as the shift path between TDI and TDO. This instruction allows interrogation of the MCU to determine its version number and other part identification data. IDCODE is the instruction placed into the instruction register when the JTAGC block is reset.

85.3.4.2 PRELOAD instruction

The PRELOAD instruction has two functions:

- The PRELOAD portion of the instruction initializes the boundary scan register cells before selecting the EXTEST or CLAMP instructions to perform boundary scan tests. This is achieved by shifting in initialization data to the boundary scan register during the Shift-DR state. The initialization data is transferred to the parallel outputs of the boundary scan register cells on the falling edge of TCK in the Update-DR state. The data is applied to the external output pins by the EXTEST or CLAMP instruction. System operation is not affected.

85.3.4.3 EXTEST external test instruction

EXTEST selects the boundary scan register as the shift path between TDI and TDO. It allows testing of off-chip circuitry and board-level interconnections by driving preloaded data contained in the boundary scan register onto the system output pins. Typically, the preloaded data is loaded into the boundary scan register using the PRELOAD instruction before the selection of EXTEST. EXTEST asserts the internal system reset for the MCU to force a predictable internal state when performing external boundary scan operations.

85.3.4.4 TEST_LEAKAGE instruction

The TEST_LEAKAGE instruction forces the jtag_leakage output signal to high. It is intended to tristate all output pad buffers and disable all of the part's pad input buffers except JCOMP and TEST. The jtag_leakage signal is asserted at the falling edge of TCK following the TAP controller state machine transition from the Update-IR state to the Run-Test-Idle state. When asserted, the part disables TCK, TMS, and TDI inputs and forces them to a logic 1. The TAP controller state machine remains in the Run-Test-Idle state until the JCOMP input is set to a value other than the JTAGC enable encoding. TEST_LEAKAGE also asserts the internal system reset for the MCU to force a predictable internal state.

85.3.4.5 HIGHZ instruction

HIGHZ selects the bypass register as the shift path between TDI and TDO. When HIGHZ is active all output drivers are placed in an inactive drive state (for example, high impedance). HIGHZ also asserts the internal system reset for the MCU to force a predictable internal state.

85.3.4.6 CLAMP instruction

CLAMP allows the state of signals driven from MCU pins to be determined from the boundary scan register when the bypass register is selected as the serial path between TDI and TDO. CLAMP enhances test efficiency by reducing the overall shift path to a single bit (the bypass register) when conducting an EXTEST type of instruction through the boundary scan register. CLAMP also asserts the internal system reset for the MCU to force a predictable internal state.

85.3.4.7 ACCESS_AUX_x instructions

The JTAGC is configurable to allow other TAP controllers on the device to share the port with it. This is done by providing ACCESS_AUX_x instructions for each of these TAP controllers.

When this instruction is loaded, control of the JTAG pins is transferred to the selected TAP controller. Any data input via TDI and TMS is passed to the selected TAP controller, and any TDO output from the selected TAP controller is sent back to the JTAGC to be output on the pins.

The JTAGC regains control of the JTAG port during the UPDATE-DR state if the PAUSE-DR state was entered. Auxiliary TAP controllers are held in RUN-TEST/IDLE when they are inactive. Instructions not used to access an auxiliary TAP controller on a device are treated like the BYPASS instruction.

85.3.4.8 BYPASS instruction

BYPASS selects the bypass register, creating a single-bit shift register path between TDI and TDO. BYPASS enhances test efficiency by reducing the overall shift path when no test operation of the MCU is required. This allows more rapid movement of test data to and from other components on a board that are required to perform test functions. When the BYPASS instruction is active the system logic operates normally.

85.3.5 Boundary scan

The boundary scan technique allows signals at component boundaries to be controlled and observed through the shift-register stage associated with each pad. Each stage is part of a larger boundary scan register cell, and cells for each pad are interconnected serially to form a shift-register chain around the border of the design. The boundary scan register consists of this shift-register chain, and is connected between TDI and TDO when the EXTEST, PRELOAD instructions are loaded. The shift-register chain contains a serial input and serial output, as well as clock and control signals.

85.3.6 Clocking

There is one clock for this module. For more information See External signals.

85.3.7 Interrupts

This module has no interrupts.

85.3.8 Reset

The JTAGC block is placed in reset when:

- Power-on reset is asserted
- TMS input is held high for enough consecutive rising edges of TCK to sequence the TAP controller state machine into the Test-Logic-Reset state

Holding TMS high for five consecutive rising edges of TCK guarantees entry into the Test-Logic-Reset state regardless of the current TAP controller state. Asserting power-on reset results in asynchronous entry into the reset state.

When in reset, the following actions occur:

- The TAP controller is forced into the Test-Logic-Reset state, thereby disabling the test logic and allowing normal operation of the on-chip system logic to continue unhindered.
- The instruction register is loaded with the IDCODE instruction.

85.3.8.1 JTAGC reset configuration

When in reset, the TAP controller is forced into the Test-Logic-Reset state, thus disabling the test logic and allowing normal operation of the on-chip system logic. In addition, the instruction register is loaded with the IDCODE instruction.

85.4 External signals

JTAGC includes a set of signals that connect to off-chip development tools and allow access to test support functions. The JTAGC signals are outlined in the following table and described in the following sections.

Table 769. JTAG signal properties

Name	I/O	Function	Reset state
TCK	Input	Test clock	Weak pulldown
TDI	Input	Test data in	Weak pullup
TDO	Output	Test data out	High Z[1]
TMS	Input	Test mode select	Weak pullup

1. TDO output buffer enable is negated when the JTAGC is not in the Shift-IR or Shift-DR states. A weak pull may be implemented at the TDO pad for use when JTAGC is inactive.

85.4.1 Test clock input (TCK)

Test Clock Input (TCK) is an input pin used to synchronize the test logic and control register access through the TAP.

85.4.2 Test data input (TDI)

Test Data Input (TDI) is an input pin that receives serial test instructions and data. TDI is sampled on the rising edge of TCK.

85.4.3 Test data output (TDO)

Test Data Output (TDO) is an output pin that transmits serial output for test instructions and data. TDO is tristateable and is actively driven only in the Shift-IR and Shift-DR states of the TAP controller state machine, which is described in TAP controller state machine.

85.4.4 Test mode select (TMS)

Test Mode Select (TMS) is an input pin used to sequence the IEEE 1149.1-2001 test control state machine. TMS is sampled on the rising edge of TCK.

85.5 Initialization

To initialize the JTAGC block and enable access to registers, the following sequence is required:

1. Place the JTAGC in reset through TAP controller state machine transitions controlled by TMS.
2. Load the appropriate instruction for the test or action to be performed.

85.6 Application information

The test logic is a static logic design, and TCK can be stopped in either a high or low state without loss of data. However, the system clock is not synchronized to TCK internally. Any mixed operation using both the test logic and the system functional logic requires external synchronization.

85.7 Register description

This section provides a detailed description of the JTAGC block registers accessible through the TAP interface, including data registers and the instruction register. Individual bit-level descriptions and reset states of each register are included. These registers are not memory-mapped and can only be accessed through the TAP.

85.7.1 Instruction register

The JTAGC block uses a 8-bit instruction register as shown in the following figure.

The instruction register allows instructions to be loaded into the block to select the test to be performed, or the test data register to be accessed, or both. Instructions are shifted in through TDI when the TAP controller is in the Shift-IR state, and latched on the falling edge of TCK in the Update-IR state. The latched instruction value can only be changed in the Update-IR and Test-Logic-Reset TAP controller states.

Synchronous entry into the Test-Logic-Reset state results in the IDCODE instruction being loaded on the falling edge of TCK. Asynchronous entry into the Test-Logic-Reset state results in asynchronous loading of the IDCODE instruction. During the Capture-IR TAP controller state, the instruction shift register is loaded with the value 0b1, making this value the register's read value when the TAP controller is sequenced into the Shift-IR state.

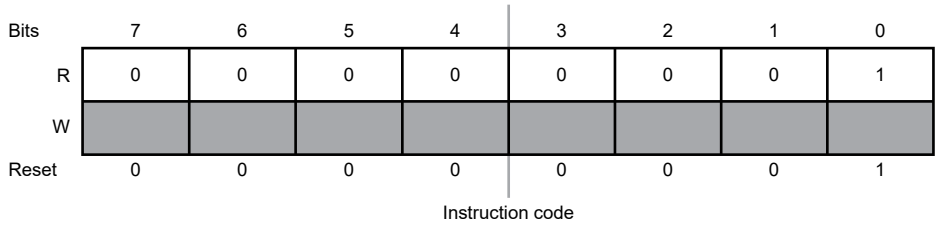


Figure 692. Instruction register

85.7.2 Bypass register

The bypass register is a single-bit shift register path selected for serial data transfer between TDI and TDO when the following instructions are active:

- BYPASS
- HIGHZ
- CLAMP

After entry into the Capture-DR state, the single-bit shift register is set to a logic 0. Therefore, the first bit shifted out after selecting the bypass register is always a logic 0.

85.7.3 Device identification register

The device identification (JTAG ID) register, shown in the following figure, allows the revision number, part number, manufacturer, and design center responsible for the design of the part to be determined through the TAP.

The device identification register is selected for serial data transfer between TDI and TDO when the IDCODE instruction is active. Entry into the Capture-DR state when the device identification register is selected loads the IDCODE into the shift register to be shifted out on TDO in the Shift-DR state. No action occurs in the Update-DR state.

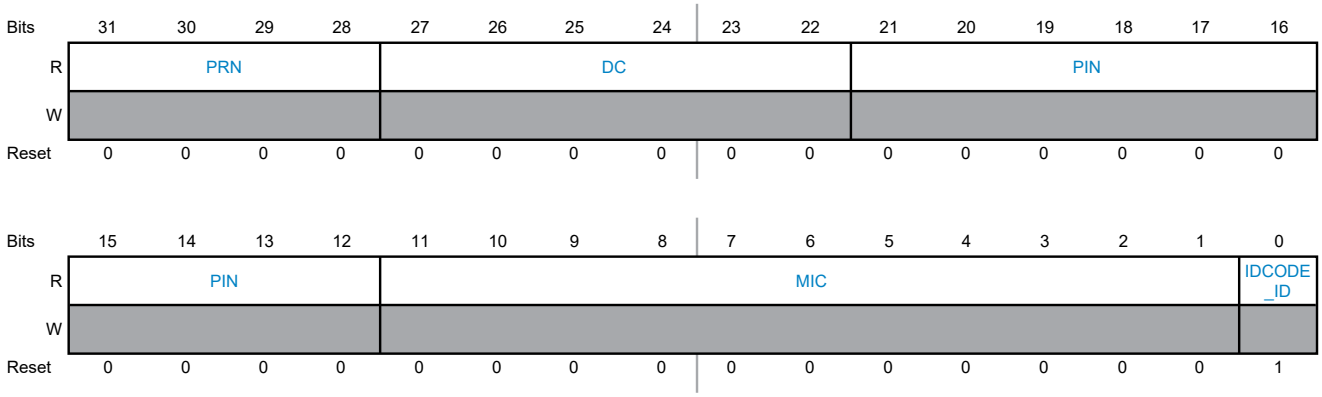


Figure 693. Device identification register

The following table describes the device identification register functions. The device identification register values are described in the chip-specific JTAGC information.

Table 770. Device identification register field descriptions

Field	Function
PRN	Part revision number Contains the revision number of the part.
DC	Design center Indicates the design center.
PIN	Part identification number Contains the part number of the device.
MIC	Manufacturer identity code Contains the reduced Joint Electron Device Engineering Council (JEDEC) ID .
IDCODE ID	IDCODE register ID Identifies this register as the device identification register and not the bypass register. Always set to 1.

85.7.4 Boundary scan register

The boundary scan register is connected between TDI and TDO when the EXTEST, PRELOAD instructions are active. It is used to:

- Capture input pin data
- Force fixed values on output pins
- Select a logic value and direction for bidirectional pins

Each bit of the boundary scan register represents a separate boundary scan register cell, as described in the IEEE 1149.1-2001 standard and discussed in Boundary scan. The size of the boundary scan register and bit ordering is device-dependent and can be found in the device BSDL file.

85.8 Glossary

TAP	Test access port
TCK	Test clock
TDI	Test data in
TDO	Test data out
TMS	Test mode select
JCOMP	JTAG compliance

Chapter 86
JTAG Data Communication (JDC)

86.1 Overview

JDC module provides the capability to move register data between the IPS and JTAG domains. This facilitates communication between internal resources that access memory-mapped register space and an external tool that accesses the JTAG port.

The JDC module consists of:

- IPS-accessible registers
- JTAG-accessible registers
- Associated logic to coordinate movement of data from one register domain to another

The JDC implements the following IPS data registers, occupying separate memory space:

- 1 32-bit memory mapped register that can be read or written via IPS (JTAG Output Data Register (JOUT_IPS)), and whose contents are ported out for capture into a JTAG register (JOUT) to be read via the JTAG port.
- 1 32-bit memory mapped register that can only be read via IPS (JTAG Input Data Register (JIN_IPS)), and whose contents are loaded from a JTAG register (JIN).

JDC indicates when:

- New data has been shifted in via the JTAG port and is ready to be read from the JTAG Input Data Register (JIN_IPS) register
- New data has been written to the JTAG Output Data Register (JOUT_IPS) register and is ready to be read via the JTAG port

A Module Status Register (MSR) captures the state of these flags and also provides the flags to a JTAG register (JOUT) for tool visibility.

86.1.1 Block diagram

There is a single bus interface to port register data out to the JTAGC, and a single bus interface to port data in from the JTAGC. The following figure is the JDC module block diagram.

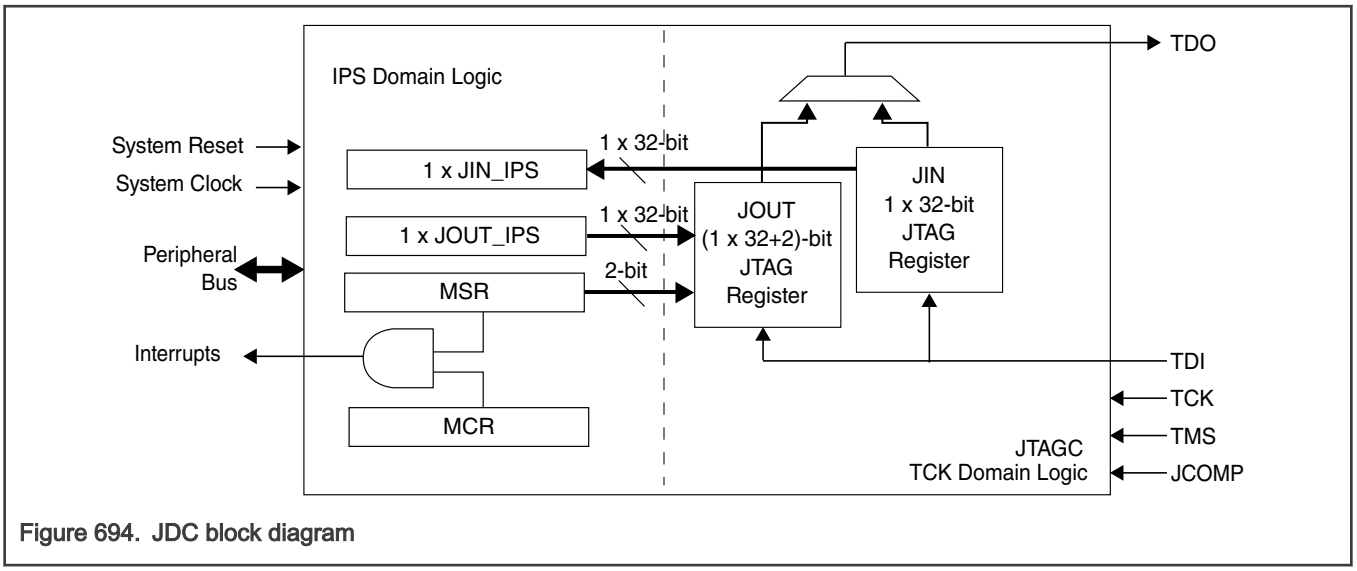


Figure 694. JDC block diagram

86.2 Functional description

The JDC module provides the ability to shift in data via the JTAG port and capture that data in memory-mapped register that can be accessed via IPS. It also provides the ability to capture data written to memory-mapped register into a JTAG shift register for output via the JTAG port.

86.2.1 JDC functionality

An overview of the module functionality is described here:

- Software write to the JOUT_IPS register:
  1. The JDC sets the JOUT_RDY flag bit, indicating new data is available to be read from the JOUT register via the JTAG port.
  2. The MSR reflects the state of the JOUT_RDY bit.
  3. The JDC also captures the state of the JOUT_RDY bit in the JOUT register.
  4. A JTAG read of the JOUT register via execution of the JOUT_READ instruction with a JOUT_RDY bit whose value is logic 1 indicates that the register contains new data.
  5. The JDC clears the JOUT_RDY flag bit upon exit of the Capture-DR JTAG state during execution of the JOUT_READ instruction.
  6. Clearing the JOUT_RDY bit indicates to software that a new data value can be written to the JOUT_IPS register.
- JTAG write to the JIN register via execution of the JIN_WRITE JTAG instruction:
  1. The JDC updates the contents of the JIN_IPS register upon exit of the Update-DR state.
  2. An update of the JIN_IPS register sets the JIN_RDY flag bit, indicating new data is available to be read via IPS.
  3. The MSR register reflects the state of the JIN_RDY bit.
  4. The JDC also captures the state of the JIN_RDY bit in the JOUT register.
  5. The JDC clears the JIN_RDY flag bit upon software read of the JIN_IPS register.
  6. A JTAG read of the JOUT register with a JIN_RDY value of logic 0 indicates that new data can be written to the JIN register.

86.2.2 JTAG register access

See the JTAGC documentation for information on how to access the JTAG registers.

86.2.2.1 JDC block instructions

The JDC block implements the instructions listed in Table 771. This section gives an overview of each instruction. All undefined opcodes are reserved.

Table 771. JTAG instructions

Instruction	Code[4:0]	Instruction summary
Reserved	00001	Factory debug reserved.
JOUT_READ	00010	Selects JOUT data register. The JDC captures data from JOUT_IPS into JOUT data register upon entry to Capture-DR state when JOUT_READ is active.
JIN_WRITE	01110	Selects JIN data register. The JDC captures data from JIN into JIN_IPS upon exit of Update-DR state when JIN_WRITE is active.

Table continues on the next page...

Table 771. JTAG instructions (continued)

Instruction	Code[4:0]	Instruction summary
BYPASS[1]	11111	Selects bypass register for data operations.
Reserved	All other opcodes	Decoded to select bypass register.

1. This is an IEEE 1149.1-2001 defined instruction. See the IEEE 1149.1-2001 standard for more details.

86.2.3 Clocking

JDC module uses TCK and inverted TCK as clock source.

86.2.4 Interrupts

This module has no interrupts.

86.3 External signals

JDC signals are listed in the following table.

Table 772. Signal properties

Name	Function	I/O	Reset
TCK	Test clock input	I	—
TMS	Test mode select	I	0
TDI	Test data in	I	0
JCOMP	JTAG compliance pin	I	0
TDO	Test data out	O	HiZ

86.4 Initialization

This module does not require initialization.

86.5 Secure challenge/response connection procedure

A summary of how the JDC can be used to interact with a security module to perform challenge/response password authorization is as follows:

1. After exit of reset, all registers are at their reset values. JIN_RDY bit value of 0 indicates that the tool may write data to the JIN register. JOUT_RDY bit value of 0 indicates that software may write data to the JOUT_IPS register.
2. The MCR register is programmed to enable JOUT and JIN interrupts, or not.
3. Once the tool is ready to start the authorization process, it writes a value to the JIN register via execution of the JTAGC JIN_WRITE instruction.
4. Software monitors the state of the JIN_RDY bit or enables the JIN interrupt and uses the interrupt assertion as a trigger to start the authorization process.
5. Once the authorization process is started, software writes the first JOUT value to the JOUT_IPS register. This sets the JOUT_RDY bit value to 1.

6. Following the initial tool write to the JIN register, the tool polls the JOUT register to determine when software has provided a challenge word. Upon reading the JOUT register with JOUT_RDY bit set, the tool records the data value to be used to generate the appropriate response. The read of the JOUT register clears the JOUT_RDY bit. The clearing of the JOUT_RDY bit also sets the JOUT_INT bit and asserts the JOUT interrupt if the MCR[JOUT_IEN] is set.
7. With the JOUT_RDY bit cleared, software may now provide the next challenge word.
8. Once the tool has generated a response word, it uses the value of the JIN_RDY bit from the JOUT register read to determine when it can perform a write to the JIN register to provide the response.
9. The security module can provide additional challenge words and read back the corresponding response words as needed, repeating the process.

Simply providing a password without using the challenge/response protocol can be done in a similar way. The tool provides 32-bits of the password at a time with each write to the JIN register, and monitors the JIN_RDY bit value of the JOUT register to determine when the next JIN register value can be written. There is no need for software to write the JOUT_IPS register in this case.

For details related to the lifecycle stage at which this process is performed, see the "Hardware Security Engine" chapter.

86.6 JDC register descriptions

The following sections describe the implemented 32-bit registers. Only 32-bit accesses are valid. The effects of access that are not 32 bits are not defined.

86.6.1 JDC memory map

JDC base address: 4039_4000h

Offset	Register	Width (In bits)	Access	Reset value
0h	Module Configuration Register (MCR)	32	RW	0000_0000h
4h	Module Status Register (MSR)	32	RW	0000_0000h
8h	JTAG Output Data Register (JOUT_IPS)	32	RW	0000_0000h
Ch	JTAG Input Data Register (JIN_IPS)	32	R	0000_0000h

86.6.2 Module Configuration Register (MCR)

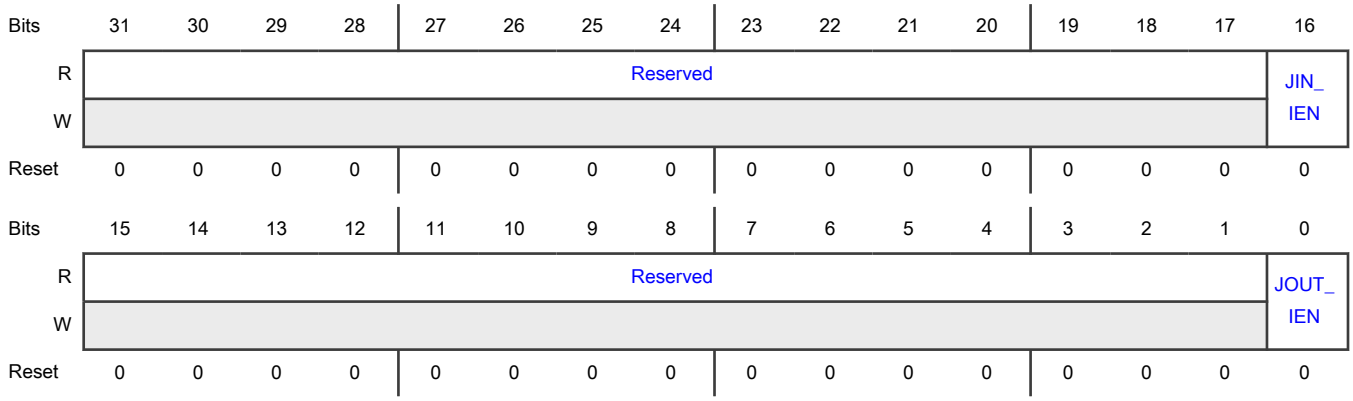
Offset

Register	Offset
MCR	0h

Function

The MCR enables the interrupt outputs of the JDC. This register is reset by system destructive reset.

Diagram



Fields

Field	Function
31-17 —	Reserved
16 JIN_IEN	JIN Interrupt Enable 0b - Setting MSR[JIN_INT] bit does not assert the JIN interrupt 1b - Setting MSR[JIN_INT] bit asserts the JIN interrupt
15-1 —	Reserved
0 JOUT_IEN	JOUT Interrupt Enable 0b - Setting MSR[JOUT_INT] bit does not assert the JOUT interrupt 1b - Setting MSR[JOUT_INT] bit asserts the JOUT interrupt

86.6.3 Module Status Register (MSR)

Offset

Register	Offset
MSR	4h

Function

The MSR holds the JTAG register status and interrupt bits. This register is reset by system destructive reset.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	Reserved													JIN_RDY	Reserved	JIN_INT
W																W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	Reserved													JOUT_RDY	Reserved	JOUT_INT
W																W1C
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-19 —	Reserved
18 JIN_RDY	JIN Ready (read only) 0b - Cleared upon software read of JIN_IPS contents via IPS 1b - Set when new data is written to the JIN_IPS register
17 —	Reserved
16 JIN_INT	JIN Interrupt 0b - Cleared by writing logic 1 1b - Set when new data is written to the JIN_IPS register
15-3 —	Reserved
2 JOUT_RDY	JOUT Ready (read only) 0b - Cleared upon tool read of JOUT register via JTAG port 1b - Set when new data is written to the JOUT_IPS register
1 —	Reserved
0 JOUT_INT	JOUT Interrupt 0b - Cleared by writing logic 1 1b - Set when JOUT_RDY bit is cleared by tool reading JOUT register

86.6.4 JTAG Output Data Register (JOUT_IPS)

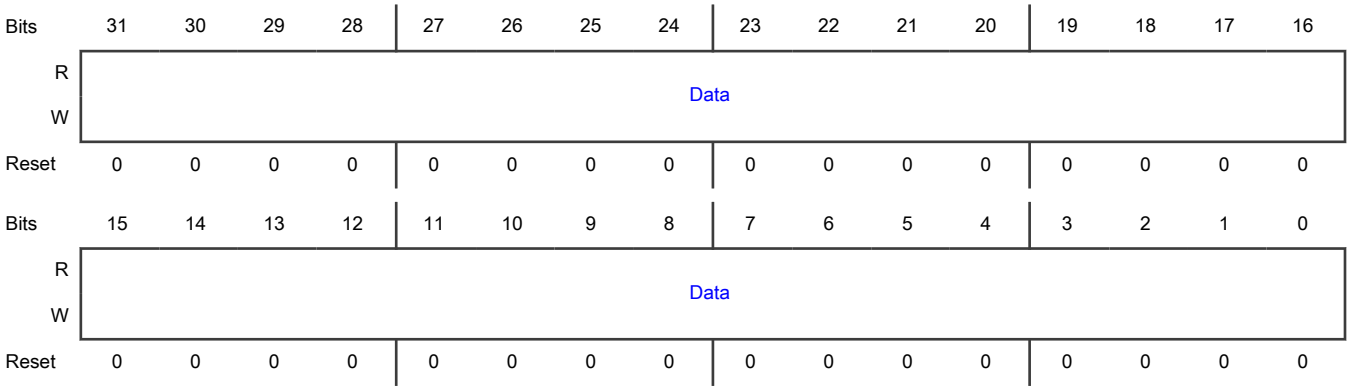
Offset

Register	Offset
JOUT_IPS	8h

Function

The JOUT_IPS register holds data written via IPS. The JDC captures the JOUT_IPS contents into the JOUT register to be read via the JTAG port. This register is reset by system destructive reset.

Diagram



Fields

Field	Function
31-0 Data	JOUT_IPS Data

86.6.5 JTAG Input Data Register (JIN_IPS)

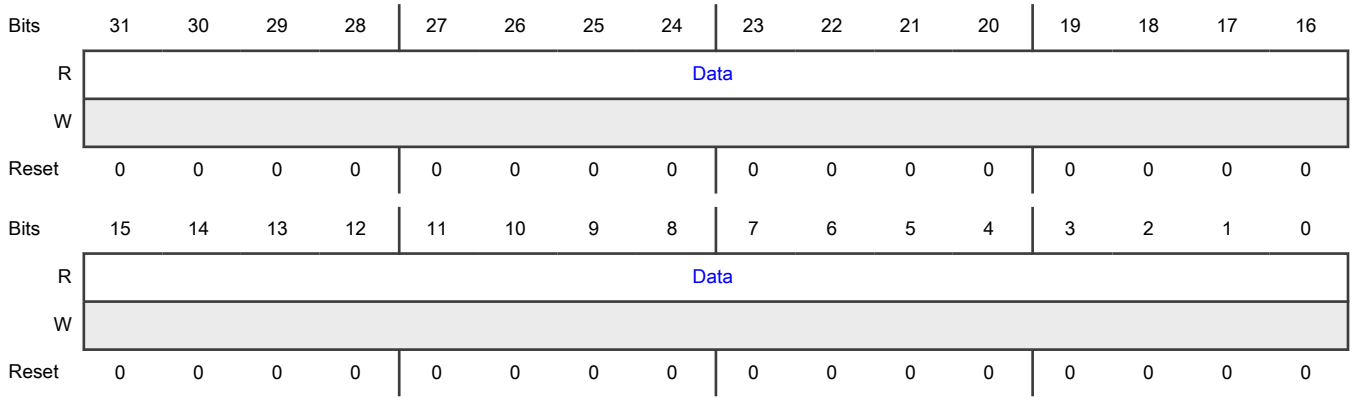
Offset

Register	Offset
JIN_IPS	Ch

Function

The JIN_IPS register holds data written to the JTAG input data register (JIN) via the JTAG port, where the data can be read via IPS. Any IPS write to the JIN_IPS register returns a transfer error. This register is reset by system destructive reset.

Diagram



Fields

Field	Function
31-0 Data	JIN_IPS data

86.7 Non-memory-mapped register definition

The JDC also implements two JTAG accessible registers that are not memory-mapped. One JTAG register shifts in data to be placed in the JIN_IPS register. The other JTAG register captures data from the JOUT_IPS register plus ready status from the MSR, to be shifted out via the JTAG port.

86.7.1 JTAG output data register (JOUT)

The JOUT register captures data from the JOUT_IPS register upon execution of the JOUT_READ JTAG instruction. It also holds the JIN_RDY and JOUT_RDY status bits. This register is reset by system destructive reset and JTAG reset. The reset value of the JOUT register is 0. The following figure shows the format of the JOUT register.

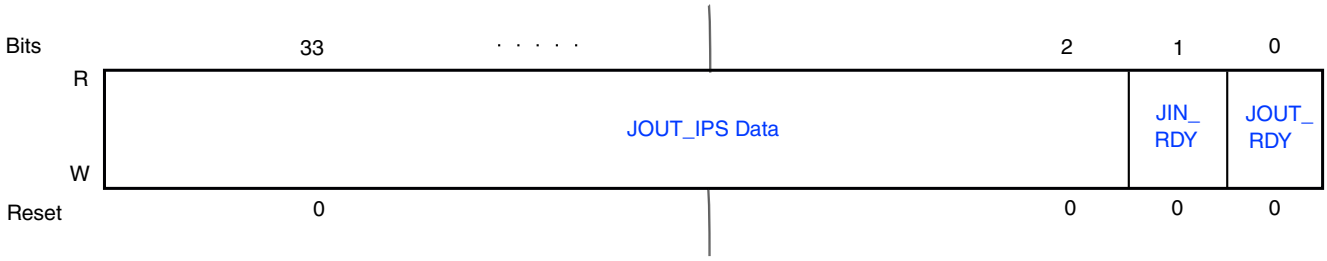


Figure 695. JOUT

The JOUT register is described in the following table.

Table 773. JOUT JTAG register field descriptions

Field	Function
JOUT_IPS Data	JOUT_IPS Data Data value from JOUT_IPS register

Table continues on the next page...

Table 773. JOUT JTAG register field descriptions (continued)

Field	Function
JIN_RDY	JIN_RDY State of JIN_RDY bit from MSR
JOUT_RDY	JOUT_RDY State of JOUT_RDY bit from MSR

86.7.2 JTAG input data register (JIN)

The external tool writes data to the JIN register via JTAG during execution of the JIN_WRITE JTAG instruction. The JDC later captures JIN data in the JIN_IPS register to be read via IPS. This register is reset by system destructive reset and JTAG reset. The reset value of the JIN register is 0. The following figure shows the format of the JIN register.

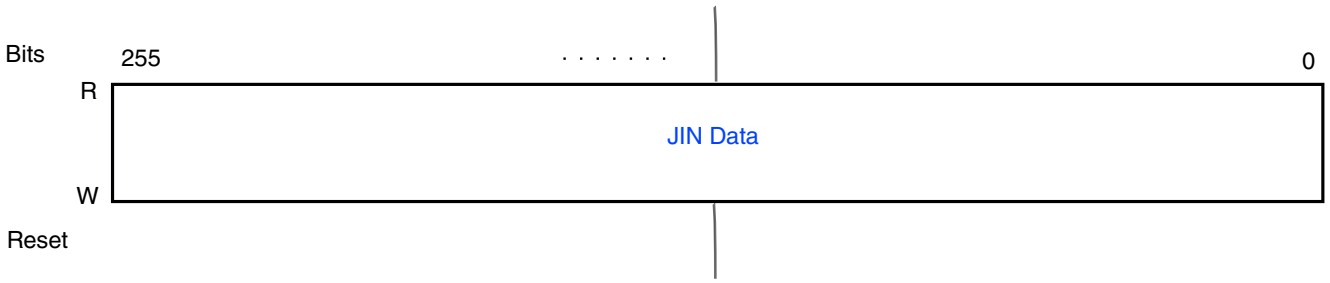


Figure 696. JIN

The JIN register is described in the following table.

Table 774. JIN JTAG register field descriptions

Field	Description
JIN Data	Contains data to be captured in JIN_IPS register upon exit of Update-DR state when executing WRITE_JIN JTAG instruction.

86.8 Glossary

IPS	Internal peripheral system
XBAR	Crossbar bus interface

Chapter 87
Temperature Sensor (TempSense)

87.1 Chip-specific TempSense information

87.1.1 TempSense configuration

TEMPSENSE module depends on the V25 FLA voltage.

TEMPSENSE module temperature is not dependent on different supply voltages 2.97 V, 3.3 V, and 5 V (VDD_HV_A = VDD_HV_B = VREFH).

87.2 Overview

TEMPSENSE is used to measure the temperature on the chip through an ADC and to flag if an overtemperature condition occurs.

The TEMPSENSE module contains control registers for use with the Engineering temperature sensor (ETS) hard block and the flag generation hard block. These registers use a peripheral bus interface to communicate with the chip.

87.2.1 Block diagram

The functional structure of the TEMPSENSE can be seen in the block diagram in Figure 697.

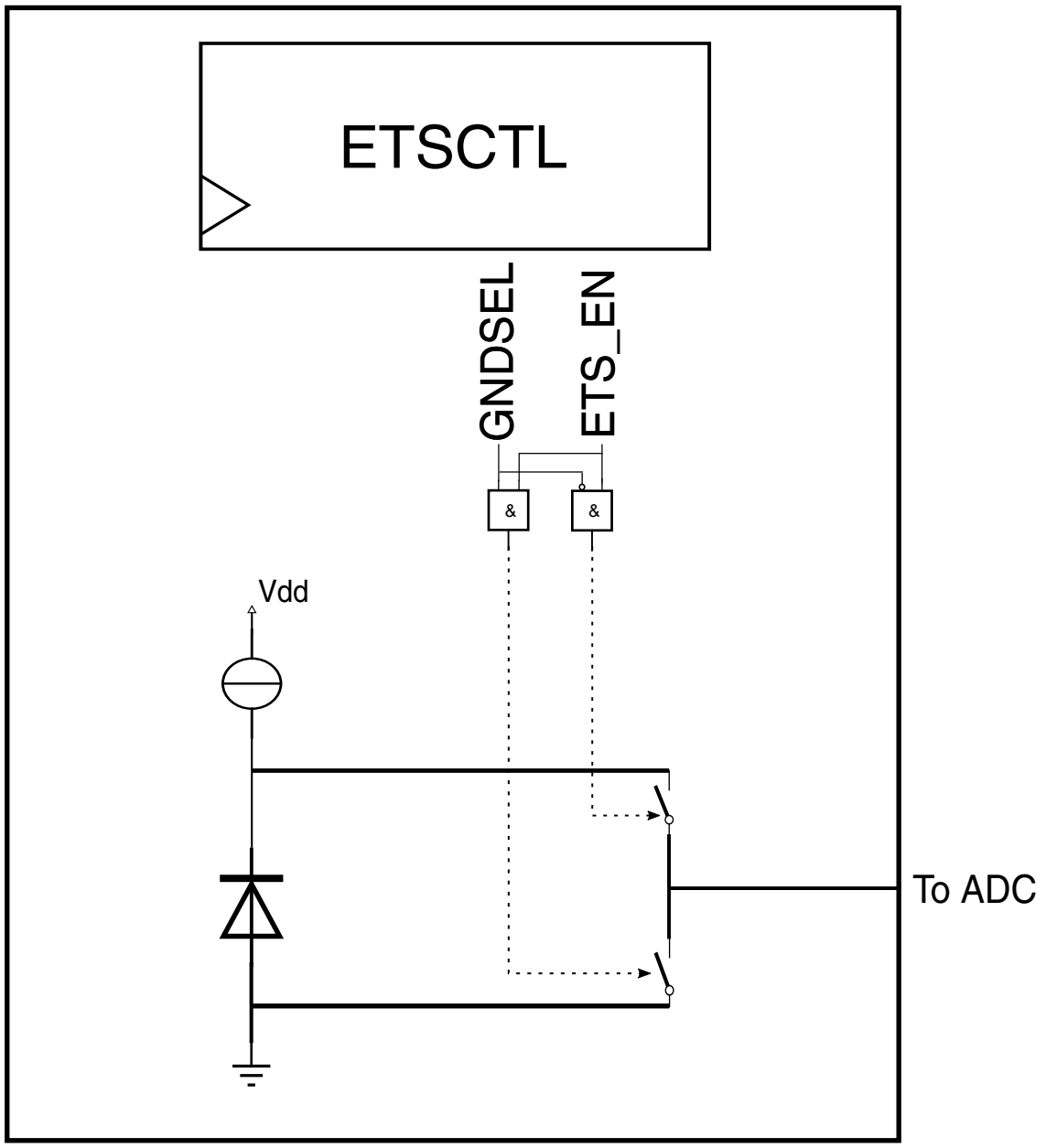


Figure 697. TEMPSENSE block diagram

87.2.2 Features

The TEMPSENSE includes the following features:

- Provide a voltage proportional to the temperature which will be read out by ADC
- Ground selection for improved precision in the ETS. The ETS ground could be different from the ADC ground. By exposing it to the ADC, the temperature calculation could be improved as the voltage value will be more precise.

87.3 Functional description

87.3.1 Clocking

This module has no clocking considerations.

87.3.2 Interrupts

This module has no interrupts.

87.3.3 General

The TEMPSENSE module is designed to measure the temperature on the chip.

The TEMPSENSE output can be read by an ADC on demand so that the software can determine the current die temperature. The software should enable the TEMPSENSE by setting ETSCTL[ETS_EN].

The TEMPSENSE output can be read by an ADC on demand so that the software can determine the current die temperature..

Coefficients are used to allow a simple and accurate calculation of linearized temperature directly from the ADC. The increase of the sampling time of the ADC from the minimum sampling value is increasing the temperature accuracy.

87.3.4 Initialization

87.3.4.1 Conversion from voltage to temperature

Solve the equation for the conversion from voltage to temperature, where V_{ETS} is the difference of V_{be} and V_{GND}. V_{GND} is expose on the ADC output when ETSCTL[GNDSEL] is set.

$$T_{ETS} = TCA_0 + TCA_1 \cdot V_{ETS} + TCA_2 \cdot V_{ETS}^2$$

The coefficients TCA0, TCA1 and TCA2 are read from the corresponding registers. They are stored in a signed fixed-point format as the following TCAx(11,4) (1 bit for the sign, 11 bits for the integer part and 4 bits for the decimal part).

The calculation of the temperature should be done with the actual coefficient values provided in the TCAx fields. See the example below for an ambient temperature of 25C, and an ADC reference voltage (V_{REFH}) of 5V. See the ADC section of the device data sheet for more details on V_{REFH} and N-bit level resolution.

$$TCA0 = (000110100100.1110)_2 = (000110100100)_2 + (1110)_2 \times \frac{1}{2^4} = +((420)_{10} + (14)_{10} \times \frac{1}{2^4}) = +420.8750\ C$$

$$TCA1 = (100010101111.1110)_2 = (100010101111)_2 + (1110)_2 \times \frac{1}{2^4} = -((175)_{10} + (14)_{10} \times \frac{1}{2^4}) = -175.8750\ C/V$$

$$TCA2 = (100000011101.1110)_2 = (100000011101)_2 + (1110)_2 \times \frac{1}{2^4} = -((29)_{10} + (14)_{10} \times \frac{1}{2^4}) = -29.8750\ C\ /V^2$$

$$V_{ETS} = (010110001011)_2 = (1419)_{10} \times \frac{V_{REFH}}{2^N}$$

By using the formula, the junction temperature calculated is 26.5838 C.

The maximal calculation error is 0.0313 C.

87.4 External signals

There are no external signals for this module.

87.5 Memory map and register definition

87.5.1 Transfer error description

The following actions will cause a transfer error and will not change the register content:

- Any access to an unused register address
- Write access to a read-only register (TCAx)

87.5.2 TempSense register descriptions

87.5.2.1 TempSense memory map

TEMPSENSE base address: 4037_C000h

Offset	Register	Width (In bits)	Access	Reset value
0h	ETS Control (ETSCTL)	32	RW	0000_0000h
8h	Temperature Coefficient (TCA0)	32	R	See section
Ch	Temperature Coefficient (TCA1)	32	R	See section
10h	Temperature Coefficient (TCA2)	32	R	See section

87.5.2.2 ETS Control (ETSCTL)

Offset

Register	Offset
ETSCTL	0h

Function
This register contains control bits that control ETS.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	0														GNDSEL	ETS_EN
W																
Reset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fields

Field	Function
31-2 —	Reserved
1 GNDSEL	Ground selection 0b - No exposure of the ground 1b - Expose ground on the ADC output if ETSCTL[ETS_EN]=1
0 ETS_EN	Temperature Sensor enable Power up the ETS. 0b - Power down 1b - Functional mode

87.5.2.3 Temperature Coefficient (TCA0)

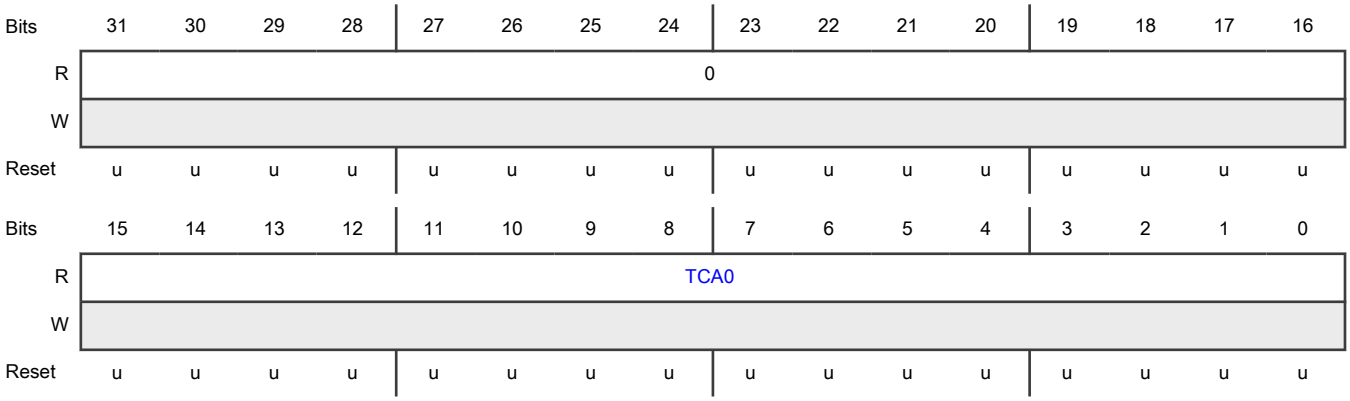
Offset

Register	Offset
TCA0	8h

Function

This register contains the coefficient TCA0 needed to calculate the temperature. the reset value is specific for each chip.

Diagram



Fields

Field	Function
31-16	Reserved

Table continues on the next page...

Table continued from the previous page...

Field	Function
—	
15-0 TCA0	Temperature coefficient A0 see Conversion from voltage to temperature for the usage of this coefficient

87.5.2.4 Temperature Coefficient (TCA1)

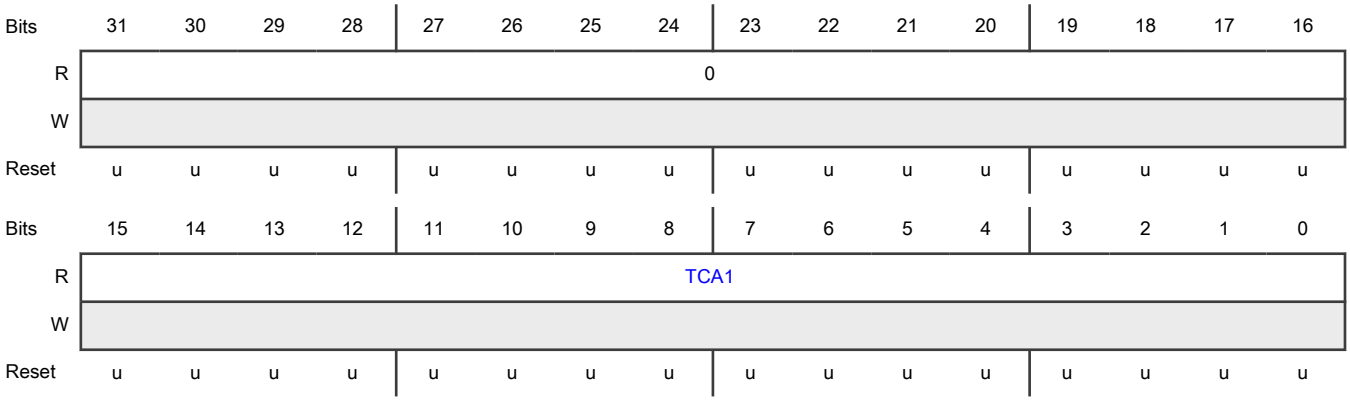
Offset

Register	Offset
TCA1	Ch

Function

This register contains the coefficient TCA1 needed to calculate the temperature. the reset value is specific for each chip.

Diagram



Fields

Field	Function
31-16 —	Reserved
15-0 TCA1	Temperature coefficient A1 see Conversion from voltage to temperature for the usage of this coefficient

87.5.2.5 Temperature Coefficient (TCA2)

Offset

Register	Offset
TCA2	10h

Function

This register contains the coefficient TCA2 needed to calculate the temperature. the reset value is specific for each chip.

Diagram

Bits	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
R	0															
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	TCA2															
W																
Reset	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u

Fields

Field	Function
31-16 —	Reserved
15-0 TCA2	Temperature coefficient A2 see Conversion from voltage to temperature for the usage of this coefficient

87.6 Glossary

ADC	Analog to digital converter
ETS	Engineering temperature sensor
CTS	Customer temperature sensor
V_{be}	Base emitter voltage
V_{ETS}	Engineering temperature sensor voltage
V_{GND}	Ground voltage

Appendix A
General Changes

A.1 General changes

- Editorial changes
  - Each new release of this document includes editorial improvements such as:
    - Spelling
    - Grammar
    - Punctuation
    - Voice
    - Tense
    - Capitalization
    - Formatting
    - Presentation
    - Navigation

Appendix B
Release Notes

B.1 About This Manual changes

- Removed the "Attachments" section.
- Replaced the 'Master with controller' and 'slave with the target'in the diagram of the "Example of chip-specific information that refers to a different chapter" and "Example: chip-specific information that supersedes content in the same chapter".

B.2 Introduction changes

- Updated sections "S32K396 product series", "Feature summary", and "Feature comparison".

B.3 Memory map changes

No substantial content changes.

B.4 Signal Multiplexing changes

No substantial content changes.

B.5 Cortex-M7 Overview changes

- Added a note to Introduction.

B.6 Overlay Management Unit (OMU)

B.6.1 Chip-specific OMU information changes

- Added a note to Calibration.

B.6.2 OMU module changes

- Updated offset of Global Zone Request (GZRR) and Global Zone Request Update Delay (GZRUDR) registers.

B.7 Miscellaneous Control Module (MCM)

B.7.1 Chip-specific MCM information changes

No substantial content changes.

B.7.2 MCM module changes

No substantial content changes.

B.8 Miscellaneous System Control Module (MSCM)

B.8.1 Chip-specific MSCM information changes

No substantial content changes.

B.8.2 MSCM module changes

- Corrected a few typographical errors in the DCSZ and ICSZ fields.
- Removed cache size information from all ICSZ and DCSZ fields, and added a note referencing the MCM chapter for details on cache sizes.

B.9 Virtualization Wrapper (VIRT_WRAPPER)

B.9.1 Chip-specific VIRT WRAPPER information changes

No substantial content changes.

B.9.2 VIRT_WRAPPER changes

- In Virtualization of interrupt control registers, added "The PDAC that...16 KB space" and "Access to mirrored...region".
- In Modes of operation, added see "Chip specific... for more details".

B.10 System Integration Unit Lite2 (SIUL2)

B.10.1 Chip-specific SIUL2 information changes

No substantial content changes.

B.10.2 SIUL2 module changes

No substantial content changes.

B.11 Crossbar Switch Lite (AXBS_Lite)

B.11.1 Chip-specific AXBS information changes

No substantial content changes.

B.11.2 AXBS module changes

No substantial content changes.

B.12 Peripheral Bridge (AIPS_Lite)

B.12.1 Chip-specific AIPS_Lite information changes

No substantial content changes.

B.12.2 AIPS_Lite module changes

No substantial content changes.

B.13 Direct Memory Access Multiplexer (DMAMUX)

B.13.1 Chip-specific DMAMUX information changes

No substantial content changes.

B.13.2 DMAMUX module changes

No substantial content changes.

B.14 Enhanced Direct Memory Access (eDMA3)

B.14.1 Chip-specific eDMA3 information changes

No substantial content changes.

B.14.2 eDMA3 module changes

- Updated the description of CSR[GMRC] and CH0_SBR[EMI].

B.15 INTM module changes

No substantial content changes.

B.16 Semaphores2 (SEMA42)

B.16.1 Chip-specific SEMA42 information changes

No substantial content changes.

B.16.2 SEMA42 module changes

- Moved the "Initialization" and "External signals" section above "Memory map/register defination" section.

B.17 Crossbar Integrity Checker (XBIC)

B.17.1 Chip-specific XBIC information changes

No substantial content changes.

B.17.2 XBIC module changes

No substantial content changes.

B.18 Extended Resource Domain Controller (XRDC)

B.18.1 Chip-specific XRDC information changes

- Added a note at the end of Table 53.

B.18.2 XRDC module changes

- Added Exceptions and violations.

- Updated Handling domain access violation errors.
- Updated the register descriptions for DERR_W0_i, DERR_W1_i, and DERR_W3_i.

- Updated the register descriptions for DERR_W0_i and DERR_W1_i.

B.19 Memories and Memory Interfaces changes

No substantial content changes.

B.20 Embedded Flash Memory (c40asf)

B.20.1 Chip-specific C40asf information changes

- Updated Flash memory configuration and register settings.
- Updated MCRE register reset value for S32K3x4 variants.

B.20.2 Embedded Flash Memory (c40asf)

No substantial content changes.

B.21 Flash Memory Controller (PFLASH)

B.21.1 Chip-specific PFLASH information changes

No substantial content changes.

B.21.2 PFLASH controller module changes

No substantial content changes.

B.22 RAM Controller (PRAMC)

B.22.1 Chip-specific PRAMC information changes

No substantial content changes.

B.22.2 PRAMC module changes

No substantial content changes.

B.23 Clocking module changes

No substantial content changes.

B.24 Clock Generation Module (MC_CGM)

B.24.1 Chip-specific MC_CGM information changes

No substantial content changes.

B.24.2 MC_CGM module changes

No substantial content changes.

B.25 FIRC module changes

No substantial content changes.

B.26 SIRC module changes

No substantial content changes.

B.27 Fast Crystal Oscillator Digital Controller (FXOSC)

B.27.1 Chip-specific FXOSC information changes

- Added FXOSC configuration.

B.27.2 FXOSC module changes

No substantial content changes.

B.28 PLL Digital Interface (PLLDIG)

B.28.1 Chip-specific PLLDIG information changes

No substantial content changes.

B.28.2 PLLDIG module changes

No substantial content changes.

B.29 Reset module changes

• Updated the RESET chapter throughout.

B.30 Reset Generation Module (MC_RGM)

B.30.1 Chip-specific MC_RGM information changes

No substantial content changes.

B.30.2 MC_RGM module changes

• Updated the note in DES[F_POR]. • Updated the note in Functional /External Reset Status Register (FES).
• Updated the note in Functional /External Reset Status Register (FES).
• Updated the description of the Functional /External Reset Status Register (FES).
• Updated Figure 137.

B.31 POR_WDG module changes

No substantial content changes.

B.32 Boot Overview changes

• Made the changes throughout the chapter.
• Removed table "PE lock fields setting in HSE.CONFIG_PE_LOCK" from BAF flash programming controls

B.33 Security overview changes

No substantial content changes.

B.34 HSE_B module changes

- Updated register "CONFIG_REG_GPR".
- Added registers "CONFIG_GPR1", "CONFIG_GPR2", and "CONFIG_GPR3".
- Updated Glossary.

B.35 DCF module changes

No substantial content changes.

B.36 Device Configuration Module General-Purpose Registers (DCM_GPR)

B.36.1 Chip-specific DCM_GPR information changes

- Added DCM register fields availability in product family.

B.36.2 DCM_GPR module changes

- Revised "DCM_GPR register descriptions".
- Deleted DCMRWF2[SIRC_TRIM_BYP_STDBY_EXT].

B.37 DCM module changes

- Revised Block diagram, Figure 147, and Features.
- Revised DCF mechanism, removed the content duplicate with DCF chapter of RM.
- Revised DCF client error mechanism, changed CERS to DCMCERS in figure title.
- Revised LC to update information of valid and invalid field types, and Table 183 to change PFA to Pre_FA.
- Revised Glossary, added OTP and DCF.
- Deleted DCMSTAT[9] DCMOTAS.
- Revised the description of DCM Status (DCMSTAT), LC and LC Control (DCMLCC), LC Scan Status (DCMLCS), LC Scan Status 2 (DCMLCS_2), DCMSTAT[DCMLCST], , DCMMISC[DCMDBGE], DCMMISC[DCMDBGT], DCF Error Count (DCMEC), DCMEC[DCMECT], DCMSRRn, DCMSRR1[DCMESF1], and DCMSRR1[DCMDCFF1].

B.38 Messaging Unit (MU)

B.38.1 Chip-specific MU information changes

No substantial content changes.

B.38.2 MU module changes

• Deleted topic "Sending messages with interrupt" and revised Initialization to add information "MU does not require initialization.".
• Updated topics MUA side and MUB side, revised notes.
• Updated the description of SR[TEP] and RSR[RFn].

B.39 Power Management changes

No substantial content changes.

B.40 PMC changes

No substantial content changes.

B.41 Mode Entry Module (MC_ME)

B.41.1 Chip-specific MC_ME information changes

No substantial content changes.

B.41.2 MC_ME module changes

• Added Main Core ID Register (MAIN_COREID).

B.42 MC_PCU changes

• Updated first statement in the second paragraph of Introduction.

B.43 Wakeup Unit (WKPU)

B.43.1 Chip-specific WKPU information changes

No substantial content changes.

B.43.2 WKPU module changes

No substantial content changes.

B.44 Chip-specific Safety overview information changes

No substantial content changes.

B.45 Error Injection Module (EIM)

B.45.1 Chip-specific EIM information changes

No substantial content changes.

B.45.2 EIM module changes

No substantial content changes.

B.46 Error Reporting Module (ERM)

B.46.1 Chip-specific ERM information changes

No substantial content changes.

B.46.2 ERM module changes

No substantial content changes.

B.47 Fault Collection and Control Unit (FCCU)

B.47.1 Chip-specific FCCU information changes

No substantial content changes.

B.47.2 FCCU module changes

- For EINOUT, updated the bit field description for EINOUT[EIN1] and EINOUT[EIN0].

B.48 SELFTEST_GPR module changes

- Updated Progressive shift clock switching (PCS).

B.49 Self-Test Control Unit (STCU2)

B.49.1 Chip-specific STCU2 information changes

- Updated the chapter throughout.

B.49.2 STCU2 module changes

No substantial content changes.

B.50 Register Protection (REG_PROT)

B.50.1 Chip-specific REGPROT information changes

No substantial content changes.

B.50.2 REG_PROT module changes

No substantial content changes.

B.51 Clock Monitoring Unit – Frequency Check (CMU_FC)

B.51.1 Chip-specific CMU_FC information changes

No substantial content changes.

B.51.2 CMU_FC module changes

No substantial content changes.

B.52 Clock Monitoring Unit – Frequency Meter (CMU_FM)

B.52.1 Chip-specific CMU_FM information changes

No substantial content changes.

B.52.2 CMU_FM module changes

No substantial content changes.

B.53 Cyclic Redundancy Check (CRC)

B.53.1 Chip-specific CRC information changes

No substantial content changes.

B.53.2 CRC module changes

- In section Calculating a 16-bit CRC cross reference in step 2 “Program the transpose and complement options in Data (DATA) as required for the CRC calculation”)" changed to "Control (CTRL)".
- In section Calculating a 32-bit CRC cross reference in step 7 “CRC is computed on every data value write and the intermediate CRC result is stored back into DATA[LU] and DATA[LL]” changed to "DATA".
- In register DATA[HL] long description updated to "Generates CRC checksum in both 16-bit and 32-bit CRC modes if CTRL[WAS] = 0."

B.54 PCMC changes

No substantial content changes.

B.55 Input Glitch Filter

B.55.1 Chip-specific Input Glitch Filter information changes

No substantial content changes.

B.55.2 Input Glitch Filter module changes

No substantial content changes.

B.56 Enhanced Flex Pulse Width Modulator (eFlexPWM)

B.56.1 Chip-specific eFlexPWM information changes

No substantial content changes.

B.56.2 eFlexPWM module changes

No substantial content changes.

B.57 Analog-to-Digital Converter (ADC)

B.57.1 Chip-specific ADC information changes

- Added a note to Configuration and supported instances.

B.57.2 ADC module changes

No substantial content changes.

B.58 SIGMA DELTA ANALOG TO DIGITAL CONVERTER (SDADC)

B.58.1 Chip-specific SDADC information changes

- Added a note to SDADC instances.

B.58.2 SDADC changes

No substantial content changes.

B.59 ADCBIST module changes

No substantial content changes.

B.60 FIR Filter

No substantial content changes.

B.61 Low Power Comparator (LPCMP)

B.61.1 Chip-specific LPCMP information changes

- Added a note to Instantiation information.

B.61.2 LPCMP module changes

No substantial content changes.

B.62 Logic Control Unit (LCU)

B.62.1 Chip-specific LCU information changes

No substantial content changes.

B.62.2 LCU module

- Changed 1h to Eh in Table 307 for LUTCTRL0.
- Revised long description for LC0_SCTRL[SW_MODE].
- Revised Features to update register information.
- Revised Figure 316

B.63 Enhanced Modular IO Subsystem (eMIOS)

B.63.1 Chip-specific eMIOS information changes

- Added a note to eMIOS configuration .

B.63.2 eMIOS module changes

No substantial content changes.

B.64 Body Cross-triggering Unit (BCTU)

B.64.1 Chip-specific BCTU information changes

- Updated Trigger sources.
- Added a note to BCTU configuration.

B.64.2 BCTU module changes

No substantial content changes.

B.65 Trigger MUX (TRGMUX)

B.65.1 Chip-specific TRGMUX information changes

No substantial content changes.

B.65.2 TRGMUX module changes

No substantial content changes.

B.66 CoolFlux DSP Subsystem (DSPSS)

B.66.1 Chip-specific CoolFlux information changes

- Added a note to CoolFlux configuration.

B.66.2 DSPSS changes

No substantial content changes.

B.67 Enhanced Time Processing Unit (eTPU)

B.67.1 Chip-specific eTPU information changes

- Added a note to Device-specific features.

B.67.2 eTPU module changes

No substantial content changes.

B.68 Sine Wave Generator (SGEN)

B.68.1 Chip-specific SGEN information changes

- Added notes to SGEN configuration.

B.68.2 SGEN module changes

No substantial content changes.

B.69 Software Watchdog Timer (SWT)

B.69.1 Chip-specific SWT information changes

No substantial content changes.

B.69.2 SWT module changes

No substantial content changes.

B.70 System Timer Module (STM)

B.70.1 Chip-specific STM information changes

No substantial content changes.

B.70.2 STM module changes

No substantial content changes.

B.71 Periodic Interrupt Timer (PIT)

B.71.1 Chip-specific PIT information changes

No substantial content changes.

B.71.2 PIT module changes

• In Example configuration using chained timers: — Updated the example configuration to (60 s/10 ns). — Updated the step 6 and 7 in the configuring PIT. — Updated the example code for Disable PIT to "PIT_MCR = 0x02" • Updated the example code for Disable PIT to "PIT_MCR = 0x02" in Example configuration using the lifetimer. • Updated the example code for Disable PIT to "PIT_MCR = 0x02" in Example configuration for general timers.
• Updated the section headings of Restart counter period, Change current timer period and Dynamically setting a new timer period. • Replaced "...when it expires (CVALn - 0)" to "...when it expires (CVALn = 0)" in Chained timers.
• In PIT register descriptions, changed PIT_RTI to PIT. • Moved the statements about chip-specific PIT information from PIT register descriptions to Functional description and rewrote it.

B.72 Real Time Clock (RTC)

B.72.1 Chip-specific RTC information changes

No substantial content changes.

B.72.2 RTC module changes

• Modified note in CLKSEL.

B.73 Low Power Serial Peripheral Interface (LPSPI)

B.73.1 Chip-specific LPSPI information changes

No substantial content changes.

B.73.2 LPSPI module changes

No substantial content changes.

B.74 Low Power Inter-Integrated Circuit (LPI2C)

B.74.1 Chip-specific LPI2C information changes

No substantial content changes.

B.74.2 LPI2C module changes

- Updated Pin configuration.

B.75 Flexible I/O (FlexIO)

B.75.1 Chip-specific FlexIO information changes

No substantial content changes.

B.75.2 FLEXIO module changes

No substantial content changes.

B.76 CAN (FlexCAN)

B.76.1 Chip-specific FlexCAN information changes

No substantial content changes.

B.76.2 FlexCAN module changes

- Updated "NOTE" in MCR[LPMACK] and MCR[FRZACK].
- Updated long description of ERFSR[ERFCLR].
- Updated the section Legacy RX FIFO structure (corrected the extended ID range in RXIDB_0 of format B from "296-" to "29-16").
- Updated the section Reset.

B.77 De-serial Serial Peripheral Interface (DSPI)

B.77.1 Chip-specific SPI information changes

No substantial content changes.

B.77.2 DSPI module changes

No substantial content changes.

B.78 Ethernet Media Access Controller (EMAC)

B.78.1 Chip-specific EMAC information changes

No substantial content changes.

B.78.2 ENET_Controller module changes

- Updated registers MAC_Hash_Table_Reg0 and MAC_Hash_Table_Reg1 to add the note "In this chip, upper 6 bits should be used for 64-bit Hash Table".
- Deleted DMA_Safety_Interrupt_Status[DECIS] and DMA_Safety_Interrupt_Status[DEUIS] and added DMA_Safety_Interrupt_Status[1:0] as reserved.

B.79 Low Power Universal Asynchronous Receiver/Transmitter (LPUART)

B.79.1 Chip-specific LPUART information changes

No substantial content changes.

B.79.2 LPUART module changes

No substantial content changes.

B.80 Quad Serial Peripheral Interface (QuadSPI)

B.80.1 Chip-specific QuadSPI information changes

No substantial content changes.

B.80.2 QuadSPI module changes

- Revised TX buffer operation: a footnote is added to Fs

B.81 Zipwire changes

No substantial content changes.

B.82 Serial Interprocessor Interface (SIPI)

B.82.1 Chip-specific SIPI information changes

No substantial content changes.

B.82.2 SIPI module changes

- Added a new topic as SIPI Initialization procedure.
- Updated the description of SIPI Channel Timeout Register 0 (CTOR0), SIPI Channel Timeout Register 1 (CTOR1), SIPI Channel Timeout Register 2 (CTOR2), and SIPI Channel Timeout Register 3 (CTOR3).

B.83 LVDS Fast Asynchronous Serial Transmission (LFAST)

B.83.1 Chip-specific LFAST information changes

No substantial content changes.

B.83.2 LFAST module changes

No substantial content changes.

B.84 Debug changes

- Added a footnote to Debugger not connected.

B.85 JTAG Controller (JTAGC)

B.85.1 Chip-specific JTAGC information changes

No substantial content changes.

B.85.2 JTAGC module changes

No substantial content changes.

B.86 JDC module changes

No substantial content changes.

B.87 Temperature Sensor (TempSense)

B.87.1 Chip-specific TempSense information changes

No substantial content changes.

B.87.2 TEMPSENSE module changes

• In Overview removed Engineering Temperature Sensor (ETS) information.
• Editorial updates throughout the document
• Editorial updates throughout the document
• Long description deleted as it is already mentioned in the features section as per shared review comments of S32K3xx RM Rev1 Draft E. • In section "TempSense memory map" TMU changed to tempSense.
• Moved TempSense register descriptions to the last section.
• In topic "Conversion voltage Temperature" Unit "K" changed to "C" and V_{ets} changed to V_{ETS}.
• Renamed Introduction to Overview. • Added sections Clocking, External signals, and interrupt, to convey that there are no clock sources, external signals, and interrupts for this module. • Added the section head "Initialization" to Conversion from voltage to temperature.
• Updated Overview and Conversion from voltage to temperature
• Added ipg_scan_mode signal. • Improved LVIX signal description in and changed the coefficient unit from C2/V2 to C/V2 in Conversion from voltage to temperature.

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